

Agenda Item: 15.3
Source: Fujitsu
Title: Discussion on Backhaul link of Type-1 Relay for LTE-A TDD
Document for: Discussion and Decision

1. Introduction

Relaying has been considered as one of the key techniques in LTE-A to improve system throughput and cell coverage. It is recommended that relay shall support LTE Rel.8 UEs to provide backward compatibility. For TDD systems, data and ACK/NACK feedback collision scenario for some TDD configurations is the main issue that should be avoided. A way forward [1] related to collision avoidance is agreed on by many companies in e-mail discussion after 3GPP RAN1 #56 meeting, that

- *A scheme supported in TDD*
 - ✓ *eNB → RN in DL subframes of the eNB and RN.*
 - ✓ *RN → eNB in UL subframes of the eNB and RN.*
- *Support of DL backhaul using UL resources for eNB → RN communication or UL backhaul using DL MBSFN for RN → eNB FFS.*

According to the WF, this contribution presents two different types of data and ACK/NACK collision scenarios and proposes several solutions to handle them.

2. Discussion

Since in-band relay in TDD system cannot be in transmitting mode and receiving mode simultaneously due to the self-interference, two types of data and ACK/NACK collision may exist.

- Type I collision is due to UE ACK/NACK feedback to RN interfering with UL backhaul data. For example, one DL subframe is used as RN to UE data transmission, and meanwhile the UL subframes corresponding to this DL subframes' ACK/NACK feedback are used as UL backhaul subframes. Thus, data and ACK/NACK collision happens.
- Type II collision is due to UE access link data interfering with backhaul link ACK/NACK feedback. For example, one UL subframe is used as RN to feedback ACK/NACK information to eNB, and meanwhile RN-served-UEs are transmitting data to RN. Thus, data and ACK/NACK collision happens.

2.1. Solution Using RN cell MBSFN for UL backhaul

Using RN cell MBSFN for UL backhaul is proposed in [1], which is illustrated in Fig.1. Subframe #3 in Fig.1 is served as UL subframe for eNB-served-UEs and MBSFN subframe for RN-served-UEs. Therefore different configurations are configured for different kind of UEs with TDD configuration #4

for eNB-served-UEs and TDD configuration #5 for RN-served-UEs. Since RN-served-UEs will not feedback ACK/NACK in subframe #3, Type I ACK/NACK collision is avoided.

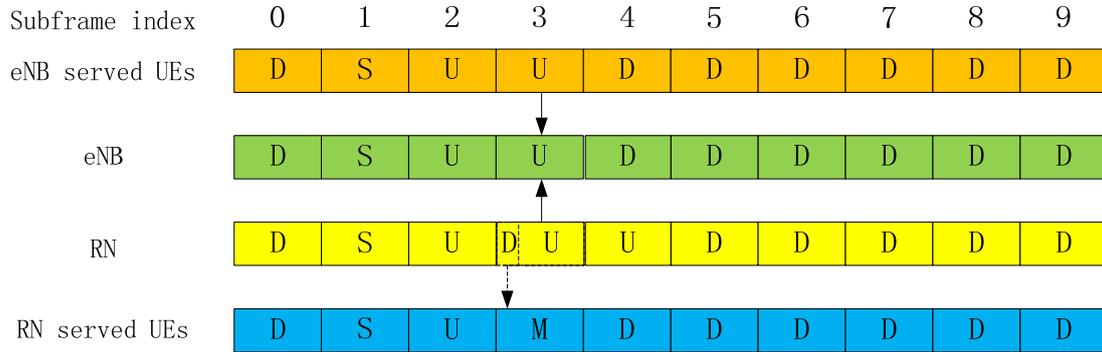


Fig.1 Using RN cell MBSFN for UL backhaul

However, as shown in Fig.2, RN in general transmits reference and control information to RN-served-UEs in the first one or two OFDM symbols in subframe #3, while eNB-served-UEs transmits partial control and/or data information in the same channel resource, interference may occur between these two kinds of information. We believe that the proposal should be validated by simulation to evaluate its relevant interference level.

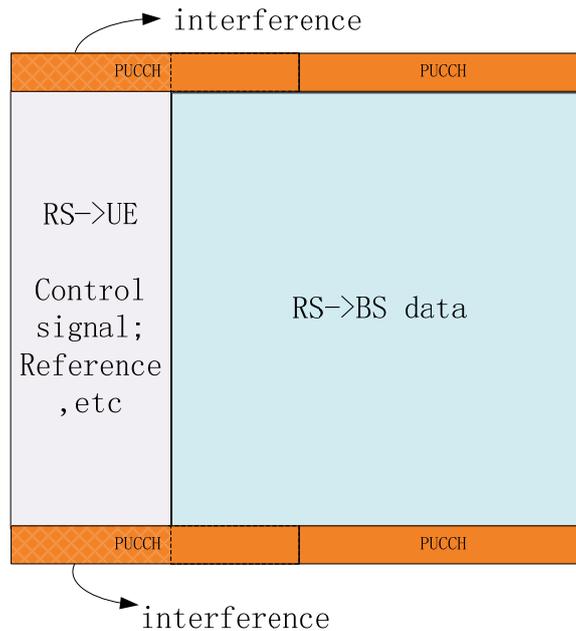


Fig.2 Interference issues

2.2. Solution Using eNB and RN cell MBSFN for UL backhaul

Using eNB and RN cell MBSFN for UL backhaul can be illustrated in Fig.3, where subframe #4 is served as MBSFN subframe for both eNB-served-UEs and RN-served-UEs. eNB and RN transmit control and reference signal to their corresponding UEs in the first one or two OFDM symbols. The following OFDM symbols, in turn, are served for UL backhaul transmission. For this purpose, subframe #4 for eNB should be configured to a specific subframe as illustrated in Fig.4, where eNB

switches from transmitting to receiving mode right after the first one or two OFDM symbols. This results in that eNB is capable of receiving RN data. Of course, it requires switching back from receiving to transmitting mode for next coming subframe. It is worthwhile noting that in reality, two gaps should be reserved for switching points to avoid the interference.

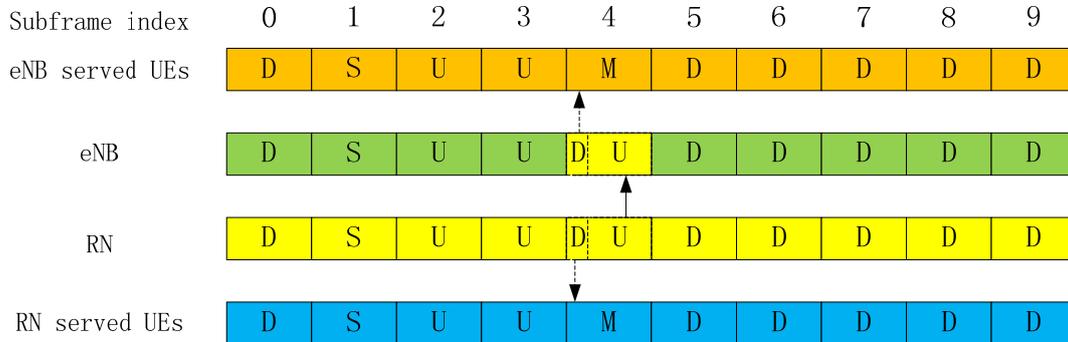


Fig.3 Using eNB and RN cell MBSFN for UL backhaul

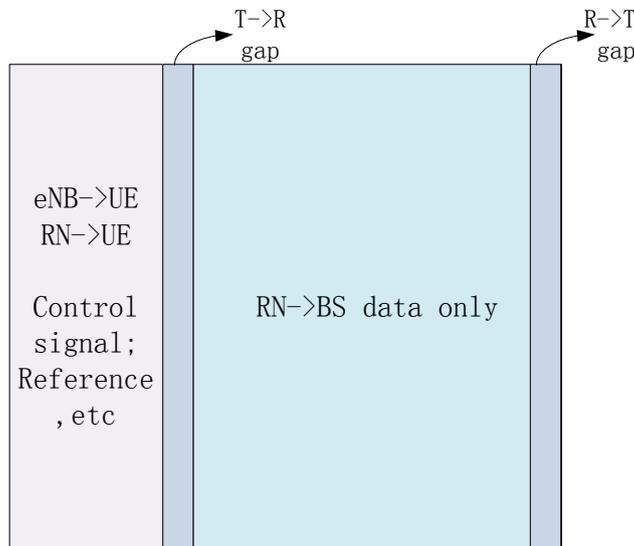


Fig.4 Interference issues

Here since an eNB DL subframe is stolen and configured to such a specific subframe to be served as UL backhaul, Type I collision is avoided. However, two kinds of interference occur:

1. As the serving eNB is in receiving mode in multiple OFDM symbols period in this specific subframe, while at the same time neighbouring eNBs is in transmitting mode, interference from the neighbouring eNBs to the serving eNB occurs.
2. As Relay is in transmitting mode in a DL subframe, while at the same time UEs in the neighbouring cells is in receiving mode, interference from Relay to neighbouring UEs occurs.

It should be noted that since multiple OFDM symbols in this specific subframe are dedicated for RN to transmit data to eNB, the transmit power can be properly adjusted to ensure the minimum required SINR for UL backhaul, and meanwhile not cause much interference to neighboring UEs. The interference level should be confirmed in a system level evaluation.

2.3. Subframe pairing

For TDD configuration #1 and #3, subframe pairing is proposed to avoid Type I and Type II ACK/NACK collision. Fig.5 depicts subframe pairing for configuration #1. Subframes #3 and #9 can be paired such that subframe #3 serves as UL backhaul and subframe #9 serves as DL backhaul. Type I ACK/NACK collision can be avoided because subframe #3 is only corresponding to ACK/NACK feedback of subframe #9 and subframe #9 does not contains RN to UEs data transmission. Similarly, Type II ACK/NACK collision can be avoided as well because after eNB transmitting data to RN in subframe #9, RN feeds back ACK/NACK to eNB multiplexing with data. Additionally, no RN served UEs is scheduled in subframe #3. Alternatively, Subframe #4 and #9 can also be paired with the same reason.

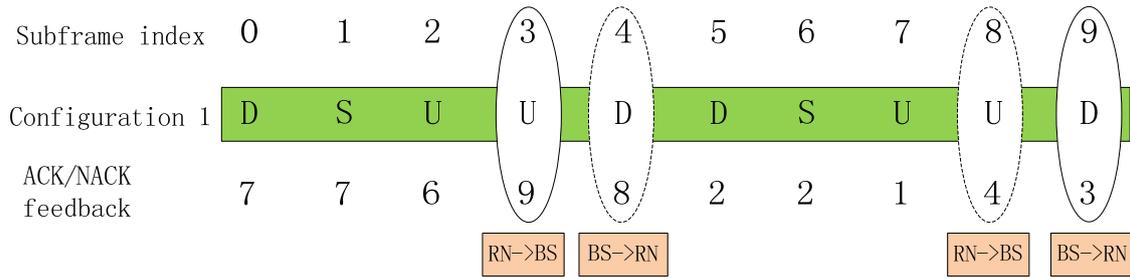


Fig.5 subframe pairing for configuration 1

Fig.6 depicts subframe pairing for configuration #3. Subframe #3 and (#7,#8) can be paired such that subframe #3 serves as UL backhaul and subframe (#7, #8) serves as DL backhaul. Type I collision can be avoided because subframe #3 is only corresponding to ACK/NACK feedback of subframe #7 and #8. Similarly, Type II collision can be avoided after changing Relay HARQ timing, i.e., changing eNB ACK/NACK feedback to RN in subframe #8, instead of in subframe #9.

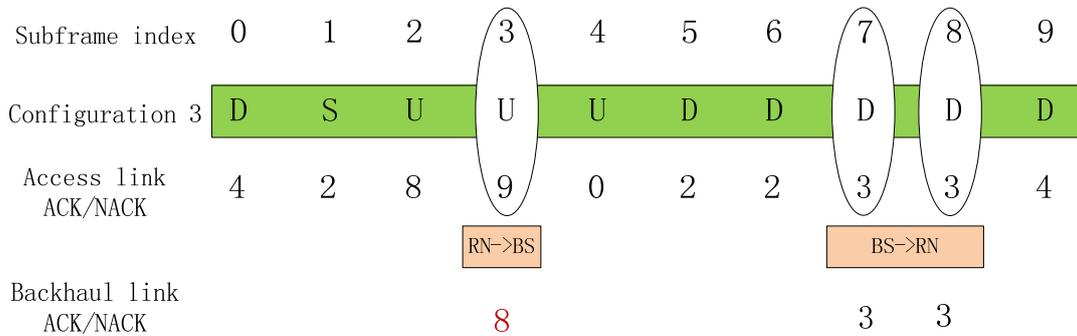


Fig.5 subframe pairing for configuration 3

3. Conclusions

In this contribution, we have discussed backhaul link of Type-1 Relay for LTE-A TDD system, mainly on the issues of data and ACK/NACK collision. By exposing two different types of data and ACK/NACK collision scenarios, we have proposed several schemes as resolvable solutions, including

- Solution of using eNB and RN cell MBSFN for UL backhaul. Relay shall adjust the transmitting power to meet the SINR requirement.
- Subframe pairing for configuration #1 and #3. Relay may adjust backhaul link ACK/NACK feedback timing.

Reference

- [1] R1-091124, “WF on Access-Backhaul partitioning of Relays”, Nokia, Nokia Siemens Networks.
- [2] R1-090734, “Considerations on TDD Relay”, Nokia, Nokia Siemens Networks, 3GPP RAN1 #56 meeting, Athens Greece.