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Title: Consideration of X2 Backhaul for CoMP

Document for: Discussion and Decision

1. Introduction

Rel-11 CoMP scheme should be designed such that it can provide a reasonable performance gain in practical deployment situations. One of the key points to be considered in studying the suitability of each CoMP scheme is the characteristics of the backhaul link which connects the CoMP coordinating points. The reason is that the effectiveness of each CoMP scheme is highly dependent on whether the information required for the cooperative transmission can be exchanged in time among the coordinating points. The backhaul latency is categorized in [2] as follows:

- Minimal latency (in the order of μs) for eNB to RRH links
- Low latency (<1 ms) associated with co-located cells or cells connected with fibre links and only limited number of routers in between
- Typical inter-cell latency associated with X2 interfaces.

X2 based backhaul links could be a bottleneck reducing a CoMP gain because of its low-capacity and high-latency characteristics. Therefore, in this contribution, we discuss the suitability of CoMP schemes in the case where backhaul links connecting the CoMP coordinating points are implemented with X2 interfaces.

2. Impact of backhaul link quality on CoMP

The maximum backhaul latency of X2 interface is on the order of 20 ms except some rare scenarios, and typical average latency is 10ms [3]. This implies that, in the case of X2 based backhaul, some existing CoMP schemes which have an iterative nature for information exchanges between transmission points are not appropriate. For example, JP or CB based on handshake between transmission points seems not practical because the actual latency for signal processing at coordinating points becomes multiples of the backhaul latency, which inevitably causes performance degradation due to CSI aging [1].

Another concern is that QoS is hardly achievable especially for delay-sensitive UEs. Depending on the inter-point communication protocol, a UE cannot be served until its scheduling information is delivered to all the coordinating points or confirmation is returned from all the coordinating points. It causes increased latency and CSI aging problems.

Therefore, non-iterative CoMP schemes with one-way signaling seem more practical for low-capacity/high-latency backhaul such as X2 backhaul than iterative CoMP schemes which require information sharing between transmission points in a handshake fashion.

3. A suitable CoMP scheme under X2 backhaul link

Rel-8/9/10 ICIC techniques might give a good intuition about proper CoMP schemes under X2 based backhaul.

Basically, Rel-8/9 ICIC in LTE is assumed to be conducted in the frequency domain using power allocation information such as RNTP. The RNTP indicator can be exchanged between eNBs over X2 interface. Each bit of the indicator corresponds to one RB in the frequency domain and informs the neighboring eNBs of the serving eNB's relative transmit power level for the RB. Thus, neighboring cells

can utilize the information to estimate the expected level of interference in each RB when scheduling their UEs.

This frequency-domain ICIC scheme has been extended to the time-domain scheme as Rel-10 eICIC [4]:

- A bitmap pattern is used to indicate Almost Blank Subframe (ABS) pattern of an aggressor cell to a victim cell
- Patterns are semi-statically updated, i.e. not faster than existing Rel-8/9 X2 RNTP signals

This implies that an aggressor cell informs a victim cell of certain ABSs in time-domain manner, and based on this information the victim cell can perform an appropriate user scheduling.

Both ICIC and eICIC schemes have much in common in that basically they are based on one-way coordination which is simple and requires low backhaul signaling overhead. Considering low-capacity and high-latency of X2 interfaces, a CoMP scheme working with such one-way coordination seems to be appropriate in the X2 backhaul network. Further possible extension of Rel-8/9/10 ICIC to Rel-11 would be the space-domain coordination. In other words, instead of sending ABS pattern or Tx power distribution in the frequency domain, an aggressor cell sends its beamforming information to a victim cell. Then, considering the aggressor cell's beams, a victim cell schedules its UEs.

More specifically, a relevant example for such one-way space-domain coordination can be illustrated as follow. An eNB_A semi-statically determines its Tx beam and sends to a neighbor eNB_B the beam information, which is possibly embedded in backhaul signaling for frequency or time domain ICIC. Then, the eNB_B may also deliver the eNB_A's beam information to its CoMP UE, and the UE can assume that the delivered beam information is actually used at the eNB_A, determine its PMI away from the eNB_A's beam direction, and calculate the corresponding CQI to be reported. In this semi-static coordination based on one-way coordination, iterative scheduling or a handshake for UE/PMI coordination isn't necessary.

4. Conclusion

In this contribution, we discussed impacts of X2 backhaul link on CoMP. we conclude that **when the coordinating transmission points are connected with low-capacity/high-latency backhaul link such as X2 backhaul link,**

- **DL CoMP scheme should be based on one-way backhaul signaling**
- **A one-way semi-static beam coordination should be considered.**

References

[1] R1-112339, CoMP Performance Evaluation under Low-capacity/High-latency Backhaul, LGE.

[2] 3GPP TR36.814 v9.0.0.

[3] R1-071804, Reply LS to R3-070527/R1-071242 on Backhaul (X2 interface) Delay.

[4] R1-105779, Way Forward on time-domain extension of Rel 8/9 backhaul-based ICIC, RAN1.