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Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
High Speed Packet Access (HSPA)
feedback and signalling efficiency enhancements for
Low Chip Rate (LCR) Time Division Duplex (TDD)
(Release 11)

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Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

During the application of HSPA, some questions occurred and needed to be solved, such as how to solve the problem the discontinuous CQI feedback will create, how to increase the control channel efficiency and how to increase the HSPA resource efficiency. Due to the fact that multi-carrier HSPA is backward compatible with HSPA, the same questions also exist in multi-carrier HSPA. In order to solve these questions, the SI “HSPA Feedback and Signalling Efficiency Enhancements for LCR TDD” is approved at the RAN#54 meeting.

This TR summarizes all the study results of the SI “HSPA Feedback and Signalling Efficiency Enhancements for LCR TDD”.

1 Scope

The present document summarizes the study results of the SI “HSPA Feedback and Signalling Efficiency Enhancements for LCR TDD”. The study results focus on the following three study items.

(1) CQI feedback enhancement

- Evaluate the impact the discontinuous CQI feedback will create
- If needed, find out how to solve the problem the discontinuous CQI feedback will create
- Evaluate how much gain will be obtained with the new methods.

(2) HSPA control channel efficiency optimisation

- find out the new methods for increasing the HSPA control channel efficiency.
- Evaluate how much gain will be obtained with the new methods.

(3) HSPA signalling enhancements for more efficient resource usage

- find out the new methods for more efficient HSPA resource usage
- Evaluate how much gain will be obtained with the new methods.

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 TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 25.211: "Physical channels and mapping of transport channels onto physical channels (FDD)".

[3] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".

[4] 3GPP TS 25.213: "Spreading and modulation (FDD)".

[5] 3GPP TS 25.214: "Physical layer procedures (FDD)".

[6] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".

[7] 3GPP TS 25.221: "Physical channels and mapping of transport channels onto physical channels (TDD)"

[8] 3GPP TS 25.222: "Multiplexing and channel coding (TDD)".

[9] 3GPP TS 25.223: "Spreading and modulation (TDD)".

[10] 3GPP TS 25.224: "Physical layer procedures (TDD)".

[11] 3GPP TS 25.225: "Physical layer – Measurements (TDD)".

[12] 3GPP TS 25.321: "Medium Control (MAC) protocol specification".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [x] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [x].

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

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

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [x] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [x].

CQI	Channel Quality Indicator
CRRI	Code resource related information
DL	Downlink
DPCH	Dedicated Physical Channel
E-AGCH	E-DCH Absolute Grant Channel
E-DCH	Enhanced Dedicated Transport Channel
E-HICH	E-DCH HARQ Acknowledgement Indicator Channel
E-PUCH	Enhanced Uplink Physical Channel (TDD only)
E-TFC	E-DCH Transport Format Combination
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
HSDPA	High Speed Downlink Packet Access
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Channel for HS-DSCH
HS-SICH	Shared Information Channel for HS-DSCH
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
PCCPCH	Primary Common Control Physical Channel
PRRI	Power resource related Information
RNC	Radio Network Controller
TBS	Transport Block Size
TDD	Time Division Duplex
TDM	Time Division Multplexing
UE	User Equipment
UL	Uplink
UMTS	Universal Mobil Telecommunications System
UTRAN	UMTS Terrestrial Radio Access Network

4 CQI feedback enhancement

4.1 Simulation assumptions for discontinuous CQI reporting

The cell parameters for evaluating the impacts of the discontinuous CQI reporting are listed in the following table.

Table 1: Cell parameters

Parameters	Values
Bandwidth	1.6MHz
Cell structure	wrap-around/three sectors, same frequency network
Inter-site distance	500m
UL: DL timeslots	2: 5
Transmission power of HS-PDSCH	30dBm
Antenna types	three sectors, directional antenna
UE Noise figure	7dB
Propagation model	Cost231 Hata model
Shadow fading standard deviation	8dB
Scheduling algorithm	PF
Channel model	PA3, VA30, VA60
Number of HS-SCCHs	1, 2
Number of UEs in each cell	1， 4， 8， 16
Traffic model	HTTP
Power control	On
Beam forming	On
Synchronization control	On

4.2 Simulation results of existing CQI reporting method

Based on the simulation assumptions in Table 1, the simulation results for both discontinuous CQI reporting (noted as D-CQI) and continuous CQI reporting (noted as C-CQI) for PA3 are presented in Table 2, where D-CQI uses the measured CQI value on HS-PDSCH for scheduling while C-CQI assumes the ideal CQI value for scheduling. It is observed that the gain of C-CQI over D-CQI increases with the increase in the number of UEs in a cell.

Table 2: Simulation results for D-CQI and C-CQI

	1UE per cell	4UEs per cell	8UEs per cell
Throughput for D-CQI	574kbps	1082kbps	1139kbps
Throughput for C-CQI	575kbps	1127kbps	1221kbps

Gain of C-CQI over D-CQI	0.17%	4%	7%

4.3 New CQI reporting methods

The new methods for improving discontinuous CQI reporting are proposed below.

4.3.1 Method 1

When an HSDPA UE is not scheduled, it can't obtain the CQI from HS-PDSCH according to the existing CQI reporting method. But it has other DL channels, such as DPCH, E-AGCH, E-HICH and HS-SCCH. It can receive PCCPCH. UE can obtain the CQI information from one of the other DL channel it has or it can receive. Then UE can obtain the CQI information from another DL channel than HS-PDSCH and send it to NodeB through the paired or assigned UL channel, where the paired or assigned UL channel is defined as below.

1) paired UL channel for DL DPCH is: UL DPCH or non-scheduled E-PUCH;
2) paired UL channel for E-AGCH is: scheduled E-PUCH;
3) paired UL channel for E-HICH is: non scheduled E-PUCH;
4) paired UL channel for HS-SCCH is: HS-SICH;
5) assigned UL channel for PCCPCH: configured by RNC and informed by RNC to both NodeB and UE.

UE can obtain the CQI information from another DL channel than HS-PDSCH through the following steps:

Step 1: obtain the received power of the corresponding DL channel: Ps

Step 2: obtain the average power of the interference over the assigned DL timeslots by RNC: Pi. Typically, RNC assigns the DL timeslots included in the HS-PDSCH resource pool to UE.

Step 3: obtain the SNR of the corresponding DL channel: SNR=10lg(Ps/Pi)

Step 4: obtain the CQI information from SNR

Step 5: send SNR directly or the CQI information to NodeB through the paired or assigned UL channel

4.3.2 Method 2

In order to improve discontinuous CQI reporting, a new DL reference channel (signal) for CQI measurement can be introduced. The detailed method is described as below.

Downlink reference channel (signal) can be introduced for HSDPA UEs to perform CQI measurement. Each UE can be assigned a dedicated reference channel (signal) or a common periodic reference channel (signal) that is TDM shared among UEs. For example, standalone midambles can be used as reference signal.

The reference channel (signal) can be transmitted by Round Robin algorithm among all the UEs thus all the UEs get equal chances to perform CQI measurement based on reference channel (signal). An optimal scheme is that the transmission of reference channel (signal) is based on the scheduling of the UE's HS-PDSCH. Before scheduling the UE's HS-PDSCH, the Node B sends reference channel (signal) to the UE, and the UE performs CQI measurement and feeds back the result to the Node B. Then the Node B transmits the UE's HS-PDSCH based on the latest CQI feedback.

As in the current HSPA, HS-SICH can be used to feed back the CQI measured based on the reference channel (signal) while the timing between reference channel (signal) and CQI feedback should be further considered and evaluated.

4.3.3 Method 3

Another method to improve discontinuous CQI reporting is to shorten CQI feedback delay by scheduling implementation. The detailed method is described as below.

The Node B can shorten the CQI feedback delay by appropriate scheduling implementation.

One scheme is that the Node B can firstly transmit HS-PDSCH with a small TBS to the UE. After the UE feeds back CQI based on this HS-PDSCH, the Node B schedules HS-PDSCH with a larger TBS to the UE thus the latter HS-PDSCH transmission can benefit from the updated CQI information.

Another similar scheme is that when a UE is to be scheduled, the Node B schedules the UE in a continuous way so that the UE can receive HS-PDSCH in several or tens of consecutive subframes. In this way, most of the UE's HS-PDSCH transmissions can make use of the latest CQI feedback.

4.4 Analysis and suggestions for future study

Whether or not the new methods are introduced need further study on the following aspects:

(1) Gain and complexity of the new methods

(2) Impact on the 3GPP specifications and legacy UE and UTRAN implementation

5 HSPA control channel efficiency optimization

5.1 Target scenario for HSPA control channel efficiency optimization

For multi-carrier HSPA, the mapping relationship between the traffic channel and the associated control channel limits the control channel efficiency. The traffic channel and associated control channel are on the same carrier for multi-carrier HSUPA. The mapping relationship between the traffic channel and associated control channel is configured by RNC for multi-carrier HSDPA. When no UE is scheduled on one carrier, the control channel associated with the traffic channel on this carrier is spare. But it can't be used for the traffic channel on another carrier.

5.2 New methods for HSPA control channel efficiency optimization

In order to solve the problem in the target scenario above, the carrier number field is suggested to add on HS-SCCH/E-AGCH to indicate to UE the scheduled carrier.

5.3 Analysis and suggestions for future study

The new method in section 5.2 can achieve flexible scheduling across carriers. But it has significant impact on the L1 specifications. The potential gains should be provided to justify the specification changes.

6 HSPA signalling enhancements for more efficient resource usage

6.1 Target scenarios for HSPA signalling enhancements

Three downlink target scenarios and one uplink target scenario for HSPA signalling enhancements for more efficient resource usage are listed as follows.

DL Scenario 1:

The non-rectangular HS-PDSCH resources consist of channelization codes in TS0 and other downlink timeslot(s). Only partial channelization codes in TS0 can be used as HS-PDSCH resources and the available channelization codes are semi-static. An example of HS-PDSCH resource pool in DL Scenario 1 is illustrated in Figure 6.1.

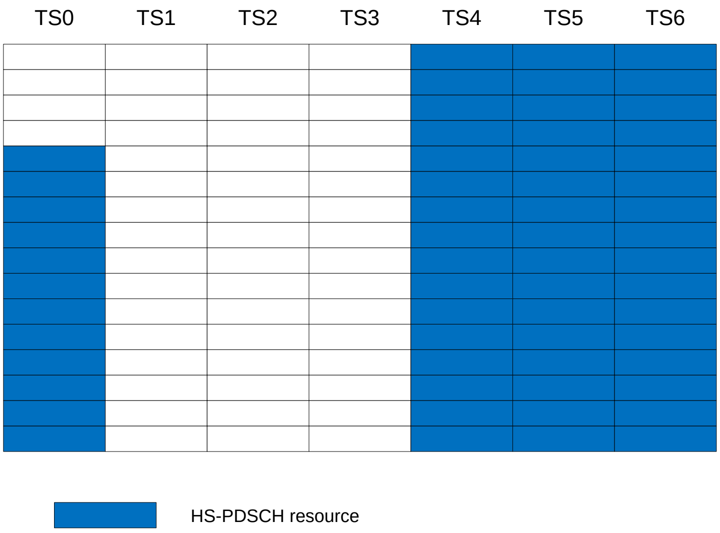

Figure 6.1 HS-PDSCH resource pool in DL Scenario 1

DL Scenario 2:

The non-rectangular HS-PDSCH resources consist of channelization codes in the timeslot where DL DPCH and/or DL control channels are configured and other downlink timeslot(s). Only partial channelization codes in the timeslot where DL DPCH and/or DL control channels are configured can be used as HS-PDSCH resources and the available channelization codes may vary in different subframes due to e.g. TDM of DPCH or increase/decrease of DPCH configuration. An example of HS-PDSCH resource pool in DL Scenario 2 is illustrated in Figure 6.2.

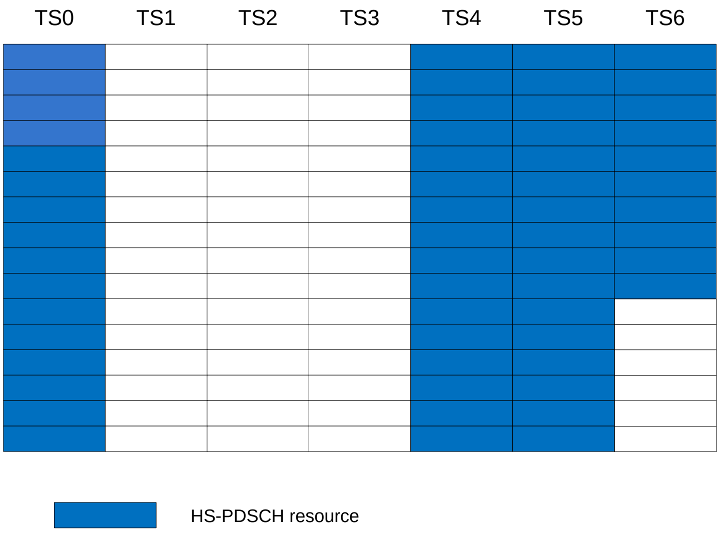

Figure 6.2: HS-PDSCH resource pool in DL Scenario 2

DL Scenario 3:

The non-rectangular HS-PDSCH resources consist of three rectangular resources, i.e. channelization codes in timeslot 0, the timeslot where DL DPCH and/or DL control channels are configured and other downlink timeslot(s). The available channelization codes in TS0 are semi-static while the available channelization codes in the timeslot where DL DPCH and/or DL control channels are configured may vary in different subframes. An example of HS-PDSCH resource pool in DL Scenario 3 is illustrated in Figure 6.3.

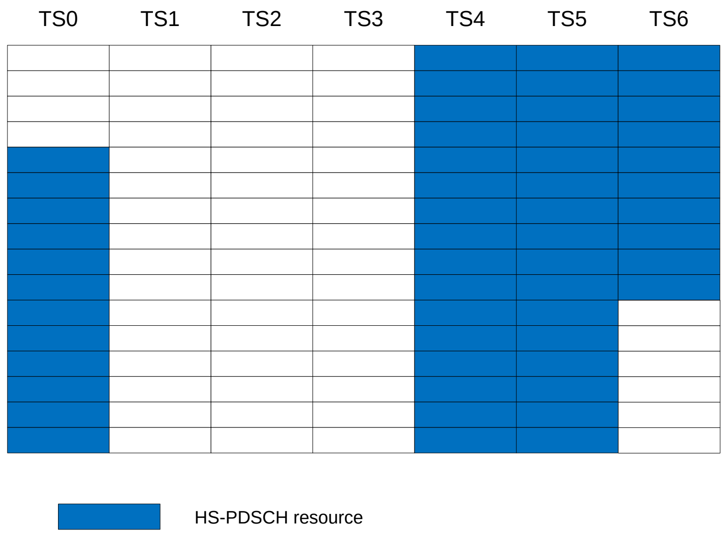

Figure 6.3: HS-PDSCH resource pool in DL Scenario 3

<u>**UL Scenario 1:**</u>

The non-rectangular E-PUCH resources consist of OVSF codes in the timeslot where UL DPCH and/or UL control channels are configured and other uplink timeslot(s). Only partial OVSF codes in the timeslot where UL DPCH and/or UL control channels are configured can be used as E-PUCH resources and the available OVSF codes may vary in different subframes due to e.g. TDM of DPCH or increase/decrease of DPCH configuration. An example of E-PUCH resource pool in UL Scenario 1 is illustrated in Figure 6.4.

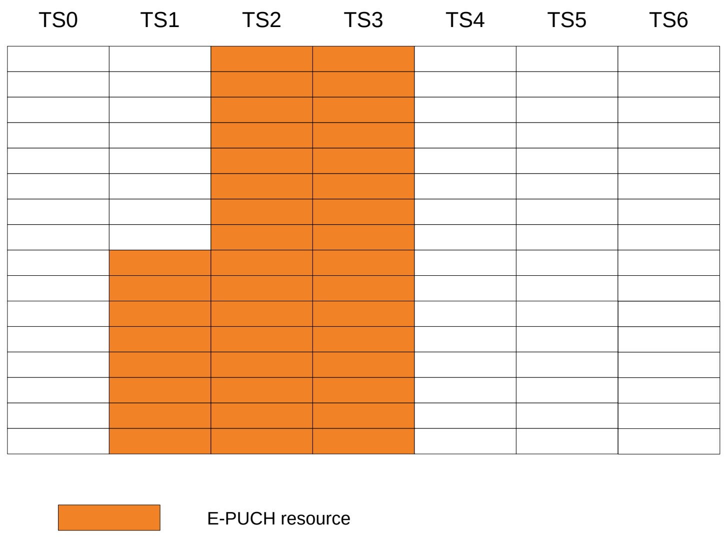

Figure 6.4: E-PUCH resource pool in UL Scenario 1

6.2 New methods for HSDPA signalling enhancements

The new methods for HSDPA signalling enhancements are given in the following sections.

6.2.1 Method 1

In DL scenario 1 and DL scenario 2, the non-rectangular resource consists of two rectangular resources: the first rectangular resource includes the entire or partial resource in some DL timeslots while the second rectangular resource includes some OVSF codes in the DL timeslot where DPCH and/or control channels are configured.

In method 1, the timeslot information field on HS-SCCH keeps the existing meaning unchanged but is used to indicate the timeslot information for the first and second rectangular resources. The channelization code set information field on HS-SCCH can be divided into two parts with one part indicating the code information of the first rectangular resource and the other part indicating the code information of the second rectangular resource. For example, the part for the first rectangular resource has 0 or 2 bits to indicate the code information of the first rectangular resource with the minimum HS-PDSCH resource allocation grid as 1 SF=1 code (0 bits) or 1 SF=2 code (2 bits). The other part uses the left bits to indicate the code information of the second rectangular resource.

When the part for the first rectangular resource has 0 bit, the other part can use the entire code set information field to indicate the start and end codes of the second rectangular resource. When the part for the first rectangular resource has 2 bits, the other part can use the left bits to indicate the node number of the second rectangular resource.

The code set information field has at least 6 bits. Therefore the other part has at least 4 bits. Assume the node number indicated by the other part is n, the HS-PDSCH resource allocated to UE can be defined as: (1) equal to this node or (2) equal to B-n where B stands for 8 SF=8 OVSF codes in each timeslot and B-n stand for all the left OVSF codes with the node n excluded. When RNC configures the component timeslots of the second rectangular resource to both NodeB and UE, RNC can select one definition between the above two definitions and inform NodeB and UE of its selection.

Because only some SF=8 OVSF codes can be used in the second rectangular resource, the node with SF=1 or SF=16 will not be used. Only 8 SF=8 nodes, 4 SF=4 nodes and 2 SF=2 nodes can be used in the second rectangular resource. The total number of the available nodes is 14. In addition, two special nodes can be defined to indicate 3 SF=8 OVSF codes with one for the first 3 SF=8 OVSF codes in each timeslot and the other for the last 3 SF=8 OVSF codes in each timeslot. The other part of at least 4 bits can indicate to UE any node among the above 14 available nodes and 2 special nodes.

In the HSDPA commercial use, when a timeslot is scheduled to a UE, all the codes in this timeslot is allocated to this UE at the most scenarios. Therefore, it's suggested that the part for the first rectangular resource is 0 bit.

Based on the above analysis, method 1 is summarized as below.

- In DL, the component timeslots of the second rectangular resource are informed to both NodeB and UE by RNC.
- In DL, the detailed timeslot and code information of the second rectangular resource are dynamically informed to UE on HS-SCCH through re-defining the channelization code set information field on HS-SCCH.
- In DL, the channelization code set information field on HS-SCCH is used to indicate the start and end code of the second rectangular resource with the constraint that in the first rectangular resource all the codes in a timeslot are allocated to UE when this timeslot is scheduled to UE.

6.2.2 Method 2

Method 2 is applied to all DL scenarios. The detailed description is as below.

- The channelization-code-set information (CCS) field on HS-SCCH only indicates the channelization code resource allocation in the specific timeslot.
- The specific timeslot is the one with the maximum timeslot number in all the downlink timeslot scheduled to the UE in this subframe.
- For the other timeslots except TS0, all the codes are allocated to the UE when the timeslot is scheduled.
- For TS0, the CCS information is signalled to the UE via higher layer signalling.
- In addition, the specific timeslot can be limited to a timeslot set. If the scheduled specific timeslot belongs to this set, the above non-rectangular resource allocation scheme is used. Otherwise, the legacy allocation method is effective, i.e. the CCS field in HS-SCCH indicates the same channelization code resources in all allocated timeslots.

6.3 New methods for HSUPA signalling enhancements

When a non-rectangular resource is allocated to UE in UL, how to define the E-TFC selection and power grant needs studying. Therefore, in this section, E-TFC selection and power grant for non-rectangular resource allocation are defined first and then the new methods for HSUPA signalling enhancements are given.

6.3.1 E-TFC selection and power grant

In order to be backward compatible with the existing E-TFC selection procedure, it's better to send only one TB through non-rectangular resource and reuse the existing E-TFC selection procedure to determine the size and modulation scheme of this TB.

At present, the PRRI field on E-AGCH is used to send the power grant to UE, where the power grant corresponds to the power offset of an SF=16 OVSF code. It's better to keep the power grant definition unchanged in non-rectangular resource allocation. But due to the fact that the different nodes may be allocated to UE in the different UL timeslots, the E-PUCH transmission power of each of the two rectangular resources needs to be calculated independently.

Based on the above analysis, the E-TFC selection and power grant for the non-rectangular resource allocation is defined below:

- In UL, only one TB is sent through non-rectangular resource. Reuse the existing E-TFC selection procedure to determine the size and modulation scheme of this TB.
- In UL, the power grant definition that the power grant corresponds to the power offset of an SF=16 OVSF code keeps unchanged in non-rectangular resource allocation.

6.3.2 Method 1

Method 1 is described as below.

In the target scenario for UL, the non-rectangular resource consists of two rectangular resources: the first rectangular resource includes the same node in some UL timeslots while the second rectangular resource consists of the partial OVSF codes in the UL timeslot where DPCH and/or control channels are configured. It's better for RNC to tell NodeB and UE the UL timeslot where the second rectangular resource is configured. The detailed timeslot and code information of the second rectangular resource are dynamically indicated to UE by E-AGCH.

In detail, the timeslot information field on E-AGCH keeps the existing meaning unchanged but is used to indicate the timeslot information for the first and second rectangular resources. The CRRI field on E-AGCH can be divided into two parts with one part indicating the node information for the first rectangular resource and the other part indicating the node information for the second rectangular resource. For example, the part for the first rectangular resource has 0 or 2 bits to indicate the node of the first rectangular resource with the minimum E-PUCH resource allocation grid as 1 SF=1 code (0 bits) or 1 SF=2 code (2 bits). The other part uses the left bits of the CRRI field to indicate the node of the second rectangular resource.

In the HSUPA commercial use, when a timeslot is scheduled to a UE, the node with SF=1 is allocated to this UE at the most scenarios. Therefore, it's suggested that the part for the first rectangular resource has 0 bit.

When the part for the first rectangular resource is 0 bits, the entire CRRI field can be used to indicate the node of the second rectangular resource. Because SF=1 and SF=16 can't be used in the second rectangular resource, only 8 SF=8 nodes, 4 SF=4 nodes and 2 SF=2 nodes can be used. There are totally 14 available nodes. Two special nodes can be defined to indicate 3 SF=8 OVSF codes with one for the first 3 SF=8 OVSF codes in each timeslot and the other for the last 3 SF=8 OVSF codes in each timeslot. The CRRI field can indicate to UE any node among the above 14 available nodes and 2 special nodes.

Based on the above description, method 1 is summarized as below.

- In UL, the component timeslots of the second rectangular resource are informed to both NodeB and UE by RNC.
- In UL, the detailed timeslot and code information of the second rectangular resource are dynamically informed to UE on E-AGCH through re-defining the CRRI field on E-AGCH.

- In UL, the CRRI field on E-AGCH is used to indicate the node of the second rectangular resource with the constraint that in the first rectangular resource all the codes in a timeslot are allocated to UE when this timeslot is scheduled to UE.

6.3.3 Method 2

Method 2 is described as below.

- The code resource related information (CRRI) field on E-AGCH only indicates the channelization code resource allocation in the specific timeslot.
- The specific timeslot is the one with the minimum timeslot number in all the uplink timeslot scheduled to the UE in this subframe.
- For the other timeslots, all the codes are allocated to the UE when the timeslot is scheduled.
- In addition, one reserved bit in E-AGCH can be used to indicate whether the method above is used.

6.4 Capability reporting

In order to keep backward compatible, UE/NodeB supporting non-rectangular resource allocation needs to report its capability to RNC. The following methods can be considered to report the capability:

- UE/Node B reports the capability through RRC/NBAP signaling

When NodeB supports non-rectanguar resource allocation, RNC shall forward the related UE capability information to NodeB. For the UE supporting non-rectangular resource allocation, NodeB supporting non-rectangular resource allocation can schedule the non-rectangular resource to it.

When NodeB supports non-rectangular resource allocation, RNC shall inform UE supporting non-rectangular resource allocation of the related configuration information to make UE analyze the control information on HS-SCCH/E-AGCH correctly.

- bundle non-rectangular resource capability of UE with the UE release information

With this method, RNC recognizes the non-rectangular resource capability of UE through its release information.

6.5 Analysis and suggestions for future study

In order to improve UE peak rate and throughput, the new methods for HSPA signalling enhancement for more efficient resource usage are recommended to be specified. Further study should focus on the following aspects:

(1) Complexity of the new methods

(2) Impact on the 3GPP specifications and legacy UE and UTRAN implementation

Annex A:
Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2012-03	RAN1#68 bis	R1-121819			Initial draft version		0.1.0
2012-05	RAN1#69	R1-121983			TR25.874 v0.2.0 for "HSPA feedback and Signalling Efficiency Enhancements for LCR TDD"	0.1.0	0.2.0
2012-08	RAN1#70	R1-124017			TR25.874 v0.3.1 for "HSPA feedback and Signalling Efficiency Enhancements for LCR TDD"	0.2.0	0.3.1
2012-08	RAN1#70	R1-124018			Version 1.0.0 agreed for one step approval by RAN	0.3.1	1.0.0
2012-09	RAN#57	RP-121407			Approved by RAN as version 11.0..0	1.0.0	11.0.0