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Contents

Foreword

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1 Scope

The present document is related to the study item "Further advancements for E-UTRA" [2].

The document describes relay architectures being discussed for E-UTRA (LTE-Advanced).

2 References

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

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

[1]	3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
[2]	3GPP TD RP-091360: "Revised SID on LTE-Advanced".
[3]	3GPP TR 36.912: "Further Advancements for E-UTRA (LTE-Advanced)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

DeNB	Donor eNB
DS	DiffServ
RN	Relay Node

4 Architectures

Editor's note: Primary responsible WG for this clause is RAN3.

4.1 General

The following two architectures have been identified for supporting relays in LTE:

- Architecture A, with following variants:

  - Alt 1: Full-L3 relay, transparent for DeNB;
  - Alt 2: Proxy S1/X2;
  - Alt 3: RN bearers terminate in DeNB;
- Architecture B, with following variant:
  - Alt 4: S1 UP terminated in DeNB.

We follow the above grouping of architectures and alternatives when describing the different solutions throughout this document.

Although not a prioritized scenario, it is assumed that all alternatives in principle support multi-hop RN deployments.

RN mobility is also not considered a prioritized scenario.

4.2 Architecture A

4.2.1 Overview

Architecture A is based on the termination of both U-plane and C-plane of the S1 interface at the RN. This architecture is then differentiated in a basic variant, Alt 1 and two other variants, Alt 2 and 3.

4.2.1.1 Relationship among alternatives in architecture A

Alternatives 1-3 share the common characteristics of Un interface.

The S1-MME interface is unmodified in all three architectures. In alternative 2, it terminates in a proxy sense in the DeNB, while in the others it terminates at the relay node after being tunnelled through a bearer on the Un interface; whether these differences are visible to the core network is currently under discussion.

Finally, the X2 interface is also unmodified by all alternatives; again, alternative 2 affects its nominal termination point, but the peer at the other end of this proxied interface sees no impact. The same applies to the DeNB; functioning as a donor does not oblige an eNB to support any changes to the X2 interface.

As illustrated in Fig. 4.2.1.1-1, the different optimization approaches offered by the alternative 1, 2, and 3 are transparent to a RN. Fig. 4.2.1.1-1 also shows that the alternative 1, 2 and 3 are the architecture options in the same family, which can be realized by grouping/collocating different functional entities within/out of the DeNB.

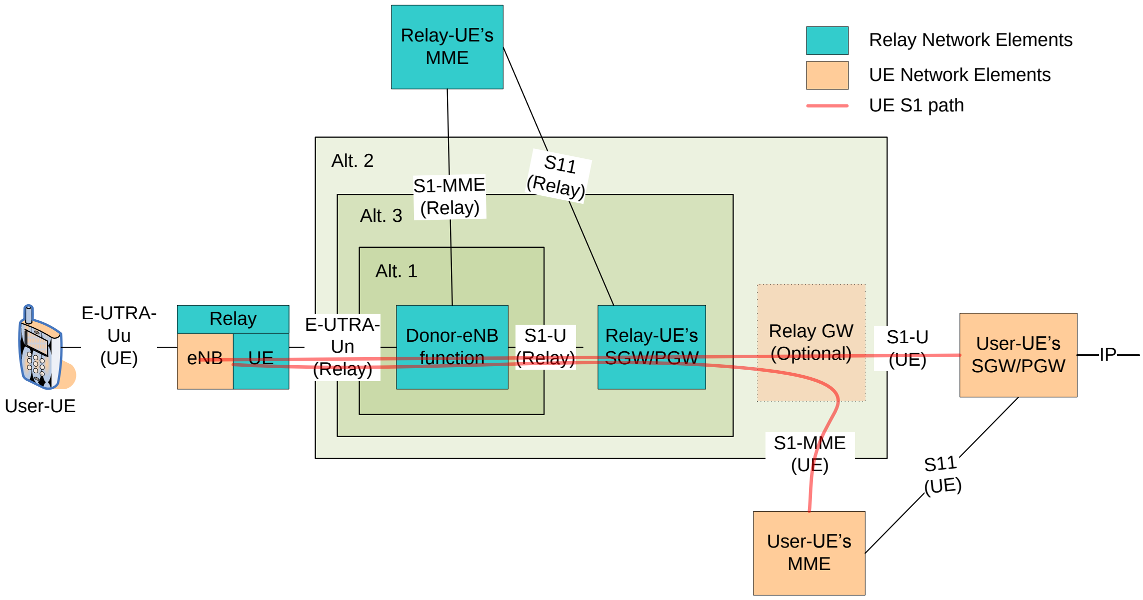


Figure 4.2.1.1-1. Relationship among alternatives in architecture A

Note that Relay GW in Fig. 4.2.1.1-1 has "home eNB GW" type of functionality, which is optional and transparent to the relay, the core network of the UE, and other eNBs. The Relay GW is included for the alternative 2, but is not included in the alternative 1 and 3.

The issue of compatibility in the Un interface is important since it means that no definitive choice really needs to be made among alternatives 1-3: maintaining the central concepts of this architecture family characterising all three alternatives, it is possible to either optimise the solution with incremental steps or to deploy directly what would be considered as the most optimised choice.

4.2.2 User plane aspects

In this set of alternatives, the U-plane of the S1 interface is terminated at the RN. In the baseline option of Alt 1 (Figure 4.2.2-1), the U-plane packets of a UE served by the RN are delivered via the Relay's P/S-GW. The UE's P/S-GW maps the incoming IP packets to the GTP tunnels corresponding to the EPS bearer of the UE and sends the tunnelled packets to the IP address of the RN. The tunnelled packets are routed to the RN via the Relay's P/S-GW, as if they were packets destined to the RN as a UE.

Figure 4.2.1-2 illustrates the packet routing in the downlink for the "Full L3 relay" architecture alternative, showing the UE and RN bearers and the corresponding GTP tunnels.

- A packet destined to the UE is classified into UE EPS bearer at the PGW serving the UE according to the corresponding packet filtering rules and encapsulated into the respective GTP tunnel (spanned between SGW /PGW of the UE and the RN).
- The RN-PGW, which serves the RN, also needs to decide on the UE bearer to RN bearer mapping. The RN bearer type may be indicated as a Diffserv codepoint in the DS field of the IP header of the GTP IP packet sent by the UE-S/PGW.
- The PGW of the RN receives the GTP tunneled packet addressed to the RN and classifies the packet into RN bearer according to packet filtering rules (based on the DS field of the packet) and encapsulates the packet into a second GTP tunnel, corresponding to the RN bearer. This means that EPS bearers of different UEs connected to the RN with similar QoS are mapped into the same RN bearer.
- The donor eNB associates the RN GTP tunnel with the corresponding RN radio bearer and sends the packet to the RN over the radio interface.
- The RN associates the received packet with the UE radio bearer according to the UE GTP tunnel and sends the packet to the UE.

In the uplink, the RN performs the UE bearer to RN bearer mapping, which can be done based on the QCIs of UE bearers.

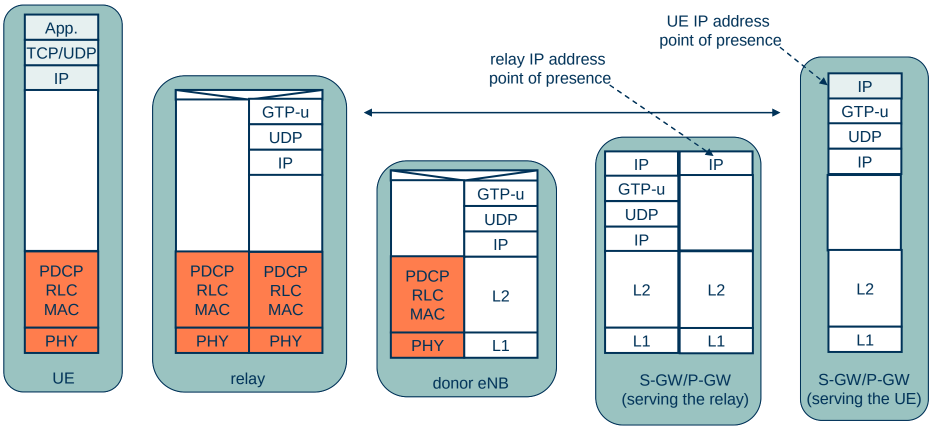


Figure 4.2.2-1: User plane protocol stack – Alt 1

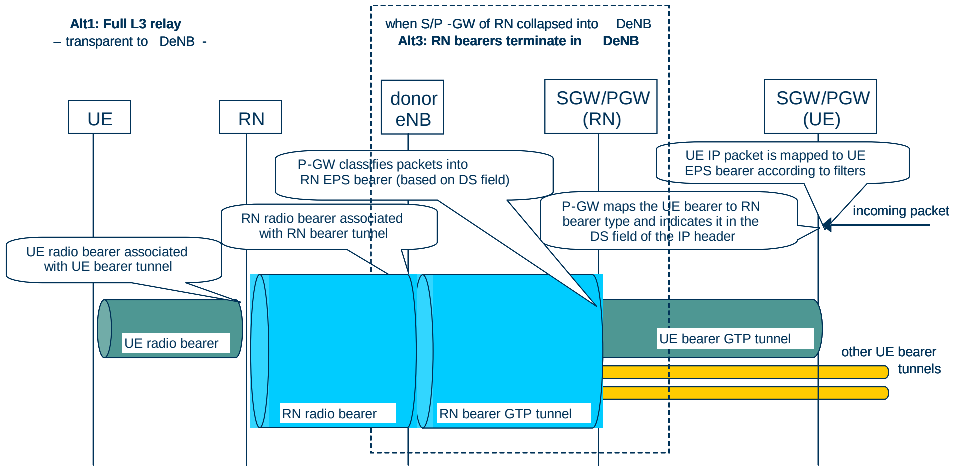


Figure 4.2.2-2: Packet delivery steps – Alt 1, 3

Figure 4.2.2-3 shows the user plane protocol stack in case of Alt 3, where the baseline solution is enhanced by integrating the SGW/PGW functionality for the RN into the DeNB. Thereby, the routing path is optimized as packets do not have to traverse via a second PGW/SGW but otherwise the same functionality and packet handling apply as in case of Alt 1.

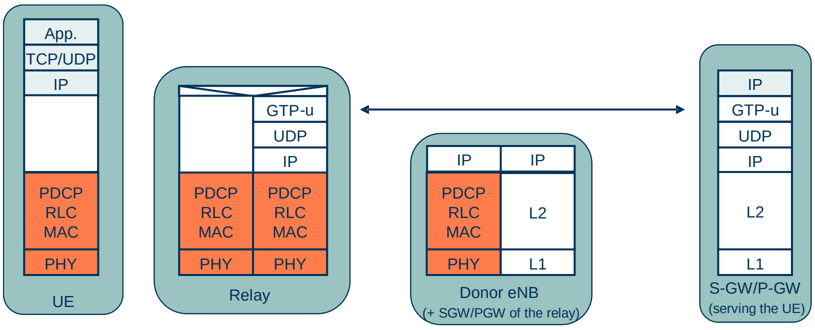


Figure 4.2.2-3: User plane protocol stack – Alt 3

Another way of enhancement of the baseline solution is to add “home eNB GW” type of functionality into the DeNB, which results in the “Proxy S1/X2” architecture alternative (Alt 2). The user plane protocol stack and the packet processing and tunneling functionality in case of Alt 2 are shown in Figure 4.2.2-4 and in Figure 4.2.2-5, respectively. In this case there is a GTP tunnel per UE bearer, spanning from the SGW/PGW of the UE to the donor eNB, which is switched to another GTP tunnel at the DeNB, going from the DeNB to the RN (one-to-one mapping).

- The downlink UE packet is mapped to UE bearer at the PGW serving the UE and the packet is sent in the corresponding UE bearer GTP tunnel to the donor eNB.

- The donor eNB classifies the incoming packets into RN radio bearers based on the QCI of the UE bearer (by filtering on the GTP TEID, where the association is established at bearer setup) and switches the UE bearer GTP tunnel from the SGW/PGW to another UE bearer GTP tunnel toward the RN (one-to-one mapping). Note that EPS bearers of different UEs connected to the RN with similar QoS are mapped in one radio bearer over the Un interface.

- The RN associates the received packet with the corresponding UE radio bearer based on the per UE bearer GTP tunnel.

In the uplink, the RN performs the UE bearer to RN bearer mapping, which can be done based on the QCIs of UE bearers.

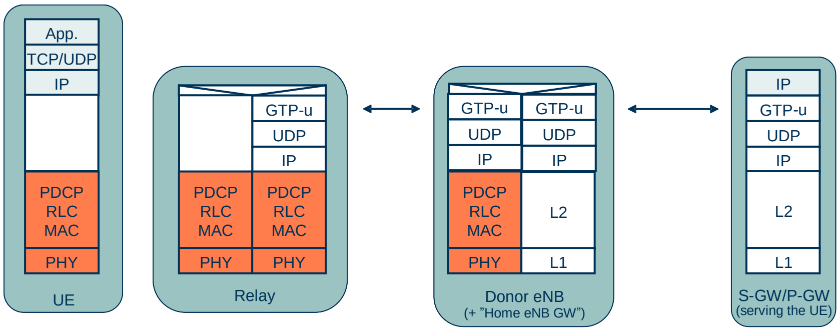


Figure 4.2.2-4: User plane protocol stack – Alt 2

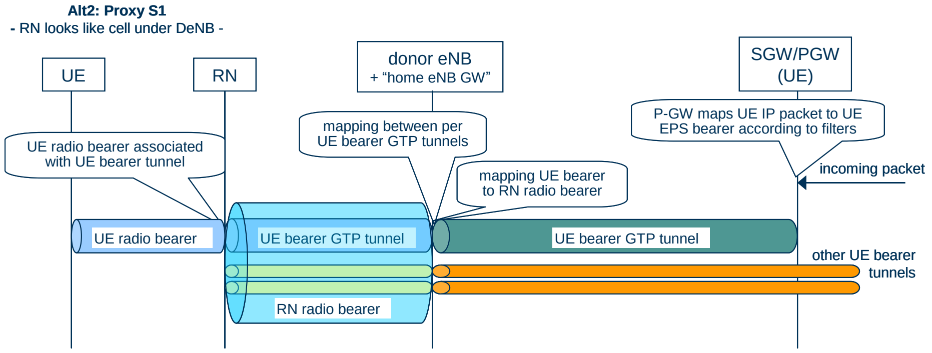


Figure 4.2.2-5: Packet delivery steps – Alt 2

4.2.3 Control plane aspects

The control plane protocol stack that applies in case of Alt 1 and Alt 3 is shown in Figure 4.2.3-1. As it can be seen in the figure the S1-AP protocol terminates at the RN and the signaling messages go via the DeNB and the SGW/PGW of the RN acting as user plane transport nodes from the signaling traffic point of view. This means that the S1 signaling messages sent between the RN and MME are mapped on user plane EPS bearers of the RN.

The RN has to maintain one S1 interface relation to each MME in the respective MME pool where there is one S1 signaling connection for each connected UE on the given S1 interface between the RN and the MME serving the UE, as illustrated in Figure 4.2.3-2 (legacy behavior). The S1 interface and the signaling connections are spanning through the donor eNB transparently.

Note that the DeNB also maintains its S1 interfaces and it has an S1 signaling connection corresponding to the RN as a UE, going between the DeNB and the MME serving the RN. We note also that a similar logical structure would apply for the X2 interface relations (not shown in the figures).

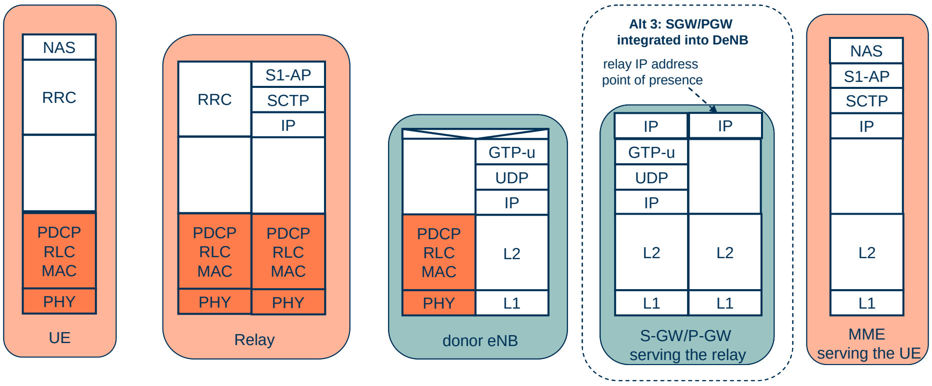


Figure 4.2.3-1: Control plane protocol stack – Alt 1, 3

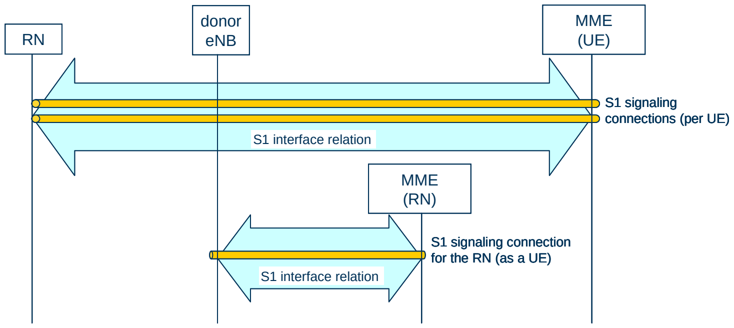


Figure 4.2.3-2: S1 interface relations and signaling connections – Alt 1, 3

The control plane protocol architecture for the proxy alternative (Alt2) is shown in Figure 4.2.3-3. In this case, the S1-AP messages are sent between the MME and the DeNB, and between the DeNB and the RN. Upon the DeNB receiving the S1-AP messages, it translates the UE IDs between the two interfaces by means of modifying the S1-AP UE IDs in the message but leaving other parts of the message unchanged. This operation corresponds to an S1-AP proxy mechanism and would be similar to the HeNB GW function. The S1-AP proxy operation would be transparent for the MME and the RN. That is, as seen from the MME it looks like as if the UE would be connected to the DeNB, while from the RN's perspective it would look like as if the RN would be talking to the MME directly. The S1-AP messages encapsulated by SCTP/IP are transferred over an EPS data bearer of the RN where the PGW functionality for the RN's EPS bearers is incorporated into the DeNB (as local breakout functionality for HeNB-s).

The S1 interface relations and signaling connections are shown in Figure 4.2.3-4. In this case there is one S1 interface relation between the RN and the DeNB and between the DeNB and the MME (serving the UE), where the S1 signaling connections are processed by the DeNB (indicated by the arrows in the figure). Note that the RN has to maintain only one S1 interface (to the DeNB), while the DeNB maintains one S1 interface to each MME in the respective MME pool.

Note also that there is an S1 interface relation and an S1 signaling connection corresponding to the RN as a UE, going from the DeNB to the MME serving the RN, similarly to the previous case.

Finally, we note that as neither of these alternatives (i.e., Alt 1,2,3) require any new functionality in the S1-AP (and X2-AP) protocols, the legacy S1-AP (and X2-AP) protocols can be employed in the relay.

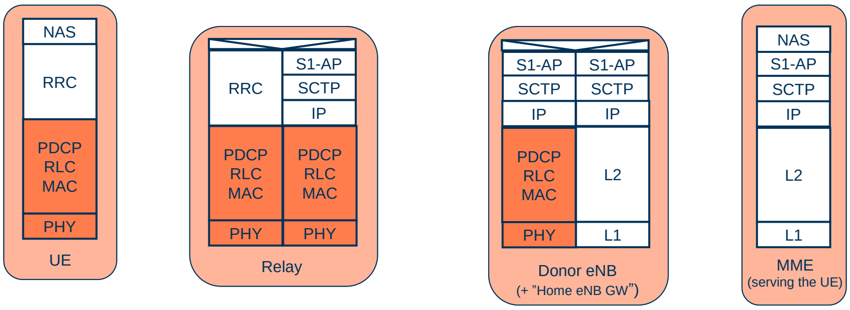


Figure4.2.3-3: Control plane protocol stack – Alt 2 -

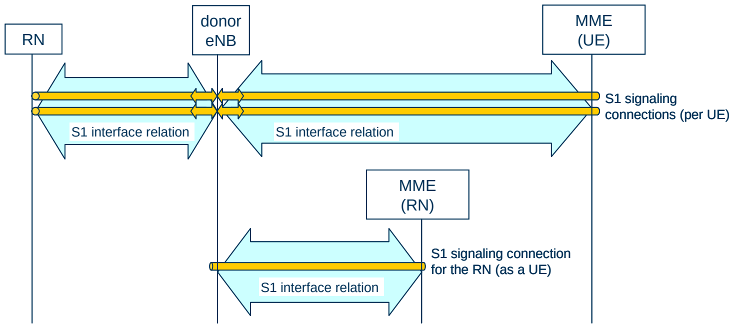


Figure 4.2.3-4: S1 interface relations and signaling connections – Alt 2

We note that the RN when acting as a UE has to support the NAS and RRC protocols toward the network, as illustrated in Figure 4.2.3-5. As there is no need for new functionality in RRC and NAS when used in the RN, the legacy RRC and NAS protocols can be employed.

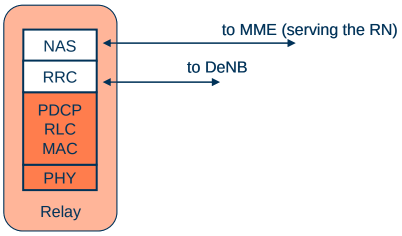


Figure 4.2.3-5: NAS and RRC protocols in the relay

4.2.4 Signalling procedures

4.2.4.1 UE access procedure

The initial attach of a UE connecting via a relay node in case of Alt 1 and 3 is shown in the figure below. (For Alt 3, the same sequence applies with the SGW/PGW of the RN moved into the DeNB.) The procedure corresponds to the legacy attach mechanism as seen from the UE, from the RN and from the MME point of view. The UE bearer handling follows the legacy procedure.

Note that for each message shown in the figure the protocol type (i.e., S1, S11, RRC, NAS) and the user context that the message belongs to (i.e., UE or RN) are also indicated.

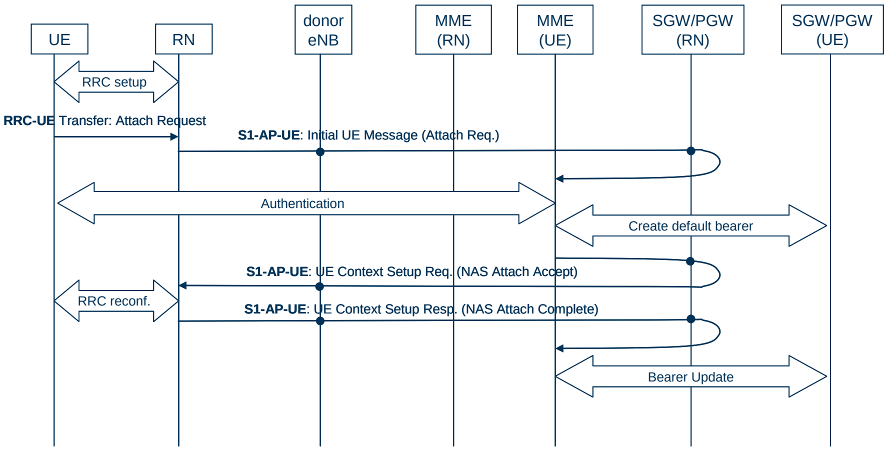


Figure 4.2.4.1-1: UE attach at RN – Alt 1, (3)

The initial attach of a UE connecting via a relay node in case of Alt 2 is shown in the figure below. The procedure corresponds to the legacy attach mechanism as seen from the UE, from the RN and from the MME point of view. The only difference is that the DeNB is involved in the procedure by relaying the corresponding S1 messages between the RN and the MME. As the S1 signalling goes via the proxy functionality of the DeNB, the DeNB is explicitly aware of a UE attaching via the RN.

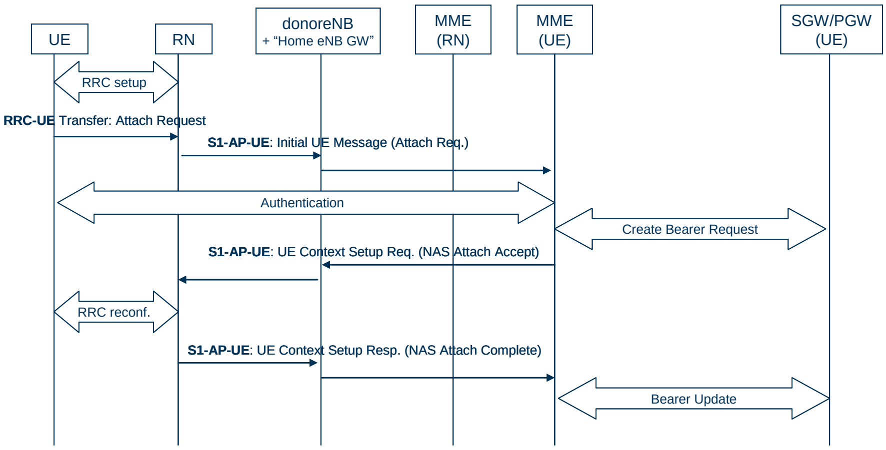


Figure 4.2.4.1-2: UE attach at RN – Alt 2

4.2.4.2 UE bearer management procedures

The UE dedicated bearer setup procedure in case of Alt 1, 3 is shown in the figure below. (For Alt 3, the same sequence applies with the SGW/PGW of the RN moved into the DeNB.) The procedure is seen as legacy bearer management sequence as see from the UE, RN and MME point of view. Additional optimization that could be introduced is to renegotiate the RN bearer resources, e.g., the bit rate of GBR RN bearers in response to the setup of a new UE bearer. The update of the RN bearer may be initiated from the RN using the UE initiated "NAS Bearer Resource Request" procedure.

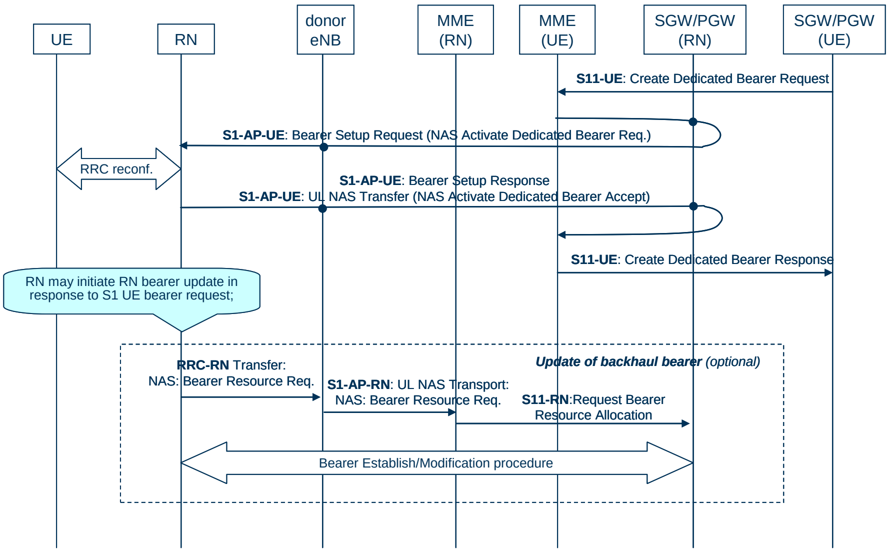


Figure 4.2.4.2-1: UE bearer setup – Alt 1, (3)

The UE bearer setup sequence in case of the "Proxy S1/X2" architecture option is illustrated in the figure below. In this solution the S1 message carrying the bearer setup request arrives to the donor eNB directly. In case the RN bearer needs to be updated (e.g., in case of GBR bearers) the "PGW" functionality in the DeNB can initiate the bearer update toward the MME serving the RN (network initiated bearer modification). Alternatively, the bearer update may be initiated from the RN acting as a UE by invoking the UE initiated bearer resource request procedure, as we have seen in the previous example.

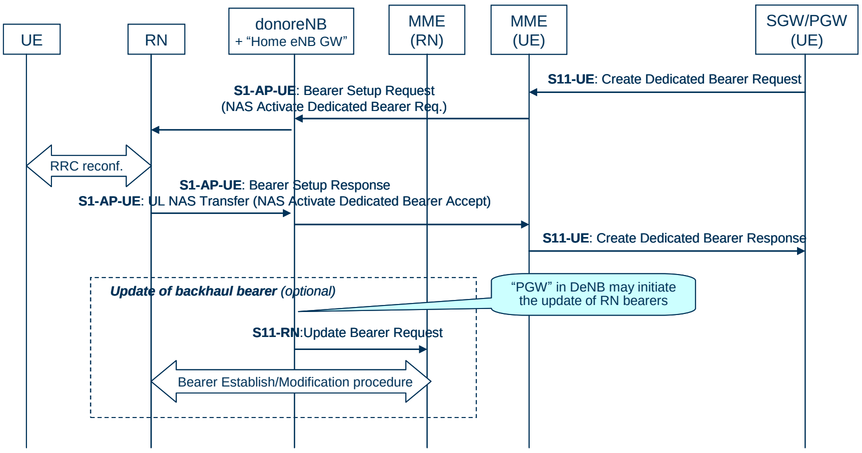


Figure 4.2.4.2-2: UE bearer setup – Alt 2

4.2.4.3 Handover procedure

The procedure of an X2 handover, where a UE under an RN makes a handover to an eNB (donor or non-donor eNB) is shown in the figure below, for architecture alternative Alt 1 and 3. We note that similar procedure would apply in case of the UE making a handover to another RN (connecting via the same DeNB or a different DeNB).

- The RN makes a handover decision based on UE measurement report and selects a target cell.
- The RN sends the Handover Request message to the target eNB over an EPS data bearer that is provided by the DeNB and the S/P-GW of the RN.
- The target eNB receives the message and may reply with a Handover Request Ack message which is routed over the EPS data bearer via the S/P-GW of the RN and the DeNB back to the RN. For the target eNB the request will look as if coming from an eNB.
- After the completion of the X2 signalling, forwarding tunnels are established from the RN over EPS bearer(s) via the DeNB and the S/P-GW of the RN and further on to the target eNB. The RN may start packet forwarding at this point.

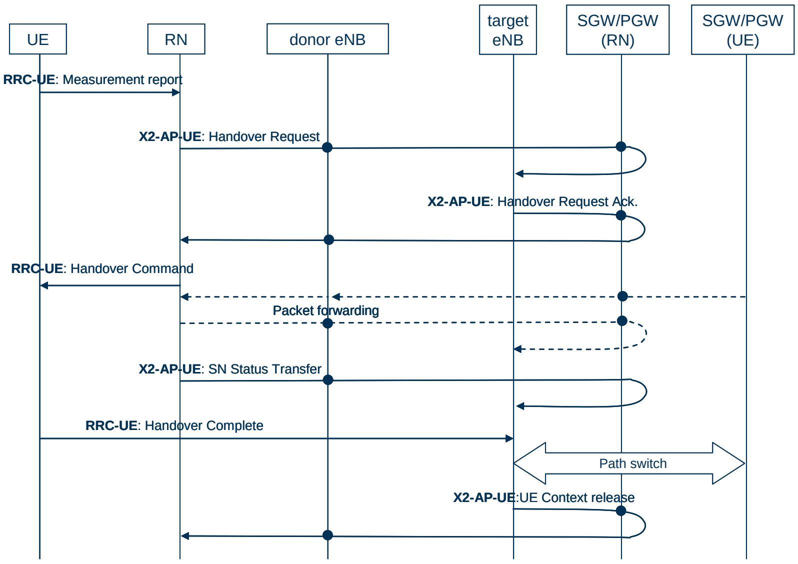


Figure 4.2.4.3-1: X2 handover from RN to target eNB – Alt 1, (3)

The procedure of an X2 handover, where a UE under an RN makes a handover to an eNB different from the donor eNB is shown in the figure below, for architecture alternative Alt 2. We note that similar procedure would apply in case of the UE making a handover to another RN (connecting via a different DeNB) or in case of a handover to the DeNB.

- The RN makes a handover decision based on UE measurement report and selects a target cell.
- The RN sends the Handover Request message to the DeNB. The DeNB reads the target cell ID from the message and finds the target eNB corresponding to the target cell ID and forwards the X2 message toward the target eNB. Note that the RN has to maintain only one X2 interface, which is to the DeNB and it can send all handover requests to the DeNB, irrespective of the target cell ID.
- The target eNB receives the message, which looks like from the target eNB point of view as if the UE would be making the handover under a cell from the DeNB.
- After the completion of the X2 signalling, forwarding tunnels are established from the RN via the DeNB to the target eNB. The GTP tunnels are switched at the DeNB. As the DeNB can access the per UE bearer forwarding tunnels and it is also aware of the ongoing handover through the bypassed X2-AP messages, the packet forwarding path can also be shortcut; i.e., unnecessary back and forth forwarding over the Un interface can be avoided.

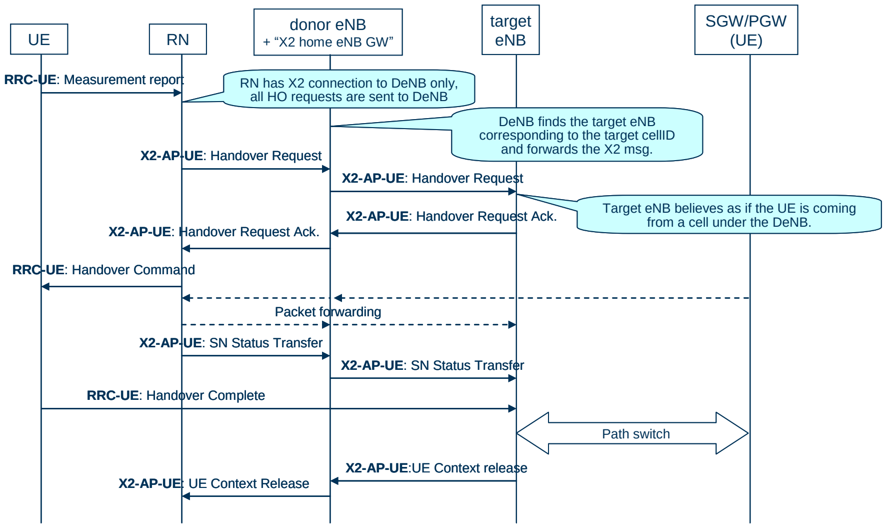


Figure4.2.4.3-2: X2 handover from RN to target eNB – Alt 2

4.2.4.4 RN startup procedure

The RN startup sequence, applicable for Alt 1 and 3, is shown in the figure below, where the procedure can be divided into two main parts:

- In the first part the RN attaches to the network via the legacy UE attach procedure to authenticate the UE (function of the RN) and to establish basic connectivity.
- When IP connectivity is established, the O&M system authenticates the eNB (function of the RN) and downloads configuration data to the RN. The RN establishes the necessary S1/X2 interfaces and it goes into normal operation.

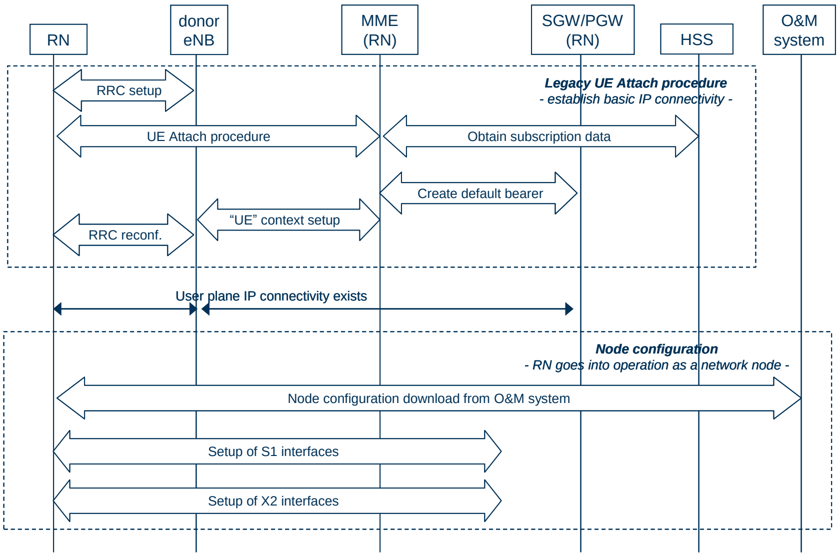


Figure 4.2.4.4-1: RN startup procedure – Alt 1, (3)

The RN startup sequence in case of Alt 2 is similar as in the previous case with some difference in the S1/X2 interface setup. The RN needs to establish only one S1 interface and one X2 interface, both terminated in the DeNB, irrespective of the number of MMEs and neighbour eNBs.

The S1/X2 setup signalling initiated from the RN will be terminated by the donor eNB and the existing S1/X2 connectivity of the DeNB will be used to proxy the S1/X2 connection of the RN. This may require that the existing S1/X2 connections of the DeNB need to be updated, e.g., to register the new cell(s) of the RN toward the neighbour eNBs of the DeNB or to register new tracking area codes (TAC) corresponding to the RN cells toward the MME. The existing "eNB Configuration Update" procedure on the S1/X2 interfaces can be used for this purpose.

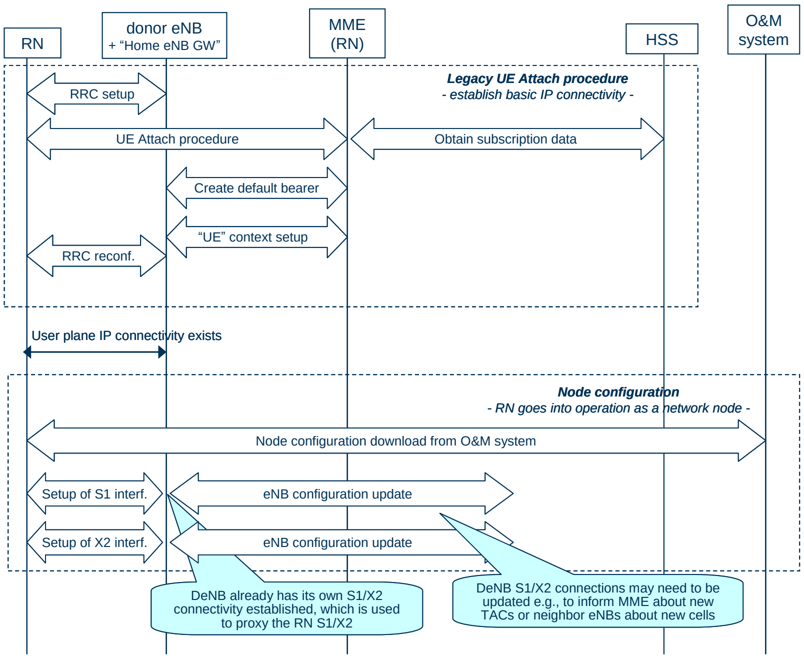


Figure 4.2.4.4-2: RN startup procedure – Alt 2

4.3 Architecture B

4.3.1 Overview

In this architecture, the DeNB acts as the termination for S1 connections towards EPC, and RN can be simply seen as a cell managed by the DeNB from EPC and neighbour eNBs point of view. The DeNB acts as a S1-AP gateway, similar to HeNB gateway.

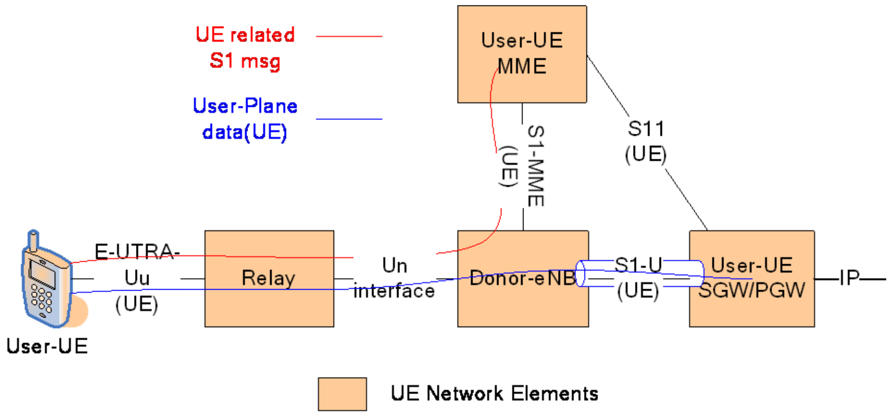


Figure 4.3.1-1: Overview of Architecture B

4.3.2 User plane aspects

In Architecture B/Alt 4, the U-plane of the S1 interface is terminated at the DeNB. The PGW/SGW serving the UE maps the incoming IP packets to the GTP tunnels corresponding to the EPS bearer of the UE and sends the tunnelled packets to the IP address of the DeNB. Upon the DeNB receiving the tunnelled packets from the S-GW, the received packets are de-tunnelled, and the inner user IP packets are mapped to Un radio bearers corresponding to the EPS bearer of the UE (see Figure 4.3.2-2).

Each EPS bearer of a UE connected to the RN is mapped to separate radio bearers over the Un interface (one-to-one mapping). In order to identify individual UE bearers on the Un interface a UE identifier needs to be added to one of the PDCP, RLC or MAC protocol layers; i.e., some parts of the legacy MAC/RLC/PDCP protocols would need to be modified.

NOTE: A possible alternative bearer mapping model could map EPS bearers of different UEs connected to the RN with similar QoS in one radio bearer over the Un interface.

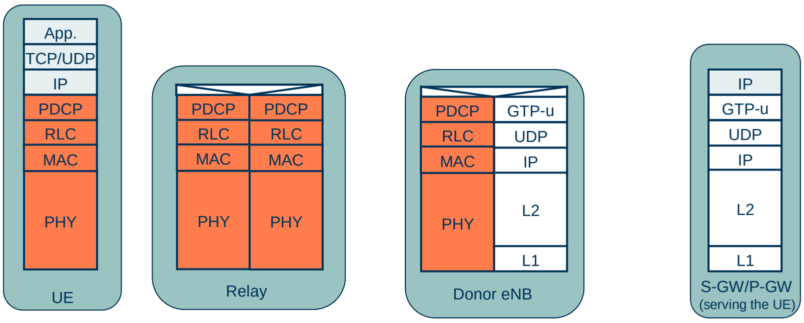


Figure 4.3.2-1: User plane protocol stack – Architecture B/Alt 4

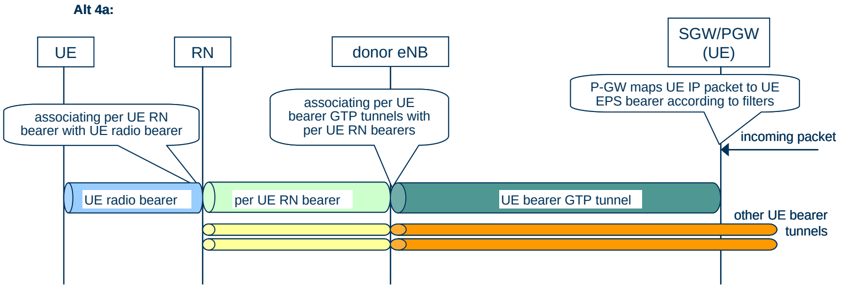


Figure 4.3.2-2: Packet delivery steps – Architecture B/Alt 4

4.3.3 Control plane aspects

The control plane protocol architecture for Alt 4 is shown in Figure 4.3.3-1. In this case, the S1-AP messages are sent between the MME and the DeNB, and between the DeNB and the RN. Upon the DeNB receiving the S1-AP messages, it translates the UE IDs between the two interfaces by means of modifying the S1-AP UE IDs in the message but leaving other parts of the message unchanged. This operation corresponds to an S1-AP proxy mechanism and would be similar to the HeNB GW function. The S1-AP proxy operation would be transparent for the MME and the RN. That is, as seen from the MME it looks like as if the UE would be connected to the DeNB, while from the RN's perspective it would look like as if the RN would be talking to the MME directly. Over the Un, S1-AP (one per UE served by the RN) is carried in new containers over RRC instead of over SCTP/IP as currently defined for S1 signalling.

The S1-C interface relations and signaling connections are shown in Figure4.3.3-2. In this case there is one S1-C interface relation between the RN and the DeNB and between the DeNB and the MME (serving the UE), where the S1 signaling connections are processed by the DeNB (indicated by the arrows in the figure). Note that the RN has to maintain only one S1-C interface (to the DeNB), while the DeNB maintains one S1-C interface to each MME in the respective MME pool.

Note also that there is an S1-C interface relation and an S1-C signaling connection corresponding to the RN as a UE, going from the DeNB to the MME serving the RN.

Finally, the architecture is not expected to require any new functionality in the S1-AP (and X2-AP) protocols, it seems possible to use the legacy S1-AP (and X2-AP) protocols in the relay. However, modifications to RRC are required (e.g., to carry S1-AP).

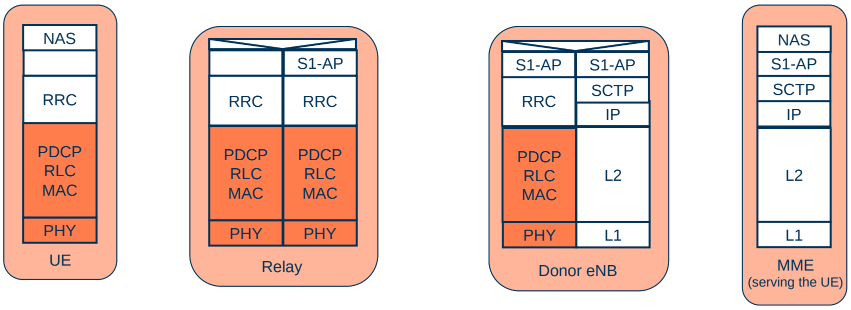


Figure 4.3.3-1: Control plane protocol stack – Architecture B/Alt 4 –

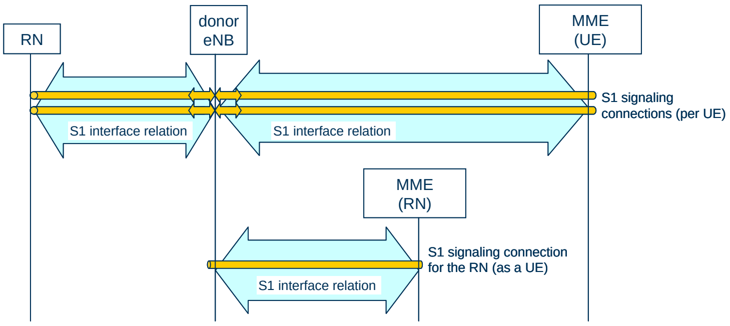


Figure4.3.3-2: S1 interface relations and signaling connections – Architecture B/Alt 4

We note that the RN when acting as a UE has to support the NAS and RRC protocols toward the network, as illustrated in Figure 4.3.2-3.

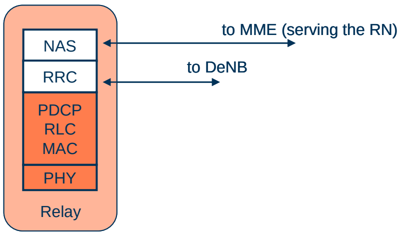


Figure 4.3.3-3: NAS and RRC protocols in the relay

4.3.4 UE Context at DeNB

The DeNB is aware of every UE under the RN and the DeNB will store information for each bearer of such UE. The information expected to be stored is:

- UE identity
- Radio Bearer Configuration information Un (expected that part can be common for a group of bearers).
- Addressing per bearer: <EPS-bearer-id, Un bearer-id, GTP endpoint>
- QoS information per bearer (as signaled over S1-AP).

In the case of mobile relay, it is expected that UE context for UEs in the mobile RN is transferred to the target DeNB at handover preparation.

4.3.5 Signalling procedures

4.3.5.1 UE access procedure

The initial attach of a UE connecting via a relay node in case of Alt 4 is shown in the figure below. The procedure corresponds to the legacy attach mechanism as seen from the UE, from the RN and from the MME point of view. The only difference is that the DeNB is involved in the procedure by relaying the corresponding S1 messages between the RN and the MME. As the S1 signalling goes via the proxy functionality of the DeNB, the DeNB is explicitly aware of a UE attaching via the RN.

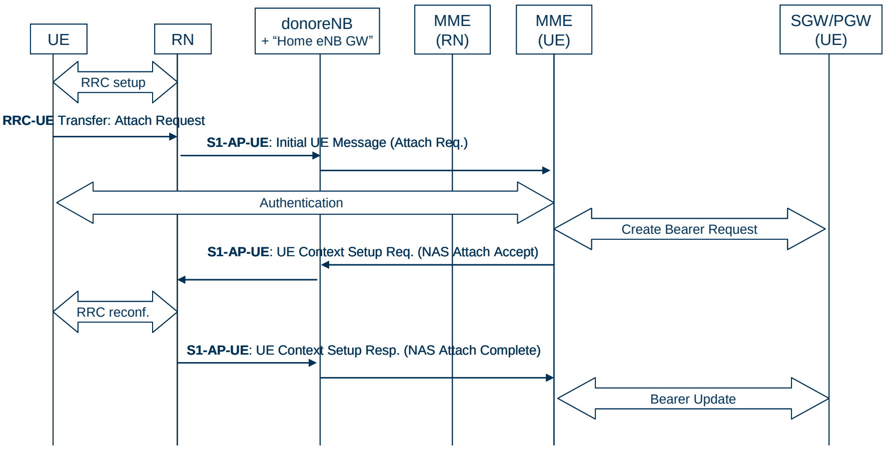


Figure 4.3.5.1-1: UE attach at RN – Architecture B/Alt 4

4.3.5.2 UE bearer management procedures

The UE bearer setup sequence in case of Alt 4 is illustrated in the figure below. In this solution the S1 message carrying the bearer setup request arrives to the donor eNB directly.

In case of Alt 4 the DeNB needs to initiate the establishment of the corresponding radio bearer over the Un interface and forward the S1-AP message to the RN, which steps might be executed with the same or separate RRC messages. With alternative 4, the RN radio bearers carrying UE radio bearers are managed by the DeNB and do not have corresponding RN EPS bearers and, hence, are not under the control of the EPC.

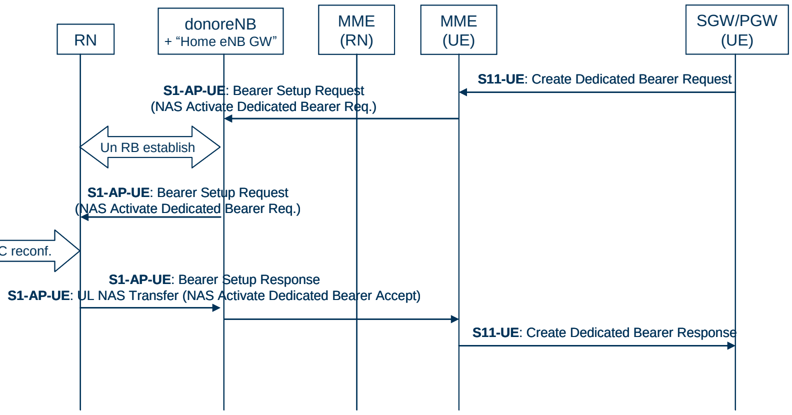


Figure 4.3.5.2-1: UE bearer setup – Architecture B/Alt 4

4.3.5.3 Handover procedure

The procedure of an X2 handover, where a UE under an RN makes a handover to an eNB different from the donor eNB is shown in the figure below, for architecture alternative Alt 4. We note that similar procedure would apply in case of the UE making a handover to another RN (connecting via a different DeNB) or in case of a handover to the DeNB.

- The RN makes a handover decision based on UE measurement report and selects a target cell.
- The RN sends the Handover Request message to the DeNB. The DeNB reads the target cell ID from the message and finds the target eNB corresponding to the target cell ID and forwards the X2 message toward the target eNB. Note that the RN has to maintain only one X2 interface, which is to the DeNB and it can send all handover requests to the DeNB, irrespective of the target cell ID.

- The target eNB receives the message, which looks like from the target eNB point of view as if the UE would be making the handover under a cell from the DeNB.

- After the completion of the X2 signalling, forwarding tunnels are established from the RN via the DeNB to the target eNB. The GTP tunnels are switched at the DeNB. As the DeNB can access the per UE bearer forwarding tunnels and it is also aware of the ongoing handover through the bypassed X2-AP messages, the packet forwarding path can also be shortcut; i.e., unnecessary back and forth forwarding over the Un interface can be avoided.

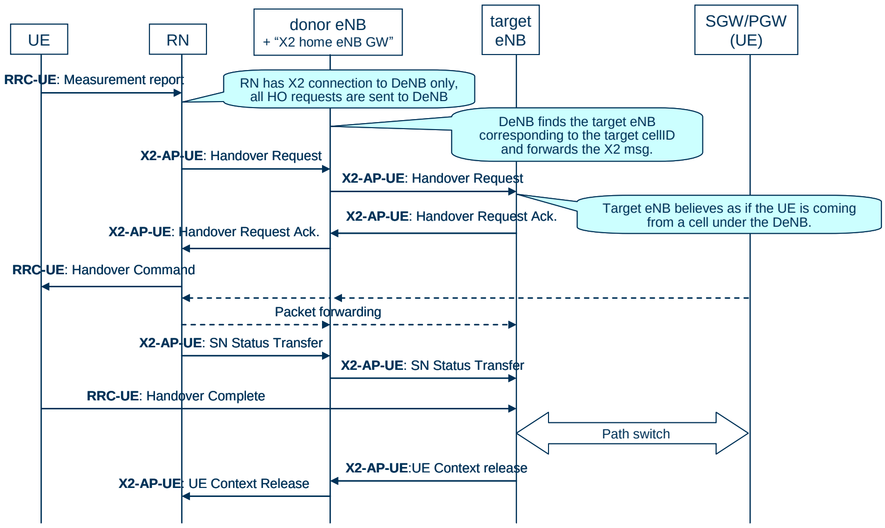


Figure 4.3.5.3-1: X2 handover from RN to target eNB – Architecture B/Alt 4

4.3.5.4 RN startup procedure

The RN startup sequence for Alt 4 is shown in the figure below, where the procedure can be divided into two main parts:

- In the first part the RN attaches to the network via the legacy UE attach procedure to authenticate the UE (function of the RN) and to establish basic connectivity.

- When IP connectivity is established, the O&M system authenticates the eNB (function of the RN) and downloads configuration data to the RN. The RN establishes the necessary S1/X2 interfaces and it goes into normal operation.

The S1/X2 setup signalling initiated from the RN will be terminated by the donor eNB and the existing S1/X2 connectivity of the DeNB will be used to proxy the S1/X2 connection of the RN. This may require that the existing S1/X2 connections of the DeNB need to be updated, e.g., to register the new cell(s) of the RN toward the neighbour eNBs of the DeNB or to register new tracking area codes (TAC) corresponding to the RN cells toward the MME. The existing "eNB Configuration Update" procedure on the S1/X2 interfaces can be used for this purpose.

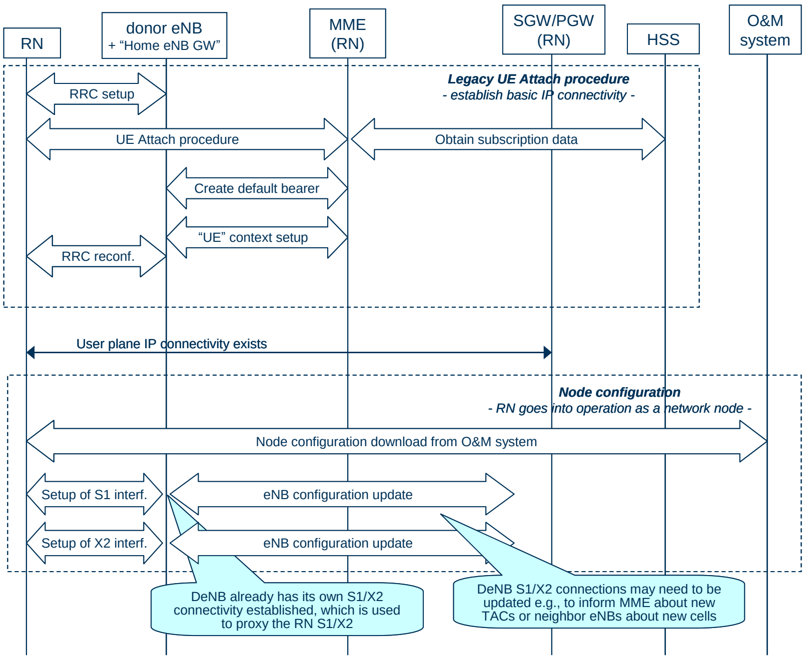


Figure 4.3.5.4-1: RN startup procedure – Architecture B/Alt 4

5 Radio aspects

Editor's note: Primary responsible WG for this clause is RAN2.

5.1 Header Compression in PDCP for Relay Architectures and Header Overhead

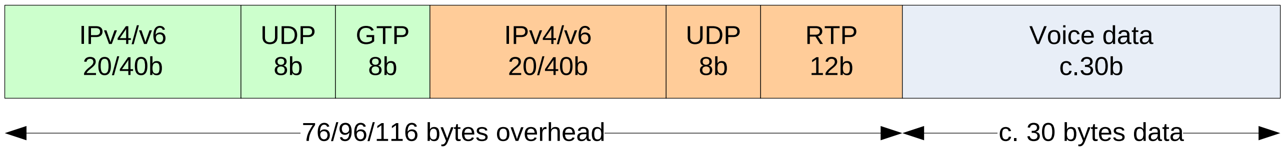
5.1.1 General

RObust Header Compression (ROHC) is used in the PDCP layer to reduce the overhead of the IP and transport headers. A number of profiles have been defined in the IETF and a subset can be used in PDCP. Header compression is particularly important when the payload of user data is small e.g. voice data, or non-existent e.g. TCP acknowledgements for bulk transfer.

From the architectures discussed in this TR there are two possible U-plane protocol stacks on the Un interface that can benefit from compression which are discussed in the following subsections.

5.1.2 Architecture A

In this case the protocol stack within PDCP has an outer part (the GTP tunnel) and an inner part (the contents of the GTP tunnel). Using an 8byte GTP header makes the assumption that the GTP sequence number is not in use.



IPv4/v6 20/40b	UDP 8b	GTP 8b	IPv4/v6 20/40b	UDP 8b	RTP 12b	Voice data c.30b

Figure 5.1.2-1: Protocol headers in case of Voice over IP packets in Architecture A

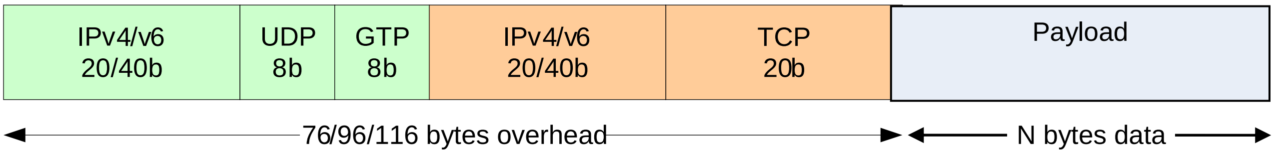


Figure 5.1.2-2: Protocol headers in case of TCP packets in Architecture A

There are a number of options for reducing and compressing the overhead, which are discussed below.

5.1.2.1 Compress the entire header chain

This suggestion uses one profile and corresponding context identifier to compress the inner and outer headers together as one header chain. The detail of the derivation is not given here but the calculation assumes the minimum compressed header size rather than the average and that the bytes in question are the following:

NOTE: The flow is assumed to be well behaved; i.e., IP-ID in step with RTP sequence number and no large breaks in TCP timestamp (either due to codec or lack of silence suppression). Even so, there will be packets where an additional byte is needed.

NOTE: It is harder to analytically establish the average size because it depends on the behaviour of the flow, the configuration of the ROHC implementations and the versions of the profiles in use. If the IP-ID or other fields are less well behaved, there will occasionally be a need to send an additional byte or two. The average is expected to be no more than a byte larger than the minimum. If the IP-ID is random, the minimum for the inner headers will be 2 bytes larger.

- ROHC PT Hdr: 1 byte which is the equivalent of a UO-0 format containing format identifier, 3-bit CRC and the compressed sequence number and 2 bytes for the Context Identifiers (CIDs)

NOTE: The context identifier is agreed between the compressor and decompressor and tells the decompressor which profile to use to decompress the header and which stored context to decompress it against. Large CIDs can be 1 or 2 bytes so we assume 2 bytes for throughout this document.

- Compressed outer part: 2 bytes of IP-ID and 2 bytes of UDP checksum
- Compressed GTP-U: it is assumed that the GTP header can be compressed to zero bytes due to most of the GTP header fields being static, where: the version field would be static, the flags would be zero (assuming an 8 byte GTP header), the message type would be static, the length would be inferred and the TEID would be static and part of the flow definition and the sequence number would not be used. If the sequence number were in use, this could possibly be correlated to the RTP sequence number and so would still not be 2 bytes.
- Compressed inner part: 2 bytes of UDP checksum

So the minimum would, in actual fact, be 9 bytes as shown in Figure 5.1.2.1-1.

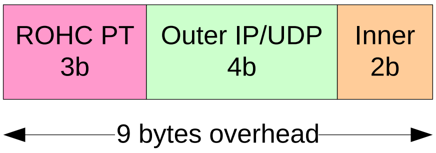


Figure 5.1.2.1-1: Estimate of compression of entire header chain

For TCP, the compressed inner IP/TCP header (again assuming a well behaved flow) would be a total 4 bytes – 2 for the scaled acknowledgement number and 2 for the TCP checksum. Thus the minimum would be 11 bytes. Changing the inner stack to TCP has the same impact for all the other options and so will not be discussed further.

In this approach the correlation between any fields can be taken account of. In particular, a flow can be defined by the IP addresses (outer and inner), port numbers (outer and inner) and the TEID. However, in order this solution to be applicable, a new ROHC profile would have to be defined for each set of inner protocols.

This could, and probably should, be done in the IETF to avoid defining a non-IETF ROHC profile and polluting the profile identifier space. However, the work would need to be adopted by the ROHC working group and the pace of the

IETF is partly dependent on the level of support for the work. The ROHC working group is in the process of deciding whether to re-charter or conclude with the latter looking more likely. That does not mean that more profiles cannot be written but the level of support in the IETF for doing so is, at the moment, very low.

An alternative is to produce the profile in 3GPP but that would also require time, effort and expertise.

5.1.2.2 Compress the outer and inner headers separately, excluding GTP

This does not require any further standardization in the IETF. The outer header (the IP and UDP headers) would be compressed using the ROHC IP/UDP profile. The inner headers would be compressed independently using the relevant ROHC profile (IP/UDP/RTP or IP/TCP). And both header compressions are performed in the DeNB for DL and the relay node for UL.

For the overall compression, there would be 1 byte identifying the ROHC packet type and 2 bytes of CID (assuming large CIDs). This should apply to both the outer and the inner compressions

Because the outer headers are compressed separately from the inner headers, correlation between the outer IP-ID and the sequence number in the ROHC PT header can be assumed so the compressed outer part is only 2 bytes.

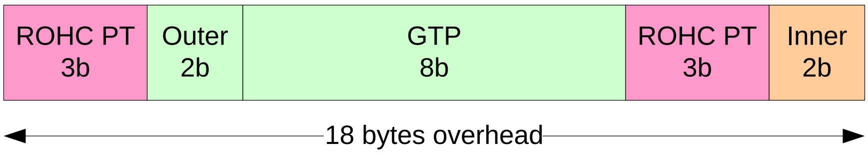


Figure 5.1.2.2-1: Overhead with of two levels of compression

There is currently no GTP packet type for a ROHC compressed header so this would need to be added to GTP.

This approach uses existing ROHC profiles.

5.1.2.3 Compress the outer and inner headers separately, including GTP

This solution is similar to that in section X.2.2 but includes compressing the GTP header. Based on the analysis of the GTP header in section X.2.1 the GTP header can be compressed to zero bytes. However, it requires the definition of a new ROHC profile for IP/UDP/GTP, which as discussed in section X.2.1 requires effort from the IETF or 3GPP. The resulting compressed header would be as shown in Figure 5.1.2.3-1.

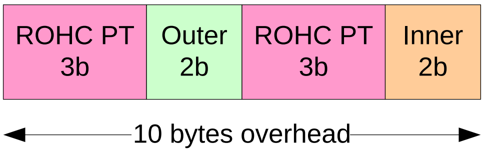


Figure 5.1.2.3-1: Two levels of compression including GTP header

5.1.2.4 Compress just the outer headers, excluding GTP

This solution included for completeness. It is simply to use the existing ROHC IP/UDP profile to compress the outer two headers. The inner headers will stay as they are without compression. The result would be as shown in Figure 5.1.2.4-1.

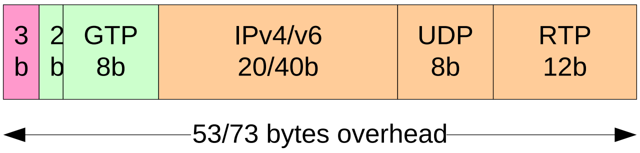


Figure 5.1.2.4-1: Outer headers compressed

5.1.2.5 Strip the outer headers, excluding GTP

An alternative to header compression is header stripping. In this case any essential information in the headers is transmitted out of band, namely via dedicated signaling that will need to be specified in the specifications, and then the headers are simply stripped at the sender (the donor eNB in this case, downlink) and recreated at the receiver (the relay node, downlink). Actually the information carried in the outer IP header is not essential and could be recreated arbitrarily by the RN without the need of dedicated signaling for downlink. The recreation will produce headers that are different from the original ones, which may cause problems especially for IP packets to be forwarded onwards.

Transparency of the outer headers is lost. For UL direction, this scheme may not be applicable for Alt1 and Alt3 since DeNB would then need to reconstruct the outer IP which would be difficult.

The resulting headers would be 13 bytes in length as shown in Figure 5.1.2.5-1.

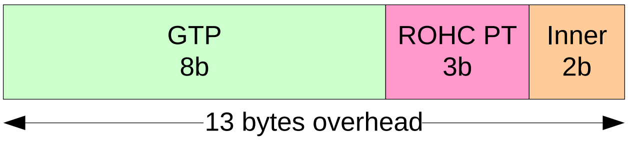


Figure 5.1.2.5-1: Estimate with header stripping

This solution does not require new ROHC profiles but requires some modification in PDCP to simply skip the GTP header and then perform compression as normal. A new GTP message type for a ROHC compressed header would also need to be added to GTP, similarly to the solution in X.2.2).

5.1.2.6 3GPP Compression

This solution strips the outer headers (i.e., IP, UDP and GTP, the green parts in Figure 5.1.2-1 and Figure 5.1.2-2) and replaces it with a 2 byte context information and it compresses the inner headers using the existing ROHC. The context information identifies the information needed to recreate the outer headers (e.g., IP address of the relay, TEID of the relay, etc.), which is assumed to be transmitted via dedicated signaling that will need to be specified in the specifications. The outer headers are simply stripped at the sender (the donor eNB in this case, downlink) and recreated at the receiver (the relay node, downlink). The IP-ID of the outer IP header can be compressed to zero length since the donor eNB can ensure segmentation is not used or if used, any segmented packets can be transmitted non-compressed. The UDP checksum of the outer UDP header can be disabled (set to 0's) since transmission reliability is already provided by the Un air-interface. The PDCP can be made to skip the 2 byte context information and compress the inner headers.

For UL direction, in case of alternative 1 and 3, the DeNB shall reconstruct the outer IP.

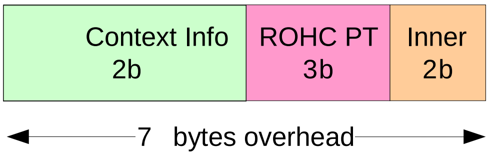


Figure 5.1.2.6-1: Outer IP/UDP/GTP headers compressed

5.1.3 Architecture B

In this case IP/UDP/RTP or IP/TCP would be carried in PDCP in the same way as it is over the Uu interface. There would be 40/60 bytes of overhead as shown in the inner parts of Figure 5.1.2-1 and Figure 5.1.2-2. The headers could be compressed in the same way as on the Uu interface as shown in Figure 5.1.3-1.

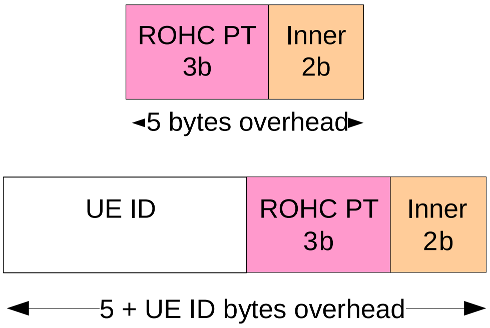


Figure 5.1.3-1: Compressed overhead for alternative 4a with and without the UE ID

It is assumed that the relay node would decompress and recompress the headers to keep the compression at the same point in the network as for an ordinary eNB. If this were not done, there would be additional complexity required to cope with a UE handing over to a different relay node. Additionally it is expected that some form of UE id would be required over Un to distinguish UEs. This should be included as corresponding header overhead. UE ID based on UE C-RNTI has been proposed but the details of the UE ID (e.g., type and size) are FFS.

5.1.4 Summary

A summary of the options considered most feasible is provided here. It is based on the trade-off between efficiency and standardisation effort.

Table 5.1.4-1: Comparison of efficiency and standardization effort

	Alternatives 1, 2 & 3					**Alternative 4**
	Entire header chain comp	**Separate comp excl GTP**	**Header stripping**	**Separate comp incl GTP**	**3GPP Comp**	
Initial header size	76/96/116 bytes	76/96/116 bytes	76/96/116 bytes	76/96/116 bytes	76/96/116 bytes	40/60 bytes
Minimum compressed header size	9 bytes	18 bytes	13 bytes	10 bytes	7 bytes	5 + UE IDbytes (potentially, 5+2 (FFS) bytes)
Standardization effort required	High – new ROHC profile	Low - new packet type for GTP	FFS - PDCP needs to know about GTP	High - new ROHC profile	FFS – PDCP needs to know about the context information	FFS - depending on mapping of Un to Uu RABs, UE identifier would be needed
Other comments		Double compression – should not present problem	Transparency not maintained – This solution may not be applicable to Alt1 and Alt3	Double compression – should not present problem	Transparency not maintained – This solution might not be applicable to Alt1 and Alt3 (FFS)	

Whether there is a need to define a new ROHC profile will depend on the architecture and approach to header compression that is taken.

The complexity of defining a new profile would depend on whether it was a profile for the entire header chain or an IP/UDP/GTP profile. In either case effort would be needed.

6 Backhaul aspects

Editor's note: Primary responsible WG for this clause is RAN3.

6.1 X2 Interface

It is assumed that the X2 interface is allowed at the relay node and that the applicable X2 functions comprise all specified X2 functions.

The concern for allowing X2 at the relay node mainly stem from the concern that too many relays may try to establish X2 connection with the macro eNBs, as in the case of HeNBs. However, number of Relays within the coverage of a macro eNB is likely to be much lower than the number of HeNBs, as the relays normally will be managed and operated by the operator, and the Relays need to use the air interface of the Donor-eNB.

Hence, the existence of the X2 interface at the relay node is under the assumption of a similar order of magnitude of X2 interface connections as a Release 8 deployment.

The X2AP protocol is also terminated at the relay node. Terminating the X2 protocols at the relay has the following benefits:

- Eliminates any changes to the Donor-ENB, facilitating easier and faster deployment of the relays;
- Eliminates the need for new protocols between the relay and the Donor-eNB to translate the X2 protocol messages and payload.

It is assumed that data forwarding should be supported for HO between the relay node and another cell.

7 Agreements

This sub clause contains agreements reached and serves as a basis for the inclusion of a description of relaying functionality in [3]:

- S1AP is terminated at the RN.

8 Comparison

Table 8-1: Architecture Comparison

Metric		Architecture A			Architecture B
		Alt 1	**Alt 2**	**Alt 3**	**Alt 4**
RN Complexity		RN = eNB + UE	RN = eNB + UE	RN = eNB + UE	New model New functionalities needed for one-to-one mapping between two DRBs (one over Un and one over Uu) that need to be kept synchronized
DeNB Complexity		Layer 1 / 2 changes for inband relays	Deployed with an embedded RN UE's P/S-GW + HeNB GW like functionality. Layer 1 / 2 changes for inband relays	Integrating the SGW/PGW functionality into the DeNB Layer 1 / 2 changes for inband relays	HeNB GW like functionality RRC impact Layer 1 / 2 changes for inband relays
Node Impact	MME	If 3GPP based QoS mapping (based on e.g. QCI, ARP, etc.) is needed new SDF filter is required In case of dynamic Un bearer update MME signalling is doubled HSS/MME/S1 changes needed to authorize RN operation	In case of dynamic Un bearer update MME signaling is doubled HSS/MME/S1 changes needed to authorize RN operation	If 3GPP based QoS mapping (based on e.g. QCI, ARP, etc.) is needed new SDF filter is required In case of dynamic Un bearer update MME signaling is doubled HSS/MME/S1 changes needed to authorize RN operation	HSS/MME/S1 changes needed to authorize RN operation *or* new RRC authentication via new S1/CN signaling model
	S/P-GW	PGW of the RN needs to perform bearer mapping Higher CN load due to signaling traffic passing through S/PGW	No impact	No impact	No impact
	Other Nodes	In case of X2 signalling and static QoS mapping eNB needs to perform DSCP marking appropriately	No Impact	In case of X2 signalling and static QoS mapping eNB needs to perform DSCP marking appropriately	No Impact
Deployment	Implementation impact for early deployment	From the RAN side, could be deployed in Rel-9 only out-of-band RN with limited functionalities such as static bearer configuration assuming implementation specific solutions (e.g. addressing how to distinguish RN-UE and UE), no header compression, no improved QoS via additional QCIs. MME will be upgraded to support such deployment.	Cannot be deployed in Rel-9	Cannot be deployed in Rel-9	Cannot be deployed in Rel-9

	Deployment flexibility	Same RN for Alt 1, 2, 3 Optimisation requires changes in the DeNB and/or in the architecture	Same RN for Alt 1, 2, 3 Optimisation can occur within the same architecture	Same RN for Alt 1, 2, 3 Some optimisation can occur within the same architecture. Full optimisation requires changes in the DeNB and/or in the architecture	Unique RN for Alt. 4
	Scalability with respect to number of RNs	The complexity of radio bearer handling in Un at the DeNB is proportional to the number of first hop RNs attached to it. Number of Connections to MMEs could be a scalability issue in high density RN scenario Number of X2 connections between neighbour RNs/eNBs could be a scalability issue in high density RN scenario	The complexity of radio bearer handling in Un at the DeNB is proportional to the number of first hop RNs attached to it. No scalability issue towards MMEs or neighbour RNs/eNBs due to HeNB GW-like functionality	The complexity of radio bearer handling in Un at the DeNB is proportional to the number of first hop RNs attached to it. Number of Connections to MMEs could be a scalability issue in high density RN scenario Number of X2 connections between neighbour RNs could be a scalability issue in high density RN scenario	The complexity of radio bearer handling in Un at the DeNB is proportional to the total number of RNs. No scalability issue towards MMEs or neighbour RNs/eNBs due to HeNB GW-like functionality
	Scalability with respect to number number of UEs	No scalability issue due to EPS bearer aggregation with similar QoS on Un	No scalability issue due to EPS bearer aggregation with similar QoS on Un	No scalability issue due to EPS bearer aggregation with similar QoS on Un	Number of DRBs could be a scalability issue on Un when large number of UEs connect to RN
Standardization Effort and Complexity		Low impact.	Medium Impact.	Medium Impact	High Impact
Header Overhead/Compression		Extra development effort in case of new header compression mechanism Header stripping also supported provided that extra signalling is in place	Extra development effort in case of new header compression mechanism. Header stripping also supported.	Extra development effort in case of new header compression mechanism Header stripping also supported provided that extra signalling is in place	Can reuse the Rel-8 header compression mechanism of PDCP
UE mobility	Complexity	In case of dynamic Un bearer update extra signalling may be needed	In case of dynamic Un bearer update extra signalling may be needed	In case of dynamic Un bearer update extra signalling may be needed	Due to one to one bearer mapping Un bearer setup process needed during RN inbound mobility
	Efficiency	DeNB is not aware of UE S1/X2 handover signalling, signalling routed through RN S/P-GW with longer paths Un-optimized data forwarding over X2	DeNB is aware of per UE S1/X2 handover signalling, signalling routing optimisation can be provided	DeNB is not aware of UE S1/X2 handover signalling. However, signalling routing is fully optimised. Un-optimized data forwarding over X2	DeNB is aware of per UE S1/X2 handover signalling, signalling routing optimisation can be provided
	Delay	Handover signalling delay is larger than that under Alt. 2, 3, and 4 for about two transmission delays between the DeNB and the RN P/S-GW.	No extra handover signalling delay	No extra handover signalling delay	No extra handover signalling delay
QoS	Bearer mapping between Un and UE EPS bearer	RN bearer granularity …	RN bearer granularity …	RN bearer granularity …	UE bearer granularity …

	and Number of Un bearers				
	QoS Control: UE AMBR; ARP; QCI; Control plane	New QCI could be introduced if the existing QCIs cannot meet the requirements for the transport of S1 signalling. ARP not visible at DeNB. Mapping of EPC bearers into Un bearers on the basis of ARP could be achieved via static implementation configuration, which may have an impact on DSCP configuration	New QCI could be introduced if the existing QCIs cannot meet the requirements for the transport of S1 signalling. ARP visible at DeNB. Mapping of EPC bearers into Un bearers could be done on the basis of ARP. Fixed configuration of QCI-ARP supported per Un bearer.	New QCI could be introduced if the existing QCIs cannot meet the requirements for the transport of S1 signalling. ARP not visible at DeNB. Mapping of EPC bearers into Un bearers on the basis of ARP could be achieved via static implementation configuration, which may have an impact on DSCP configuration	No additional QCI needed. New SRB could be introduced if needed. ARP visible at DeNB. Mapping of EPC bearers into Un bearers could be done on the basis of ARP. Flexible configuration of QCI-ARP supported per Un bearer.
	RB setup/reconfiguration delay	Higher but only when Un bearers to be updated otherwise same	Medium but only when Un bearers to be updated otherwise same	Higher but only when Un bearers to be updated otherwise same	Lower CN is not involved in Un bearer setup/reconfiguration procedures
Flow control	Necessity	No conclusion	No conclusion	No conclusion	No conclusion
	Efficiency	Per-QoS (per Un bearer) or per RN	Per UE-RB Per-QoS (per Un bearer) or per RN	Per-QoS (per Un bearer) or per RN	Per UE-RB Per-QoS (per Un bearer) or per RN
S1 issues		Higher number of SCTP connections between RN and MME	End to end reliability depends on SCTP over the Un	Higher number of SCTP connections between RN and MME	End to end reliability depends on RRC over the Un Impact on S1 transport (S1AP over RRC)
X2 issues		X2 interface needs to be maintained between any RN and neighbouring nodes. X2 must always go through RN S/P-GW with long path.	X2 interface needs to be maintained only towards the DeNB.	X2 interface needs to be maintained between any RN and neighbouring nodes.	X2 interface needs to be maintained only towards the DeNB. Impact on X2 transport (X2AP over RRC)
RRC issues					Potential head of line issues involving RRC. Impacts due to transport of S1AP and X2AP
Security		USIM and NDS (Note 1)	USIM and NDS (Note 1)	USIM and NDS (Note 1)	USIM (Note 1)
Future Enhancements		Captured in the Deployment section	Captured in the Deployment section	Captured in the Deployment section	Captured in the Deployment section

NOTE 1: Subject to SA3 response.

Matrix Fields interpretation (informative):

RN Complexity: What is the complexity in specification, design and implementation of the RN? How easy it is to derive such node from existing nodes?

DeNB Complexity: What is the complexity in specification, design and implementation of the DeNB? How easy it is to derive such node from existing nodes?

Deployment: Implementation impact for early deployment: How easy it is to deploy the alternative given the current Rel9 architecture as a reference starting point?

Deployment flexibility: Is the deployment sub-optimal or is it already optimised to a viable level? Can the deployment be easily optimised?

Scalability (with respect to number of RNs and number of UEs): How does the deployment cope with increasing numbers of supported RNs and UEs (connected to RNs)?

Standardization Effort and Complexity: What is the anticipated impact on standardization? Is it easy to standardize the alternative as is, or are simplifications required? Is there any unclear issue that can end up being a showstopper delaying the standardization process? Is the alternative achievable for release 10 or should it be postponed for future releases?

Header Overhead/Compression: How much header overhead there is over the Un, as well as other interfaces due to tunnelling, multiplexing, etc… Is it possible to use legacy header compression or new ROHC profiles or header compression algorithms required? If legacy methods can not be used, what is the complexity and efficiency of the new compression mechanisms/profiles?

UE mobility: Complexity: Relaying is expected to work with release 8 UEs, but are there any differences from the UE handover procedures of release 8, from the CN point of view?

Efficiency: Any unnecessary back and forth forwarding?

Delay: What is the total required time for a UE handover? What is the handover interruption time? Does the delay fall within the limits set by release 8 standards?

QoS: Bearer mapping between Un and UE EPS bearer and Number of Un bearers: Is it straightforward to guarantee the per-bearer QoS over the Un interface? If not, what upgrades have to be made to support it? Do these changes affect CN entities such as MME and P/S-GW? How flexible the bearer mapping can be (per bearer, per UE, per QoS class, etc…)

Can the release 8 limit of 8 bearers per UE be kept over the Un interface (i.e. 8 Un bearers per RN) or is there a need for more Un bearers? If more bearer are needed what is the impact of such increased number?

QoS Control (UE AMBR; ARP; QCI; Control plane): Can we control the DL AMBR of UEs over the Un interface? Can the ARP of the UE EPS bearers be used during admission over the Un? Are the nine QCIs of release 8 sufficient or there is a need to define new ones? Will it be possible to keep the requirements of the release 8 QCIs as is, or would they have to be redefined taking the extra delay incurred due to relaying?

Can we satisfy the requirements of control plane messages between the RN and MME? Can control plane messages such as S1/X2 be transported over the Un with the required priority within signalling radio bearers? Or do they have to be mapped to DRBs? If so, are the current QCIs capable of satisfying the requirements? How about the impact of head of line blocking if DRBs are used for signalling transport?

RB setup/reconfiguration delay: What is the latency of radio bearer setup and reconfigurations? Does it meet the release 8 requirements?

Flow control: Do we require new flow control mechanisms between the RN and DeNB for the different architectures? What kind of flow control mechanisms can be realized in the different architectures (per-bearer, per – UE, per QoS, per RN, etc), and what is the efficiency of each?

S1 issues: How is S1AP impacted with respect to the currently available protocol? How efficient is the S1 messaging, especially in the case of high density deployment? Does the RN have to keep S1 links directly with the MME and as such use part of the Un resources for S1 maintenance, such as SCTP keepalive or GTP-U echo messages? If so, what is the impact on overall system utilization as well as the incurred S1 latency?

X2 issues: How is X2AP impacted with respect to the currently available protocol? How efficient is the X2 messaging, especially in the case of high density deployment? Does the RN have to keep X2 connections with all neighbour RNs at all time, as well as (non-donor) eNBs, or it has to keep only one X2 towards the donor eNB? What is the impact of both cases on the Un resource utilization, i.e. considering the SCTP keepalive and GTP-U echo messages as well as signalling required to enable optimizations such as ICIC where the RN might be required to forward its load information towards all the nodes with which it has X2 connection with?

RRC issues: How is RRC impacted with respect to the currently available protocol? How efficient is transport of protocols over RRC?

Security: What is the impact on security? Can we still keep the security requirements of release 8 (ciphering for both SRBs and DRBs and integrity protection for SRBs)? What kind of security mechanisms should be used over the Un?

Node Impact: MME: Any upgrades needed in the MME to support RNs? Can the release 9 bearer setup, modification and QoS control be enough or major upgrades required?

S/P-GW: Any upgrades needed in the S/P-GW to support RNs? Can the release 9 S/P-GW be able to support RNs or major upgrades required?

Other Nodes: Is there any impact on other nodes (such as eNBs not supporting RNs), or is there the need of extra nodes?

Future Enhancements: Does the straightforward standardization of an alternative entails the need for future enhancements (standard revisions), which can already be identified at the moment, in order to provide optimized performance? Or is the alternative relatively difficult to standardize as is, but no further enhancements (standard revisions) are required for optimized performance, or at least no major ones can be seen at the moment?

9 Conclusion

During the study of LTE-Advanced many architecture alternatives for relays were investigated, four of which are described in this TR. It is concluded that architecture alternative 2 herein has most benefits overall and is selected for Rel-10.

Annex A: Additional Signalling Flow Examples

A.1 Multi-Hop UE Attach procedure

The picture below illustrates UE Attach for a two-relay scenario in Alt 1. This is not a prioritized scenario for Release 10.

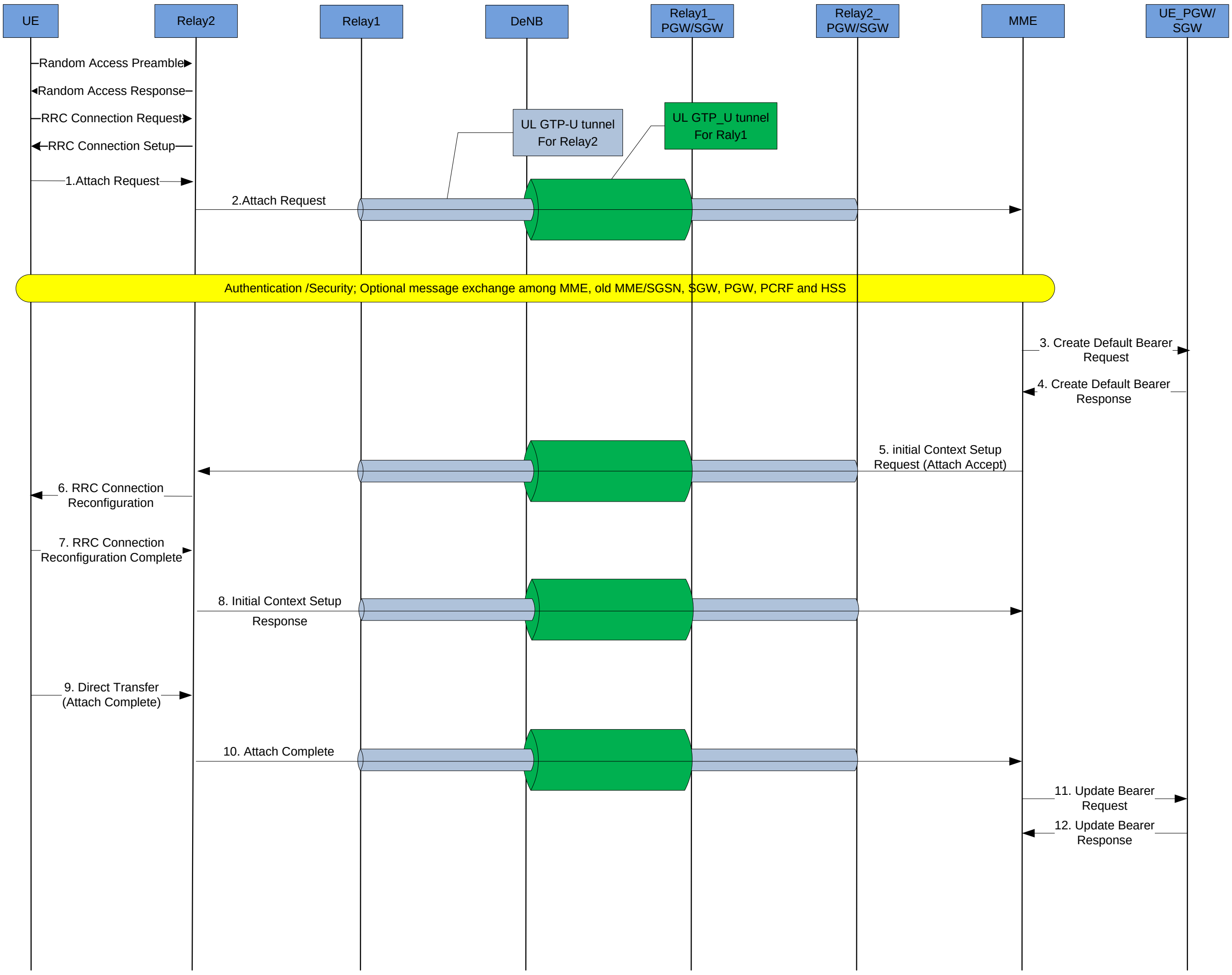


Figure A.1-1: UE Attach for two-relay scenario – Alt 1

A.2 RN Mobility

The picture below illustrates relay mobility between donor eNBs for Alt 1. This is not a prioritized scenario for Release 10.

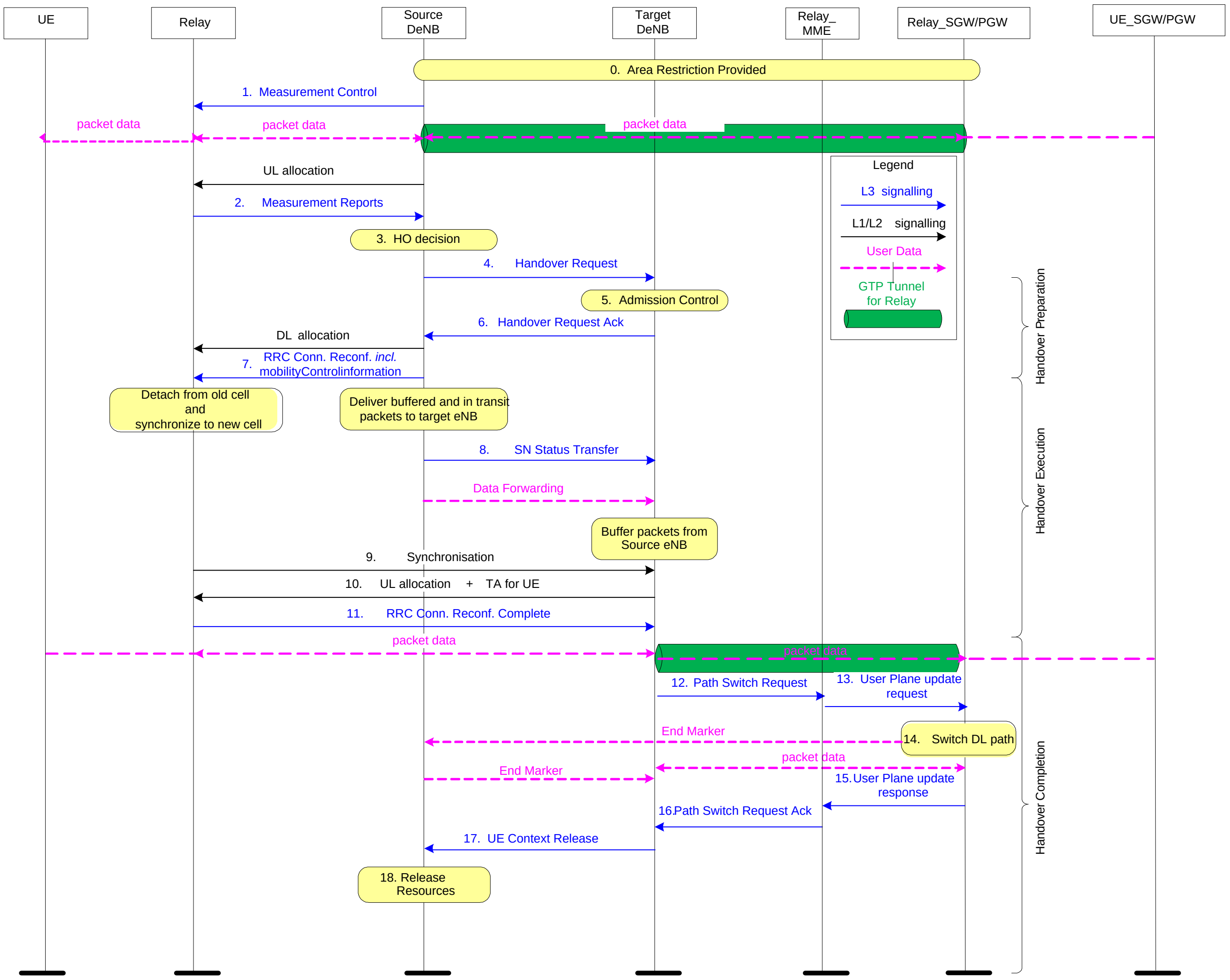


Figure A.2-1: RN Mobility – Alt 1

Annex B: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2009-09	RAN2#67	R2-095391			First version	-	0.1.0
2009-11	RAN2#68	R3-093096			RAN3 changes to the TR	0.1.0	0.1.1
2009-11	RAN2#68	R2-097537			Agreed version after RAN2 #68 (agreed by email)	0.1.0	0.2.0
2010-02	RAN2#69	R2-101529			Captured TP from R2-100787	0.2.0	0.2.1
2010-02	RAN2#69	R2-101608			Corrected figure and table numbering in clause 5.1	0.2.1	0.2.2
2010-02	RAN2#69	R2-101844			Agreed version at RAN2#69	0.2.2	0.3.0
2010-02	RAN2#69	R2-101870			Captured comparison table and conclusion	0.3.0	0.3.1
2010-02	RAN2#69	R2-101900			Agreed version to TSG RAN for approval	0.3.1	2.0.0
2010-03	RP-47	-			TR 36.806 approved as v9.0.0 at RAN #47	2.0.0	9.0.0