3G TR 25.888 V6.0.0 (2003-9)

Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Improvement of inter-frequency and inter-system Measurement for 1.28 Mcps TDD
(Release 6)

Keywords

UMTS, radio, antenna

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Contents

Foreword

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Version x.y.z

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1 Scope

In order to improve monitoring other RAT systems or performing inter-frequency measurements in 1.28 Mcps TDD , the channel re-assigning scheme with signaling support and other possible solutions are proposed and investigated, potentially allowing the UE to have a longer measurement window or to avoid possible measurement failures.The purpose of this document is to help the TSG RAN WG1, WG2, WG3 and WG4 to understand potential benefits with respect to the respective study areas, to investigate the proposed method and to identify the impacts to current specifications, which is needed for the introduction of the improvement of inter-frequency and inter-system measurement for1.28 Mcps TDD.

The different study areas will be described in subsequent chapters.

It is intended to gather all information in order to trace the history and the status of the SI in each WGs.

The TR should:

- describe the proposed methods for each study area.
- describe the impacts due to this SI.
- describe agreed requirements related to the SI.
- identify the affected specifications according to the introduction of inter frequency and inter system measurement for 1.28 Mcps TDD and
- also describes the schedule of the SI.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TS 25.123: "Requirements for Support of Radio Resources Management".

[2] 3GPP TS25.222: "Mulplexing and channel coding (TDD)".

[3] 3 GPP TS25.224: "Physical Layer Procedures (TDD)".

[4] 3GPP TS25.423: "UTRAN Iur Interface RNSAP Signalling".

[5] 3GPP TS25.433: "UTRAN Iub Interface NBAP Signalling".

[6] 3GPP TS 25.331: "RRC Protocol Specification".

3 Definitions, symbols and abbreviations

For the purposes of the present document, the following terms and definitions apply.

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

(void)

3.2 Symbols

For the purposes of the present document, the following symbols apply:

(void)

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

(void)

4 Requirements

The general requirements of any proposed schemes are summarised as follows:

- Full backward compatibility with the previous release should be kept.
- The signalling overhead in the higher layers should be minimized.
- The proposed scheme must show a reasonable performance improvement.

5 Scenarios for improvement

At the start of the inter-frequency and inter-system measurement process for the handover preparation, the LCR TDD UE shall find synchronization to the cell to measure using the synchronization channel during its idle timeslots. For a TDD cell to monitor after this procedure the exact timing of the midamble of the P-CCPCH is known and the measurements of P-CCPCH RSCP, pathloss, etc. can be performed. Still there is room for improvements in the following 4 scenarios.

Scenario 1: GSM measurement with low cost terminal

In TS25.225, the formula to calculate the minimum idle time to detect a complete FCCH burst for all possible alignments between the GSM and the 1.28 Mcps TDD frame structure (called 'guaranteed FCCH detection'), assuming that monitoring happens every sub-frame, is given as following (t_{FCCH} = one GSM slot):

$$t_{\min,\,guaranteed} = 2 \times t_{synth} + t_{FCCH} + \frac{5\text{ms}}{13} = 2 \times t_{synth} + \frac{25\text{ms}}{26}$$

In all kinds of traffic timeslots allocation, the minimum of longest consecutive idle timeslots for one kind of allocation is 3 consecutive timeslots. For example, TS1 for UL traffic and TS5 for DL traffic. Then

$$t_{\min,\,guaranteed} = 3 * TS_{duration} = 3 * 0.675ms = 2.025ms\,,$$

Corresponding synthesizer switching time t_{synth} can be calculated to be 0.6ms. That means successful synchronisation with target GSM cell can't be guaranteed if synthesizer switching time is higher than 0.6ms in some kind of traffic timeslots allocation. In this scenario, particular improved procedure is needed to avoid the synchronisation failure.

Scenario 2: measurement of coordinated inter-frequency 1.28 Mcps TDD cells

For coordinated inter-frequency cells, target DwPTS is timing aligned with DwPTS in the serving cell. When taking synthesizer switching time into account, UE will not capture target DwPTS or P-CCPCH in its idle timeslots if its traffic timeslots are allocated as TS0 or TS6 for DL and TS1 for UL, until timeslots allocation is changed to the proper position. Figure 1 gives an example of target DwPTS overlapping with UE traffic channel.

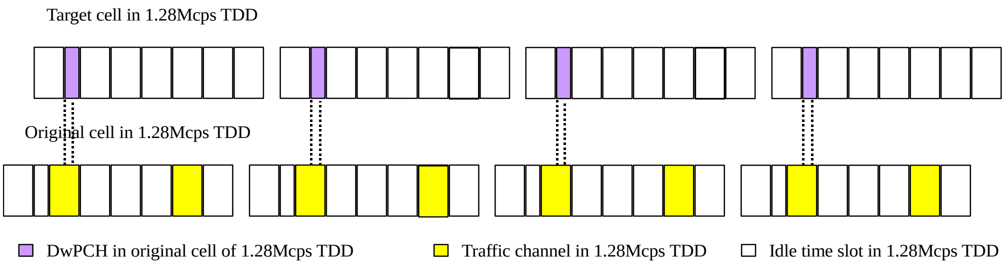

Figure2: Scenario 3 for improvement during 1.28 Mcps TDD measurement for uncoordinated inter-frequency cells

Scenario 4: 3.84Mcps TDD measurement

With unknown timing alignment between 3.84Mcps TDD target cell and 1.28 Mcps TDD serving cell and the flexible position of SCH in 3.84Mcps TDD frame, if target SCH or P-CCPCH is overlapping with UE traffic timeslot including synthesizer switching time, UE will not capture target SCH or P-CCPCH in its idle timeslots until timeslots allocation is changed to the proper position. Figure 3 gives an example of target SCH overlapping with UE traffic channel.

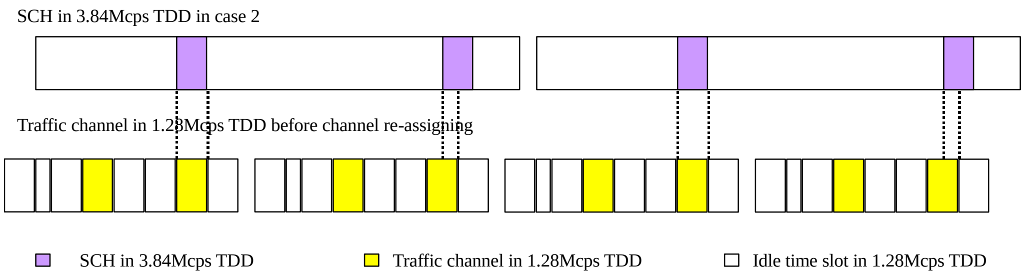

Figure 3: Scenario 4 for improvement during 3.84Mcps TDD measurement

If DTX and DCA are taken into account during inter-frequency and inter-system measurement, followings should be considered:

- **DTX:**

  Consideration of DCCH transmission with bearing higher layer signaling and the transmission of background noise when no voice, DTX probability can not reach as high as voice activation factor 40%~50%.

  The appearance of UL or DL DTX can't be guaranteed when inter-RAT measurement is requested. Once it exceeds the synchronization time requirement specified in RAN4, unsuccessful synchronization will be resulted in.

  UL and DL DTX usually appear individually.

  The statistical likelihood of synchronisation failure due to a lack of UL and DL DTX within the synchronisation window has not been investigated, but qualitatively speaking it is expected that a breach of the RAN4 prescribed synchronisation time will arise from that mechanism for some proportion of the time.

- **DCA:**

  DCA obeys the criterion to limit the interference and maximize the system capacity due to minimising reuse distance, which is different from the purpose of the improved IF/IS measurement to enlarge the measurement window or change the position of measurement window in synchronisation failure cases. So DCA may on one hand reallocate traffic timeslots from the bad position to the proper position for IF/IS measurement, and on the other hand, may also reallocate traffic timeslots from the proper position to the bad position, because DCA algorithm does not know where is the proper position for inter-RAT measurement user.

Considering the frequency of DCA happens, if it is relatively slow, inter-RAT measurement user may not have the chance to change timeslot allocation before call is dropped.

No data on the statistical likelihood of DCA leading to or hindering successful synchronisation is available, but qualitatively speaking this is likely to happen for a proportion of the time, probably for a greater proportion than DTX.

6 Study Areas

6.1 Asymmetric pattern for time slot allocation

In current Rel-4 specification, some idle time slots without traffic can be used for inter-frequency or inter-system monitoring in 1.28 Mcps TDD. In the conventional scenarios, traffic channel allocation is symmetric, which means two sub-frames in one frame will use the same time slot allocation pattern. However, it can occur that the measurement window may be very short and result in relatively long synchronisation time or synchronisation failure. Especially in FDD case, only small number of consecutive SSCs can be acquired in one measurement window.

In order to synchronize with FDD when UE handover to FDD from 1.28 Mcps TDD, 1.28 Mcps TDD UE should monitor Primary SCH in order to get time slot timing, and monitor Secondary SCH of FDD to get frame timing. For Primary SCH, PSC with length of 256 chips is the same for every cell in the system and transmits once every slot. For Secondary SCH, it repeatedly transmits a sequence of 15 SSCs with length of 256 chips every frame. Figure4 give an example of traffic channels allocation in conventional scheme. Whenever we take traffic channel allocation in conventional scheme as described Figure 4, the measurement window may be so short that at most two consecutive SSCs can be acquired in one measurement window. Consequently, it may be possible that we can’t get enough timing information for synchronization with FDD, and the probability of successful handover will be decreased greatly. Considering the best case of conventional scheme which means UL and DL are neighboring the second switching point, the measurement window length is 5 idle timeslots, and at most 4 consecutive SSCs can be acquired. During the procedure of measurement, all the possible traffic channel allocation should be considered.

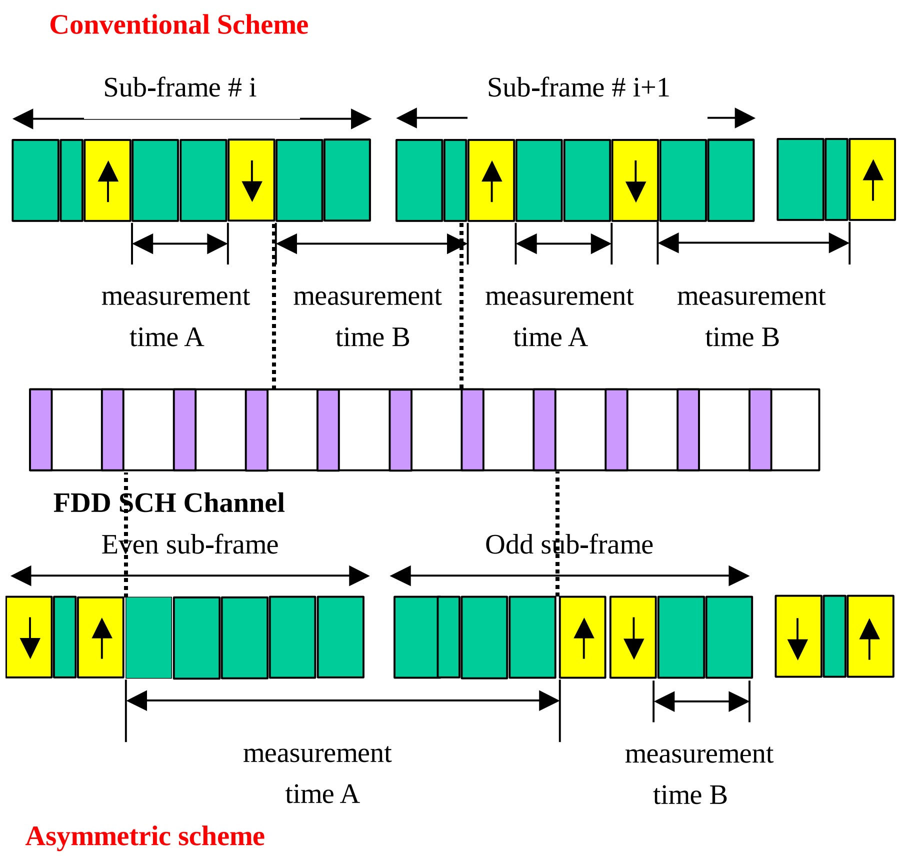

Figure 4: Comparison of the measurement window length between symmetric and asymmetric time slot allocation pattern.

Therefore, in order to solve the addressed problems in conventional scheme, special kind of asymmetric pattern for time slot allocation in each 1.28 Mcps TDD frame is proposed to get a longer measurement window. In asymmetric channel allocation pattern, channel allocation is different in two sub-frames of one frame. In one frame, the first sub-frame is called as even sub-frame, and the second sub-frame as odd sub-frame. In even sub-frame, downlink traffic channel is re-assigned to TS0, and uplink traffic channel is re-assigned to TS1; in odd sub-frame, downlink traffic channel is re-assigned to the timeslot just after the second switching point, and the uplink traffic channel to the timeslot just before the second switching time. So measurement can be carried out during all idle time slots except the pre-assigned traffic timeslots.

It can be seen from Figure 4 that asymmetric pattern for time slot allocation provides larger measurement window than conventional scheme. This is partially due to the reduction of number of RF frequency switching, hence the consideration for switching time in this study area is needed.

Considering the impact on other function, further investigations on the impact of power control, beam-forming, uplink synchronization, DCA, and the maximum number of traffic channels in TS0 which is also used for the P-CCPCH resulted from employing the asymmetric time slot allocation pattern are necessary in relation to this study item.

6.2. Combination of different time slot allocation pattern

In order to synchronize with 3.84Mcps TDD before handover to 3.84Mcps TDD from 1.28 Mcps TDD, 1.28 Mcps TDD UE needs to monitor Primary SCH and Secondary SCH of 3.84Mcps TDD. There are 2 cases of SCH and P-CCPCH allocation in 3.84 Mcps TDD: case 1; SCH and P-CCPCH allocated in TS #k, k=0,1,…,14; case 2; SCH allocated in two timeslots, TS #k and TS#k+8, k=0,1,…,6, and P-CCPCH allocated in TS #k. SCH consists of parallel of a primary and three secondary code sequences each 256 chips long.

In current Rel-4 specification, some idle time slots without traffic can be used for inter-frequency or inter-system measurement in 1.28 Mcps TDD. When 1.28 TDD UE monitors the 3.84Mcps TDD cell, SCH in 3.84Mcps TDD cannot be acquired in current measurement window in 1.28 Mcps TDD whenever the traffic channel in 1.28 Mcps TDD is aligned with SCH in the 3.84 Mcps TDD. Refer to Figure 5 and Figure 6 which exist problems during 1.28 Mcps

TDD UE synchronisation with 3.84Mcps TDD cell in case 1 and case 2 respectively. Even if the traffic channel in 1.28 Mcps TDD may change, there is still the probability of not being able to acquire SCH in 3.84 Mcps TDD, this probability depends on the location to which traffic channels change.

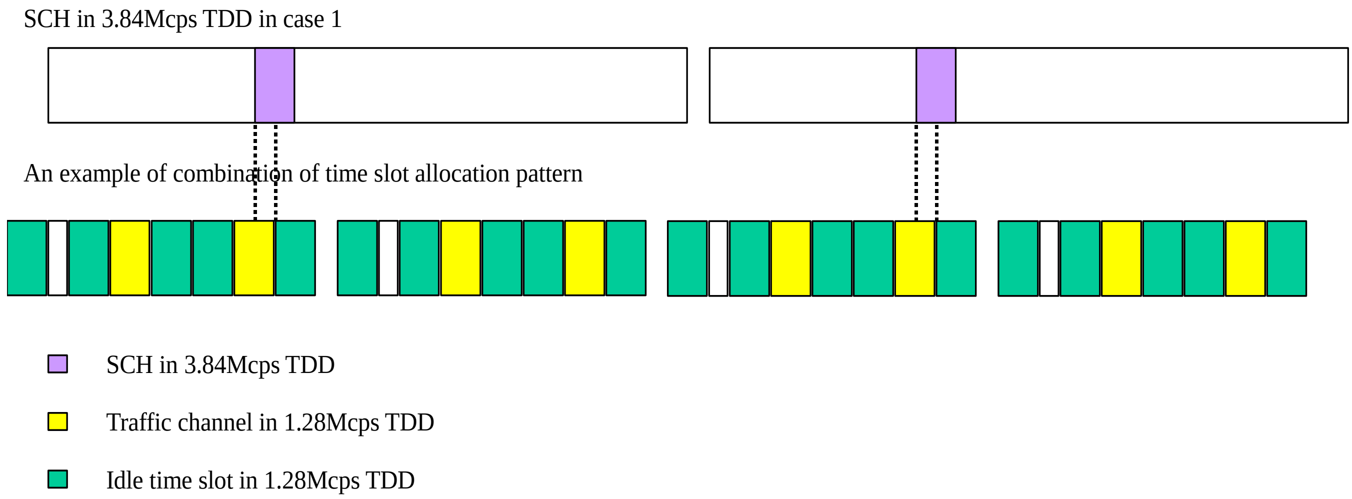

Figure 5: Problem identification in case 1 when 1.28 Mcps TDD UE monitoring 3.84Mcps TDD cell

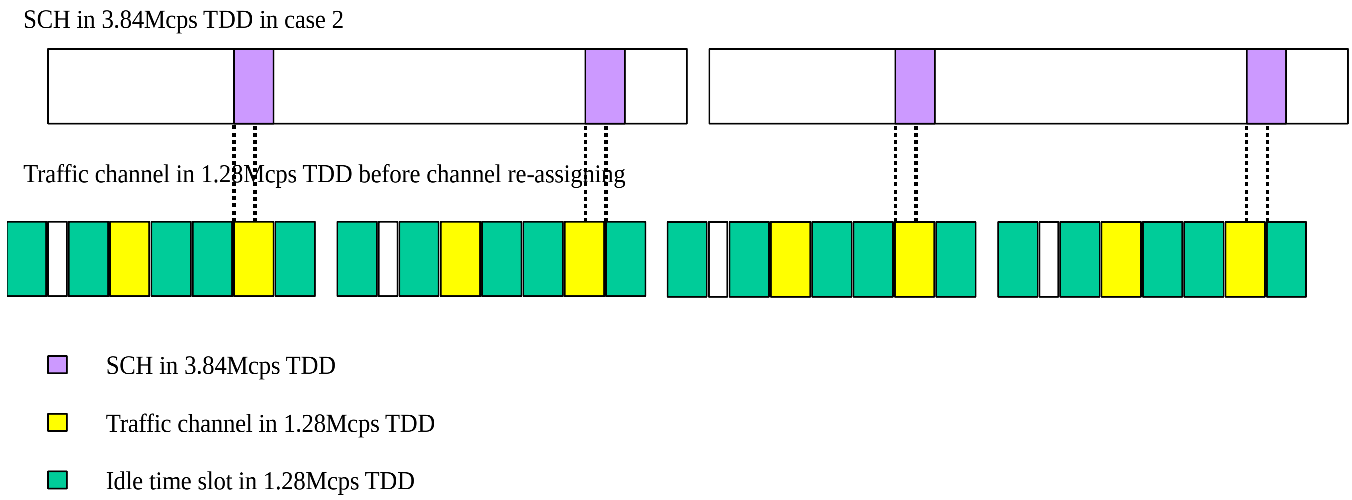

Figure 6: Problem identification in case 2 when 1.28 Mcps TDD UE monitoring 3.84Mcps TDD cell

Therefore, in order to solve the addressed problems in conventional scheme, combination of different time slot allocation pattern is proposed to change traffic time slots according to some kind of predefined time slot allocation pattern in order to guarantee the higher or perfect (100%) probability of acquiring SCH in 3.84Mcps TDD.

Combination of different time slot allocation pattern means that traffic channels is re-assigned according to some predefined time slot allocation frame by frame periodically like this:

1st frame: pattern # A

2nd frame: pattern # B

3rd frame: pattern # A

4th frame: pattern #B

This cycle repeats periodically …..

Here pattern #A or pattern #B refers to one kind of traffic time slot allocation in one frame.

Figure 7 is an example of such combination of different time slot allocation pattern. Pattern #A is configured as TS3 for UL, TS4 for DL;

Pattern #B is configured as TS1 for UL, TS6 for DL;

That means:

1st frame: TS3 for UL, TS4 for DL

2nd frame: TS1 for UL, TS6 for DL

3rd frame: TS3 for UL, TS4 for DL

4th frame: TS1 for UL, TS6 for DL

This cycle repeats periodically….

All idle time slots without traffic can be used for measurement.

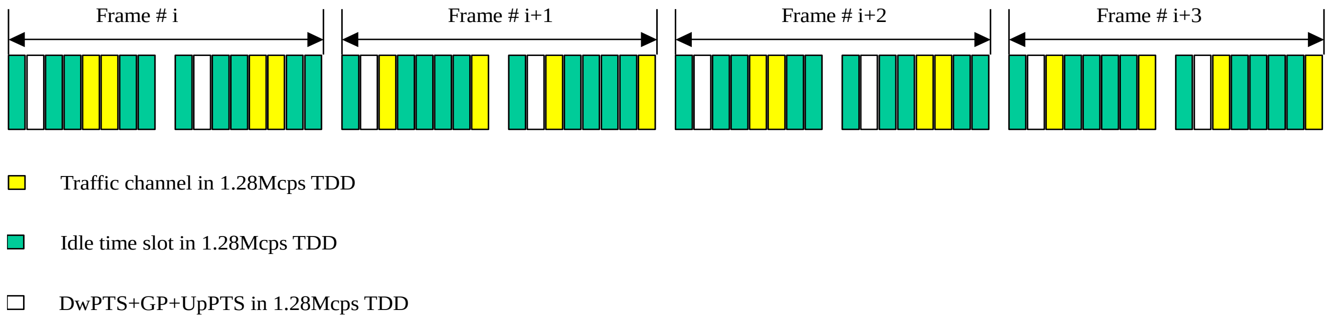

Figure 7: An example of combination of different time slot allocation pattern

Figure 8 and figure 9 give an example to illustrate the necessity of using the combination of time slot allocation pattern, and it also provides preventing the measurement failure during synchronization procedure.

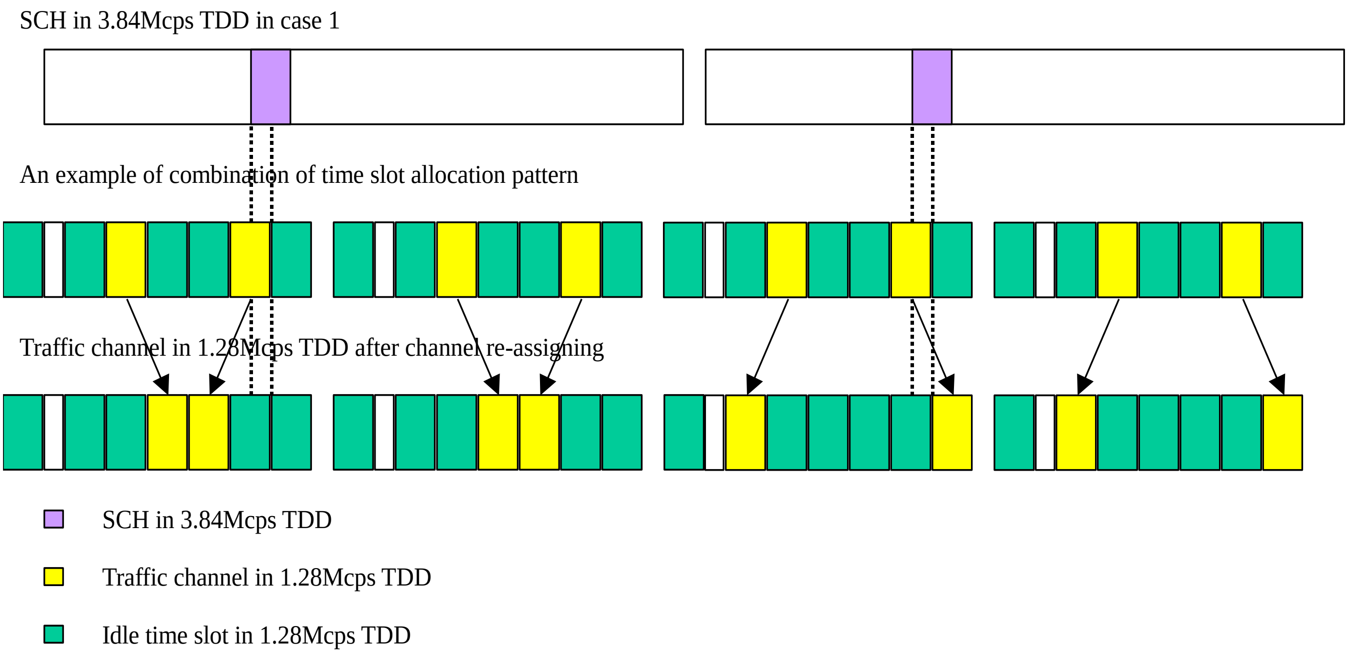

Figure 8: Comparison of monitoring SCH in 3.84Mcps TDD by using combination of time slot allocation pattern and conventional scheme in case 1

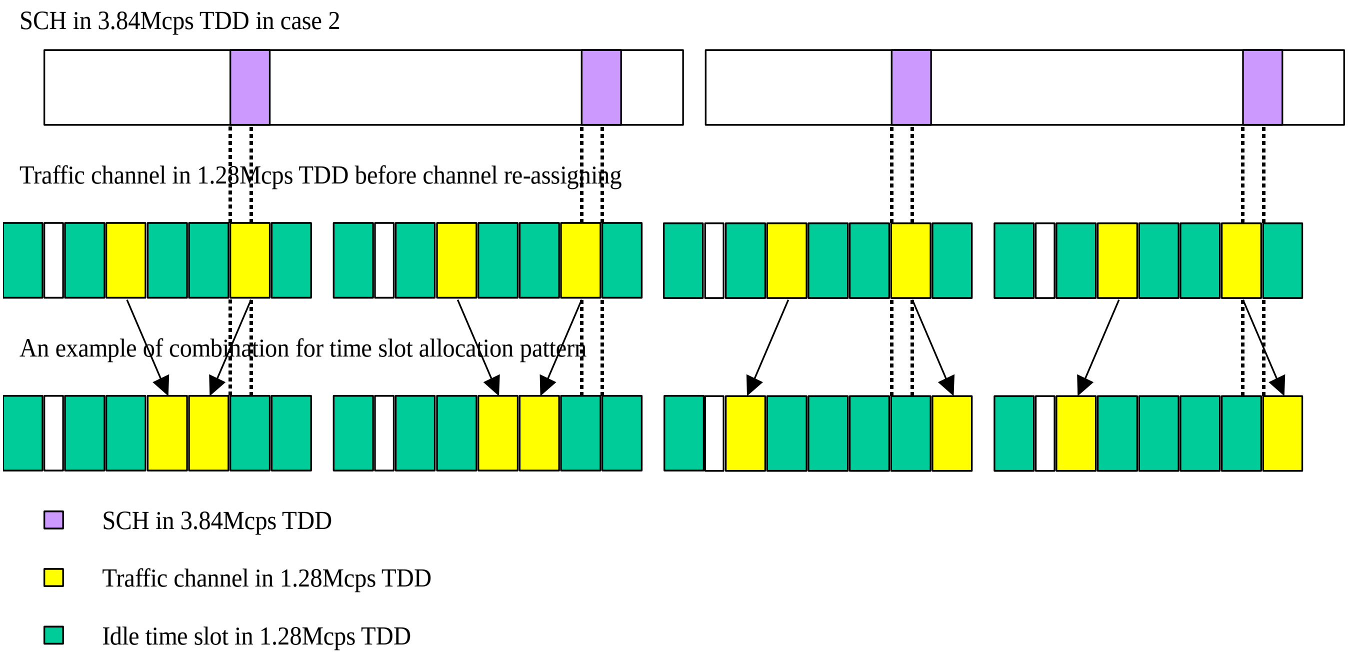

Figure 9: Comparison of monitoring SCH in 3.84Mcps TDD by using combination of time slot allocation pattern and conventional scheme in case 2

In order to resolve the addressed problems, it is necessary to study the combination method of different time slot allocation pattern in which traffic time slots can change according to some kind of predefined time slot allocation pattern in order to guarantee the higher or perfect (100%) probability of acquiring SCH in 3.84Mcps TDD.

Considering the impact on other functions of 1.28 Mcps TDD, further investigation of the impact on the power control, beam-forming, uplink synchronisation and DCA etc. by employing proposed combination method is also necessary in relation to this SI.

7 Proposed methods

7.1 Channel reassigning method

7.1.1 Overview of proposed channel re-assigning method

In FDD mode, compressed mode is used for inter-frequency and inter-system measurements, since the transmission in the physical channels in FDD are continuous. But for 1.28 Mcps TDD, the transmissions are discontinuous, so some idle time slots which have no traffic can be used for inter-frequency and inter-system measurement.

A channel re-assigning procedure before starting inter-frequency and inter-system measurement is proposed to enlarge measurement window length or change the position of measurement window in order to reduce synchronisation time and increase the probability of successful synchronisation. Channel re-assigning method means that traffic time slots assigned for uplink and downlink can be reallocated before inter-frequency and inter-system measurement.

In section 5 – Study Area, asymmetric pattern and pattern combination scheme are introduced as two channel re-assigning methods.

7.1.2 GSM measurement

During GSM measurement, synchronisation with GSM will be performed in order to verify BSIC.

Here we consider synchronize with FCCH and FCCH+SCH both by conventional scheme and by asymmetric pattern.

7.1.2.1 Asymmetric pattern applying for GSM measurement

In conventional scheme, idle time slots which have no traffic is proposed to be used for inter-frequency and inter-system measurement. In order to reduce synchronisation time or avoid synchronisation failure case with low cost terminal, asymmetric pattern can be used for GSM measurement. Comparison of asymmetric pattern and conventional scheme during synchronisation with FCCH and FCCH+SCH are shown in Table 1. Simulation assumptions refer to Annex A.

Table1: Comparison of asymmetric pattern and conventional scheme during GSM measurement

	0.5ms switching time			0.8ms switching time (This has not been decided by RAN4 yet)		
	Asymmetric pattern	Conventional scheme	Special case in conventional scheme*	Asymmetric pattern	Conventional scheme	Special case in conventional scheme

Average sync time with FCCH (ms)	65.7	167.2	75.6	77.8	Measurement failure probability**: 41.9%	95.1
Average sync time with FCCH+SCH (ms)	136.2	272.6	92.5	162.2		114.2
Max sync time with FCCH (ms)	184.2	656.5	187.2	274.5		232.5
Max sync time with FCCH+SCH (ms)	234.9	896.5	237.2	514.5		237.5
Min sync time with FCCH (ms)	1.1	1.1	1.1	1.4		1.4
Min sync time with FCCH+SCH (ms)	51.8	6.1	6.1	52.1		6.3
`*Note: Conventional scheme in Table 1 considers all possible traffic channel allocation. Special case in conventional scheme means one of the special traffic channel allocation which produces the best performance in conventional scheme. This corresponds to the case that TS3 for UL and TS4 for DL is allocated every sub-frame. ** Measurement failure criterion is according to the requirement in TS25.123. $T_{identify\ abort}$ = [5000] ms.						

In case of GSM measurement scenarios, when switching time is 0.5ms, proposed asymmetric pattern scheme can achieve the reduction of synchronization time than conventional scheme, but the special case in conventional scheme attains less synchronisation time than asymmetric pattern. And for low cost terminal with 0.8ms switching time, the use of asymmetric pattern can avoid synchronisation failure case compared to the conventional scheme. However, further study on both asymmetric pattern scheme and special case is needed, such as impact on power control, beamforming, UL synchronisation and DCA.

7.1.2.2 Pattern Combination Scheme applying for GSM measurement

Comparison of pattern comparison scheme and conventional scheme during synchronisation with FCCH and FCCH+SCH are shown in Table 2.

Table 2: Comparison of pattern combination scheme and conventional scheme during GSM measurement

	0.5ms switching time			0.8ms switching time (This has not been decided by RAN4 yet.)		
	Pattern combination scheme	**Conventional scheme**	**Special case in conventional scheme***	**Pattern combination scheme**	**Conventional scheme**	**Special case in conventional scheme***
Average sync time with FCCH (ms)	112.1	167.2	75.6	measurement failure probability**: 4.2%	measurement failure probability: 41.9%	95.1
Average sync time with FCCH+SCH (ms)	232.5	272.6	92.5			114.2
Max sync time with FCCH (ms)	506.6	656.5	187.2			232.5
Max sync time with FCCH+SCH (ms)	746.6	896.5	237.2			237.5
Min sync time with FCCH (ms)	1.1	1.1	1.1			1.4
Min sync time with FCCH+SCH (ms)	6.1	6.1	6.1			6.3
*Note: Conventional scheme in Table 2 considers all possible traffic channel allocation. The best case in conventional scheme means one of the special traffic channel allocation in conventional scheme which is TS3 for UL and TS4 for DL every sub-frame.						
** Measurement failure criterion is according to the requirement in TS 25.123. $T_{identify\ abort}$ = [5000] ms.						

The table shows that pattern combination scheme has less synchronisation time than conventional scheme when considering all the possible traffic channel allocation and pattern combination scheme has longer synchronisation time than special case of traffic channel allocation in conventional scheme. After comparing the simulation results with those of asymmetric pattern, the performance of pattern combination scheme is worse than that of asymmetric pattern scheme in the case of GSM measurement.

7.1.3 FDD measurement

During FDD measurement, 1.28 Mcps TDD UE should synchronize with FDD Primary SCH and Secondary SCH.

7.1.3.1 Asymmetric pattern applying for FDD measurement

In section 5, FDD measurement is described as an example of asymmetric pattern application. In this section simulation results of monitoring Primary SCH and Secondary SCH by using asymmetric pattern and conventional scheme are given in order to make comparison. Simulation assumptions refer to Annex A. Simulation results of synchronisation with primary SCH or secondary SCH by using conventional scheme and asymmetric pattern are shown in Table 3.

Table 3: Comparison of synchronisation time of monitoring Primary SCH or Secondary SCH by using asymmetric pattern and conventional scheme

	Average Sync time (ms)			Max Sync time (ms)			Min Sync time (ms)		
	Asymmetric pattern	Conventional scheme	Special case in conventional scheme *	Asymmetric pattern	Conventional scheme	Special case in conventional scheme	Asymmetric pattern	Conventional scheme	Special case in conventional scheme
Acquiring 75PSCs or 75SSCs	106.1	149.4	96.6	124.1	248.6	107.9	104.1	107.2	92.6
Acquiring 150PSCs or 150SSCs	217.0	299.7	194.1	244.1	498.6	212.9	214.1	212.2	187.6
Acquiring 225PSCs or 225SSCs	328.8	451.2	292.8	374.1	748.6	322.9	324.1	322.2	282.6
*Note: Conventional scheme in Table 3 considers all possible traffic channel allocation. Special case in conventional scheme means one of the special traffic channel allocation which produces the best performance in conventional scheme. This corresponds to the case that TS3 for UL and TS4 for DL is allocated every sub-frame.									

In case of FDD measurement scenarios, proposed asymmetric pattern scheme can achieve the reduction of synchronization time than conventional scheme, but the special case in conventional scheme attains less synchronisation time than asymmetric pattern. However, further study on both asymmetric pattern scheme and special case is needed, such as impact on power control, beamforming, UL synchronisation and DCA.

7.1.3.2 Pattern Combination Scheme applying for FDD measurement

In this section, pattern combination scheme applies for FDD measurement to see the performance. Simulation results of monitoring Primary SCH and Secondary SCH by using pattern combination scheme and conventional scheme are given in order to make comparison.

Simulation results of synchronisation with primary SCH or secondary SCH by using pattern combination scheme and conventional scheme are shown in Table 4.

Table 4: Synchronisation time of monitoring Primary SCH or Secondary SCH by using pattern combination scheme and conventional scheme

	Average Sync time (ms)			Max Sync time (ms)			Min Sync time (ms)		
	Pattern Combination scheme	Conventional scheme	Special case in conventional scheme*	Pattern Combination scheme	Conventional scheme	Special case in conventional scheme	Pattern Combination scheme	Conventional scheme	Special case in conventional scheme
Acquiring 75PSCs or 75SSCs	119.9	149.4	96.6	146.2	248.6	107.9	114.6	107.2	92.6
Acquiring 150PSCs or 150SSCs	240.7	299.7	194.1	297.5	498.6	212.9	229.6	212.2	187.6
Acquiring 225PSCs or 225SSCs	360.0	451.2	292.8	446.2	748.6	322.9	342.6	322.2	282.6
*Note: Conventional scheme in Table 4 considers all possible traffic channel allocation. Special case in conventional scheme means one of the special traffic channel allocation in conventional scheme, which allocate TS3 for UL and TS4 for DL every sub-frame.									

This table shows that pattern combination scheme has less synchronisation time than conventional scheme when considering all the possible traffic channel allocation, and pattern combination scheme has longer synchronisation time than special case of traffic channel allocation in conventional scheme. However, compared with the simulation results of asymmetric pattern, the performance of pattern combination scheme is worse than that of asymmetric pattern scheme in the case of FDD measurement.

7.1.4 3.84Mcps TDD measurement

During 3.84Mcps TDD measurement, 1.28 Mcps TDD UE should synchronize with 3.84Mcps TDD Primary SCH and Secondary SCH. Problem identification of 3.84Mcps TDD measurement from 1.28 Mcps TDD in conventional scheme is described in section 5.2.

7.1.4.1 Asymmetric pattern applying for 3.84Mcps TDD measurement

Asymmetric pattern described in section 5.1 can be used to solve the problem addressed in the conventional scheme. Simulation results of monitoring 3.84Mcps TDD by using asymmetric pattern and conventional scheme are given in Table 5. Case 2 of 3.84Mcps TDD SCH is considered. Simulation assumptions refer to Annex A.

Table 5: Simulation results comparison by using asymmetric pattern and conventional scheme with different switching time in 3.84Mcps TDD SCH case 2

Switching time	Successful sync probability by using asymmetric pattern	Successful sync probability in conventional scheme	Successful sync probability of special case in conventional scheme
0.2ms	98.75%	62.92%	70.34%
0.3ms	96.72%	56.79%	66.43%
0.4ms	94.47%	50.78%	62.37%
0.5ms	92.12%	44.50%	58.31%

From the above table, it can be seen that in case of 3.84 Mcps TDD measurement scenario, asymmetric pattern can greatly increase the successful synchronisation probability compared with conventional scheme and special case during 3.84Mcps TDD measurement. Even when synthesizer switching time is 0.5ms, the probability of successful synchronisation is more than 90%.

7.1.4.2 Pattern Combination Scheme applying for 3.84 Mcps TDD measurement

Pattern combination scheme can be used to solve the problem addressed in the conventional scheme during 3.84Mcps TDD measurement. Simulation results of monitoring 3.84 Mcps TDD by using pattern combination scheme and conventional scheme are given in Table 6. Case 2 of 3.84Mcps TDD SCH is considered.

Table 6: Simulation results comparison by using pattern combination scheme and conventional scheme with different switching time in 3.84Mcps TDD SCH case 2

Switching time	Successful sync probability by using pattern combination scheme	Successful sync probability in conventional scheme	Successful sync probability of special case in conventional scheme
0.2ms	100%	62.92%	70.34%
0.3ms	100%	56.79%	66.43%
0.4ms	100%	50.78%	62.37%
0.5ms	97.50%	44.50%	58.31%

From the above table, it is observed that the probability of successful synchronisation with SCH in conventional scheme is around 40 ~ 60 %, which is not a satisfactory reliability of the synchronization performance, even 0.2ms switching time is allowed. Pattern combination scheme can greatly increase the successful synchronisaiton probability compared with conventional schemes and special case during 3.84Mcps TDD. It nearly attains 100 % (perfect) synchronization probability when synthesizer switching time is no more than 0.4ms. Comparing the simulation results with those of asymmetric pattern, similar performance is achieved in case of 3.84 Mcps TDD measurement.

7.1.5 1.28 Mcps TDD measurement

In order to synchronize with 1.28 Mcps TDD of different frequency before inter-frequency handover, original 1.28 Mcps TDD cell needs to monitor DwPCH in target 1.28 Mcps TDD cell with different frequency. The similar problem may occur during 1.28 Mcps TDD measurement as that in 3.84Mcps TDD measurement, when the case of traffic channels in original cell in 1.28 Mcps TDD overlapping with DwPCH in target cell occurs.

7.1.5.1 Asymmetric pattern applying for 1.28 Mcps TDD measurement

Asymmetric pattern described in section 5.1 can be used to solve the problem addressed in the conventional scheme. Simulation results of monitoring 1.28 Mcps TDD by using asymmetric pattern and conventional scheme are given in Table 7. Simulation assumptions refer to Annex A.

Table 7: Simulation results comparison by using asymmetric pattern and conventional scheme with different switching time

Switching time	Successful sync probability by using asymmetric pattern	Successful sync probability in conventional scheme	Successful sync probability in special case in conventional scheme
0.2ms	100%	53.20%	63.93%
0.3ms	100%	47.38%	59.88%
0.4ms	96.57%	41.33%	56.13%
0.5ms	92.51%	35.28%	52.07%

From the above table, it can be seen that asymmetric pattern can greatly increase the successful synchronisaiton probability compared with conventional scheme and special case during 1.28 Mcps TDD measurement, even can reach 100% when switching time is no more than 0.3ms.

7.1.5.2 Pattern Combination Scheme applying for 1.28 Mcps TDD measurement

Pattern combination scheme can be used to solve the problem addressed for 1.28 Mcps TDD measurement in the conventional scheme. Simulation results of monitoring 1.28 Mcps TDD by using pattern combination scheme and conventional scheme are given in Table 8.

Table 8: Simulation results comparison by using pattern combination scheme and conventional scheme with different switching time

Switching time	Successful sync probability by using pattern combination scheme	Successful sync probability in conventional scheme	Successful sync probability in special case in conventional scheme
0.2ms	100%	53.20%	63.93%
0.3ms	100%	47.38%	59.88%
0.4ms	93.13%	41.33%	56.13%
0.5ms	85.01%	35.28%	52.07%

From the above table, it is observed that the probability of successful synchronisation with SCH in conventional scheme is around 30 ~ 50 %, which is not a satisfactory reliability of the synchronization performance, even though 0.2ms switching time is allowed. Pattern combination scheme can also greatly increase the probability of successful synchronisation compared with conventional scheme and special case during 1.28 Mcps TDD measurement. It also attains 100%(perfect) synchronization probability when synthesizer switching time is no more than 0.3ms. Comparing the simulation results with those of asymmetric pattern, similar performance is achieved in case of 1.28 Mcps TDD measurement.

7.1.6 Impacts on other function

7.1.6.1 Impact on beam-forming

Figure 10-16 show different beam-forming schemes for conventional scheme, special case in conventional scheme, asymmetric pattern and pattern combination scheme. Beam-forming scheme 1 for special case in conventional scheme, asymmetric pattern and pattern combination scheme can be used when the speed of the hardware of Node B is fast enough to complete the estimation and generating antenna weight before the neighboring downlink channel transmits. While beam-forming scheme 2 in these three schemes can be used when the beam-forming algorithm is complex and the speed of the hardware of Node B is not fast enough.

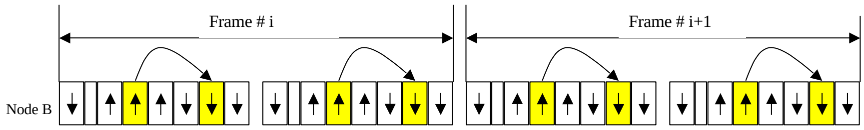

Figure 10: Beam-forming in conventional scheme in 1.28 Mcps TDD

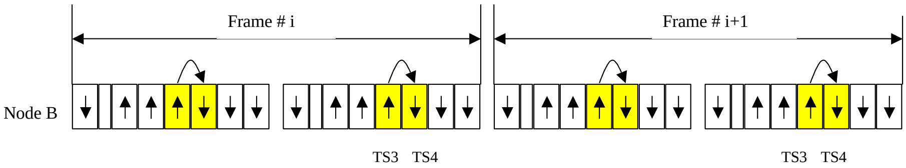

Figure11: Beam-forming scheme 1 in "special case in conventional scheme" in 1.28 Mcps TDD

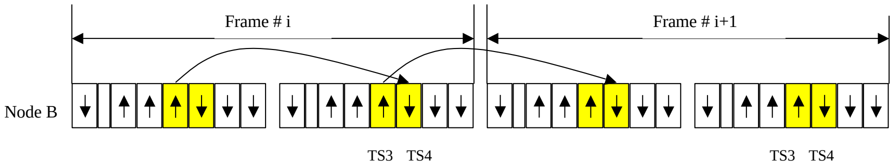

Figure 12: Beam-forming scheme 2 in "special case in conventional scheme" in 1.28 Mcps TDD

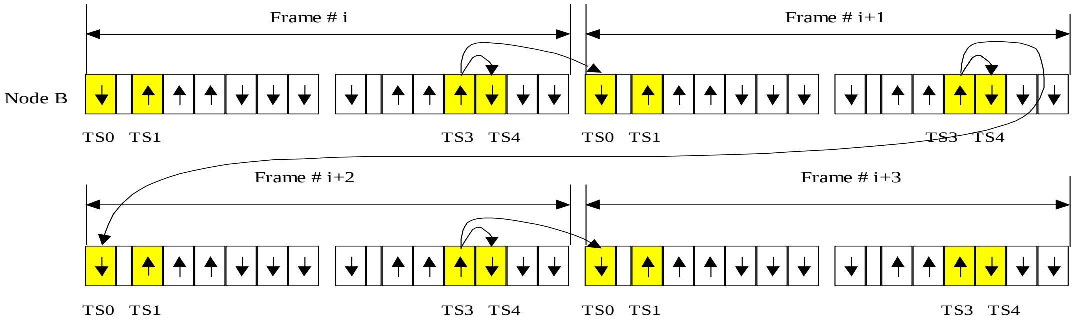

Figure 13: Beam-forming scheme 1 for asymmetric pattern in 1.28 Mcps TDD

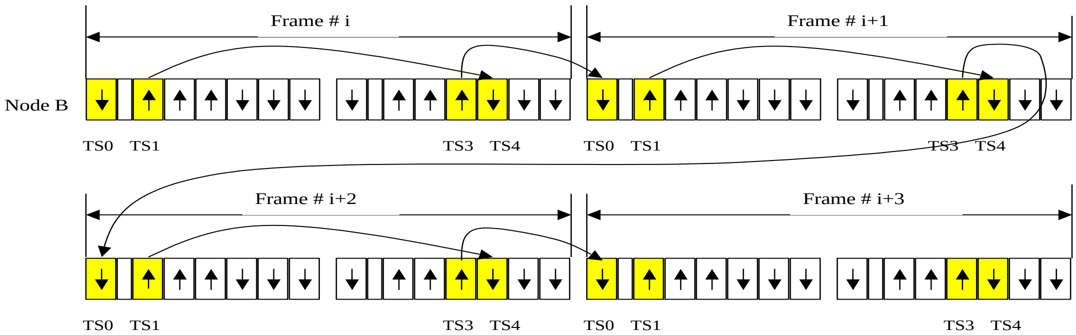

Figure 14: Beam-forming scheme 2 for asymmetric pattern in 1.28 Mcps TDD

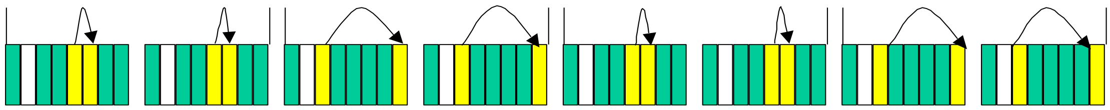

Figure 15: Beam-forming scheme 1 for pattern combination scheme in 1.28 Mcps TDD

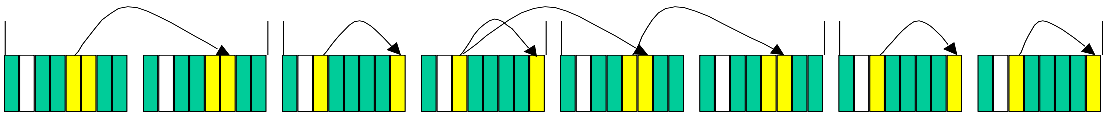

Figure 16: Beam-forming scheme 2 for pattern combination scheme in 1.28 Mcps TDD

Table 9 gives comparison of beam-forming rate and delay in different schemes.

Table 9: Comparison of beam-forming rate and delay by using different schemes.

	Conventional scheme	Special case in conventional scheme		Asymmetric pattern		Pattern combination scheme	
		Scheme 1	Scheme 2	Scheme 1	Scheme 2	Scheme 1	Scheme 2
Beam-forming rate	200Hz	200Hz	200Hz	200Hz	200Hz	200Hz	200Hz
Beam-forming delay	In one sub-frame	In one sub-frame	One frame	In one sub-frame	In one frame	In one sub-frame	In one frame

Beam-forming scheme 1 for asymmetric pattern, pattern combination scheme, and special case in conventional scheme have no impact on beam-forming. And beam-forming scheme 2 for these 3 schemes has no more than one sub-frame delay of beam-forming compared with scheme 1, and will cause little impact on beam-forming.

7.1.6.2 Impact on DCA

The purpose of DCA is, on one side, the limitation of the interference (keeping required QoS) and on the other side, to maximise the system capacity due to minimising the reuse distance. Therefore, DCA algorithm performs the channel reallocation based on the interference measurement report in order to maximize the system capacity. However, the purpose of channel reallocation for inter-RAT measurement is to enlarge the measurement window, which is the somewhat different criteria compared with the channel reallocation in DCA. Hence, the impact on DCA depends on the frequency and duration of inter-RAT measurement occurrence and also the frequency of DCA operation and update period. However, detailed DCA procedure is not exactly specified in the current specification, it also means that the a lot of flexibility can be provided to implement DCA procedure in order to reduce the impact on it. Hence the impact on DCA will be little because we can modify the DCA initiation and operation procedure not to interfere the inter-RAT measurement procedure which occurs from time to time, not very often. The conclusion applies if codes are already available or some codes are reserved for inter-RAT measurement and the power is available.

7.2 Other methods

7.2.1 RNC based implementation method

Background:

In cases as in section 5 during IF/IS measurement, synchronisation with target IF/IS cell fails for the reason of traffic timeslot overlapping with synchronisation channel of the target cell. Although the change of the overlapped traffic timeslot will make UE capture synchronisation channel, both RNC and UE do not know which traffic timeslot, UL or

DL timeslot, is overlapping with synchronisation channel of the target cell, so where to reallocate traffic timeslot? Moreover, whether channel reallocation is needed or not once synchronisation with target cell fails?

Main principle:

RNC based implementation method is based on the two basic points above. Flow chart in Fig. 17 shows the procedure of RNC based implementation method with two steps added.

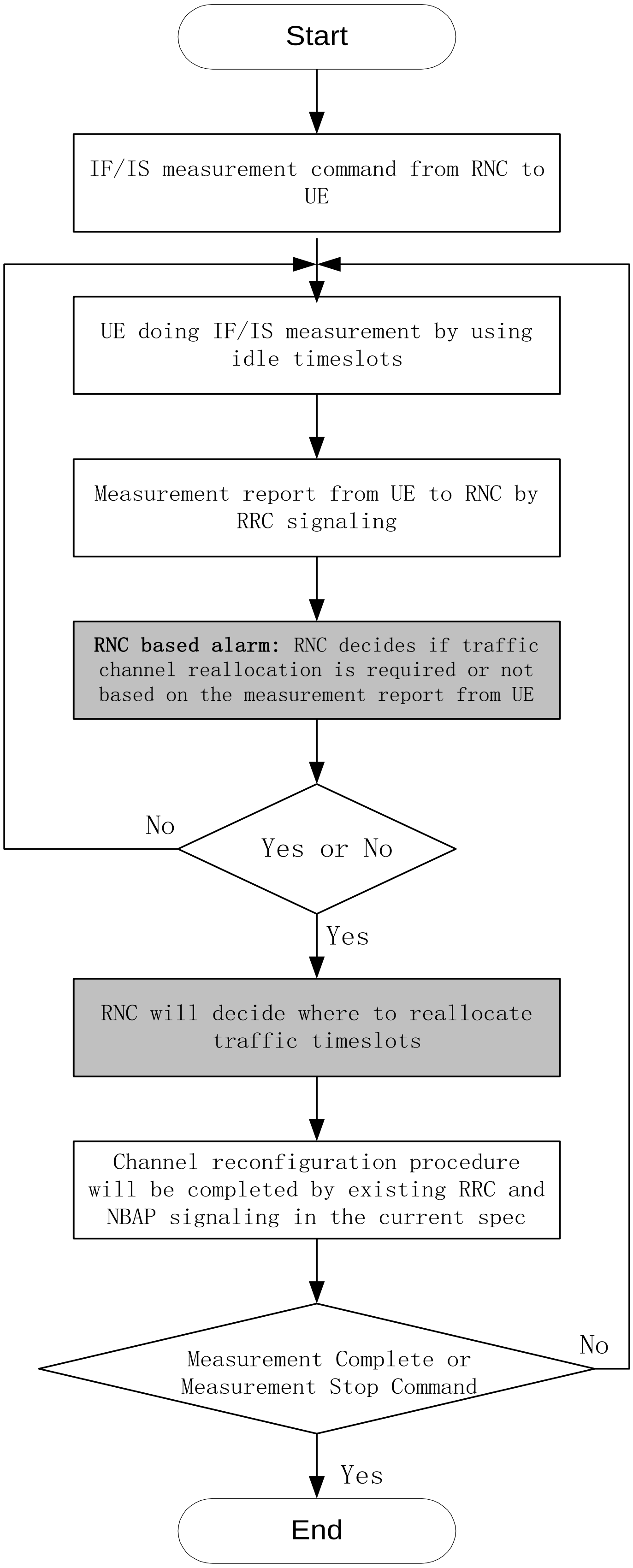

Figure 17: Procedure of RNC based implementation method

First step, RNC based alarm during IF/IS measurement:

When RNC becomes aware that the P-CCPCH RSCP of the UE in the serving cell becomes weaker and weaker, the RNC monitors the reports arising from inter-RAT/frequency measurement attempts for each of the inter-RAT/frequency cell it is monitoring. From these measurement reports, the RNC makes an estimate of whether the UE is able to achieve synchronisation with each of the RAT/systems with its current timeslot allocations. For each RAT/system to which the UE can achieve synchronisation, an appropriate received signal strength report (P-CCPCH RSCP, GSM carrier RSSI) is examined to determine whether the alternative RAT/system is suitable for handover. In the case that there are no RATs/frequencies to which the UE can obtain synchronisation and that are suitable for handover, the RNC activates its alarm procedure and carries out channel re-allocation in order to allow the UE to achieve better synchronisation.

Examples of means by which the RNC can determine whether a UE has achieved synchronisation or not include examination of no measurement results of P-CCPCH RSCP existing in the measurement report, looking for TDD P-CCPCH measurement failure (The UE must be able to read the DwPCH or SCH to locate the P-CCPCH for measurement) or inability to verify a GSM BSIC.

Take an example as in Figure 18 for this RNC based alarm procedure. Six Inter-RAT/frequency neighboring cells, numbering cell 1, 2, 3, 4, 5, and 6, exist in the neighboring list for the UE to monitor. From the measurement reports, the RNC makes an estimate of whether the UE is able to achieve synchronisation with each of the 6 neighboring cells with its current timeslot allocations. In the case that RNC finds UE synchronizes with some of the neighboring cells (e.g. 1~4), and P-CCPCH RSCP or GSM carrier RSSI in these cells exceeds a RNC implementation related threshold, even if the other neighboring cells (e.g. cell 5~6) are failed to be synchronized, such synchronisation failure with cell (5, 6) can be accepted, because the first four neighboring cells can be as the candidates for UE to handover. Otherwise, in the case that RNC finds UE fails to synchronize with any of the 6 neighboring cell, synchronisation failure will become serious. RNC will activate its alarm procedure and perform channel reallocation.

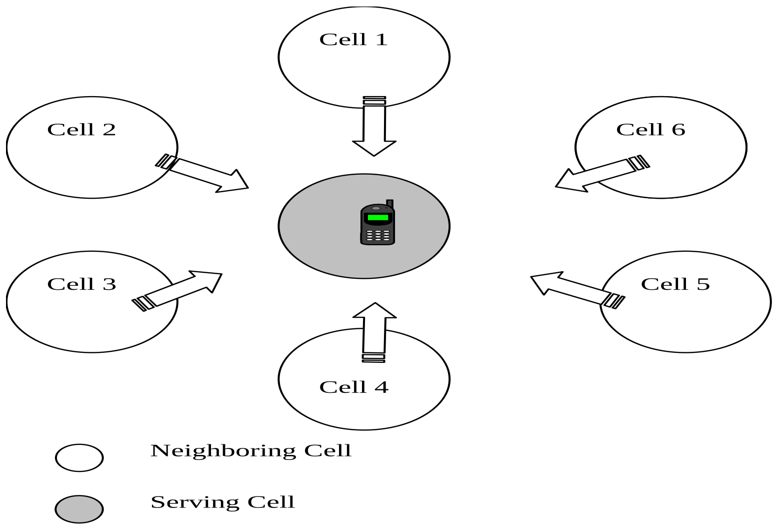

Figure 18: An example of RNC based alarm during inter-frequency and inter-system measurement for 1.28 Mcps TDD

The RNC based alarm will simplify the radio resource allocation by performing channel reallocation procedure only when necessary once synchronisation failure happens.

Second step, RNC decides the position of traffic timeslots reallocation if alarm comes from RNC

With the coming of alarm from RNC, RNC will decide the timeslot UE reallocates. Without the information that either current uplink or downlink timeslot is overlapping with the synchronisation channel of the target cell, RNC has to decide the traffic timeslot to reallocate according to the pre-defined rule in order to make the minimum number of times of channel reallocation can guarantee the successful synchronisation with the target cell.

For GSM measurement with more than 0.6ms switching time of UE, RNC can simply decide to reallocate traffic timeslots with more than 4 consecutive idle timeslots if RNC alarms in the first step, such as (TS1 for UL, TS6 for DL), (TS2 for UL, TS4 for DL), and etc.

For measurement of coordinated 1.28 Mcps TDD cell, RNC can simply decide to reallocate DL traffic timeslot TS0/ TS6, and UL traffic timeslot TS1 to any other downlink and uplink timeslot if RNC alarms in the first step.

For measurement of uncoordinated 1.28 Mcps TDD cell, or 3.84Mcps TDD cell, with RNC alarming, similar scheme as pattern combination can be one choice as Fig. 19, which aims to change the position of the measurement windows in order to make all the measurement windows cover the whole frame duration. Pattern 1 (TS1 for UL, TS6 for DL) and Pattern 2 (TS3 for UL, TS4 for DL) in Fig. 19 can cover the whole frame duration within 0.3ms synthesizer switching time and can be scheduled by RNC with existed RRC signaling (Channel Reconfiguration) and NBAP signaling (RL Reconfiguration) in the current specification. If synchronisation succeeds with Pattern 1 (or Pattern 2), Pattern 2 (Pattern 1) will be no need to be scheduled. Otherwise, RNC based alarm will decide whether another channel reallocation procedure is needed or not.

Compared with pattern combination scheme, patterns do not change very fast with frame by frame, but the synchronisation time will be much longer if synchronisation still fails after the first time of channel reallocation procedure, even if it may meet RAN4 requirement.

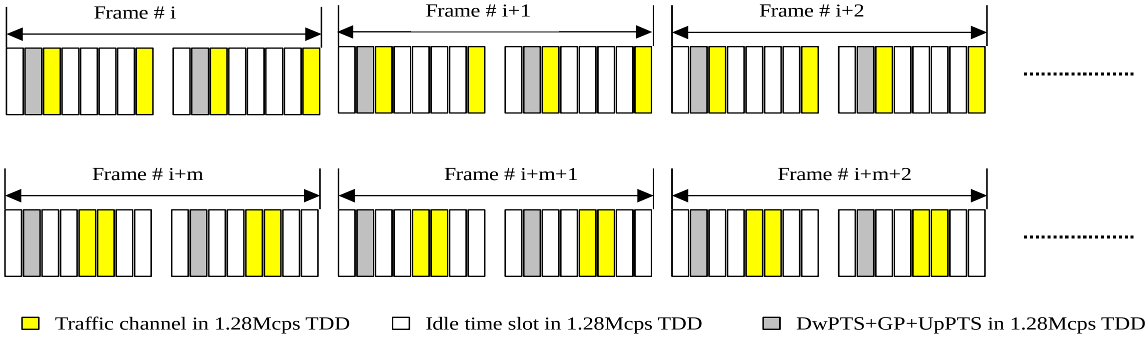

Figure 19: Example of channel reallocation method in the case of RNC alarming

Here, only one choice of channel reallocation method is depicted, and other channel reallocation method is also permitted.

8 Conclusions

In this SI, three methods are discussed to improve the 4 listed scenarios during inter-frequency and inter-system measurement for 1.28 Mcps TDD. Based on the analysis and discussion of the first two methods -- asymmetric pattern and pattern combination scheme, it is thought that both of them have impact on power control and UL synchronisation functions, although they can obtain improvement of reduced synchronisation time and increased synchronization probability. In order to compromise on the impact and performance improvement, the third method -- RNC based implementation method without modification on the current specification is recommended.

In a conclusion, RNC based implementation method can improve IF/IS measurement for handling the 4 scenarios in section 5 with no change of the current specification and can be the best option for improvement.

Annex A: Simulation Assumptions of monitoring GSM/FDD/3.84Mcps TDD/1.28 Mcps TDD

- Timing information with GSM/FDD/3.84Mcps TDD/1.28 Mcps TDD is not known before monitoring.
- Timing alignment between GSM/FDD/3.84Mcps TDD/1.28 Mcps TDD and 1.28 Mcps TDD is random, and obeys uniform distribution.
- Step size of timing alignment is 10chips of 1.28 Mcps TDD.
- Low data rate traffic with only 1 uplink and 1 downlink is considered.
- 3 uplink time slots (TS1, TS2, TS3) and 4 downlink time slots (TS0, TS4, TS5, TS6) channel structure in one sub-frame are assumed in the simulation.
- In 1.28 Mcps TDD, TS1 is fixed for uplink traffic, and the probability of downlink channel allocation in TS4, TS5, TS6 and TS0 is equal.
- Monitoring channel in different purposes:
    - ➢ During GSM measurement, two cases of monitoring scheme are considered. One is acquiring a complete FCCH burst and the other is a complete FCCH burst and SCH burst together.
    - ➢ During FDD measurement, First, Primary SCH is monitored. Synchronisation is considered successful when 75 SSCs, 150 SSCs, or 225 SSCs are acquired. Secondary SCH will be monitored after synchronisation with Primary SCH is successful.
    - ➢ During 3.84Mcps TDD measurement, First, Primary SCH is monitored. Second, Secondary SCH will be monitored after synchronization with Primary SCH is successful. Synchronisation with SCH is considered successful when both synchronization with Primary SCH and Secondary SCH are successful.
    - ➢ During 1.28 Mcps TDD measurement, DwPTS of 1.28 Mcps TDD is considered for measurement.

Annex B: Project Plan

B.1 Schedule

Date	Meeting	Scope	[expected] Input	[expected]Output
2003.03	RAN#19	TR Submission		V6.0.0

B.2 Work task Status

	Planned Date	Milestone	Status

Annex C: Change History

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
22/09/03	RAN_21	RP-030500	-	-	Approved to put under version control	2.0.0	6.0.0