TSG-RAN Meeting #28 **RP-050231**

Quebec, Canada, 01 - 03 June 2005

Presentation of Specification to TSG or WG

Presentation to: **TSG RAN Meeting #28**

Document for presentation: **TR 25.902 IubIur Congestion Control, Version 1.0.0**

Presented for: **Information**

Abstract of document:

During TSG RAN WG3#46, it was proposed to create a TR which captures the solutions, agreements and open issues during the realisation of a Congestion Control Solution for EDCH and - if possible - for HSDPA.

The purpose of the TR 25.902 is to record all the information related to this item and trace its status.

Changes since last presentation to TSG RAN Meeting #27:

The TR is presented for the <u>first</u> time.

Significant progress was made during the last RAN3 Working Group Meeting.

CRs for congestion control with respect to the EDCH & HS-DSCH frame protocols, and against TS 25.423 (RNSAP) have been agreed and are provided to RAN#28.

Outstanding Issues:

1. When NodeB is in Softhandover what (if any) is the relationship/interaction with E-DCH Congestion Control.
2. Is it agreed that the S/CRNC decides whether a particular E-DCH flow is subject to congestion control at flow setup?
3. Should an Iub/Iur Congestion Control solution consider Rate Adaptation?
4. Thus far Iub/Iur Congestion Control has been considered for HSDPA and HSPUA only. Could any final solution be applicable for UL and DL DCH?

Contentious Issues:

3GPP TR 25.902 V1.0.0 (2005-06)

Technical Report

3rd Generation Partnership Project;
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(Release 6)

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Contents

Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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.

1 Scope

The present document is part of the Release 6 work item “FDD Enhanced Uplink”.

The purpose of the present document is to help the TSG RAN WG3 group to specify the changes to existing Iub/Iur specifications, needed for the introduction of “Iub/Iur Congestion Control” measures for Release 6.

This work task belongs to the TSG RAN Building Block “FDD Enhanced Uplink: UTRAN Iub/Iur Protocol Aspects”, and as such this document is *expected* to be completed within the Release 6 timeframe.

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 41.001: "GSM Release specifications".

[2] 3GPP TS 25.309: "FDD Enhanced Uplink: Overall Description ".

[3] 3GPP TS 25.308: “UTRA High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2”.

[4] 3GPP TR 25.877: “High Speed Downlink Packet Access (HSDPA) - Iub/Iur Protocol Aspects”

3 Definitions, symbols and abbreviations

3.1 Definitions

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

E-DCH: Enhanced DCH, a new dedicated transport channel type or enhancements to an existing dedicated transport channel type.

Serving E-DCH Cell: Cell from which the UE receives Absolute Grants from the Node-B scheduler. A UE has one Serving E-DCH cell.

Serving E-DCH RLS or Serving RLS: Set of cells which contains at least the Serving E-DCH cell and from which the UE can receive and combine one Relative Grant. The UE has only one Serving E-DCH RLS.

Non-serving E-DCH RLS or Non-serving RLS: Set of cells which does not contain the Serving E-DCH cell and from which the UE can receive and combine one Relative Grant. The UE can have zero, one or several Non-serving E-DCH RLS.

Serving Node B: Node B controlling the Serving E-DCH Cell for a specific UE

E-DCH Active Set: the set of cells carrying E-DCH for a specific UE. It can be a subset of the DCH Active Set

HARQ profile: One HARQ profile consists of a power offset attribute and maximum number of transmissions.

Power offset attribute: Represents the power offset between E-DPDCH(s) and reference E-DPDCH power level for a given E-TFC. This power offset attribute is set to achieve the required QoS in this MAC-d flow when carried alone in a MAC-e PDU and subsequently in the corresponding CCTrCh of E-DCH type. Details on the mapping on Beta factors can be found in RAN WG1 specifications. The reference E-DPDCH power level for a given E-TFC is derived from the beta factor signaled to the UE for a reference E-TFC (see details in subclause 10.1).

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:

AG	Absolute Grant
E-AGCH	E-DCH Absolute Grant Channel
E-DPCCH	E-DCH Dedicated Physical Control Channel
E-DPDCH	E-DCH Dedicated Physical Data Channel
E-HICH	E-DCH HARQ Acknowledgement Indicator Channel
E-RGCH	E-DCH Relative Grant Channel
E-RNTI	E-DCH Radio Network Temporary Identifier
E-TFC	E-DCH Transport Format Combination
HARQ	Hybrid Automatic Repeat Request
HSDPA	High Speed Downlink Packet Access
RG	Relative Grant
RLS	Radio Link Set
RSN	Retransmission Sequence Number
SG	Serving Grant
TSN	Transmission Sequence Number

4 Background and Introduction

In RAN Plenary Meeting #27, it was agreed to create a Technical Report on the subject of "*Iub/Iur Congestion Control (Rel-6)*".

The technical objective of this TR is to improve the Congestion Handling performance of the UTRAN over the Iub and the Iur interfaces.

Any solution should take into account backwards compatibility aspects.

This work item is applicable to UTRA FDD only.

5 Requirements

In addition to the overall system requirements outlined and agreed upon in Section 5 of [2], the following specific requirements to RAN3 should be applied:

- RNC shall have a means for detecting congestion.
- *Receiving* node shall have a means for notifying the source of congestion i.e. *sending node*, that congestion has occurred.
- Iub/Iur Congestion control for both HSDPA and HSUPA should – if possible – employ similar solutions.

- The development of an Iub/Iur Congestion control solution should bear in mind both the existing HSDPA and soon to be completed HSUPA features.
- Any solution should take into account backwards compatibility aspects.

6 Study Areas

6.1 Background Information

6.1.1 Introduction

There are many types of congestion control mechanisms, the main groups are window based, rate based or combination of both. The method often used for the congestion detection is the method based on the loss of packets. Other methods appropriate for congestion detection are: packet delay, average queue and rate difference.

Several congestion control algorithms exist. ATM ABR against TCP/IP was compared in [1] with the result to use ABR with some changes. The first one is windows based, the second one is rate based congestion control mechanism.

Different congestion control algorithms might be used for IP network and ATM network respectively. It is known, that in IP network as a congestion control protocol mostly TCP is used, so to ensure fairness and other quality congestion control parameters, TCP like congestion control protocol should be used. TFRC protocol (TCP-Friendly Rate-based congestion Control protocol), as one of the many examples, which intends to compete fairly for bandwidth with TCP flows, could be named.

6.1.2 Example 1: TFRC

Congestion Factor depends on the congestion control algorithm, and on the congestion detection method. By detecting the loss of packets and using some method to derive RTT, transmit rate could be prepared according to transmit rate formula X=f(s, RTT, p) where s is the packet size in bytes/second, RTT – the round trip time in seconds, p is the loss event rate (based on the packet loss derived from the congestion detection). Details about TFRC see [3].

Congestion Factor depends on the computed data rate X. The Credit, Interval and Repetition Period of FC Allocation message will be influenced by computed Congestion Factor in Congestion Control and the message Capacity Allocation with modified IEs will be sent to RNC.

6.1.3 Example 2: "ABR like" congestion control

Transposal of ABR Congestion Control is proposed in [1]. This "ABR like" congestion control has "additive increase, exponential decrease" type of algorithm. Different formulas exist for computing of ACR for increase and for decrease. ACR (Allowed Cell Rate), i.e. current transmission rate in cell/s, should be computed in octets or in number of MAC-d PDUs. Then from the computed ACR according to [1], by a given HS-DSCH Interval, HS-DSCH Credits can be derived, because ACR is equal to Credits divided by Interval. Capacity Allocation message will be sent to RNC.

6.2 Functional Description

6.2.1 Iub/Iur Congestion Detection

The Node B scheduler decides on when and with which bit rate each and every UE is allowed to transmit in the cell. Each received MAC-es PDU is placed in a frame protocol data frame and sent to the SRNC (in some cases several PDUs are bundled into the same data frame). For each data frame, the Node B attach the following information:

- A reference time, that gives an indication on when the frame was sent.
- A sequence number, that gives an indication on which frame this is in relation to other data frames.

At the reception of the data frames the SRNC can do the following:

- With the use of the reference time, the SRNC can compare the relative reception time with the relative transmission time (the reference time included in the data frame). With that information the SRNC can detect if there is a delay build-up in the transmission path. A delay build-up is an indication on that frames are being queued due to overload in the transport network.

- With the use of the sequence number, the SRNC can detect a frame loss. A frame loss is an indication that packets have been lost in the transport network due to overload reasons.

This procedure is illustrated in Figure 1.

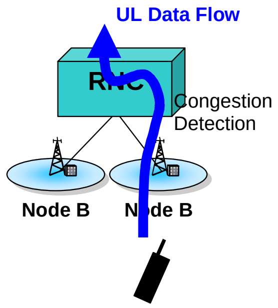

Figure 1: Iub/Iur Congestion Detection

6.2.2 Iub/Iur Congestion Reduction

When the RNC has detected that there is a congestion situation in the transport network, it needs to inform the Node B that this is the case. This is done by means of a frame protocol control frame, in which the Node B is informed about the congestion situation. This control frame will be called Congestion Indication. This is illustrated in Figure 2.

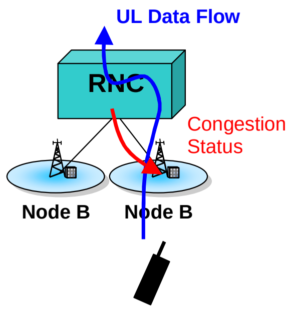

Figure 2: Iub/Iur Congestion Indication

As the RNC can detect congestion in two different ways, there exist no motivation why such information should not be communicated to the Node B. For that reason the Congestion Indication Control Frame can take the following values: “Congestion – detected by frame loss”, “Congestion – detected by delay build-up”, and “No congestion”.

At the reception of the Congestion Indication control frame, the Node B should reduce the bit rate on the Iub interface. The exact algorithm the Node B should use is outside the scope of the specifications, but the specifications should address the expected behaviour of the Node B.

Such behaviour should include:

- At the reception of a congestion indication control frame indicating “congestion” the Node B should reduce the bit rate for at least the MAC-d flow on which the congestion indication control frame was received.

- At the reception of a congestion indication control frame indicating “no congestion” the Node B can gradually go back to normal operation.

- If the Node B has not received a congestion status control frame indicating congestion for the last X seconds, the Node B can gradually go back to normal operation. The value of the parameter X is configured by higher layers.

Editor’s note: Whether the third bullet above should be included in the specifications is an open issue.

This level of specification of the Node B behaviour is sufficient, for the following reasons:

1. The purpose of the congestion control, is not to act as a flow control but rather as an “emergency break” in order to keep the system at a stable state.

2. The output bit rate from the node B depends on many things, for example radio interference, distance from mobile to Node B, available hardware resources etc. The Node B scheduler will need to take all that into consideration when assigning the bit rate to each mobile.

3. Performance wise, to specify very detailed behaviour when the control frame is received is not possible due to the reasons in bullet 2.

6.2.3 A Similar Solution for HSDPA

It has been acknowledged that similar functionality shall also be introduced for HSDPA. Further it was expressed that such a solution should be as similar as possible to any solution for HSUPA. In this section such functionality is proposed and analysed.

From a conceptual point of view, the reuse of the concept that the detection of Iub/Iur congestion is done by measuring a delay build-up, and/or by detecting frame loss (or lost number of bytes/bits) is proposed.

For HSUPA it was required to introduce a specific congestion indication control frame for informing the Node B about the congestion. This is not required in the case of HSDPA - a working flow control mechanism already exists. In order to minimize complexity, implementation and tuning efforts, the reuse of this mechanism for the purpose of congestion control is proposed.

As a result, the only required changes in the specifications would be to add support for the Node B to detect congestion situations. From the discussion on HSUPA, it is known that this mechanism should be based on the measuring of a delay build-up or by detecting some kind of sequence loss.

Time stamp for measuring delay build-up

For HSUPA a “time stamp” has already been agreed implicitly by the introduction of CFN and SFN for reordering purposes. The CFN and SFN fields can be used also for the purpose of detecting delay build-up and there is no need for any additional information.

For HSDPA, CFN and SFN are not used. Therefore, the introduction of a delay reference time tied to RFN is proposed. RFN is already defined and should not impose and additional complexity. The Node B can detect delay build-ups by noting the arrival time of subsequent Delay-Reference-Time (DRTs) and comparing them.

Sequence Number for detecting frame/data loss.

Furthermore, some kind of sequence number added to the data frame is required - in order to allow the receiver to detect when a frame has been lost. There are two possible options, a frame sequence number (FSN) or a quantum sequence number (QSN). The pros and cons with those has been discussed and it has been concluded that for HSUPA the usage of a 4 bit field (FSN) would be sufficient.

The HSDPA solution should be as similar as possible – if possible - as for HSUPA. A 4 bit FSN would fit into the spare bits of today’s data frame, while an introduction of a 12-16 bit (minimum) QSN would require to make use of the spare extension mechanism, adding a minimum of three octets to the data frame. Considering that data frames are not bundled for HSDPA, results in a general smaller frame, as well as a lower standard deviation of the frame size, the extra overhead with QSN is motivated.

The usage of Congestion Indication Control Frame

For HSUPA the usage of a control frame for indicating that there is a congestion situation is proposed. Such a solution would be possible to apply also for HSDPA. There is however an important difference in the functional split between HSDPA and HSUPA. HSDPA already has a flow control mechanism in order not to overflow the Node B buffers. For that reason the easiest (both specification wise and implementation wise) will be to reuse the mechanism for flow control. For that reason, only the need to specify the means for the Node B to detect a congestion situation, i.e. DRT and FSN, is required.

Conclusion

The outlined solutions for HSDPA and Enhanced Uplink are functionality wise similar, congestion detection is done by observing a time stamp and a sequence number.

Although it would be nice to have the exact same coding of the detection and notification for both HSDPA and Enhanced Uplink, smaller differences can be accepted if that leads to more efficient coding, and implementation, saving overhead. The most obvious case is the time stamp, CFN and SFN, already exists for Enhanced Uplink, but it cannot be inserted into the HSDPA user data header. As there is no CFN and SFN defined for HSDPA, using a time stamp linked to the RFN is proposed.

There is a possibility to have the exact same coding of the sequence number: A 4 bit FSN fits into both the HSDPA and the Enhanced Uplink user data frame headers.

For the notification message a control frame for HSUPA is proposed and the reuse of the existing flow control mechanism for HSDPA.

6.2.4 Handling of the Iur

Two philosophies can be distinguished for the handling of the Iub traffic, referred to as the "Iub pipe" and the "Iub cloud".

6.2.4.1 Iub Pipe philosophy

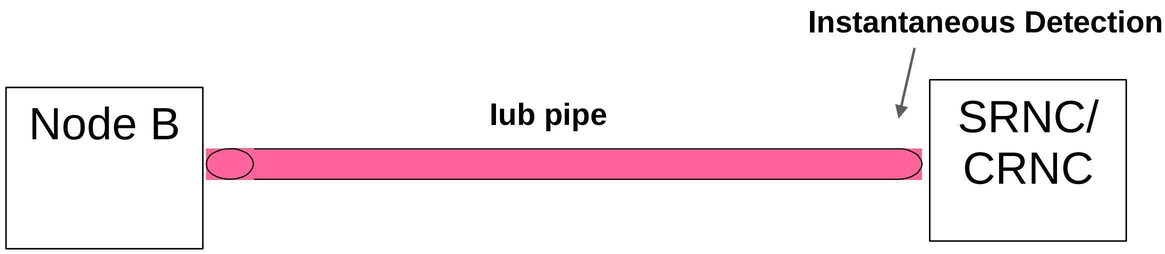

Figure 3. "Iub pipe" philosophy

With the "Iub pipe", logic the CRNC enforces the traffic limit injected on the Iub interface in the DL, so it is able to instantaneously detect any congestion situation. The advantage of this approach is that there is no need for using any new congestion mechanisms in the Node B, because the congestion detection is instantaneous – the only place it can occur is at the "pipe" entry. The drawback of the "pipe" logic is that in some scenarios it may require complex configuration of TNL topologies in the CRNC in order to leverage statistical multiplexing.

If the "pipe" logic on the Iub is to be preserved, when the HS-DSCH connection extends across the Iur interface it is important to note that the HS-DSCH Flow Control should be terminated in the DRNC. This case is depicted in Figure 4.

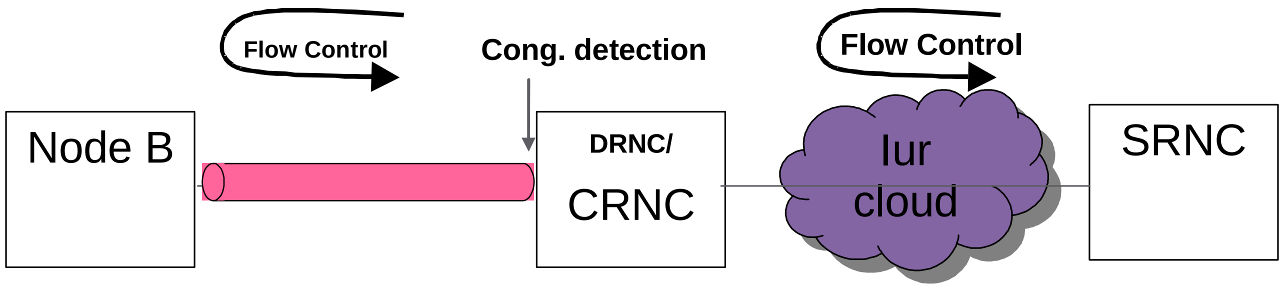

Figure 4. FC termination in DRNC and "pipe" on Iub

As illustrated in Figure 4, there are two separate Flow Control loops exerted on both Iub and Iur.

6.2.4.2 Iub Cloud philosophy

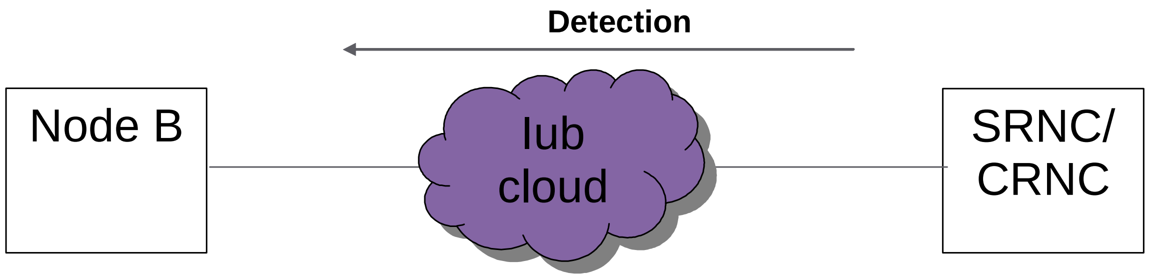

Figure 5. "Iub cloud" philosophy

With the "Iub cloud" logic, the traffic injected by the RNC is less tightly controlled i.e. the RNC is likely to inject too much traffic in the network, thus yielding a congestion situation. This approach should allow for statistical multiplexing in some scenarios without complex configuration of TNL topology in the CRNC. However, with this approach a new congestion control mechanisms become a necessity.

This "Iub cloud" logic can easily be extended to the handling of the Iur as shown in figure 6:

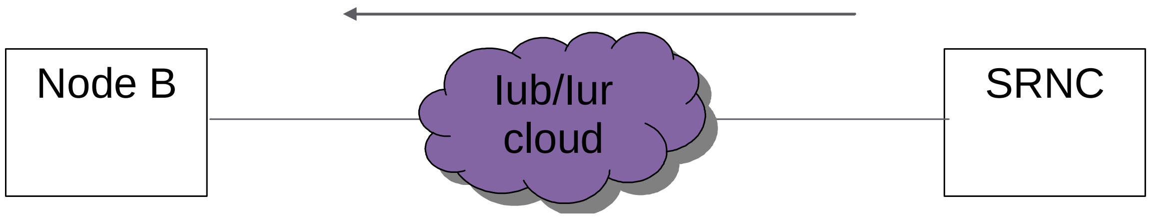

Figure 6. "Iub cloud" philosophy extended to the Iur

6.2.4.3 Co-existence of the two philosophies

In the situation where the HS-DSCH connection extends across the Iur interface it is important to note that – should it be employed - the HS-DSCH Flow Control may be terminated in the DRNC.

In this scenario, two separate Flow Control loops would then be employed on both Iub and Iur.

If, in the "Iub pipe" logic, a DRNC detects congestion, it will either buffer or discard the excess data. In either case, a CC-enabled NodeB (i.e. a Node B with the "Iub cloud" logic) would detect the congestion situation as well.

In order to avoid race conditions between the two competing mechanisms (Congestion Control in the Node B and Congestion Control in the CRNC), it is thus proposed to introduce the possibility to turn off Congestion Control in the Node B via Control Plane mechanisms. By doing so, congestion will be detected and handled in only one place in the network.

There are two possible solutions to achieve that result:

1. The DRNC makes the decision to use Congestion Control and indicates to the Node B – via Control Plane - not to perform Congestion Control (e.g. using the Physical Shared Channel Reconfiguration procedure).
2. The DRNC makes the decision and indicates to the SRNC that it shall include the user plane protocol extensions that are used by the Node B to detect congestion (namely the timestamp and the Frame Sequence

Number) by introducing a new *User Plane Congestion Field Inclusion* IE in the *HS-DSCH FDD/TDD Information Response* IEs.

This would allow the DRNC to indicate to the SRNC if User Plane fields destined to be used for Congestion detection by the Node B are to be included or not in the HS-DSCH Data Frames. If not included, Congestion detection and Congestion Control will not be employed by the Node B.

This second approach is preferred as it allows to save bandwidth on the UTRAN interfaces and it really allows not to perform any Congestion Control in the Node B as no information is available.

6.3 Impacts on Iub/Iur Control Plane Protocols

TS 25.423

- a new *User Plane Congestion Field Inclusion* IE in the *HS-DSCH FDD/TDD Information Response* IEs.

6.4 Impacts on Iub/Iur User Plane Protocols

TS 25.427

- EDCH data frame: Introduction of a 4 bit Frame Sequence Number (FSN) field.
- EDCH data frame: Clarification that CFN and SFN can be used for dynamic delay measurements.
- Introduction of a Congestion Status control frame.
- Specification of desired behaviour when Node B receives the Congestion Status control frame.

TS 25.425 and TS 25.435

- HS-DSCH data frame: Introduction of a 4 bit Frame Sequence Number (FSN) field.
- HS-DSCH data frame: Introduction of a 16 bit Delay Reference Time (DRT) field.

6.5 Open Issues

1. When NodeB is in Softhandover what (if any) is the relationship/interaction with E-DCH Congestion Control.
2. Is it agreed that the S/CRNC decides whether a particular E-DCH flow is subject to congestion control at flow setup?
3. Should an Iub/Iur Congestion Control solution consider Rate Adaptation?
4. Thus far Iub/Iur Congestion Control has been considered for HSDPA and HSPUA only. Could any final solution be applicable for UL and DL DCH?

6.6 Backwards Compatibility

void

7 Agreements and associated contributions

1. The development of an Iub/Iur Congestion control solution should bear in mind both the E-DCH *and* HSDPA features.
2. Iub/Iur Congestion control for both HSDPA and HSUPA should – if possible – employ similar solutions.
3. The RNC remains the entity in charge of the Congestion Control function.
4. NodeB *behaviour* when receiving the congestion indication shall be specified.
5. The detection *algorithm* will not be specified in the TR. (However example algorithms may be given in an annex.)
6. Congestion indication should be signalled via the user plane.
7. Signalling of Congestion via the user plane will also include varying levels of congestion severity.
8. Congestion Detection will be performed on a per flow basis.
9. Within the E-DCH data frame (user plane), congestion detection will be based upon a time reference or a sequence number.
10. For the handling of Iub/Iur Congestion due to HSDPA, the CRNC decides whether all or none of the HS-DSCH MAC-d Flows of a context are subject to Congestion Control.
11. A “counter” field be attached to EVERY E-DCH data frame.
12. The “counter” field within the E-DCH frame will take the form of a “frame sequence number” (FSN).
13. Different levels of congestion shall be indicated by “*No congestion*”, “*TNL Congestion – detected by delay build-up*”, “*TNL Congestion – detected by frame loss*”.
14. The resulting *behaviour* following the signalling of Congestion Indication will not be defined – this is an implementation matter.
15. For impacts upon RNL xxxAP Signalling protocols, please refer to CR 1080 against TS 25.423.

8 Specification Impact and associated Change Requests

This section is intended to list the affected specifications and the related agreed Change Requests. It also lists the possible new specifications that may be needed for the completion of the Work Task.

9 Project Plan

9.1 Schedule

Date	Meeting	Scope	[expected] Input	[expected]Output

9.2 Work Task Status

	Planned Date	Milestone	Status
1.			
2.			

Annex A (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
06/2005	TSG-RAN#28	RP-050231			Presentation of TR for information	-	1.0.0