

St. Julian's, Malta, 28th January – 1st February, 2013

Agenda Item: 7.2

Source: NTT DOCOMO, INC.

Title: Discussion on U-plane architecture for dual connectivity

Document for: Discussion, Decision

1 Introduction

In RAN#58, Small Cell Enhancement (SCE) Higher Layer SI was approved [1]. In [1], the following objectives are conducted:

- *Identify and evaluate the benefits of UEs having dual connectivity to macro and small cell layers served by different or same carrier and for which scenarios such dual connectivity is feasible and beneficial.*
- *Identify and evaluate potential architecture and protocol enhancements for the scenarios in TR 36.932 and in particular for the feasible scenario of dual connectivity and minimize core network impacts if feasible, including:*
 - *Overall structure of control and user plane and their relation to each other, e.g., supporting C-plane and U-plane in different nodes, termination of different protocol layers, etc.*
- *Identify and evaluate the necessity of overall Radio Resource Management structure and mobility enhancements for small cell deployments:*
 - *Mobility mechanisms for minimizing inter-node UE context transfer and signalling towards the core network.*
 - *Measurement and cell identification enhancements while minimizing increased UE battery consumption.*

In this document, the U-plane architecture and the protocol stack for dual connectivity will be addressed.

2 Discussion

To realize the deployment scenario and to satisfy the requirement indicated in [2], the “dual connectivity” to macro-cell and small cell with both ideal and non-ideal backhaul should be considered. Since “ideal backhaul case” has been already covered in CA scenario#4 [3], “non-ideal backhaul” case should be mainly studied. Note that, [2] is indicating that the requirements are applicable to both co-channel and separate carrier scenario, but we think that from the NW architecture/protocol stack perspective, there will not exist much difference.

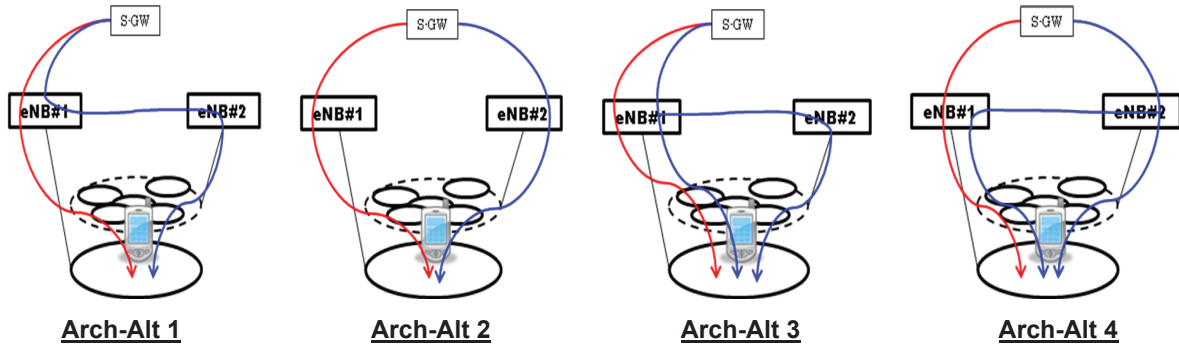
2.1 Consideration of the U-plane architecture for dual connectivity

In Rel-10/11, a UE is basically served by one eNB. With dual connectivity, a UE can be served by multiple-eNBs connected to each other with non-ideal backhaul (i.e., excluding RRH). In that sense, the following questions should be considered to investigate the U-plane architecture:

- QUESTION 1) Who is responsible for bearer routing, eNB or Core Network?
- QUESTION 2) Can multiple-radio bearers be mapped on one EPS bearer?

Considering above QUESTIONS, the following alternatives can be foreseen:

- ✧ **Arch-Alt 1) eNB routing and one radio bearer can be mapped on one EPS bearer**
- ✧ **Arch-Alt 2) CN routing and one radio bearer can be mapped on one EPS bearer**
- ✧ **Arch-Alt 3) eNB routing and multiple-radio bearers can be mapped on one EPS bearer (multi-flow)**
- ✧ **Arch-Alt 4) CN routing and multiple-radio bearers can be mapped on one EPS bearer (multi-flow)**



NOTE1: Real-time service is assumed to be served by macro-cell layer [4]; Red line is a real-time data bearer (e.g. VoIP), and Blue line is a Best Effort bearer

NOTE2: Assuming eNB#1 as macro-eNB, and eNB#2 as small eNB.

NOTE3: Multi-flow CN routing (i.e., one EPS bearer split in CN and sent via eNB#1 and eNB#2) is excluded because the significant impact on CN is foreseen.

We show the comparison table of the alternatives:

Table.1 Comparison table of Arch-Alt

Comparison Item	Arch-Alt1	Arch-Alt2	Arch-Alt3	Arch-Alt4
Alternative Description	-eNB routing with single-flow	-CN routing with single-flow	-eNB routing with multi-flow	-CN routing with multi-flow split in eNB
CN impact/Cost	-No impact	-Small (NOTE1) -CN signaling load	-No impact	-Small (NOTE1) -CN signaling load
eNB impact/Cost	-Medium (NOTE1) on macro-eNB -Potential impact on small eNB (NOTE2)	-No impact on macro-eNB -Potential impact on small eNB (NOTE2)	-Large (Data flow control is needed) on macro eNB	-Large (Data flow control is needed) on anchor eNB
UE impact	-Not so large	-Not so large	-Large	-Large
Additional latency caused by backhaul between eNBs	-Yes	-No	-Yes	-Yes
System performance (High Tput)	-Peak data rate cannot be achieved (NOTE3)	-Peak data rate cannot be achieved (NOTE3)	-More chance to achieve peak data rate	-More chance to achieve peak data rate
Security (NOTE4)	-Can be robust	-May not be robust	-Can be robust	-May not be robust

Applicable for separate carrier scenario	-Applicable			
Applicable for co-channel scenario	-Applicable, coordination for resource allocation between eNBs is needed	-May not be applicable, coordination for resource allocation between eNBs may be challenging	-Applicable, coordination for resource allocation between eNBs is needed	-Applicable, coordination for resource allocation between eNBs is needed
Signaling load on bearer setup/release to/from small eNB, and bearer re-establishment	-Small	-Large	-Small	-Large

NOTE1: CN/eNB is already equipped with per UE per bearer routing functionality. Additional function is to enable different routing address for per bearer of the same UE.

NOTE2: More CCs should be supported in one small eNB to achieve higher data rate.

NOTE3: Since no BE transmission via eNB#1, the maximum data rate corresponding to the number of CCs configured in UE cannot be achieved.

NOTE4: Security robustness for allocating security key management function in the small eNB is questionable, since malicious user might be able to reach the small eNB easily.

From the comparison table, following can be seen:

- For QUESTION1, the complexity of the routing node (eNB or CN) should be studied from the overall system point of view.
- For QUESTION2, although the average throughput is the main target of the small cell deployment, from the data rate perspective, the multi-flow operation should be supported, unless the significant impact on UE is foreseen.

From an operator point of view, the peak data rate is one of the important aspect, so the multi-flow is the desirable functionality.

Proposal1 : Arch-Alt 1 and 3 should be further studied for U-plane architecture.

2.2 Consideration of the U-plane protocol stack for dual connectivity

In Rel-10/11 CA, the protocol stack of U-plane is shown in Fig.1:

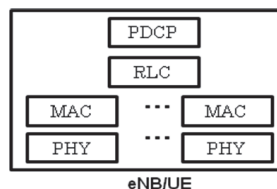


Fig.1 Protocol stack of CA in Rel-10/11

If the current protocol stack is reused, the protocol stack of the dual connectivity (dual connectivity) case is illustrated in Fig.2:

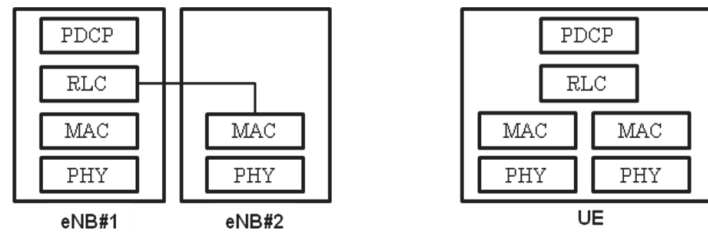


Fig.2 Protocol stack of dual connectivity utilizing Rel-10/11 CA

As shown in Fig.2, the common RLC has to manage MAC in different node. However, since RLC needs to obtain TBS dynamically from MAC, this type of protocol stack architecture is hard to realise especially in case of non-ideal backhaul. Therefore, for dual connectivity case, RLC is required to be located in each eNB.

Observation: Common RLC for multiple-eNBs is hard to be realized for dual connectivity.

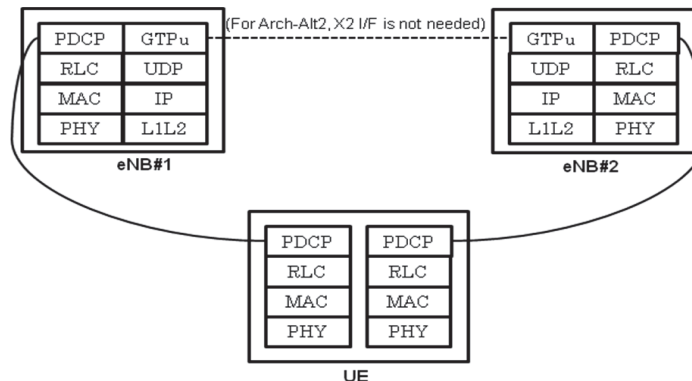
Proposal2: Protocol stack should be studied assuming the independent RLC in each node for dual connectivity.

On the other hand, since PDCP does not require dynamic operation, the following alternatives can be considered:

- ✧ **Alt A) Each eNB has independent PDCP**
- ✧ **Alt B) Distributed PDCP function in each eNB; Master-PDCP in anchor eNB and Slave-PDCP in other eNB**
- ✧ **Alt C) Only anchor eNB has the centralized PDCP**

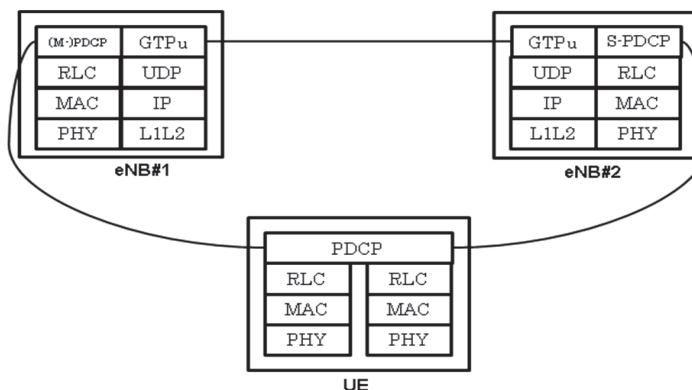
For each alternative, the protocol stack can be investigated:

➤ **Alt A) Each eNB has independent PDCP**



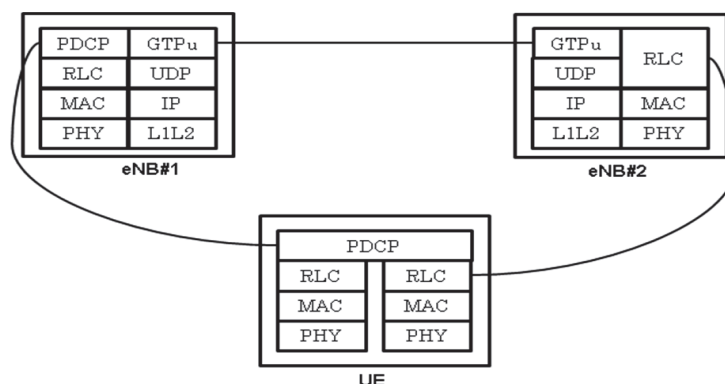
In this alternative, each eNB has PDCP independently, so the security of small eNB might not be robust. This alternative can be applicable to Arch-Alt1 and 2 (for Arch-Alt2, X2 I/F is not needed).

➤ **Alt B) Distributed PDCP function in each eNB; Master-PDCP in anchor eNB and Slave-PDCP in other eNB**



In this alternative, each eNB has PDCP, but for the bearer routed to the eNB#2, the Master-PDCP in anchor eNB (eNB#1) manages the PDCP SN (re-ordering) and, the Slave-PDCP in non-anchor eNB (eNB#2) manages other functions of PDCP. The security function is in eNB#2, so security might not be robust. This alternative can be applicable to Arch-Alt1, 3 and 4.

➤ **Alt C) Only anchor eNB has the centralized PDCP**



In this alternative, only the anchor eNB has PDCP (i.e., no PDCP in other eNBs) and thus, security will be robust. This alternative can be applicable to Arch-Alt1 and 3.

The comparison table is shown below:

Table.2 Comparison table of protocol stack Alt

Comparison item	Alt A	Alt B	Alt C
Alternative description	Independent PDCP	Master/Slave-PDCP	Centralized PDCP
Macro-eNB (eNB#1) impact/cost	-No impact	-Small impact to perform as Master-PDCP	-X2 impact to transfer RLC SDU
Applicability for U-plane architecture alternative	- Arch-Alt1 and 2 (※In Arch-Alt3/4, reordering is not possible)	- Arch-alt1, 3 and 4 (※In Arch-Alt2, coordination for M-/S-PDCP may not be possible)	- Arch-alt1 and 3 (※In Arch-Alt-2/4, PDCP is required in small eNB)
Security	- May not be robust	- May not be robust	- Robust

From the table, we think that to reduce the number of alternatives, following points should be discussed:

- **POINT1) Which Arch-Alt will be employed**
- **POINT2) How severe is the security requirement of small eNB. (i.e., whether the security management can be in the small eNB)**

As a way forward, we propose following:

Proposal3: Security requirement of the small eNB needs to be further studied.

3 Conclusion

In this document, the possible U-plane architecture and protocol stack for dual connectivity were addressed and following alternatives were shown:

- For U-plane NW architecture:
 - ✧ **Arch-Alt 1) eNB routing and one radio bearer can be mapped on one EPS bearer**
 - ✧ **Arch-Alt 2) CN routing and one radio bearer can be mapped on one EPS bearer**

- ✧ *Arch-Alt 3) eNB routing and multiple-radio bearers can be mapped on one EPS bearer (multi-flow)*
- ✧ *Arch-Alt 4) CN routing and multiple-radio bearers can be mapped on one EPS bearer (multi-flow)*
- For protocol stack:
 - ✧ *Alt A) Each eNB has independent PDCP*
 - ✧ *Alt B) Distributed PDCP function in each eNB; Master-PDCP in anchor eNB and Slave-PDCP in other eNB*
 - ✧ *Alt C) Only anchor eNB has the centralized PDCP*

Also, the followings were observed and proposed:

Proposal1 : Arch-Alt 1 and 3 should be further studied for U-plane architecture.

Observation: Common RLC for multiple-eNBs is hard to be realized for dual connectivity.

Proposal2: Protocol stack should be studied assuming the independent RLC in each node for dual connectivity.

Proposal3: Security requirement of the small eNB needs to be further studied.

4 References

- [1] RP-122033, *New Study Item Description: Small Cell enhancements for E-UTRA and E-UTRAN – Higher-layer aspects*, NTT DOCOMO, INC
- [2] TR36.932, *Scenarios and Requirements for Small Cell Enhancements for E-UTRA and E-UTRAN*
- [3] TS36.300, *Overall description Stage-2*
- [4] R2-130444, *Deployment scenarios and design goals for dual connectivity*, NTT DOCOMO, INC