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(Release 6)

Keywords

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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

This present document is for the 3GPP Release 6 Study Item “Evolution of UTRAN Architecture”(see [1]).

The purpose of the present document is to help TSG RAN WG3 to define different UTRAN Architecture scenarios and compare the benefits of each of them. The study on the evolved architecture shall be performed for both transport options, the ATM transport option and IP transport option.

This document is intended to gather all information in order to compare the solutions and to draw a conclusion on the way forward.

This document is a ‘living’ document, i.e. it is permanently updated and presented to TSG-RAN meetings.

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.*

[<seq>] <doctype> <#>[([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

[1] 3GPP TD RP-020670: "Proposed SI, Evolution of UTRAN Architecture".

[2]

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

***<defined term>**: <definition>.*

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 following abbreviations apply:

RNG	Radio Network Gateway

4 Introduction

At the 3GPP TSG RAN #17 meeting, Study Item description on “Evolution on UTRAN Architecture” was approved [1].

Considering the first step of UTRAN architecture evolution as the introduction of the IP transport in Rel-5, the step taken here is to study the architectural evolution of UTRAN that could lead to improvements in radio performance and transport layer utilization. The study could for example consider new distribution of RAN functionalities e.g. Node Bs would contain more control operation. Also potential benefits for the radio capacity could be achieved by the proposed methods due to e.g. reduced delay.

This study is aimed at UTRAN architecture evolution considering a new functional split between the nodes. Also considered are the impacts on the existing UTRAN interfaces and co-existence with the present UTRAN architecture as well as potential benefits for the system performance, deployment and radio interface evolution.

The study will include new distribution of some RAN functionalities between existing nodes e.g. moving radio related protocols closer to radio interface which leads to shorter delays for users, necessary interface enhancements, improvements in protocol stacks and enhancements of UTRAN procedures to support the evolved UTRAN architecture.

5 Requirements

A) The evolved architecture shall not introduce any changes to the Uu interface.

B) The evolved architecture shall allow interworking and assure backward compatibility with the existing architecture.

C) The evolved architecture shall have open standard interfaces to enable the operators to deploy different vendors' equipment.

D) The evolved architecture shall enable network operators to improve at least one of the following aspects of their network, resulting in an overall improvement in UTRAN without significantly degrading the others, these shall include but are not limited to: performance, scalability, flexibility and reliability.

E) The evolved architecture shall allow maximum reuse of existing protocols.

F) The evolved architecture shall allow for a smooth migration process in deployment.

G) The evolved architecture shall efficiently support existing and enhanced radio-related functionality.

H) The evolved architecture shall allow minimal impact on core network.

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6 Study Areas

6.1 General

The Study Area chapter includes first the analysis of the demand for evolution in the R99 architecture i.e. the different areas of improvement in the current R99 architecture that the different proposals for an evolved architecture should address. Next the second section within the Study Area chapter lists and presents those different proposals. Their characteristics, benefits and drawbacks, impacts, interworking with R99 architecture and open issues are developed in their respective sections.

If seen necessary, a comparison section may be introduced.

6.2 Analysis of the demand for evolution in R99 UTRAN Architecture

[Here it shall be stated what are the needs and potential for architectural evolution in the current R99 UTRAN]

6.2.1 Analysis of R99 Architecture

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General

This section is intended to analyse the needs and drivers for architecture evolution in the current R99 UTRAN architecture. It is emphasised that the introduction of an alternative architecture in parallel with the already existing and well established R99 architecture not only introduces new work for RAN WG3 but it also creates a point of divergence in the development of 3GPP RAN. For this reason any new architecture needs to provide some significant advantages in order to justify its introduction.

Radio Interface Protocols

R99 Radio Interface Protocol Architecture and Functional Split

In this chapter we identify some specific aspects of the functional split in UTRAN and their effect on radio capacity and transport capacity utilisation and QoS. In the figure 1 the radio interface protocol architecture is shown as the basis for the evaluation. In the figure also the Frame Protocol and underlying transport bearers are shown. The radio interface protocol architecture is defined in TS25.301 [3].

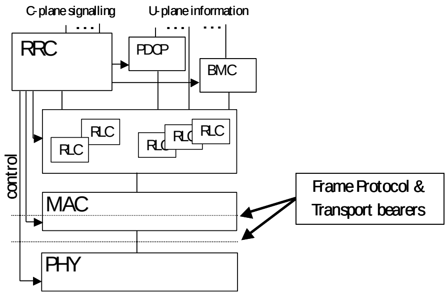


Figure 1 The current radio interface protocol architecture.

One of the characteristics of the current protocol architecture is that there is a transport network layer interface (i.e., transport bearers, dotted line) between the radio interface Layer 2 and Layer 1 or between the Layer 2 (MAC) sublayers. In addition, the RRC control also needs to be arranged through the external transport network layer interface(s). The interfaces in question are Iub and Iur.

In the following some detailed implications of the current protocol architecture are further discussed.

Frame Protocol Synchronisation and Radio Frame Scheduling

For both Dedicated Channels and Common Channels there is the Frame Protocol in Iub to convey the Transport Block Sets (TBS) of the given transport channels. On Iur the Frame Protocol conveys either the TBSs (DCH) or MAC-c/sh SDUs (CCH). The transport channel synchronisation and Connection Frame Number-based TBS scheduling, that are provided in-band by the Frame Protocol, set a delay/delay variation requirement for the underlying transport. This requirement is independent of the delay/delay variation requirements of the end user service that is conveyed by the given transport channel.

Generally in a packet switched transport network better transport resource utilisation is achieved if the delay/delay variation requirements of the transport are less stringent. This is due to the resulting possibility for more efficient statistical multiplexing. Consequently, when the volume of Non-Real Time services (IP-based traffic) increases, the inability to take into account the Non-Real Time (NRT) characteristics of the traffic and thus to benefit from the statistical multiplexing gain become significant.

An additional consequence of the Frame Protocol is the synchronisation delay when the transport bearer is made operational. The delay is caused by the DCH Synchronisation (DCH, Iur and Iub) and Downlink Synchronisation (CCH, Iub only) procedures. They add an additional round-trip time in the radio bearer setup delay before the *already existing* transport bearer can be used for data transfer. Thus the longer the transport delay in Iub the longer it takes before any user data can be sent on the already established transport bearer.

It should be studied as part of the ongoing UTRAN architecture evolution study how to allow transport arrangements where the QoS requirements (delay, delay variation) of the access transport would be generally determined by the actual end user service requirements instead of the requirements of the radio interface. This is to have a significant effect on transport costs as soon as the volume of NRT traffic (IP) becomes significant.

It should also be studied how to minimise the effect of Frame Protocol synchronisation procedure on the radio bearer setup/switching delay.

Radio Link Control Protocol (RLC)

Today the Radio Link Control (RLC) protocol and its re-transmission buffers reside in the Serving RNC and in the UE. When RLC is used in the Acknowledged Mode the Iub/Iur transport delay directly contributes to the RLC retransmission delay and thus to the delay and throughput experienced by the end user. In TR25.853 [4] the formula for RLC retransmission has been given as follows: $\textit{Re-transmission delay} = N_{retransmissions} * \textit{Round trip delay}_{UE\text{-}SRNC}$. From this formula it is seen that the effect of Iub/Iur round trip time can be noticeable.

The higher the service bit rate the more significant is the effect of the RLC re-transmission delay. In order to get the benefit from a high speed radio bearer conveying NRT data, either the re-transmission delay needs to be small or the Block Errors need to be eliminated. Otherwise the user application would not get the full benefit from the high bit rate, thanks to the frequent re-transmissions with the additional delay. In Rel5 HSDPA and its Layer 1 Hybrid ARQ are a good example of how to reduce the need for RLC re-transmissions.

Another characteristics in RLC re-transmission delay is that by making the re-transmission delay shorter, the transport delay for the actual data transfer other than re-transmissions can be made relaxed. This is only an evidence of the effect of re-transmissions on the overall data throughput.

As said earlier in section 2.2, the need to constrain the transport delay limits the amount of statistical multiplexing gain that would otherwise be available in the transport of NRT data services.

As part of the UTRAN Architecture Evolution study it should be considered how to minimise the RLC re-transmission delays and thus to maximise the RLC level data throughput without sacrificing the transport benefits of NRT data.

Outer Loop Power Control

Outer loop power control is an RRC function executed today in the SRNC to control the SIR target to be used by the uplink inner loop power control. In the uplink the information about the current radio link condition is derived from the Transport Block and transport channel specific information (CRCI, QE) conveyed in-band by the corresponding DCH Frame Protocol data frames. From the radio interface utilisation efficiency point of view any excessive loop delay is undesired as it makes the RRC decisions on UL SIR target less accurate. Thus it is also the outer loop power control that sets an upper bound for the acceptable delay in the transport in Iub, irrespective of the end user service conveyed by the given transport channel.

Possibilities to optimise the arrangement of the Outer loop Power Control for NRT services should be considered as part of the ongoing UTRAN Architecture Evolution study. Also the overall sensitivity of the outer loop efficiency to the transport delay should be evaluated.

Considerations on RRC and on the role of NBAP

In the existing radio interface protocol architecture as defined in [3] there is interaction between the RRC and Layer 2 sublayers and between the RRC and Layer 1 (ref. Figure 1). In the current functional split of UTRAN this interaction needs to be arranged through the transport interfaces.

The RRC messages that are exchanged between the RLC peers in the RNC and in the UE are mapped to Signalling Radio Bearers. Some of these SRBs use Acknowledged Mode RLC while the others use higher layer retransmissions if needed. The corresponding RRC procedures involve critical changes in the state of operation of UE and RNC. Keeping in mind that the RRC messages get easily long, occupying many TBs, and that the SRB bit rates are low (most common 1.7, 3.4 and 13.6 kbps) and interleaving lengths may be long, the RRC messaging is in some cases slower than desired. The delay caused by retransmissions on SRB is also long for the same reasons. All additional delays e.g. due to transport on Iub are undesired as they affect the pace the RRC can operate with UEs.

RRC procedures related to state transitions and re/configurations of transport or physical channels do not only experience additional delay due to extra RLC round trip time caused by Iub, but also by NBAP signalling that has to be performed before these procedures are finalized. Especially if synchronisation is needed in an RRC procedure, like DCH switching starting from a specific CFN in UE, any additional delay from NBAP signalling over Iub is not appreciated as the RRC has to be sure that the UE has received the RRC message correctly by the time when the switching should occur. These NBAP message exchanges and long RLC RTT cause conservativeness in determining the allocation time for the given procedure.

As a conclusion the transport layer of Iub and Iur has a direct effect on the efficiency and speed of RRC procedures between the UE and the SRNC. The delay in these procedures does not only affect the use of radio resources but it is also affecting the RAN performance as seen by the end user. As the amount of interaction between the user and the network is expected to grow even dramatically when the IP services continue gaining popularity, all noticeable latency in these interactions will be unattractive both to the user and to the operator of the network.

It should be considered as part of the UTRAN Architecture Evolution study how could the architecture be evolved to achieve improvements in the efficiency and to allow more optimised implementation of RRC in UTRAN. It is to be noted that the scope of the study does not involve UE and thus the changes improving the efficiency of RRC procedures shall not cause any changes in the UE implementation.

System resilience

Robustness

In Release 99 architecture, the RNC is the centralized controlling node for hundreds of NodeBs, as a NodeB can only be connected to one RNC via the Iub interface.

As the RNC is responsible for most of the UTRAN functionalities, it requires practically, whatever size it has, much more complex implementation and significantly more processing capacity than any NodeB.

That is why, although an RNC should be protected according to its importance in the network, it is considered a single point of failure from the network topology point of view. Indeed, if one RNC crashed, it would then be the entire area covered by its tens or even hundreds of NodeBs that would go out of service, as demonstrated in the figure 2 below.

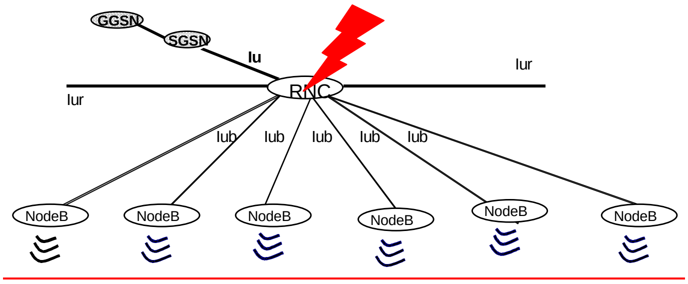


Figure 2: RNC as a single point of failure.

It should be studied how to evolve the UTRAN Architecture to avoid or reduce the presence of any critical single point of failure in UTRAN.

Deployment

[tbd]

6.3 Proposals for the Evolved Architecture

6.3.1 General

[Short introduction of the different proposals]

[Here it shall be presented the different proposals of evolved architecture, their benefits and impacts]

6.3.2 Evolved Architecture based on new location of radio functions

6.3.2.1 Overview

Note: a more detailed description of the Nokia proposal needs to be added here (see R3-030030)

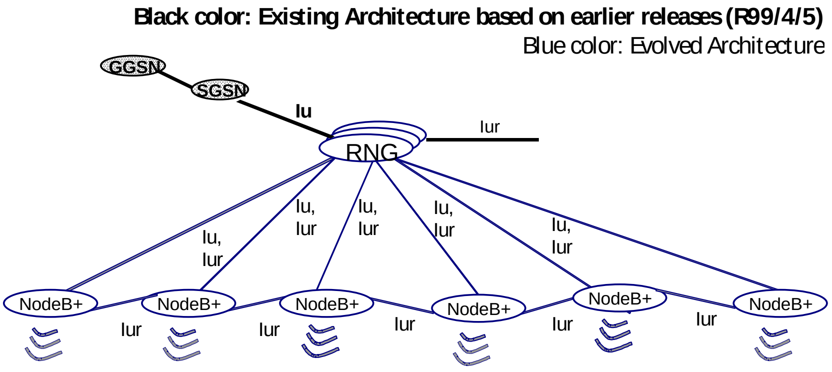
Note: A proposal for the target architecture for the Evolution of UTRAN Architecture SI, was presented in tdoc R3-030020 [1] in the RAN3 release 6 ad hoc in January 2003. The presented architecture proposal raised some questions among the meeting delegates.

The purpose of this contribution is to address some of the raised issues by giving further details of the presented architecture. This contribution describes the functional split between the RAN network elements in the presented architecture. The contribution also shows main reasons why the evolved architecture is not just an implementation of the existing R99 based architecture.

6.3.2.1.1 functional split

6.3.2.1.1.1 General

This section describes the functional split between the Radio Network Gateway (RNG) and the evolved NodeB (NodeB+). The main functions of both elements have been listed, separately for control plane and user plane. The basic scenario of the evolved architecture is presented in Figure 1.



Main highlights and legends:

- The functions of a monolithic RNC have been distributed down to NodeBs (NodeB+). There is therefore no longer an Iub interface in this evolved architecture.
- There is a Radio Network Gateway (RNG) as interworking unit to RANs and CNs of the earlier releases. The RNG hides the bigger number of NodeB+s to conventional CN over Iu and conventional RNC over Iur. Furthermore the RNG acts as a mobility anchor, hiding the SRNS relocations between NodeB+s to the CN.
- There is an Iur interface between NodeB+s and Iu interface between NodeB+s and RNGs.
- There is a many-to-many relationship between NodeB+s and RNGs.
- There is also an Iur interface between NodeB+ and RNG for the interworking with RAN from earlier releases in case of drift situation.
- Iu and Iur interfaces in the evolved architecture (blue color) have some enhancements compared with existing interfaces.

Figure 33~~1~~. Architecture for UTRAN evolution.

6.3.2.1.2 Radio Network Gateway functions

6.3.2.1.2.1 General

The RNG is used for interworking with the conventional RAN, and to act as a mobility anchor point. This includes functions both in control plane and user plane.

6.3.2.1.2.2 Control plane functions

Part of RNG functions is to act as a signalling gateway between the evolved RAN and the CN, and the evolved RAN and R99/4/5/6 UTRAN. It has the following main functions:

Comment [MJD1]:

- Iu signalling gateway, i.e. anchor point for the RANAP connection
    - RANAP connection termination, including:
        - Setup and release of the signalling connections
        - Interpretation of connectionless messages
        - Processing of RANAP connectionless messages
    - Relay of idle and connected mode paging message to the relevant NodeB+(s)
- The RNG takes the CN role in inter NodeB+ relocations
- User plane control
- Iur signalling gateway between NodeB+ and Rel99/4/5 RNC

6.3.2.1.2.3 User plane functions

The RNG is the user plane access point from the CN or conventional RAN to the evolved RAN. It has the following user plane functions:

- User plane traffic switching during relocation
- Relaying GTP packets between NodeB+ and SGSN
- Iur interworking for user plane

6.3.2.1.3 NodeB+ functions

6.3.2.1.3.1 General

NodeB+ element terminates all the RAN radio protocols (L1, L2 and L3). NodeB+ functions are studied separately for control plane and user plane.

6.3.2.1.3.2 Control plane functions

This category includes all the functions related to the control of the connected mode terminals within the evolved RAN. Main functions are:

- Control of the UE
- RANAP connection termination
    - Processing of RANAP connection oriented protocol messages
- Control / termination of the RRC connection
- Control of the initialisation of the relevant user plane connections

The UE context is removed from the (serving) NodeB+ when the RRC connection is terminated, or when the functionality is relocated to another NodeB+ (serving NodeB+ relocation). Control plane functions include also all the functions for the control and configuration of the resources of the cells of the NodeB+, and the allocation of the dedicated resources upon request from the control plane part of the serving NodeB+.

6.3.2.1.3.3 User plane functions

User plane functions include the following:

- Protocol functions of PDCP*, RLC and MAC
- Macro Diversity Combining

* It is FFS whether NodeB+ is the most feasible location for PDCP.

6.3.2.2 Benefits and drawbacks

[tbd]

6.3.2.3 Interworking with existing architecture

In the RAN WG3 release 6 ad hoc in January 2003, it was mentioned that the presented architecture in Figure 1 could be implemented with R99 standards. The objective shall indeed be that evolved RAN architecture re-uses the standard Iu/Iur interfaces to the largest possible extent. However, the procedures specified for the Release 99/4/5 interfaces are optimal for an implementation, where large centralised controllers are used to control a large number of cells. The optimisation of some procedures may be necessary to optimally support a distributed implementation where large part of the RNC functionality is distributed to small controllers (i.e. NodeB+).

The SRNS relocation procedure is an example of a procedure, which should be optimised for supporting a distributed architecture. From R99 onwards the current SRNS relocation procedure can only support the case where all radio links are in a single DRNS and that the DRNC/Drift NobeB+ is the target RNC/NodeB+. The establishment of Iur connections from the new SRNC/Serving NodeB+ to the previously existing DRNCs/Drift NodeB+s or to the previous SRNC/Serving NodeB+ is not supported by the current relocation procedures. These enhancements have already been studied in Rel5 SI "SRNS Relocation Enhancements", TR R3.010.

In the evolved RAN, as SRNS relocation frequency increases significantly due to the small number of cells handled by a NodeB+, the enhanced SRNS relocation is needed. This enhancement allows the serving NodeB+ to initiate the SRNS relocation in the previously described cases and in some other situations as well. To support the enhanced relocation, some of the RNSAP procedures need to be revised for keeping or establishing the radio links over Iur from the target NodeB+ to the existing or new drift NodeB+ elements.

Another example of a necessary modification is that of the RNC identifier [0..4095] used in Iu signalling. It needs to be extended with an optional identifier extension, to allow the extension of the address space. This is required to accommodate the increased number of NodeB+ elements with RNC functionality.

6.3.2.4 Specification impacts

[tbd]

6.3.2.5 Open issues

1. Extension of the RNC Id (Uu impact)
2. Content of the UE context in NodeB+ (control and user plane part ?). How is the UE context established in NodeB+ ?
3. Amount of mobility traffic and performance (QoS perception of users) of rt services due to frequent relocations needs to be studied
4. Optimum location of PDCP (options captured so far: NodeB+ or RNG)
5. Last mile issue, MDC location. The issue with SHO and Seamless Relocation with the proposed architecture regarding the last mile capacity needs to be studied further. Whether the constraints of the underlying TNL network (e.g. topology and link bandwidth) have to be considered for making SRNS Relocation decisions or any other RNL decisions needs to be further studied.

6.3.3 Evolved Architecture based on functional separation

6.3.3.1 Overview

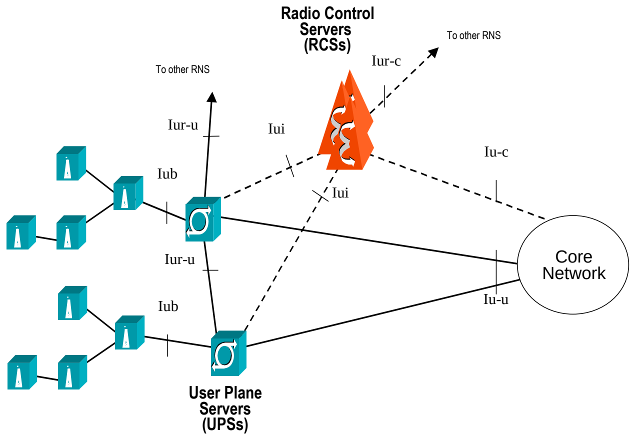


Figure 4~~42~~. Proposed Architecture for UTRAN Evolution.

The key point of the proposed architecture as depicted in Figure 4~~Figure 4Figure 2~~ is that the functions of the RNC are decomposed and mapped onto two new types of network entities that complement today's Radio Network Controllers (RNCs):

- Radio Control Servers (RCS) and
- User Plane Servers (UPS).

As a consequence, the termination points of the user- and the control plane of existing interfaces are split:

The control plane of Iu and Iur (Iu-c and Iur-c respectively) terminates in the RCS. The user plane of Iu and Iur (Iu-u and Iur-u respectively) terminates in the UPS. User Plane Servers are controlled by Radio Control Servers over a new RAN-internal interface, which is called the Iui.

The Radio Control Servers mainly perform user-related control functions and co-ordinate radio resource management. The User Plane Servers perform cell related control functions and process radio frames (including macro-diversity combining). They also forward user-related control messages between UEs and RCSs (in both directions).

User Plane Servers may be moved relatively close to the Node Bs while control plane functionality can remain more centralized on Radio Control Servers that might be organized in pools or clusters. The only new type of interface is the Iui interface between Radio Control Servers and User Plane Servers. All other interfaces can be derived from existing UTRAN interfaces, which also minimizes the impact of the distributed UTRAN architecture on the external interfaces of the RAN.

Moreover, the Uu interface is not affected at all, i.e. 3GPP R99 terminals are fully supported. And even the protocols on the new Iui interface can be derived from existing 3GPP protocols like NBAP and RRC. Mobility mechanisms in the control plane and in the user plane are designed independently from each other. This allows on the one hand to minimise the number of relocations in the control plane and on the other hand to optimise traffic flows in the user plane (according to the mobility of the terminals).

For future physical implementations of the evolved architecture, one might expect that Iu, Iur and Iui will be mostly based on IP transport (though the evolved architecture should not exclude any transport option). The Iub interface however will most probably still implement the two transport options IP and ATM in order to allow a UPS to connect to already deployed Node Bs over already deployed ATM-based infrastructure.

6.3.3.2 Functional Split between RCS and UPS

6.3.3.2.1 General

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The evolution of UTRAN is based on the distribution of user- and control plane in the UTRAN, which requires a split of the RNC functionality into a user plane and a control plane function. The control plane is assumed to reside in the radio control servers (RCS) which contains all control and signaling functions such as management of radio resources and mobility inside the RAN. The user plane resides in the user plane servers (UPS), which performs the gateway functions between the user plane protocols of the radio and the wire line interfaces of the RAN. It should be mentioned that in this proposal Node Bs can be connected directly to the UPS using either IP or ATM transport. The architecture thus supports full backward compatibility to a release '99 RAN.

The functions in control and user plane could be divided into three types, based on their scope (UE, Cell and RNS[1]). Each type of this function will consist of one or several function units (components).

Every RNS may consist of one RCS and one or more UPS. Every UPS may be connected to one or more Node B. The reliability of RCS is regarded to be implementation specific and therefore an RCS internal matter. ~~However, the standards shall support reliability of the RCS functions by allowing implementations that are based on a server pool.~~

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Regarding 3GPP standardization, the decomposition of RNC functionality to RCS and UPS requires the definition of a new, open interface between them, which is an RNC-internal interface in the R'99 architecture.

Figure 1 shows the Interfaces and also the function split between entities of evolved architecture.

The functionalities of Node B and Iub are unchanged. The interfaces Iu and Iur are split into control plane related (extension '-c') and user plane related (extension '-u') parts. This is because of real separation of the control and user plane functions on separate control and user plane servers respectively, which requires the RAN internal interfaces to be split into control and user plane interfaces, which is logically done already in the 3GPP UMTS R'99. The control plane related protocols (RANAP, RNSAP) terminate in the entities of RCS.

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[1] By minor modification, the term RNS, as defined in 25.401 can be reused. The proposed modified RNS definition reads as follows:
Radio Network Subsystem: RNS can be either a full UTRAN or only a part of a UTRAN. An RNS offers the allocation and release of specific radio resources to establish means of connection in between an UE and the UTRAN. A Radio Network Subsystem contains one RNC and is responsible for the resources and transmission/reception in a set of cells. The functions of the RNC may be decomposed into one Radio Control Server and one or more User Plane Servers.

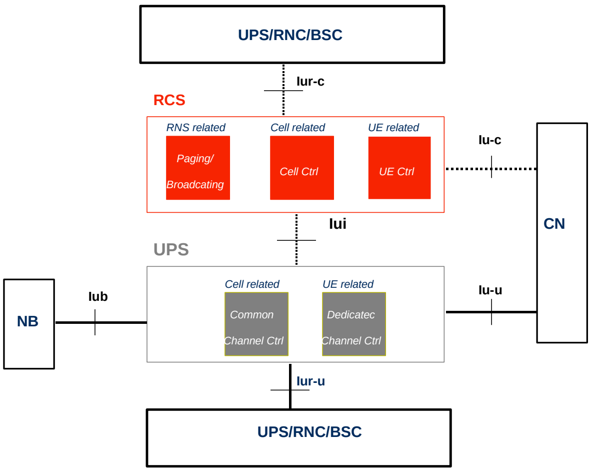

Figure 1. Interfaces of evolved UTRAN.

6.3.3.2.2 Functions of RCS and UPS

Both RCS and UPS do mainly the same tasks as Control Plane and User Plane Functions of RNC respectively. However, due to the physical separation of this two servers, some additional functions for coordination purposes are needed.

The following control functions are among responsibilities of RCS:

- Radio resource management
- UE Identification/Addressing (UE temporary context handling in CELL_DCH/FACH and CELL/URA_PCH state)
- Mobility management (Paging, URA update, Handover control)
- Call control / Session Management (RAB set up/release, RAB congestion control, RRC Connection Control, …)
- Integrity, security & authentication
- Billing / Accounting support
- U-plane management, (management of user plane data flow).

As an example, UPS provides the following user plane functions:

- Transfer of user data in an acknowledged or unacknowledged way with or without error detection / correction, according to the required Quality of Service (QoS).
- Mapping of radio bearers to logical and transport channel resources (and vice versa) according to the mapping decisions of RCS.
- ~~Handling of inband signalling data either between RCS and UE or between RCS and adjacent network nodes (e.g. UPS, Node B, CN nodes)~~

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User plane protocol stacks transport user data through UPS. This includes the radio protocols MAC, RLC, PDCP, physical layer (macro diversity) as well as the user plane protocols towards the Core Network. Radio Interface Control Protocol stacks carry radio signalling information. The User Plane Protocol stacks and the Radio Interface Control Protocol stacks are closely related. The lower level protocols (L1, MAC and RLC) are commonly used for user traffic and radio signalling. The RRC protocol is the only radio interface protocol used by radio signalling.

Figure 2 is based on the Radio Interface Protocol architecture depicted in TS 25.301 [3] and shows the proposed functional split between RCS and UPS in terms of radio interface protocol stacks. All RRC protocol and radio resource control of the radio layer 1 and 2 stacks within RAN originate in the RCS and are communicated to the UPS over the Iui.

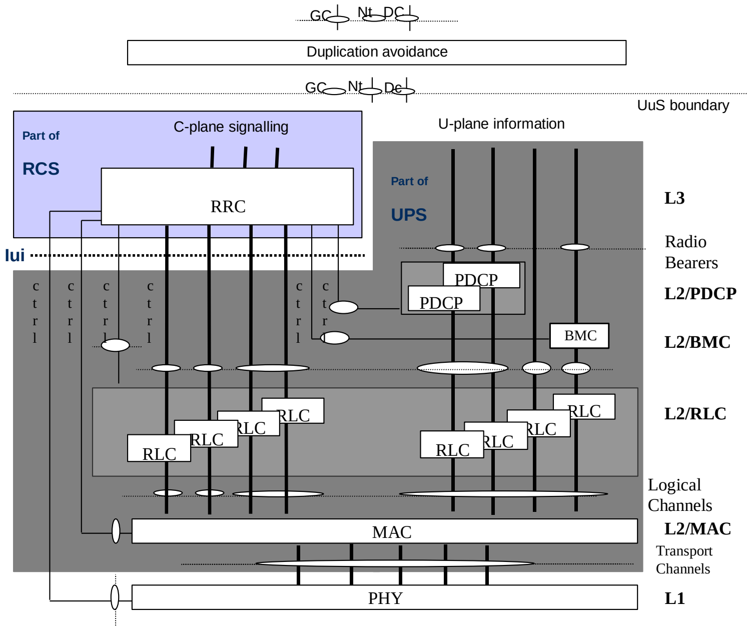

Figure 2. Proposed functional split between RCS and UPS in terms of radio interface protocol stacks.

~~6.3.3.2~~6.3.3.3 Benefits and drawbacks

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~~6.3.3.3~~6.3.3.4 Interworking with existing architecture

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~~6.3.3.4~~6.3.3.5 Specification impacts

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6.3.3.6~~5~~ Open issues

1. ~~Location of RRC (assumed to be completely in RCS)~~
2. New functional interface between RCSs (server pooling)
    - In case of a m-n relation between RCSs and UPSs?
    - In order to support load distribution among RCSs
3. Funtional split to be studied between UPS and RCS.
4. Funtional content, performance and specification impact of Iui to be studied
5. Delay caused by Iui to be studied (procedural aspects, additional protocol stack)
6. Gain v.s. pain of introducing new network elements in the UTRAN needs to be studied.
7. Termination of NBAP in RCS and forwarding of NBAP in UPS?

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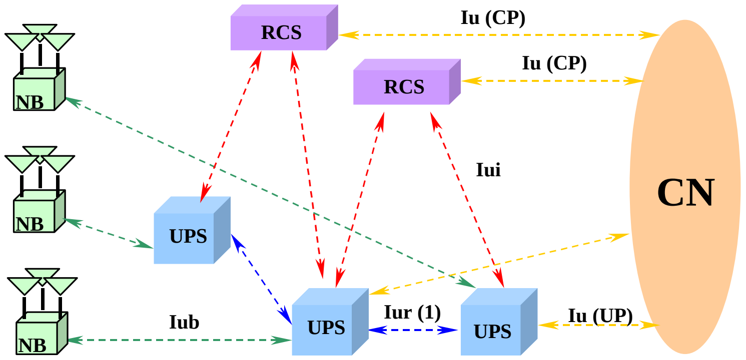
6.3.4 Evolved Architecture based on UE/Cell split

6.3.4.1 Overview

Figure n illustrates the UE / CELL split UTRAN evolved architecture.

The functions in the RNC are decoupled into two logical nodes, the RCS (Radio Control Server) and the UPS (User Plane Server). In principle, there is a many to many relationship between RCSs and UPSs. I.e. an RCS can control many UPS and a UPS may be controlled by many RCSs.

There is a one to many relationship between UPS and NodeBs. I.e. one UPS controls and terminates user plane for several NodeBs, but one NodeB is controlled and terminates user plane for a single UPS.



Note 1. Iur could be between RCSs instead of between UPSs. It is ffs which of the two approaches is more suitable.

Figure n. Proposed evolved UTRAN functional architecture.

A single RCS is involved in any given communication between UE and UTRAN (call/session, etc) for the whole duration of the communication. For UPSs, the roles of "serving" and "drift" apply with an almost identical meaning as for RNCs in the current architecture.

In principle, Iur is used to handle mobility between UPS. It is ffs whether Iur should be between RCSs or between UPS.

If Iur is located between UPSs, for any given call/session, the RCS only communicates with the "serving" UPS. The "serving" UPS and "drift" UPSs communicate always via Iur, regardless of which RCS controls each "drift" UPS.

If Iur is located between RCSs, for any given call/session, the RCS communicates with all UPS over which it has controls, and uses Iur towards another RCS for handling mobility towards UPSs that are not under its control.

A UPS, whether acting as "serving" or "drift", is a "controlling" UPS for all NodeBs attached to it.

The proposed functional mapping is depicted in table n below. The RCS implements all UE control functions and the UPS implements all cell control functions.

Table n. Functional mapping for UE / Cell split.

RCS	UPS
• Controls UEs camping in cells controlled by its associated UPSs	• Controls cells of its associated Node Bs
• Requests UPSs actions required to handle UE (paging, radio bearer setup/modification/release, etc)	• Performs actions on cells (e.g. set paging indicators, sends paging message, radio link setup/modification/release, etc) upon request from RCS
• Terminates RRC, RNSAP (?), RANAP and Iui	• Terminates NBAP, RNSAP (?), Iui and ALCAP (if applicable)
	• Handles all user plane resources and functions (CAC, synchro, DHO).
	• Terminates all UP protocols at transport (IP, GTP-U, etc) and RNL (MAC, RLC, PDCP, IuFH, Iur/b FH etc).

6.3.4.2 Benefits and drawbacks

This UTRAN evolved architecture is in line with all the requirements in section 5 of TR 25.897. It allows for:

- separate dimensioning of cell CP, UP and UE CP capacity.
- Distributed redundancy that reduces the number of single point of failures. Only UPS failures would cause service unavailability in the UPS area, which is assumed to be significantly smaller than a R99 RNC area.
- Efficient use of expensive 'last mile' link resources, by placing UPS in optimal locations (closer to NodeBs).

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This architecture does not cause degradation on any aspect when compared to the R99 architecture.

6.3.4.3 Inter-working with existing architecture

Inter-working with the R99 architecture is straightforward as shown in figure n+1.

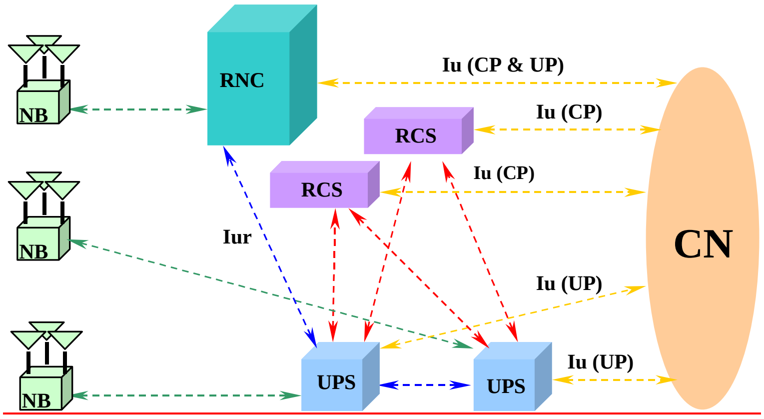

Figure n+1. Inter-working with R99 architecture for m to n RCS - UPS relationship

6.3.4.4 Specification impacts

6.3.4.4.1 Iu interface

There is not impact on Iu specs for 1 to many RCS - UPS relationship. However, impacts due to an m to n RCS - UPS relationship need to be studied.

6.3.4.4.2 Iur interface

No impact is foreseen in the Iur interface because of this architecture.

6.3.4.4.3 Iub interface

No impact is foreseen in the Iub interface because of this architecture.

6.3.4.4.4 Iui interface

This is a new control interface between RCS and UPS.

The functional content of Iui needs to include:

b. Normal MGC [Media Gateway Controller] – MGW [Media GateWay] type of functionality in which the RCS acts as MGC and the UPS acts as MGW.

c. Mechanisms to convey RRC messages received from the UE from UPS to RCS and to convey RRC messages to the UE from RCS to UPS.

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In this sense, it is proposed to use the ITU-T H.248 / IETF MEGACO protocol [x] specifically defined for architectures with CP and UP separation. This protocol defines a very suitable framework with the following key advantages:

1. Reduced effort in specifying the protocol. The framework is set by H.248 / MEGACO, only development of proper packages is required.
2. Modularity. The H.248 / MEGACO package concept encourages modular development. This increases flexibility in specification, development and testing.
3. H.248 / MEGACO implementations are already working in the field and have shown very good performance even in early deployment. I.e. use of H.248 / MEGACO has shown no performance degradation in other network scenarios, including UMTS ones.

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Figure n+2 shows the H.248 / MEGACO protocol stack for the Iui interface.

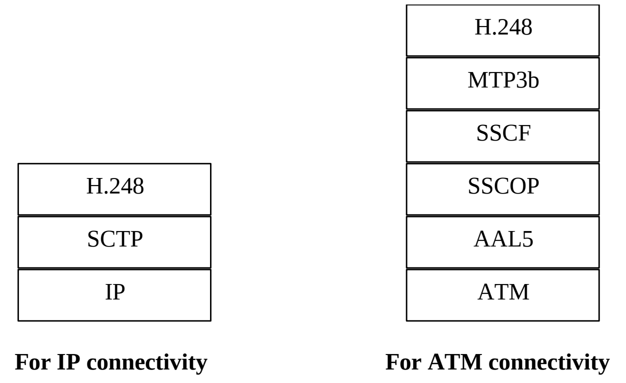

Figure n+2. Protocol stack for Iui interface.

6.3.4.5 Open Issues

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- Negative effect of the new Iui interface on the delay performance of RRC?
- Applicability and role of Megaco in Iui?
- Multiplicity of RCSs, UPSs and their relationship and redundancy?
- Termination and forwarding of NBAP in UPS?
- Increased O&M burden when distributing cell related functions to UPSs?
- Relocation from an RNC to a UPS+RCS?

6.3.5 Evolved Architecture based on iNodeB and RAN server

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6.3.5.1 Overview

The purpose of this contribution is to enable the UTRAN to fully exploit the benefits of an IP-based network between CN and Node Bs. It provides more scalability and enables service differentiation down to the radio access node for better adaptation to future needs and to reduce cost of the transport network. The proposed architecture preserves the air interface (Uu) with minimal impact on the Iu interface.

6.3.5.2 Distributed RAN

The main obstacle for the implementation of IP in the UTRAN is the radio specific processing of user traffic far away from the radio interface with the need to carry radio link frames with highest quality of service irrespective of the required QoS at application level. Therefore those functions, which interact with the air interface are separated and distributed into each radio access node.

6.3.5.2.1 Separation of Control and User Plane

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As user and control plane scale differently in future data communication, they need to be processed and carried separately. In this contribution, the control traffic from CN shall address a (centralized) RAN Server whereas the user traffic is directly routed to an extended Node B. This new Node B terminates the Iu interface for the user traffic and performs the necessary radio specific processing (Intelligent Node B = iNode B). The control part of Iu is terminated in the RAN Server.

6.3.5.2.2 Evolved Architecture

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In this contribution, the former RNC is separated into two elements: The RAN specific part migrates into the RAN Server, whereas the cell specific control functions become part of the new iNode B. Cell specific processing of user-traffic (PDCP/RLC/MAC etc.) is exclusively performed by the iNode B. This Distributed RAN architecture is presented in Figure xx.

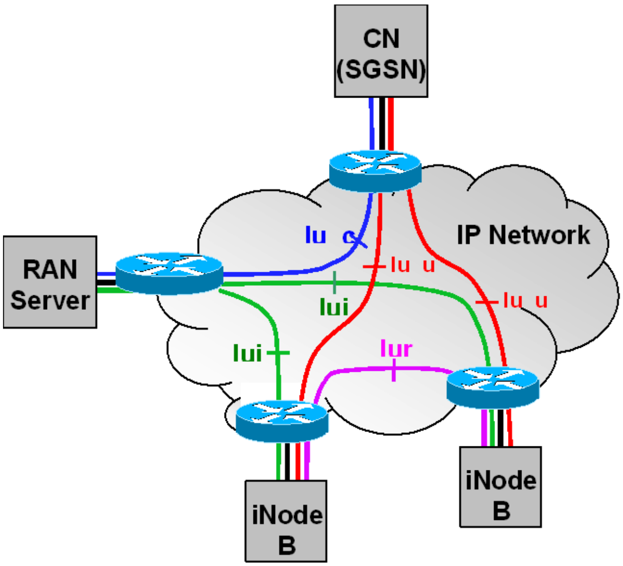

Figure xx: Distributed RAN Architecture

Iu traffic shall be split into a control part (Iu_c) and the user part (Iu_u). Iu_c terminates at the RAN Server and Iu_u at the iNode B. Control information between RAN Server and iNode B shall be transferred via the new Iui interface. Each iNode B provides an Iur interface for handover.

6.3.5.2.3 RAN Server

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Except of the user traffic handling, the RAN Server behaves similar as the former RNC. It manages mobility inside the RAN and the necessary Iu bearers for control and user traffic (Iu_c and Iu_u). For the control part of the Iu interface, the RAN Server behaves like a regular RNC from the CN point of view. For the user part of the Iu interface, the iNode B acts as the former RNC.

Furthermore, the RAN Server manages micro-mobility (i.e. mobility inside UTRAN like paging and iNode B relocation) via Iui, whereas radio-mobility (i.e. mobility between adjacent iNode Bs as soft or softer handover) is autonomously managed by the iNode B itself.

6.3.5.2.4 iNode B

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The iNode B is based on the legacy Node B extended by the distributed function of user plane processing from the former RNC. It also contains the cell specific radio resource management. This enables the iNode B to manage its radio resources autonomously. On demand, they are requested from the RAN Server via Iui interface. Soft-handover is managed between adjacent iNode Bs via the Iur interface. The general architecture of the iNode B is shown in Figure yy.

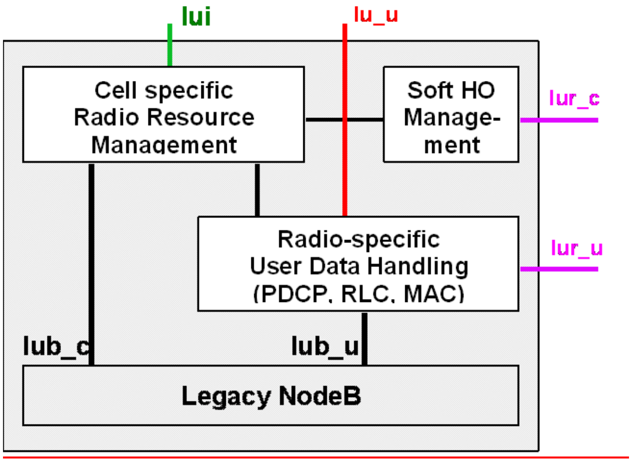

Figure yy: Intelligent Node B (iNode B)

The former Iub interface becomes an internal interface of the iNode B and Iu_u is terminated in a module inherited from the RNC.

6.3.5.3 Benefits and drawbacks

With relocation of cell specific radio processing and user specific data handling into the iNode B, in conjunction with separation of control and user plane, the proposed architecture provides service differentiation down to the radio access node. Furthermore, both can be scaled separately, which makes adaptation to future requirements (service scenario, load conditions, UTRAN extension) more flexible. In addition, means for traffic engineering may be implemented in order to reduce the cost of the transport network, based on IETF protocols.

The separation of control and user plane, together with processing the user-traffic in the radio access node allows the integration of different radio technologies (eg. Wireless LAN). The interaction between RAN-Server and access node must be adopted (i.e. Iui interface) to the specific control requirements. Because user traffic is carried in IP packets down to the access node, Iu_u does not require specific adaptation.

Not a real drawback but a more complex handling is necessary to implement handover functionality.

With relocation of Iur down to the iNode B each iNode B is (logically) connected to its neighbours. The serving iNode B performs the necessary radio specific processing to serve its own Uu interface and transfers the RLC/MAC PDUs simultaneously to the drift iNode Bs. The user-traffic in question is transferred twice on the link between the last access router and the serving iNode B: Once as IP packet and after processing as stream of RLC/MAC PDUs.

6.3.5.4 Interworking with Existing Architecture

Because the CN sees a standardized Iu interface, interworking with legacy RAN is seamlessly possible, except of soft handover between legacy NodeBs and iNodeBs. This would require a "Iur Distribution Function" at the boarder between both RNS's.

6.3.5.5 Specification Impact

With the termination of RANAP in the proposed RAN Server and handling of RRC in each iNode B, a new interface (Iui) has been introduced. This would be subject of further standardisation work in order to keep the multi-vendor capability.

6.3.5.6 Open issues

- Soft handover handling between legacy RAN and Distributed RAN

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- Inter-RAN server interface
- Multiplicity of RAN servers vs. iNodeB:s
- Impact of multiple Iu-u interfaces on Core Network functionality and performance
- Coupling between Control and User plane establishments

~~6.3.4~~6.3.6 Proposed common basis for the categorization and evaluation of UTRAN Architecture Evolution solutions

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[*Note: chapter 6.3.4 does not follow the agreed structure of the Study Area (R3-030687)*]

This proposal is intended to give a framework to analyse existing and evolved UTRAN architectures and to present guidelines which may be applied in the design of evolved UTRAN architectures. This shall be helpful both for analysis and comparison of architecture alternatives. For each guideline basic rationals advantages and disadvantages are provided.

6.3.46.1 Overview: Overall architectural principles

Based on a functional analysis of the UTRAN, related functions can be grouped together and assigned to different functional entities, based on two main principles:

1. The split of the control and user planes
2. The separation of cell, multi-cell and user related functions

The different functional entities can be bundled together in one network element or integrated in the Node B. Different bundles of functional entities lead to different types of network elements and consequently alternative RAN architectures, which can be evaluated against each other and against the current one.

Figure 5~~Figure 5Figure 3~~ shows an example functional split of the present RNC functionality into different functional entities and the classification of the resulting entities in the control or user plane according to their scope.

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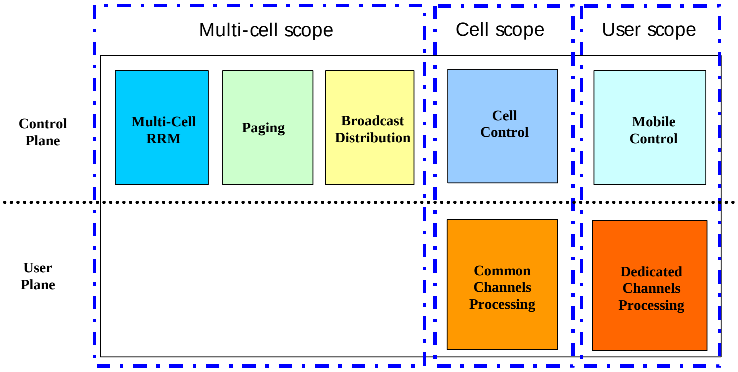

Figure 55~~3~~. Decomposition of the RNC into functional entities.

For user related functional entities, there exists one instance per user. These functional entities are not directly related to the specific topology of the network.

Cell related functional entities have the scope of a single cell, and hence there is one instance of such entities per cell. Therefore, they could potentially be integrated into or located closer to the Node B.

Finally, there are several functional entities having a multi-cell scope. One instance of such entities is responsible for a certain group of cells. Therefore, they are responsible for a certain geographical area. Thess functions include multi-cell RRM mechanisms providing a co-ordination between the different cells as well as the distribution of paging and cell broadcast service (CBS) messages.

If the RNC is separated in the above mentioned functional entities, it is necessary to define the interconnections between them. Figure 6~~Figure 6Figure 4~~ shows the functional entities, their interconnections and an approximate mapping to the UTRAN architecture. This diagram shows a functional architecture and not a network reference architecture, i.e. the main functional entities and their logical interconnections have been identified, but it is still possible to bundle several functional entities together in order to reduce the number of external interfaces and the complexity of the architecture.

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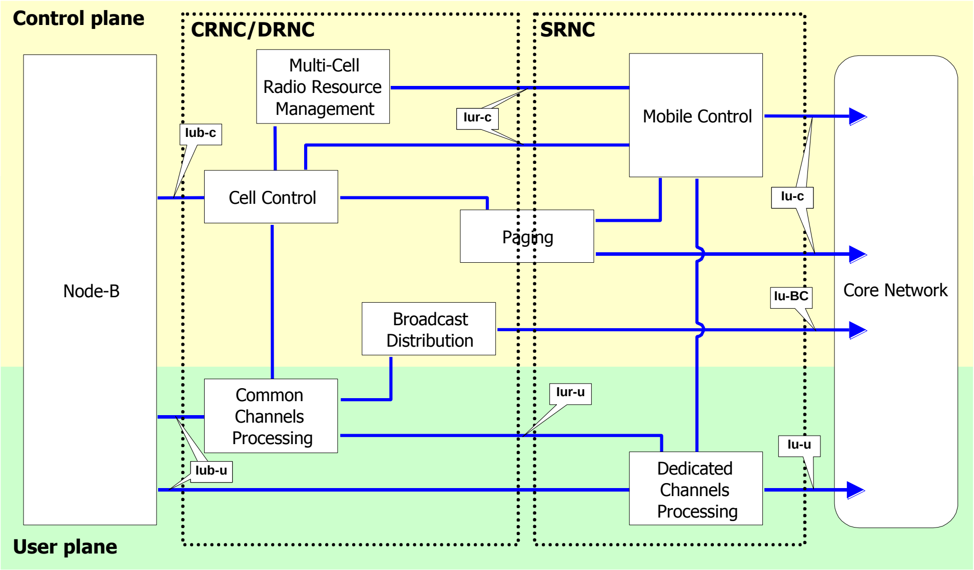

Figure 6~~64~~. Interrelation between functional entities resulting from the functional decomposition of the RNC.

This functional architecture of the RNC can be used as a tool to derive different alternative architectures for UTRAN evolution. One of the principles which can be investigated is the full split of control and user planes in the RNC, which is the object of this contribution.

6.3.~~4~~6.2 Guideline: Split of control and user planes

The split of the control and user planes has been identified as an important architectural guideline in order to evolve towards a more distributed network architecture having enhanced flexibility and scalability properties. This split can be justified based on the following reasons:

- The processing requirements for the control and user planes are quite different as user plane functions are more demanding and may need specific hardware support for specific functions. The control plane processing is more generic and less demanding and can be implemented in a general purpose machine (server).
- The required processing capacity for user plane and control plane is expected to scale differently. For example, due to the expected growth in data services, there is a strong need to increase the user plane capacity in the network while the control plane capacity will grow just moderately (see Figure 4).

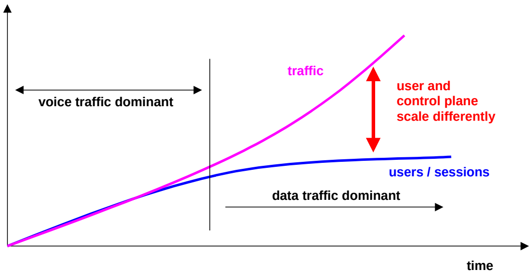

Figure 7~~75~~. Evolution of traffic in mobile networks

This leads to the idea to define two main building blocks, a control plane platform and a user plane platform. These building blocks can be used for a centralised RAN controller were both planes are implemented in a common network element interconnected via an internal interface. In a further evolution both parts could be separated in different networks elements leading to a distributed architecture where control plane and user plane servers are not necessarily co-located and are interconnected via an external interface.

While a centralised RAN controller can provide scalability on module basis, a distributed server architecture can additionally provide scalability on a network element basis. Moreover, in the distributed approach, new servers may be introduced to support new enhanced demanding features while old servers are still reused for legacy services.

However, the distributed architecture may potentially lead to an increased delay for control procedures and a more complex OAM due to the higher number of network elements. Moreover, a new external interface has to be specified. These issues should be investigated further.

As a result of the strict separation of control and user planes, it is possible to use standard hardware platforms for the control plane and potentially also for the user plane. Therefore, it could be envisaged, at least for the control plane, to reuse the same platform for other radio standards, leading to multistandard control servers able to handle different radio standards, either alternatively (according to the standard-specific software used) or in parallel, thereby supporting multi-standard RRM algorithms internally.

6.3.~~4~~6.3 Guideline: [ffs e.g.] Separation of cell, multi-cell and user related functions

~~*[to be completed]*~~

According to the functional split of the UTRAN presented in section 6.3.4.1, it is possible to separate different groups of functions according to their scope: cell, multi-cell or user related functions. This section discusses the possibilities for the placement of each group of functions.

6.3.6.3.1 Cell related functions

The only cell related functional entity in the **user plane** is **Common Channels Processing**. This functional entity is responsible for user plane functions having cell scope, which are carried out by the CRNC. This is mostly related to radio processing for common/shared channels, and hence the BMC, RLC and MAC-c/sh layers used for these channels are included in this functional entity. When the Common Channels Processing functional entity is moved towards or into the Node B, the following advantages can be envisaged:

- Since scheduling for common/shared channels is placed in the MAC-c/sh sublayer, moving it towards/into the Node B will imply faster reaction times (especially if the Cell Control functional entity is also moved towards the Node B, as explained below).
- For common/shared channels (except HS-DSCH, since the MAC-hs sublayer is already located in the Node B), the Iub interface between the RNC and the Node B is shortened (or even eliminated) in favour of Iur (with less strict timing QoS transport requirements).

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In the **control plane**, the only cell related functional entity is **Cell Control**. This functional entity is in charge of control plane functions having cell scope, which are carried out by the CRNC in the current architecture. Therefore, this functional entity includes those common parts of the RRC protocol used for the generation and processing of messages sent on the CCCH, PCCH and BCCH logical channels.

When the Cell Control functional entity is moved towards or into the Node B, the following advantages can be expected:

- Faster reaction times to changing conditions in the air interface imply better performance for common/shared channels (especially when the Common Channels Processing functional entity is also moved towards the Node B).
- Other mechanisms such as congestion control and load control can also benefit from faster reaction to changes in air interface load conditions.

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However, moving the Common Channels Processing and the Cell Control functional entity closer to or into the Node B, will probably have an impact on CAPEX, although this impact can be rather small when compared to the impact of HSDPA introduction in Release 5.

6.3.6.3.2 Multi-cell related functions

There are three different functional entities with multi-cell scope, and all three belong to the **control plane**. The first functional entity is **Multi-Cell Radio Resource Management**, which is responsible for the co-ordination of between different cells to optimise RRM. In the current architecture, the CRNC performs the co-ordination of the different cells under its control. Since the purpose of this functional entity is to carry out the co-ordination between different cells, it should preferably be kept in a central location in the network.

The second functional entity is **Paging**, which is responsible for the distribution of paging messages to the appropriate cells. In the current architecture, this function is carried out internally in the CRNC. Since this functional entity is normally linked to a rather large area (corresponding to one or several LA/RAs) it should also be kept in a central position in the network.

Finally, the **CBS distribution** functional entity is responsible for the distribution of Cell Broadcast Service messages to the appropriate cells. In the current architecture, this function is also carried out internally in the CRNC. As in the previous case (Paging functional entity), the CBS distribution functional entity should also be preferably kept in a central location.

6.3.6.3.3 User related functions

User specific functional entities are not directly related to a particular geographical area, and hence they are quite flexible in their location. Moreover, the usage of server pools for the implementation of these functional entities can also be considered. In general, moving user plane functions towards the Node B results in a better performance, but there are some limitations regarding the execution of relocation procedures and macrodiversity splitting and combining.

In the **user plane**, the only functional entity with user scope is **Dedicated Channels Processing**. This functional entity is responsible for dedicated user plane functions, which are carried out by the SRNC in the current architecture. These functions are mainly related to radio processing for dedicated channels, and hence the PDCP, RLC and MAC-d layers, as well as the macrodiversity combining and splitting unit, are included in this functional entity.

As stated before, user specific functions are in principle rather flexible in their location. Therefore, it could be envisaged to move the Dedicated Channels Processing functional entity closer to or into the Node B. In this case, the following advantages are expected:

- Faster reaction times to changes in the air interface also for dedicated channels (since more actual air interface load information could be used for scheduling in MAC-d), what can result in a better performance.
- Better performance for services using RLC acknowledged mode, due to lower RTT for acknowledgements.
- The Iub interface is shortened (or even eliminated) in favour of Iu, for which less strict transport QoS requirements are imposed on the transport network (specially in case of best-effort PS services).

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But there are also some limiting factors that must be taken into account:

- In order to avoid tromboning in the last mile, macrodiversity combining/splitting should be kept in a more central location.

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- If the PDCP, RLC and MAC-d sublayers are placed too close to the Node B, the frequency of relocations will strongly increase (involving a high number of PDCP context transfers), or a large increase in the amount of Iur traffic will be required.

Based on the above arguments, the operator should be given the flexibility to place the nodes containing user plane functions in the more convenient location according to aspects such as the transmission network topology and the capacity of the different transmission links. Depending on the particular deployment scenario, the operator can decide to keep these functions in a central location (as in the current architecture), to integrate them together with the Node B or to place them in an intermediate position.

All user specific functions in the **control plane** are carried out by the **Mobile Control** functional entity. Therefore, this functional entity is responsible for those control functions carried out by the SRNC in the current architecture. Of course, this includes dedicated parts of the RRC protocol, responsible for the generation and processing of messages exchanged through the DCCH.

In principle, the Mobile Control functional entity can be flexibly located since it is not directly responsible for a particular group of cells, and it could be envisaged to use server pools to implement this functional entity. Furthermore, it must be taken into account that this functional entity is in charge of functions such as handover control, macrodiversity control and especially relocation control, which are probably better handled from a central location.

If the Mobile Control and the Dedicated Channels Processing functional entities are separated into different network elements (e.g. after applying the guideline "split of control and user planes"), separate relocation procedures can be introduced for the control and the user plane. In this case, the frequency of control plane relocations can probably be reduced to a minimum.

6.3.~~4~~6.4 Open issues

1. The potential performance issues (referred to in the text) w.r.t. to the split of U- and C-plane processing, e.g., the increase in RRC signalling delay and the issues related to the co-ordination of the physically separate functional entities

2. Channel switching between dedicated and common channel states in case of separated cell, multicell and user related functions.

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3. Operational and Management challengies involved in flexible location of functions

~~2.~~4. The number of new network elements in the final architecture

~~3.~~5. The effect of the increased number of NEs to the operation and management of the network and to the cost of operations

~~4.~~6. The number of new interfaces needed in the final proposal

~~5.~~7. The potential issues with new interfaces to be standardised, w.r.t. to procedure delays, amount of signalling traffic, etc.

~~6.~~8. The standardisation effort of the proposed new multivendor interfaces

6.4 Discussion on benefits and drawbacks of standardizing a new UTRAN architecture

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Different proposals have been put forward for UTRAN architectural evolution. However, in general, several issues should be considered when looking at UTRAN evolution.

There are several benefits that could be achieved to varying degrees by moving logical functions between physical network elements. The architecture provided in the 3GPP specifications is a logical architecture that does not limit implementation choices.

Standardisation of new architectures also brings some issues.

The discussion below looks at the benefits and drawbacks of UTRAN evolution. It does not consider any specific proposal so some of the comments may not be relevant for some proposal. The benefits and drawbacks are compared to the Rel-5 architecture.

Benefits of architectural evolution:

- Flexibility to allocate processing capacity for traffic and for control in different locations for efficiency and cost saving.
- Flexibility to independently scale the control plane and the user plane by increasing/decreasing the number of nodes required to handle the corresponding traffic volume and service types.

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- Nodes could be supplied by different vendors increasing multi-vendor option for operators.
- Allows an independent evolution and replacement of nodes in the user plane and the control plane as the corresponding technology evolves.
- As an implementation option it is possible to have a combined logical elements into a physical one.
- Depending on the architectural choice, it may be possible to have an m:n relationship between the different hierarchical layers breaking away from the strict tree structure (some of this has happened already with Iu-flex). This brings benefits of increased redundancy, better load distribution and utilisation during overload conditions, and improved scalability.

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- Possible reduction in delay and processing in UTRAN by bypassing or limited processing in the intermediate network elements (RNC) when this is possible. .
- Exploit IP based RAN architecture with radio specific processing of user traffic in the radio access node, enables service differentiation with appropriate (existing) IETF protocols.
- Possible reduction in signalling load due to aggregation of functions into a node.

Drawbacks of architectural evolution:

- Possible increases in signalling load due to the new interfaces (if any). Implementation options of m:n relationship could also generate additional signalling loads

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- Possible increases in set up times needed for certain scenarios depending of the number of signalling messages. Normally, additional external messages can be considered to take longer than proprietary optimised signalling within a node.

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- Additional O&M interfaces are needed to configure and to operate any additional network entities.
- Difficulty in transitioning to the evolved architecture. For example it may be difficult to deploy the evolved architecture for the capacity expansion but may instead require update of all nodes of coverage area; or it may require hardware upgrade of existing network elements.
- Impact on CN if changes to Iu interface protocols cannot be ruled out.

Additional drawbacks of standardising new architectures:

It is of course possible to achieve some of these benefits with in the current 3GPP architectural and specification constraints. Changes to standards are required where it is found that current specifications prohibit certain implementations that bring clear benefits. Another motivation for standardisation is the multivendor option available to operators. However, standardisation of the architecture (as opposed to proprietary solutions) has issues:

- Increases standardisation and implementation work due to exposed interfaces. As no clear protocol exist today that can be re-used for the new interfaces (if any) as is, much of the work would need to be done by 3GPP.
- More vendor interoperability testing required for any new interfaces.
- Additional complexity is introduced as soon as new interfaces are exposed.
- Additional architectural options increase complexity. More architectural options means when new features are introduced *it is required* to handle both architectural cases – in terms of specification and inter-operability testing.
- More recovery and failure indication schemes would be required to be standardised due to more different partial system failure cases (when e.g. an RNC Server node would go down but *not* the user plane processor or vice versa)

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7 Agreements and associated Contributions

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8 Specification Impact and associated Change Requests

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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:
Change history

It is usual to include an annex (usually the final annex of the document) for reports under TSG change control which details the change history of the report using a table as follows:

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**