

Agenda Item: 15.2
Source: Fujitsu
Title: Efficient HARQ Protocol for SIC based DL CoMP
Document for: Discussion and Decision

1. Introduction

In the early LTE study item [1], there was some kicking off discussion related to the macroscopic-diversity, involving a collaborative transmission. Due to the difficulties in allocating the data into different eNode-Bs from higher layer, this technique has been abandoned. As a consequence, it has been decided that the data is only allocated into one eNode-B in order to simplify its implementation.

Recently, LTE-Advanced standard is being developed for 4th generation system (4G), where the fairly aggressive target in system performance requirements have been defined, particularly in terms of spectrum efficiency for both down-link (DL) and up-link (UL) [2]. In order to accomplish such a target, somewhat fruitful suggestions have been offered by the companies to use, such as transmit beamforming, inter-cell interference coordination, and relaying. Among them, the issue relevant to the coordinated multi-point (CoMP) transmission has been raised again for rethinking of its possibility of the implementation [3]-[7]. Considering the target of the cell edge user throughput which is set to be roughly 1.4 higher than that of release-8 LTE, it seems that the CoMP transmission is necessarily included as a major candidate in LTE-Advanced techniques.

Prior to adopting the CoMP technique in LTE-Advanced, there exist many issues which are needed to be clarified, such as data and control channel between eNode-Bs through X2 interface, transmission timing, centralized user packet scheduling over multiple eNode-Bs, and hybrid automatic-repeat-request (HARQ) process. Among them, one of the biggest concerns is related to the HARQ, which may influence the possibility whether this potential transmission technique should be included in LTE-Advanced or not. From this perspective, our intention in this contribution is focused on the design of how to properly and efficiently manipulate the HARQ process for the CoMP transmission.

One most important behavior for HARQ is that after HARQ combining, the block error rate (BLER) is normally beneath 1%, which naturally aims at facilitating the successive interference cancellation (SIC) process. This means that it is better for the UE to detect the retransmit packet first and then the other packet (either new packet or retransmit packet) by means of employing SIC mechanism. In this contribution, we investigate that when the CoMP transmission is in process, the efficient data transmission as our HARQ proposal is to deliver one new packet and one retransmission packet simultaneously from two coordinated eNode-Bs or points, and the relevant control signals are only allowed to be exchanged between one predetermined eNode-B and UE. The motivation of doing such a way is not only to significantly improve the system capacity but also to efficiently reduce the control channel burdens.

In the CoMP transmission, in general, the MIMO fashion is involved, where the precoding matrices are jointly designed such that the intended signals are orthogonal to the interference signals. Such a type of transmission may be considered as a coherent transmission. In our discussion, for simplicity at this stage, we do not taken into account the precoding feature and MIMO gain is only achieved at the

receiver by means of a minimum mean square error (MMSE) process (a type of non-coherent transmission). We believe that it is the same tendency of the capacity gain that happens to precoding based MIMO if the proposed HARQ CoMP transmission is involved.

The system level simulation confirms that the proposed HARQ CoMP transmission provides additional signal-to-noise ratio (SNR) gain significantly. Furthermore, the relevant control channels including physical uplink control channel (PUCCH), physical downlink control channel (PDCCH), and X2 based control channel (X2CCH) can be reasonably minimized.

2. HARQ Protocol for DL CoMP Transmission

In this section, we specify the system network model, and categorize the CoMP transmission by four types of scenarios. Each scenario corresponds to different channel resource allocation and requires different control channel designs. From the perspective of system performance and control channel efficiency, we attempt to select the best scenario for DL CoMP transmission.

2.1. Network Model

Without loss of generality, we simply assume that the network contains two eNode-Bs cooperatively serving certain UEs who are located in the cell edge; one denotes serving eNode-B (or S-eNB) and the other denotes collaborative eNode-B (or C-eNB), as illustrated in Figure 1. The determination of whether eNode-B belongs to serving or collaborative eNode-B is based on the long-term power strength received by each UE. Hence, the status of eNode-B for each UE could be different dependent on UE location. We reasonably define that the long-term power strength received by each UE from serving eNode-B is always higher than that from collaborative eNode-B. We further assume that the transmissions from serving eNode-B and collaborative eNode-B are perfectly synchronized. The network is concerned that the link between serving eNode-B and UE plays a more important role than the link between collaborative eNode-B and UE, because we believe that the most control signals are communicated through the link between serving eNode-B and UE.

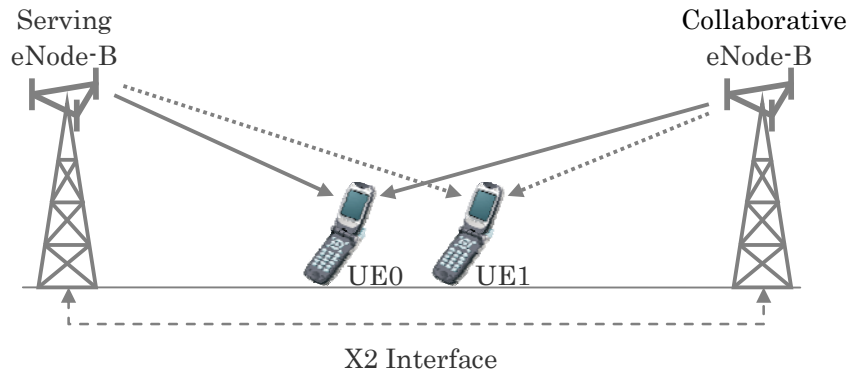


Figure 1: CoMP DL transmission.

2.2. Categorization of CoMP Transmission

There are four scenarios in which data is simultaneously delivered to the cell edge UE from both serving and collaborative eNode-Bs, by means of the CoMP transmission as illustrated in Figure 2. For simplicity, the description relies only on a single UE scenario.

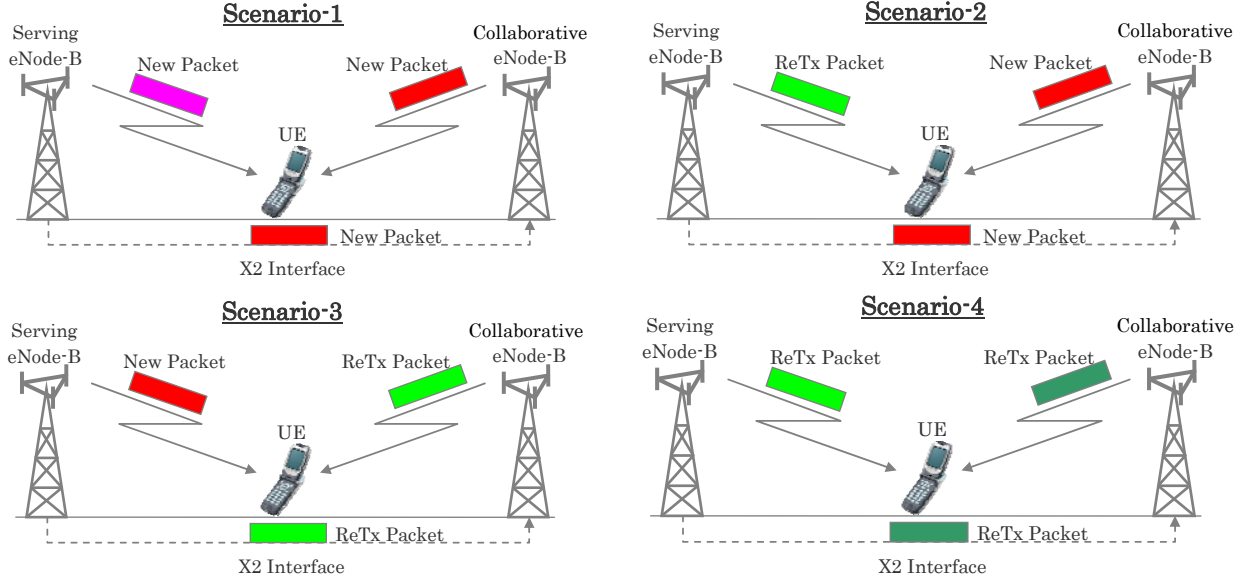


Figure 2: DL CoMP HARQ transmission (4 scenarios).

In scenario-1, we assume that only new data packets need to be delivered from serving eNode-B to the cell edge UE. In order to collaboratively accomplish the CoMP transmission, some of new data packets have to be forwarded from serving eNode-B to its collaborative eNode-B through X2 interface, and then deliver them simultaneously from both eNode-Bs to the corresponding UE. At UE site, an MMSE receiver may sufficiently suppress the interference from each other.

In scenario-2, we assume that there are two types of transmit packets needed to be delivered to the cell edge UE; one belongs to retransmit data packet and the other to new data packet. The retransmit data packet must be delivered from serving eNode-B to the UE while the new data packet forwarded through X2 interface must be delivered from collaborative eNode-B to the UE. At UE site, an MMSE plus SIC receiver may sufficiently suppress and cancel the interference from each other.

In scenario-3, the same assumption is made as scenario-2 that there are two types of transmit packets; retransmit data packet and new data packet. Dissimilar to scenario-2, the new data packet must be delivered from serving eNode-B to the UE while the retransmit data packet must be delivered from collaborative eNode-B to the UE. In this case, the retransmit data packets have to be forwarded from serving eNode-B to collaborative eNode-B through X2 interface. At UE site, an MMSE plus SIC receiver may sufficiently suppress and cancel the interference from each other.

In scenario-4, we assume that only retransmit data packets need to be delivered from serving eNode-B to the cell edge UE. To collaboratively accomplish the CoMP transmission, some of retransmit data packets have to be forward from serving eNode-B to its collaborative eNode-B through X2 interface, and then deliver them simultaneously from both eNode-Bs to the corresponding UE. At UE site, an MMSE plus SIC receiver may sufficiently suppress and cancel the interference from each other.

Here, we believe that the scenario-2 and scenario-3 are better transmission manners which may give the highest diversity gain due to macroscopic transmit antennas and cancellation gain due to SIC mechanism. This is because the BLER for retransmit data packet after HARQ combining is low enough, beneficial to detect the retransmit data packet first, and then the new data packet by means of SIC. The rule of CoMP transmission, therefore, should be always taking one new data packet and one retransmit data packet, and sending them simultaneously from both serving and collaborative eNode-Bs.

According to our system level simulation results as will be discussed in section 4.1, we have observed that the probability of retransmission is 8~10% if the UE is traveling at a speed of 3km/h, while the probability of retransmission could increase to 70~80% if traveling at a speed of 30km/h. Therefore, the probability of retransmission by mixing up the UEs who are traveling at the different speeds could be roughly estimated with 30~40%, which results in 23~29% CoMP HARQ transmission between new and retransmit data packets. We believe that the possibility of taking scenario-1 is around 70% as a normal CoMP transmission without HARQ process in which there is no special concerns, while the possibility of taking scenario-4 could be almost zero since scenario-4 does not happen in real system due to the low probability of HARQ transmission.

From the perspective of efficient control channel design, according to the late discussion in section 3, we believe that scenario-2 is the better candidate elected for CoMP HARQ transmission. Throughout this contribution, therefore, our main attention is paid to the discussion on scenario-2, but compared to scenario-3 as a reference

2.3. CoMP HARQ Transmission

Figure 3 depicts the DL CoMP HARQ transmission flow for Scenario-2, where if a new data packet received at the UE is in error (e.g., #0 new data packet) it is possibly retransmitted from serving eNode-B simultaneously with a new packet which is delivered from collaborative eNode-B (e.g., #12 new data packet) aligned with the synchronized transmit timing determined by serving eNode-B. The same process occurs to #4 (or #11) retransmit packet with #17 (or #15) new data packet, and so on.

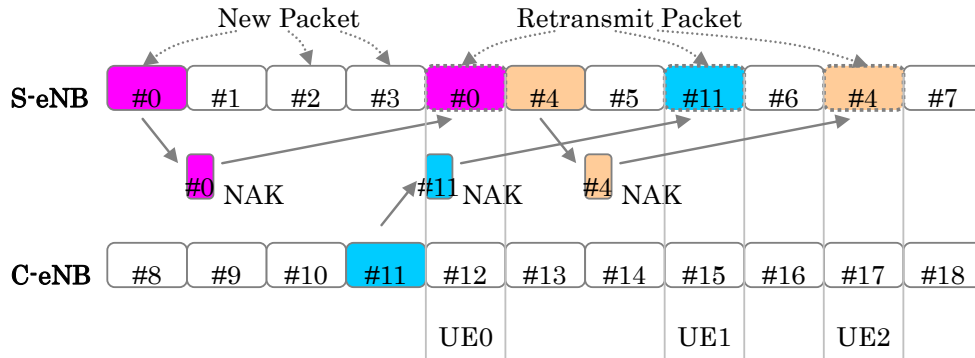


Figure 3: DL CoMP HARQ transmission for scenario-2.

Figure 4 depicts the DL CoMP HARQ transmission flow for Scenario-3, where if a new data packet received at the UE is in error (e.g., #0 new data packet), it has to be forwarded with its relative control channel to collaborative eNode-B through X2 interface, and then be delivered from collaborative eNode-B simultaneously with a new data packet from serving eNode-B (e.g., #4 new data packet) aligned with the synchronized transmit timing determined by serving eNode-B. The same process occurs to #5 (or #14) retransmit packet with #9 (or #7) new data packet, and so on.

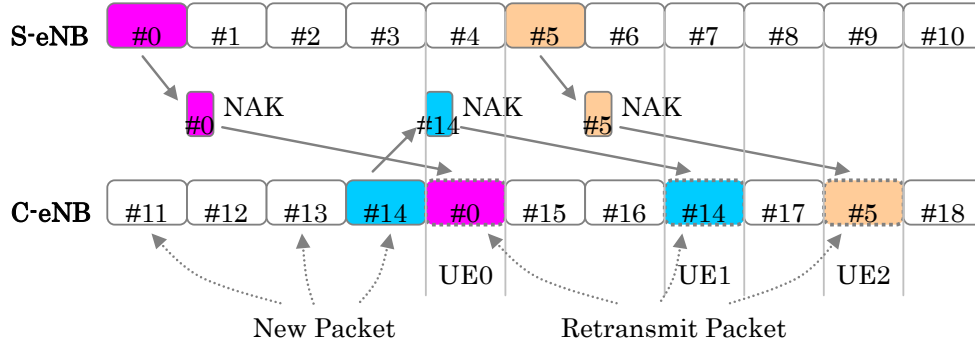


Figure 4: DL CoMP HARQ transmission for scenario-3.

2.4. SIC based Reception

We assume that SIC is employed in each UE receiver for scenario-2 and scenario-3. Figure 5 illustrates the receiver block diagram, which is composed of retransmit packet detector part and new packet detector part. The retransmit packet detector contains HARQ combiner, HARQ buffer, demodulator and decoder, while the new packet detector contains encoder, modulator, SIC canceller, demodulator and decoder.

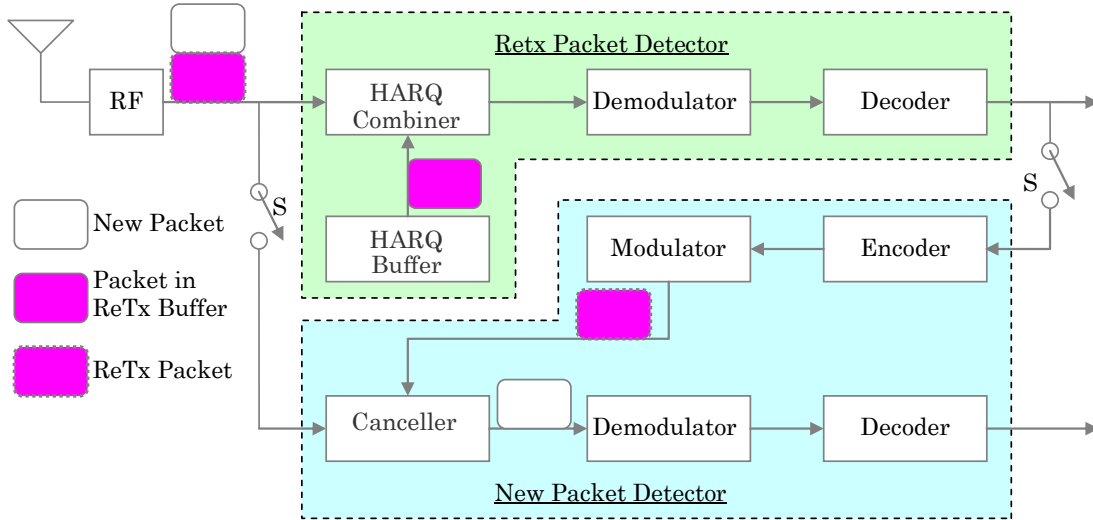


Figure 5: The block diagram of receiver for CoMP HARQ for scenario-2 and scenario-3.

In the retransmit packet detector, the received signal is first combined with the stored initial packet in HARQ buffer, and then the resultant signal is demodulated and decoded. If only if the retransmit data packet is successfully detected, it turns the switch S on and passes the outputs into the new packet detector.

In the new packet detector, if some data signal is input from the retransmit packet detector, the encoder and modulator is invoked, replicating exactly the same retransmit packet which is utilized for cancellation purpose, and otherwise, the input of canceller is set to zero, equivalently disabling the SIC canceller. The demodulator and decoder in new packet detector should be always functioned properly no matter what the output from canceller is.

For the canceller equipped with SIC, we assume that the channel is perfectly estimated by means of reference signal (RS), for instance. The RSs between serving and collaborative eNode-Bs may be reasonably assumed to be orthogonal to each other by utilizing the same RS pattern but shifting differently.

2.5. Channel Resource Allocation and User Scheduler

The retransmit data packet is always on higher priority. This means that if a retransmit data packet is decided to be transmitted on the link from either serving eNode-B (scenario-2) or collaborative eNode-B (scenario-3), the other link must assign new data packet for the same UE, both using the same channel resource.

It is worthwhile noting that the channel resource allocation and the user scheduling for CoMP transmission have to be centralized by serving eNode-B.

2.6. Important Parameters for CoMP Transmission

Here, we introduce a very important parameter denoted the link gap Δ_{ue} , alternatively called reference signal received power (RSRP) difference used in LTE as a terminology, which is defined as the difference of received signal power by UE in decibel between the serving eNode-B and the collaborative eNode-B. This parameter is used to control whether a CoMP transmission is taken place or not. If the link gap Δ_{ue} is small than a predetermined link gap target Δ (as another parameter), the CoMP transmission should be taken into account, and otherwise the normal transmission is preferable. Using those parameters, therefore, we may easy to control the zone width for CoMP transmission.

3. Control Channel Design for HARQ CoMP

In the control channel design, our attention is focused on three channels; physical uplink control channel (PUCCH), physical downlink control channel (PDCCH), and X2 based control channel (X2CCH). In addition, the control channel is designed according to scenario-2 because we believe that this scenario gives the better system performance and lower complexity, for both control and data channels. This conclusion will be confirmed in our system level simulation evaluated in section 4. Figure 6 illustrates the data and control channels with specific flow directions, where certain constraints for both types of channels are considered as follows:

- New data packet is allowed to be transmitted on both links: serving eNode-B to UE and collaborative eNode-B to UE.
- Retransmit packet is only allowed to be transmitted on the link from serving eNode-B to UE.
- PUCCH denoted as C1 must be transmitted on the link from UE to serving eNode-B.
- PDCCH denoted as C2 must be transmitted on the link from serving eNode-B to UE.
- Only new data packet and its relevant control signal are delivered from serving eNode-B to collaborative eNode-B by means of X2 interface. The control channel in X2 interface is denoted as C3.

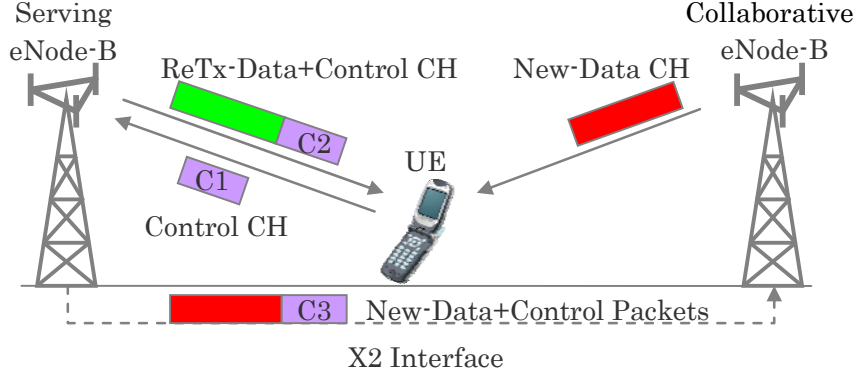


Figure 6: Data channel and control channel for scenario-2.

With such a control channel design for CoMP transmission, the fundamental features are to efficiently reduce the control channel amount and extremely shorten the system latency due to the mono-directional HARQ process. In what follows, we individually design these three channels, and give some brief descriptions.

3.1. PUCCH Design

In our design, PUCCH corresponds to uplink control information (UCI) comprising both periodic control signals. One contains channel quality indication (CQI), precoding matrix indication (PMI), and rank indication (RI), denoted CQI/PMI/RI, and the other contains HARQ-ACK/NAK. PUCCH is only transmitted on the link from UE to serving eNode-B, depicted by C1 in Figure 6. This requires that each active UE must be capable of separating the serving eNode-B and the collaborative eNode-B, by high layer control signal, for instance.

3.1.1. Periodic UCI CQI/PMI/RI

Each UE estimates the channel response according to reference signal (RS) from serving eNode-B as well as collaborative eNode-B. This requires orthogonally assigning the RS between both eNode-Bs. In periodic UCI, the contained CQI/PMI/RI corresponds to both link qualities; link from serving eNode-B to UE and link from collaborative eNode-B to UE. Most important thing is that the corresponding UCI is only sent to its serving eNode-B, with following two reasons:

- In general, the link quality from serving eNode-B to UE is better than that from collaborative eNode-B to UE. This ensures the link performance for UL control channel.
- It may significantly reduce the control channel amount and simplify the control channel design.

Figure 7 exemplifies the UCI for both links, where it contains two individual CQIs for both links, and corresponding PMI and RI. Note that the field information relevant to PMI and RI should be identical for both links.

CQI-1	CQI-2	PMI	RI
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Figure 7: An example for UCI with CQI/PMI/RI on PUCCH.

3.1.2. UCI HARQ-ACK/NAK

HARQ-ACK/NAK is only sent to serving eNode-B due to the unique transmission property for scenario-2, in which the retransmit packet must be delivered from serving eNode-B. Several reasons may be given as follows:

- It may reduce the transmission latency for retransmit packet due to the HARQ process.
- It may simplify the control channels including PDCCH and X2CCH.
- It may reduce the complexity for collaborative eNode-B, because the transmitted new packet is never remained in the buffer located at collaborative eNode-B. Collaborative eNode-B only carries out the new packet transmission by following up the control channel (X2CCH) from X2 interface.

With respect to the fields of HARQ-ACK/NAK, it must include both corresponding ACK/NAK signals (2 bits) for both collaborative transmit data packets if considering two different code words.

3.2. PDCCH Design

PDCCH is only sent by serving eNode-B to its served UE denoted as C2, depicted in Figure 6; in other words, each UE only blindly decodes the PDCCH from its serving eNode-B. Two reasons can be given as follows:

- The link quality from serving eNode-B to UE is better than that from collaborative eNode-B to UE. This ensures the performance for control channel.
- Transmitting the PDCCH from one link could efficiently relax the control channel design, and significantly reduce the burden of blind detection.

It is worthwhile noting that PDCCH is capable of indicating whether the CoMP transmission is in use or not. For this purpose, we need to introduce a new bit. Another notation is that PDCCH is used to indicate the transmission scenario, whether scenario-1 and scenario-2 for instance. This can be accomplished by using the existing new data indicator bit already specified in LTE standard.

The following information for the link from collaborative eNode-B to UE is transmitted on DCI of PDCCH from serving eNode-B to UE:

- With Format 1, Format 1A, and Format 1C, only additional modulation and coding scheme (MCS) – 5bits is necessary.
- With Format 2, additional MCS (5bits) and precoding information are necessary.

The DCI for both links should be encoded together protected by the UE specific CRC. An example of PDCCH with Format 2 is depicted in Figure 8.

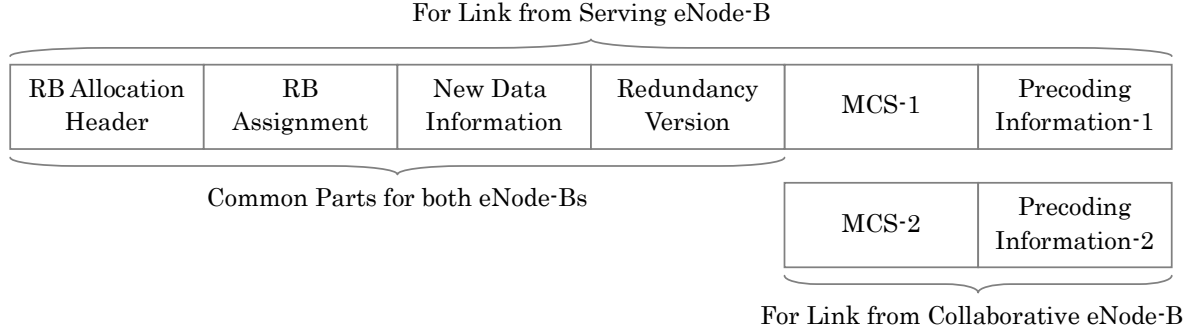


Figure 8: An example for DCI of PDCCH.

3.3. X2 based Control Channel Design

X2 based control channel (X2CCH) should be delivered with its corresponding data packet through the X2 interface denoted as C3 in Figure 6. The X2CCH contains the following information:

- Resource allocation header – 1 bit
- Resource block assignment
- Modulation and coding scheme – 5bits
- Precoding information
- Transmission timing in sub-frame

3.4. Timing between PDCCH and X2CCH

The transmission timing control is one of most important issues for CoMP transmission, which is determined by serving eNode-B and indicated to collaborative eNode-B by means of X2 interface. The transmission timing must take into account the latency of X2 interface and processing time, synchronized between the coordinated eNode-Bs. Figure 9 exemplifies the transmission timing between control channel and data channel. In this case, the data and its related X2CCH have to be forwarded to collaborative eNode-B prior to its related CoMP transmission from serving eNode-B to UE. The data transmit timing from collaborative eNode-B is determined by serving eNode according to the maximum latency of X2 interface. Thanks to the synchronization network between serving and collaborative eNode-Bs, the data from serving eNode-B and the data from collaborative eNode-B centralized by serving eNode-B are delivered on the predetermined timing, which may ensure that both data are received within the cyclic prefix window.

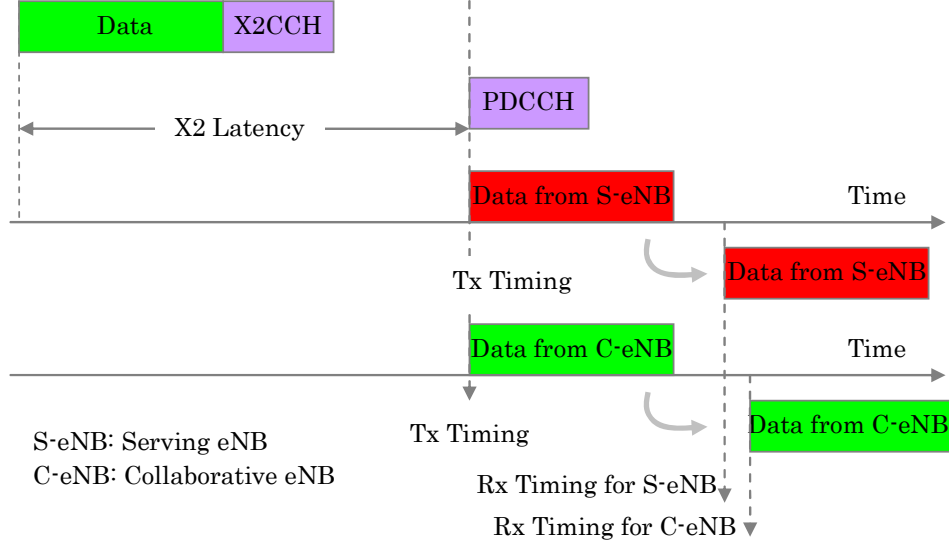


Figure 9: An example of transmission timing between control channel and data channel.

4. Performance Evaluation

To evaluate the performance of the proposed scheme, a system level simulation is taken into account. The system level simulation is implemented in a cell network formed with 7 clusters; each cluster consists of 19 hexagonal cells and each cell contains 3 sectors. The antenna of the sector is orientated with bore-sight point to the side of hexagon. To accurately model interferences incident from outer-cells, a wrap around network structure with 7 copies of the centre hexagonal cluster is employed, where the original cluster is placed in the middle and 6 copies are attached on the side symmetrically. The simulation cases and the simulation assumptions are tabulated in Table 1 and Table 2, respectively [1].

Table 1: UTRA and EUTRA simulation case minimum set.

Simulation n	CF	ISD	BW	PLoss	Speed	Channel
Cases	(GHz)	(meters)	(MHz)	(dB)	(km/h)	Model
1	2.0	500	10	20	3	TU
2	2.0	500	10	10	30	TU
3	2.0	1732	10	20	3	TU

Table 2: System level simulation assumptions.

Parameter	Value
Number of Cells	19
Number of Sectors per Cell	3
Number of UEs per sector	20
Centre Frequency	2 GHz
Antenna Configuration	1x2
Transmission Power	40 Watts (46 dBm)
Lognormal Shadowing	8dB
Noise Figure	9 dB

eNB Transmit Antenna Gain	0 dBi
UE Receive Antenna Gain	14 dBi
Maximum CIR	30 dB
Path-Loss	$128.1 + 37.6 \log_{10}(R)$, R in km
Correlation for eNB-UE	0.5
Min Distance eNB-UE	35 meters
Thermal Noise Density	-174 dBm/Hz
eNB Antenna Pattern	70 degrees beam-width
UE Antenna Pattern	Omni-Directional
UE Receiver Type	LMMSE
Channel Model	TU
Channel Estimation	Ideal from RS
MCS Operating Point	10% BLER
HARQ Type	MI based Chase Combining

In our system level simulation, firstly, we confirm the BLER in each HARQ process without CoMP transmission, for which a full system level simulation is taken into account. Secondly, we evaluate the CoMP HARQ performance by compared between scenario-2 and scenario-3, in terms of signal and interference-to-noise ratio (SINR) at the current stage of the simulation, and further detailed system level simulation will be considered at the late stage.

4.1. BLER in HARQ Process

We perform a full system level simulation without CoMP transmission by evaluating the BLER for each HARQ process. Figure 10, Figure 11 and Figure 12 show the BLER per UE as a function of geometry with respect to the initial transmission, the retransmissions #1, #2, and #3, in case1, case2, and case3, respectively.

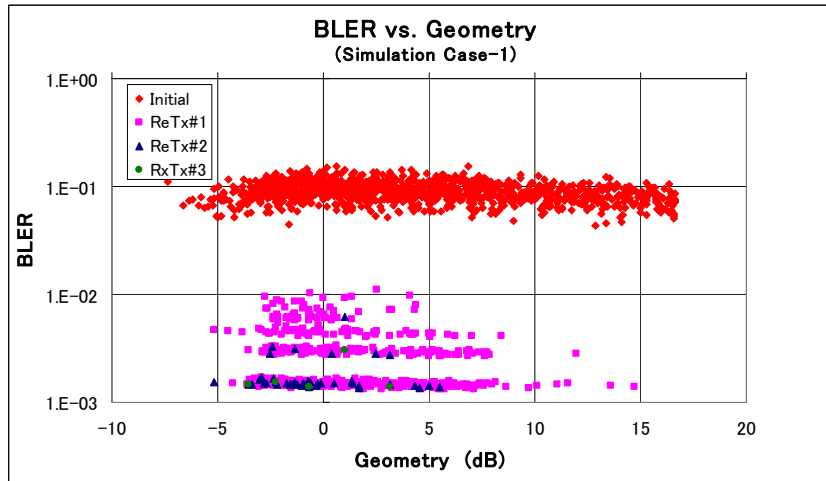


Figure 10: BLER per UE vs. geometry for initial transmission, retransmission #1, #2 and #3 in case1.

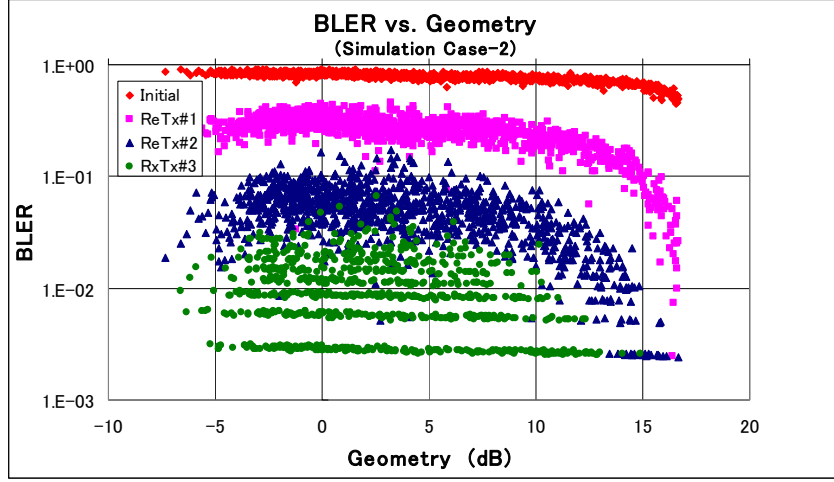


Figure 11: BLER per UE vs. geometry for initial transmission, retransmission #1, #2 and #3 in case2.

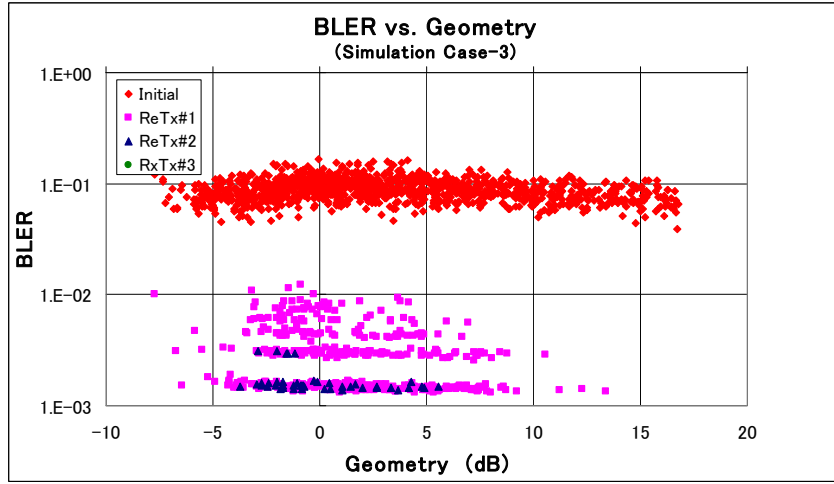


Figure 12: BLER per UE vs. geometry for initial transmission, retransmission #1, #2 and #3 in case3.

Table 3 summaries the average BLER over all the UEs for initial transmission, retransmission #1, #2, and #3 in case1, case2, and case3. It can be observed that the BLER for the initial transmission is around 9% for case1 and case3, and 78% for case2, whereas after the first retransmission, the BLER for case1 and case3 is beneath 0.1% and the BLER for case2 is beneath 25%. This surely aims at improving the system performance for CoMP HARQ transmission if a proper SIC receiver is implemented.

Table 3: The average BLER for initial transmission, retransmission #1, #2, and #3 in case1, case2, and case3.

Transmission Index	Case1	Case2	Case3
Initial Transmission	9.11E-02	7.83E-01	8.89E-02
Retransmission #1	1.21E-03	2.56E-01	1.20E-03
Retransmission #2	6.54E-05	4.79E-02	6.27E-05
Retransmission #3	7.69E-06	7.59E-03	0

4.2. SINR Gain from SIC Receiver

At the current stage of the simulation, only SINR metric is taken into account for the system performance evaluation. A full system level evaluation by calculating the sector aggregated throughput and user coverage will be considered at the late stage.

As defined in section 2.6, the parameter of link gap target Δ plays a very important role, which may influence the CoMP transmission. In our system level simulation, we use this parameter to control the zone width between coordinated eNode-Bs. The motivation of performing the system level simulation is to find out the gain achieved by scenario-2 as opposed to scenario-3. We start to plot out the CDF of received SINR among the CoMP transmission users for various specified values of link gap target Δ , 1dB, 10dB, and 19dB, whereby the SINR at a CDF point of 0.5 is able to be figured out. This may precisely show the benefit from the perspective of SINR performance for scenario-2.

It should be noted that in our simulation, we do not evaluate the performance for retransmission link because we simply assume that the link used to retransmit the data packet is always perfect with error free channel (refer to Table 3), and the performance evaluation is only focused on the link used to transmit the new data packet.

In what follows, some indications in the plotted figures are defined as

- Serving link, No-SIC: The SINR or SINR gain received by UE from serving eNode-B (or serving link) without SIC cancellation of the interference from collaborative eNodeB (or collaborative link). This corresponds to scenario-3.
- Collab link, No-SIC: The SINR or SINR gain received by UE from collaborative eNode-B (or collaborative link) without SIC cancellation of the interference from serving eNodeB (or serving link). This corresponds to scenario-2.
- Serving link, SIC: The SINR or SINR gain received by UE from serving eNode-B (or serving link) with SIC cancellation of the interference from collaborative eNodeB (or collaborative link). This corresponds to scenario-3.
- Collab link, SIC: The SINR or SINR gain received by UE from collaborative eNode-B (or collaborative link) with SIC cancellation of the interference from serving eNodeB (or serving link). This corresponds to scenario-2.

Figure 13, Figure 14, Figure 15 show the CDF of SINR received by UE, from serving eNode-B and collaborative eNode-B, with and without SIC, for various specified values of Δ , 1dB, 10dB and 19dB, respectively. As increasing the link gap target, the link quality between serving eNode-B and UE is getting better, and in addition, SIC is more functional for the link between collaborative eNode-B and UE.

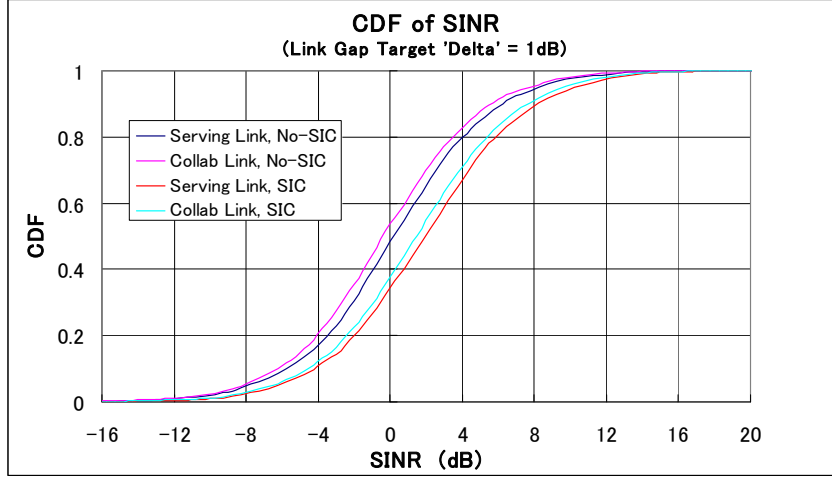


Figure 13: CDF of SINR for serving eNode-B and collaborative eNode-B, with and without SIC under the condition of $\Delta = 1\text{dB}$.

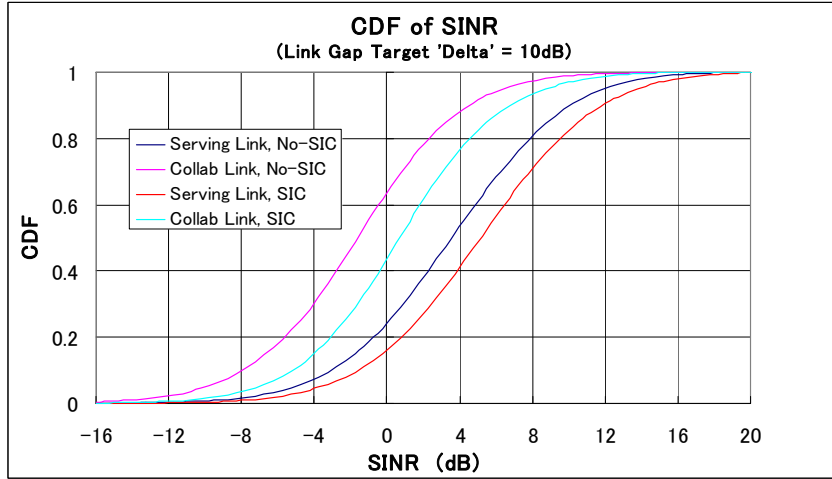


Figure 14: CDF of SINR for serving eNode-B and collaborative eNode-B, with and without SIC under the condition of $\Delta = 10\text{dB}$.

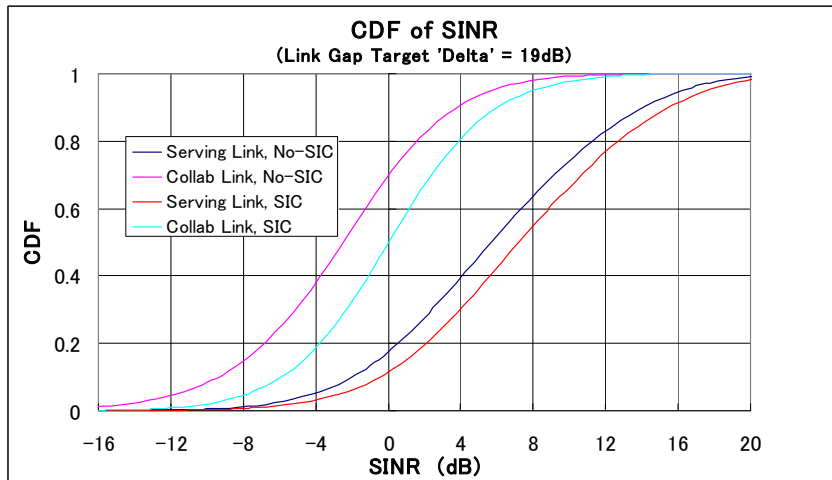


Figure 15: CDF of SINR for serving eNode-B and collaborative eNode-B, with and without SIC under the condition of $\Delta = 19\text{dB}$.

Figure 16 shows the probability of UEs, who are falling in the CoMP zone, and could be accounted for the cell edge users. For those UEs, thus, the CoMP transmission is taken place. It can be observed that when the link gap target Δ has a reasonable value around 8dB for instance, the percentage of cell edge users is near 60%, which is a fairly large percentage, requiring CoMP transmission.

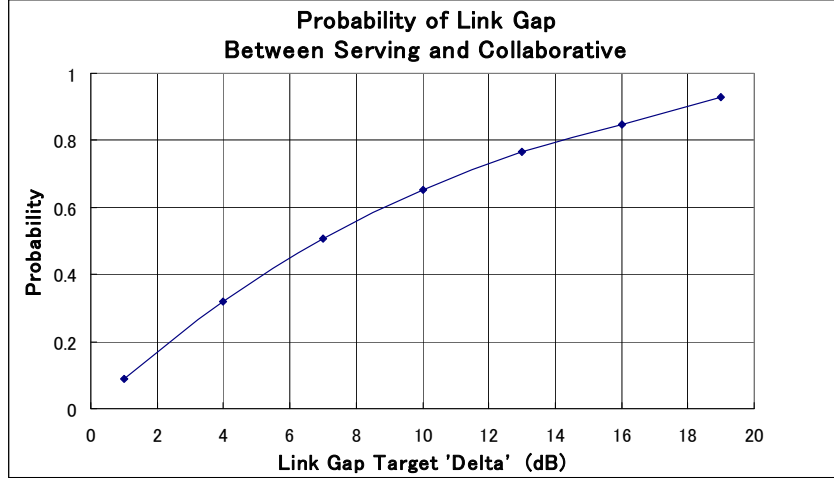


Figure 16: Probability of link gap between serving eNode-B and collaborative eNode-B.

Figure 17 shows the SINR of UEs as a function of Δ as a function of link gap target Δ , at the CDF value of 50%. From Figure 17, furthermore, we calculate the SINR gain between SIC and no-SIC for both scenarios as illustrated in Figure 18.

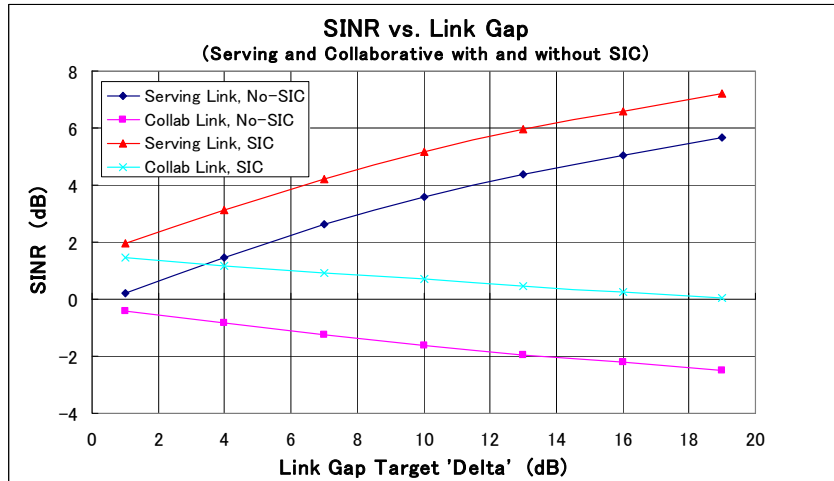


Figure 17: SINR vs. link gap between serving eNode-B and collaborative eNode-B, with and without SIC at CDF point of 0.5.

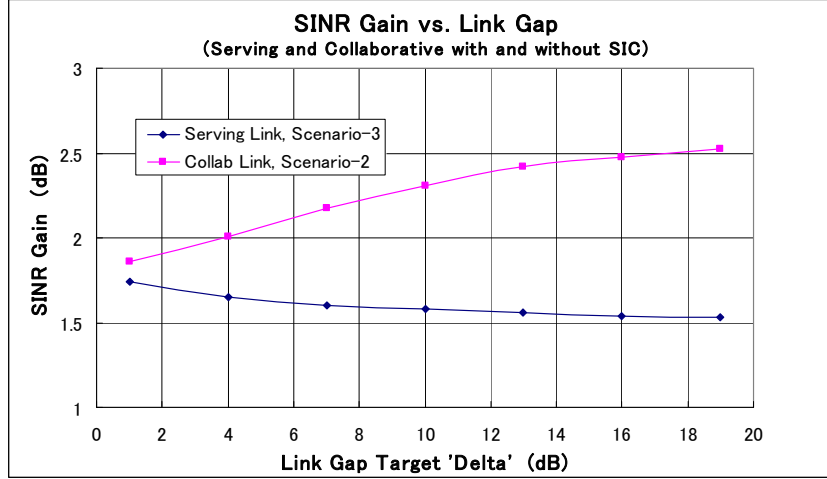


Figure 18: SINR gain due to cancellation vs. link gap between serving eNode-B and collaborative eNode-B at CDF point of 0.5.

Comparing the link from collaborative eNode-B to UE (denoted as link-1, scenario-2) and the link from serving eNode-B to UE (denoted as link-2, scenario-3), some observations and consequences can be made as follows:

- When the retransmit data packet is delivered from serving eNode-B, the SINR gain for the link-1 due to SIC is around 2~2.5dB. The gain could be even large if the MIMO related precoding mechanism is exploited.
- When the retransmit data packet is delivered from collaborative eNode-B, the SINR gain for the link-2 due to SIC is around 1.5~1.75dB
- The scenario-2 could achieve additional gain about 0.7dB as opposed to scenario-3. This is because link-1 is generally weaker than link-2, and cancelling a stronger link for scenario-2 achieves a higher SINR gain.
- When the value of Δ increases, the SINR gain of link-1 becomes larger while the SINR gain of link-2 becomes smaller. Thus, the value of Δ should not be too small or too large. The small Δ makes the probability of CoMP transmission too low while the large Δ makes the probability of CoMP transmission too high. The appropriate value of Δ is between 8dB and 10dB.
- From the perspective of SINR gain due to SIC, as a consequence, the retransmit data packet should be always delivered from serving eNode-B, corresponding to transmission scenario-2.

5. Conclusions

In this contribution, we have proposed an efficient HARQ protocol for CoMP transmission in order to achieve high SINR gain by means of SIC receiver. This proposal utilizes the HARQ unique behavior that UE always experiences low BLER after HARQ combining and facilitates SIC process even in nature. The consequences are as follows:

- In order to achieve a high SINR gain due to SIC, the retransmit data packet should be always delivered on the link from serving eNode-B to UE and meanwhile the new data packet should be delivered on the link from collaborative eNode-B to UE.

- For the control channel design, we focused on three channels; PUCCH, PDCCH, and X2CCH. From the perspective of considering the feasibility and simplicity, the control signals should be only exchanged between serving eNode-B and UE. This may significantly reduce the control channel amount and extremely shorten the system latency.

As our future work, we will complete a full system level evaluation to investigate the performance in terms of sector aggregated throughput and user coverage. Furthermore, a MIMO with precoding will be considered as a potential feature to further improve the system performance in CoMP HARQ system.

Reference

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