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Contents

Foreword

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1 Scope

This document is related to the technical report for physical layer aspect of the study item “Coordinated Multi-Point Operation for LTE” [1]. The purpose of this TR is to help TSG RAN WG1 to define the physical layer features and enhancements under consideration to operate multi-point coordination and assess the performance benefits of those features and the required specification support for both the downlink and the uplink.

This activity involves the Radio Access work area of the 3GPP studies and has impacts both on the Mobile Equipment and Access Network of the 3GPP systems.

This document is intended to gather all information and draw a conclusion on way forward.

This document is a ‘living’ document, i.e. it is permanently updated and presented to TSG-RAN meetings.

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] RP-101425: "Revised SID Proposal: Coordinated Multi-Point Operation for LTE".

[2] 3GPP TR 21.905: " Vocabulary for 3GPP Specifications".

[3] 3GPP TR 36.913: “Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN)

[4] R1-111944: “RAN1 Phase 1 CoMP results”

[5] 3GPP TR 36.814: “Further Advancements for E-UTRA, Physical Layer Aspects**”.**

3 Definitions, symbols and abbreviations

3.1 Definitions

Void

3.2 Symbols

Void

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [2] apply.

4 Introduction

At the 3GPP TSG RAN #50 meeting, the Study Item description on "Coordinated Multi-Point Operation for LTE" was agreed for Release 11 [1]. Coordinated multi-point (CoMP) transmission and reception is considered for LTE-Advanced Rel. 11 as a tool to improve the coverage of high data rates, the cell-edge throughput, and also to increase system throughput. The study item aims at evaluating the performance benefits and the standardization impact of enhanced CoMP operation. The detailed objectives are as follows.

- Consider whether further refinements to the simulation assumptions from the agreements reached during the LTE-Advanced study item are needed to align with potential deployment scenarios, considering possible antenna configurations, data traffic model, network synchronization accuracy, and coordination capability including centralized or distributed scheduler assumption and their message exchange data rate and latency

- Evaluate the performance benefits of CoMP operation and the required specification support for the following scenarios:

  - Inter- and intra-site CoMP in homogeneous macro networks

  - Coordination between a cell(s) and the distributed RRHs connected to the cell(s): negligible latency is assumed over the interface between a cell(s) and the RRHs connected to the cell(s). The RRHs may or may not form separate cells from the cell to which they are connected. The coordination between amongst different

  - Coordination between different cell layers and within a cell layer in heterogeneous networks: coordination is performed between a macro cell(s) and small cells in the coverage of the macro cell(s). The small cells may be non-uniformly distributed in the coverage of a macro cell(s).

- Identify potential enhancements for DL-CoMP operation (relating to JP and/or CB/CS) in the following areas:

  - Control signalling and procedures on Uu and network internal interfaces

  - UE feedback of downlink channel state information for multiple cells configured in the CoMP operation.

  - Uplink sounding

- Identify potential standardization impact for UL-CoMP operation and evaluate its performance benefit.

This technical report covers the physical-layer aspects of these technology components.

5 Downlink coordinated multiple point transmission

Downlink coordinated multi-point transmission implies dynamic coordination among multiple geographically separated transmission points.

5.1 Terminology and definitions

5.1.1 General terminology

- Point: Set of geographically co-located transmit antennas. Note that sectors of the same site correspond to different points.

5.1.2 CoMP scenarios

The following scenarios were selected for the evaluation of DL and UL CoMP:

- **Scenario 1:** Homogeneous network with intra-site CoMP, as illustrated in Figure A.1-1

- **Scenario 2:** Homogeneous network with high Tx power RRHs, as illustrated in Figure A.1-2
- **Scenario 3:** Heterogeneous network with low power RRHs within the macrocell coverage where the transmission/reception points created by the RRHs have different cell IDs as the macro cell as illustrated in Figure A.1-3.

Scenario 4: Heterogeneous network with low power RRHs within the macrocell coverage where the transmission/reception points created by the RRHs have the same cell IDs as the macro cell as illustrated in Figure A.1-4.

5.1.2A CoMP deployment

For intra-eNB CoMP with ideal backhaul, two deployment cases can be considered as follow:

- **Case A:** Macro/high power RRH + Macro/high power RRH CoMP scenario (Scenario 1/2)
  - The macro/high power RRH cell-edge user may be configured as CoMP mode.
- **Case B:** Macro + low power RRH CoMP scenario (Scenario 3/4)
  - The Macro or low power RRH user may be configured as CoMP mode.

In Case A, typically a small propagation delay difference between CoMP TPs could be assumed since CoMP would work for cell-edge user mainly thus similar propagation distances to different TPs can be assumed. On Case B, however, a larger propagation delay difference should be assumed due to propagation distance difference e.g. when low power RRH is in Macro cell edge and operating as a serving cell as shown in Figure 5.1-1.

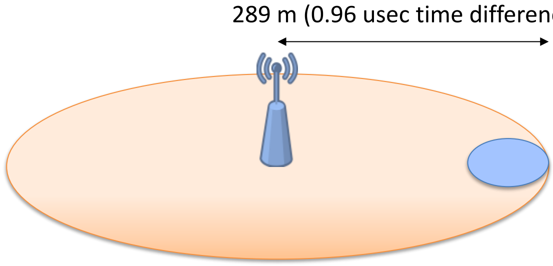


Figure 5.1-1 CoMP deployment scenario (low power RRH cell are allocated to macro cell edge)

Timing offset at the UE, which is defined as the observed timing of TP transmitting PDSCH with respect to the serving cell, can be derived for DL CoMP as follows:

Timing offset = difference of BS Timing Alignment Errors + difference of Propagation delays

where the propagation delay difference can be computed as Cell radius / The speed of light. In some cases, channel impact e.g. shadow fading may also impact the TP selection for CoMP and hence impact the timing offset observed by the UE.

In the context of Rel-11 DL CoMP, UE performance requirements are defined by assuming a typical timing offset in the range [-0.5, 2] usec. During the discussion, analysis also shows that offsets out of the tested range can also occur due to various deployed scenario, channel status, etc. CoMP deployment should take into considerations typical timing offset range and sites distance which impact the propagation delay difference.

As an example, in case B (ISD = 500 m, cell radius = 289 m), the maximum |difference of the propagation delays| = 0.96us (as defined in equation (1)), Depending on network implementation, the total timing offset at the UE can still be within the tested range.

5.1.3 CoMP categories

Each CoMP scheme may be categorized into one of the following categories.

- Joint Processing (JP): Data for a UE is available at more than one point in the CoMP cooperating set (definition below) for a time-frequency resource
  - Joint Transmission (JT): Simultaneous data transmission from multiple points (part of or entire CoMP cooperating set) to a single UE or multiple UEs in a time-frequency resource

  - Data to a UE is simultaneously transmitted from *multiple* points, e.g. to (coherently or non-coherently) improve the received signal quality and/or data throughput

- Dynamic point selection (DPS)/muting: Data transmission from one point (within the CoMP cooperating set) in a time-frequency resource. The transmitting/muting point may change from one subframe to another including varying over the RB pairs within a subframe. Data is available simultaneously at multiple points.

  - This includes Dynamic cell selection (DCS)

- DPS may be combined with JT in which case multiple points can be selected for data transmission in the time-frequency resource.

- Coordinated Scheduling/Beamforming (CS/CB): Data for an UE is only available at and transmitted from one point in the CoMP cooperating set (DL data transmission is done from that point) for a time-frequency resource but user scheduling/beamforming decisions are made with coordination among points corresponding to the CoMP cooperating set. The transmitting points are chosen semi-statically

  - Semi-static point selection (SSPS): Transmission to a specific UE from one point at a time. The transmitting point may only change in a semi-static manner

- Muting may be applied in dynamic and semi-static manner with transmission schemes above.

- Hybrid category of JP and CS/CB may be possible.

  - Data for a UE may be available only in a subset of points in the CoMP cooperating set for a time-frequency resource but user scheduling/beamforming decisions are made with coordination among points corresponding to the CoMP cooperating set. For example, some points in the cooperating set may transmit data to the target UE according to JP while other points in the cooperating set may perform CS/CB.

5.1.4 CoMP sets

- CoMP cooperating set

  - Set of (geographically separated) points directly and/or indirectly participating in data transmission to a UE in a time-frequency resource. Note that this set may or may not be transparent to the UE. The CoMP cooperating set defines the coordination area in Annex A.

    - Direct participation: point(s) actually transmitting data in the time-frequency resource

    - Indirect participation: candidate point(s) for data transmission that do not transmit data but contribute in making decisions on the user scheduling/beamforming in the time-frequency resource.

  - CoMP transmission point(s): point or set of points transmitting data to a UE

    - CoMP transmission point(s) is (are) a subset of the CoMP cooperating set

    - For JT, CoMP transmission points may include multiple points in the CoMP cooperating set at each subframe for a certain frequency resource.

    - For CS/CB, DPS, SSPS, a single point in the CoMP cooperating set is the CoMP transmission point at each subframe for a certain frequency resource.

      - For SSPS, this CoMP transmission point can change semi-statically within the CoMP cooperating set.

- CoMP measurement set: set of points about which channel state/statistical information related to their link to the UE is measured and/or reported as discussed in clause 5.2.2

  - The UE reports may down-select points for which actual feedback information is transmitted

  - How to measure interference needs to be considered.

- RRM measurement set: The set of cells for which the RRM measurements are performed (already in Rel-8). Additional RRM measurement methods can be considered e.g. in order to separate different points belonging to the same logical cell entity or in order to select the CoMP measurement set.

5.2 Radio interface aspects

DL CoMP should include the possibility of coordination between different points and/or cells. From a radio-interface perspective, there is no difference for the UE if the cells belong to the same eNodeB or different eNodeBs. If inter-eNodeB coordination is supported, information needs to be signalled between eNodeBs.

Potential impact on the radio-interface specifications is foreseen in mainly four areas:

- Channel state information feedback from the UE and measurement mechanisms at the UE
    - Reporting dynamic channel conditions between points in the CoMP measurement set and the UE
        - For TDD, channel reciprocity may be exploited
    - Reporting to facilitate the decision on the set of participating transmission points
        - For TDD, channel reciprocity may be exploited
- Preprocessing schemes
    - Coordination required prior to transmission of the signal over the multiple transmission points
- Reference signal design
    - Depending on the transmission scheme, specification of additional reference signals may be required e.g. reference signals for interference measurements
- Control signalling design
    - Downlink control signalling to support the transmission scheme
        - Enhanced PDCCH and other DL control signalling performance improvements

New forms of feedback and signalling may be needed to support CoMP that are, for example, configured by RRC for a given UE.

Part of features and procedures defined in Rel-10 specification related to carrier aggregation and resource-restricted measurements may be adapted for standardizing CoMP related downlink signalling, CSI measurement/feedback and CoMP set management in the specification.

5.2.1 DL signalling support for DL CoMP

The following downlink control signalling may be required to support DL CoMP schemes:

- Downlink control signalling to support the transmission scheme
    - Semi-static or dynamic signalling of relevant parameters, e.g.
        - CoMP sets
        - CSI-RS configurations and zero-power CSI-RS configurations for CoMP measurement set
        - Configurations if new RS is applicable for CoMP measurement
        - Transmission modes
        - Reporting modes including related uplink channel configuration

  - Control signaling to resolve problems related to different CRS frequency shifts in different cells and the PDSCH/CRS collision
    - For efficient support of CoMP JP
  - Control signalling to resolve problems related to different PDCCH region sizes in different cells
    - For efficient support of CoMP JP
  - Antenna ports and related scrambling sequences
  - Cross point scheduling
    - A UE receives a PDSCH assignment from one point and receives the PDSCH from at least one other point.
- Enhanced PDCCH and other control channel performance improvements, e,g
  - E-PDCCH region to flexibly adjust (and possibly increase) the number of resources available for the control channel
    - More REs can be assigned for control channels within a subframe. PDSCH resources could be re-assigned as E-PDCCH resources.
      - The additional resource allocated could be either a plurality of OFDM symbols, and/or a plurality of RBs in the legacy PDSCH region.
    - How to multiplex UEs on the newly allocated E-PDCCH region needs further investigation.
    - Integration of operational aspects with legacy control and with enhanced control needs further investigation.
  - MIMO/CoMP transmission to enhance the spectral efficiency of the PDCCH transmission in legacy PDCCH region and/or E-PDCCH region
    - A part(s) of R-PDCCH design could be reused for a certain component(s) of Release-11 E-PDCCH.
  - Compact DCI format to reduce signaling overhead
  - Other enhancements including e.g. the use of higher order of modulation can be considered

5.2.2 Channel state information feedback for DL CoMP

The three main categories of CoMP feedback mechanisms have been identified to be:

- Explicit channel state/statistical information feedback
  - Channel as observed by the receiver, without assuming any transmission or receiver processing
- Implicit channel state/statistical information feedback
  - Feedback of a transmission format (e.g. CQI/PMI/RI) derived using hypotheses of different transmission and/or reception processing
- UE transmission of SRS can be used for CSI estimation at eNB exploiting channel reciprocity.

Combinations of all or a subset of the above three mechanisms are possible in the form of periodic or aperiodic reports.

For the CoMP schemes that require feedback, individual per-point feedback with or without complementary inter-point feedback is considered as baseline. Aggregated CoMP feedback is not precluded.

For the CoMP categories described in clause 5.1.3, different feedback schemes may be applicable for different CoMP categories, or a single feedback scheme may enable support of more than one CoMP categories.

- CS/CB: CS/CB necessitates CSI feedback from multiple points. Inter-point phase information is not required. It is possible to configure multiple CSI feedback instances.

- JT: As part of the CSI feedback from multiple points, coherent JT requires inter-point phase information which is a new specification aspect that needs to be defined. Additional information such as inter-point amplitude information, which is another new specification aspect, may be needed. Similar to CS/CB, enhancements or modifications to the existing CSI reporting procedures are not precluded.
- DPS: Dynamic point selection requires similar CSI feedback as CS/CB in the sense that no inter-point phase information is required (some additional CQI report targeting other points may be needed). Similarly to the other schemes, optimizations to existing CSI reporting procedures are not precluded. DPS may require UE recommendation on selected point(s)

A common feedback framework may be considered for downlink CoMP, i.e, JT can be supported with CS/CB feedback with additional feedback of inter-point properties; DPS/SSPS can be supported as a special case of data availability of JT or CS/CB.

The UE CoMP feedback reports may contain CSI relative to one or more individual points in the CoMP measurement set. What points the UE reports are received at is a network implementation issue. The exchange of feedback reports between individual points, subject to backhaul limitations when applicable, is not precluded.

Feedback support for CoMP does not have to be confined to payload sizes currently supported by PUCCH operation.

The following possibilities should be studied for the “container” of the DL CoMP feedback:

- Expand the supported PUCCH payload sizes
- Use periodic/aperiodic reports on PUSCH
- Other enhancements such as e.g. increased PUCCH reporting instances

UE procedures for feedback reporting may also require changes. Especially it will need to be considered whether the 4 ms feedback processing time requirement is reasonable in light of any specified CoMP feedback techniques.

5.2.2.1 Explicit feedback

This clause lists different forms of explicit feedback in support of DL CoMP. They are all characterized by having a channel part and a noise-and-interference part.

Channel part:

- For each point in the UE’s measurement set that is reported in a given subframe, one or several channel properties are reported
- Channel properties include (but are not limited to) the following (‘i‘ is the point index):
  - Channel matrix (Hi) – short term (instantaneous)
    - Full matrix Hi, or
    - Main eigen component(s) of Hi
  - Transmit channel covariance (Ri), where Ri = (sum{Hij†Hij})/J, j=0,1,2,…,J-1, (‘j’ spans over time and/or frequency)
    - Full matrix Ri, or
    - Main eigen component(s) of Ri
  - Inter-point channel properties may also be reported

Noise-and interference part, e.g.,

- Interference outside
  - The points reported by the UE
  - CoMP transmission points

- Total receive power (Io) or total received signal covariance matrix
  - Covariance matrix of the noise-and-interference
  - Full matrix, or
  - Main eigen component(s)

It is noted that in case of explicit feedback, in addition to the actual feedback schemes there is also expected to be specification impact from revising current feedback testing methodology assumed by RAN4, which is developed for implicit feedback.

5.2.2.2 Implicit feedback

There are hypotheses at the UE and the feedback is based on one or a combination of two or more of the followings, e.g.:

- Single vs. Multi user MIMO
- Single cell/point vs. coordinated transmission
  - Within coordinated transmission: Single point (CS/CB) vs. multi-point (JP) transmission
    - Within JP CoMP:
      - Subsets of transmission points or subsets of reported points in the CoMP measurement set (JT)
      - CoMP transmission point(s) (DPS)
- Transmit precoder (i.e. tx weights)
  - JT: multiple single-point PMI and inter-point amplitude and/or phase information or multi-point aggregated PMI capturing coherent or non-coherent channel across reported points
  - CS/CB and DPS: multiple single-point or multiple point PMIs capturing channel from the reported point(s) to the UE
  - Other types of feedbacks may be considered, e.g.
    - PMI with finer quantization granularity than Rel. 8-10 PMI
  - Wideband and subband based PMI feedback can be considered
- Receive processing (i.e. rx weights)
- Interference based on particular tx/rx processing
- CQI feedback
  - CQI only accounting for interference outside the CoMP measurement sets or relative received power between CoMP transmission points
  - Wideband and subband based CQI feedback may be considered
  - CQI that accounts for post-CoMP channel quality under a certain CoMP scheme assumption (e.g., interfering cell/point precoding or muting)

There may be a need for the UE to convey to the network the hypothesis or hypotheses used (explicit signalling of hypothesis to eNB). And/or, there may be a semi-static hypothesis configuration e.g. grouping of hypotheses (explicit signalling of hypothesis to the UE). And/or, precoded RS may be used to allow UE to generate refined CQI/RI feedback

5.2.2.3 SRS

This clause considers issues relating to UE transmission of SRS in support of DL CoMP. UE transmission of SRS can be used for CSI estimation at multiple cells/points exploiting channel reciprocity. Enhanced SRS schemes may be considered for new scenarios and transmission mechanisms, including enhancement of multi-cell/point orthogonality, SRS capacity and SRS power control.

The associated CQI feedback(s) for the transmission point(s) in the CoMP measurement set may be needed, when SRS transmission for CSI feedback is used as a tool for transmission points to gather other CSI information. For CQI, Rel-10 CQI feedback (TxD based) may be reused, while other methods are not precluded. Also inter-point channel properties feedback is not precluded.

5.2.3 Decision on CoMP sets

The management of the CoMP measurement set may be based on UL SRS/DMRS/PUCCH transmission and/or DL RRM measurements (e.g., RSRP/RSRQ information). Measurement based on CRS and/or CSI-RS may be considered.

The CoMP cooperating set and the transmission points would be determined in the higher layers based on the CSI measurement of points included in the CoMP measurement set. Depending on the level of coordination, the cooperating set could be determined at the RRC level or at the MAC scheduler level.

5.2.4 DL Reference signal design

Further consideration on reference signal design can be in the following areas:

- Non-zero-power and zero-power CSI-RS have been introduced in Rel-10 for CSI measurement and reporting perspectives. CSI-RS may be re-used for CoMP to identify and measure the downlink channel status of multiple transmission points. Points can be allocated orthogonal resources avoiding mutual interference between the CSI-RS transmissions. New types of CSI-RS configurations may be considered to facilitate CoMP CSI measurements. Enhancements to CSI-RS for improved interference and/or timing estimation are not precluded.
- The reference signals for interference measurements for DL CoMP feedback may be considered.
- Enhancement of existing DMRS may be considered, e.g.
  - DMRS orthogonality enhancement
- Consider performance requirements on CSI-RS and DM-RS to ensure flexible mapping of antenna ports to transmission points.

5.3 Overhead in support of DL CoMP

Compared to Rel. 10,

- DL overhead increase due to multiple CSI-RS and/or muting patterns may be expected.
- UL overhead increase due to CSI measurement related to multiple points may be expected,
- and/or UL overhead increase due to SRS transmissions related to multiple points may be expected.

Most of the CoMP schemes considered in this study rely on TM9 for PDSCH transmission for UEs beyond Rel-10. When comparing with baseline schemes, especially ones that are not based on TM9, the additional overhead of DM-RS and CSI-RS should be taken into account.

Due to the presence of CSI-RS REs in an RB, the puncturing of PDSCH transmissions may lead to some performance degradation for Release 8 and 9 UEs. Scheduling restrictions may be applied to avoid performance degradations,

5.4 Receiver implementation consideration aspects

Several MMSE receiver implementations are possible, depending on the degree of available interference information at the UE. It is generally understood that cell edge performance is improved when directional structure of the interference information is available at the receiver.

Coordinated transmission in support of interference aware receivers may improve the UE interference estimation possibilities, leading to further improved cell edge performance. The signalling needed for such coordinated transmission techniques may require specification changes.

5.5 Inter/Intra-site backhauling support for downlink CoMP

In all scenarios described in Clause 5.1.2, points may be viewed as belonging to the same eNB or different eNBs. Those scenarios encompass different deployment architectures, depending on backhaul quality between points. Two cases are being considered:

- Point-to-point fiber (zero latency and infinite capacity backhaul) applicable to scenarios 2, 3, 4.
- Higher latency and limited capacity backhaul applicable to scenarios 2 and 3. Backhaul links between macro eNodeBs may be used. Backhauling links may include in-band relays, out-of-band relays or a combination.

Depending on backhaul technology, latency and capacity may be asymmetric in the two directions connecting two points.

For scenarios 2 and 3 described in Clause 5.1.2, points may also belong to different eNBs. In this case, backhaul information exchanges may require some standardization support. Note that the case of a higher latency and limited capacity backhaul is most relevant for this deployment architecture.

In all scenarios, it may be beneficial to leverage existing backhaul connections among macro eNBs (e.g., based on the X2 interface). This has the potential to mitigate interference conditions at the boundaries of RRH coordination areas.

6 Uplink coordinated multiple point reception

Coordinated multi-point reception implies coordination among multiple, geographically separated points. Uplink CoMP reception can involve joint reception (JR) of the transmitted signal at multiple reception points and/or coordinated scheduling (CS) decisions among points to control interference and improve coverage.

6.1 Terminology and definitions

6.1.1 General terminology

See clause 5.1.1.

6.1.2 CoMP scenarios

See clause 5.1.2.

6.1.3 CoMP categories

Each CoMP scheme may be categorized into one of the following categories.

- Joint Reception (JR): PUSCH transmitted by the UE is received jointly at multiple points (part of or entire CoMP cooperating set) at a time, e.g., to improve the received signal quality
- Coordinated Scheduling and Beamforming (CS/CB): user scheduling and precoding selection decisions are made with coordination among points corresponding to the CoMP cooperating set. Data is intended for one point only.

6.1.4 CoMP sets

- CoMP cooperating set

- Set of (geographically separated) points that may be intended for data reception from a UE.
- CoMP reception point(s): point or set of points receiving data from a UE
  - CoMP reception point(s) is (are) a subset of the CoMP cooperating set
  - For JR, CoMP reception points may include multiple points in the CoMP cooperating set at each subframe for a certain frequency resource.
  - For CS/CB, a single point in the CoMP cooperating set is the CoMP reception point at each subframe for a certain frequency resource.

6.2 Radio interface aspects

UL CoMP should include the possibility of coordination between different RX points/cells for reception of data and reference signals from UEs. If inter-eNodeB coordination is supported, information needs to be signalled between the eNodeBs.

The eNodeB aspects and UE aspects of reception point selection need to be discussed.

Enhancements to PUCCH, e.g., pseudo orthogonality (inter-cell and intra-cell for scenario 4) and/or inter-cell orthogonality, may be considered to

- improve resource utilization efficiency in the UL CoMP operation
- avoid high inter-cell/point interference

Enhancements to the DM-RS (applicable to both PUCCH and PUSCH) and SRS design, e.g., pseudo orthogonality (inter-cell and intra-cell for scenario 4) and/or inter-cell orthogonality, may be considered to

- increase the DM-RS and SRS capacity
- improve the DM-RS and SRS reception

Enhancements to the uplink power control for open-loop as well as closed-loop operation may be considered including e.g.

- enhancement to support selection of intended reception point(s)
  - potentially take into account new interference environment
- path-loss determination and signalling that targets intended reception point(s)
  - reception point(s) may vary for different uplink physical channels

To ensure accurate reception of SRS at the coordinating points, further enhancements to the power control scheme for SRS may be considered.Enhancement for the uplink timing advance control to support efficient JR CoMP operation may be considered

- including possible enhancement on RACH transmission

In addition, coexistence with legacy UEs should be considered in these UL CoMP enhancements.

6.3 Overhead in support of UL CoMP

System SRS and control channel overhead may be increased if additional SRS and control channel resources are used to support the UL CoMP operation, which may require higher SRS and control channel capacity.

6.4 Inter/Intra-site backhauling support for uplink CoMP

See clause 5.5.

7 Evaluation of coordinated multiple point transmission/reception

RAN1 has performed extensive evaluations of CoMP techniques as part of the CoMP study item. Clause 7.1 to 7.4 present the evaluation results obtained by various sources in the following four agreed deployment scenarios (details provided in Appendix A.1):

- Scenario 1: Homogeneous network with intra-site CoMP
- Scenario 2: Homogeneous network with high Tx power RRHs
- Scenario 3: Heterogeneous network with low power RRHs within the macrocell coverage where transmission/reception points created by the RRHs have different cell IDs as the macro cell
- Scenario 4: Heterogeneous network with low power RRHs within the macrocell coverage where the transmission/reception points created by the RRHs have the same cell IDs as the macro cell

In scenarios 1 and 2, simulation results from a total of 20 sources have been collected [4]. In scenarios 3 and 4, simulation results from a total of 25 sources have been collected [5].

Even though there is a detailed evaluation methodology (Appendix A.1) that was used by all sources in the evaluation campaign, we acknowledge that performance differences among sources exist and could be explained by the fact that different sources may use different assumptions on e.g. the channel estimation error modelling , channel reciprocity modelling, the feedback/SRS mechanisms, the scheduler, and the receiver. Detailed simulation assumptions used by a specific source can be obtained by looking at the contribution number referred in [4].

We also note that the evaluation assumptions used in this study item are different from the one used in [1]. For instance, contrary to [1] where the receiver was based on IRC, the baseline receiver for this study item is a simplified MMSE receiver (see Appendix A.1).

Absolute performance and relative performance gain are provided.

In the full buffer evaluations of phase 1, cell average spectral efficiency (denoted as "cell avg") [bits/s/Hz/cell] and 5% user spectral efficiency (denoted as "Cell-edge") [bits/s/Hz/user] are provided.

In the non-full buffer evaluations of phase 1, served cell spectral efficiency (denoted as "cell avg") [bits/s/Hz/cell], 5% user spectral efficiency (denoted as "5% cell-edge") [bits/s/Hz/user] and mean user spectral efficiency (denoted as "mean user") [bits/s/Hz/user] are provided.

- Mean, 5%, user spectral efficiency
  - User spectral efficiency = amount of data (file size) / time needed to download data / Bandwidth
    - time needed to download data starts when the packet is received in the transmit buffer, and ends when the last bit of the packet is correctly delivered to the receiver
- Served cell spectral efficiency
  - Served cell spectral efficiency = total amount of data for all users / total amount of observation time / number of cells / Bandwidth

In the full buffer evaluation of phase 2, macro cell area average spectral efficiency [bits/s/Hz] and 5% worst user spectral efficiency [bits/s/Hz/user] are provided.

In the non-full buffer evaluation of phase 2, macro cell area average spectral efficiency [bits/s/Hz], 5% worst user spectral efficiency [bits/s/Hz/user], and mean user spectral efficiency [bits/Hz/user] are provided.

For phase 1, in order to provide the reader with some observations on the range of gains achievable by CoMP over single-cell processing, relative performance gains are measured in terms of average relative gain, smallest relative gain and largest relative gain. For a given source i, the relative gain A_i vs. B_i is defined as A_i/B_i-1. The average relative gain is obtained by averaging the relative gain among multiple sources. The number of sources used for averaging is indicated in the following tables under the label "number of sources". The smallest (resp. largest) relative gain is the relative gain corresponding to the minimum (resp. maximum) value among the relative gains of all sources available in the considered simulation set-up.

For phase 2, in order to provide the reader with some observations on the range of gains achievable by CoMP over non-CoMP processing, relative performance gains are measured in terms of average relative gain.

It is important to note that the impact of CoMP on the legacy UEs is not addressed in those evaluations.

The simulation results for Scenarios 1, 2, 3, and 4 assume the following overhead computation:

- For DL FDD: 6 MBSFN subframes

  - 4 subframes out of 10 have an overhead of 3OFDM symbols (PDCCH) + 2CRS ports outside PDCCH region + DMRS

  - 6 subframes out of 10 have an overhead of 2OFDM symbols for PDCCH + DMRS.

- For DL TDD: configuration 1 with 2 MBSFN subframes

  Baseline asymmetry during 5 subframes period:

  2 full DL subframes (1 MBSFN and 1 non-MBSFN),

  Special subframe: DwPTS 11symbol, GP 1 symbol, UpPTS 2 symbol,

  2 full UL subframes

- For UL, assume 4RB/10MHz PUCCH overhead + DMRS + SRS

Additional downlink overhead assumptions relative to zero-power and non-zero power CSI-RS, as well as the number of DMRS, may be assumed by different sources.

7.1 Scenario 1: Homogeneous network with intra-site CoMP

Performance evaluation for scenario 1 (intra-site 3-cells coordination) is provided in Clause 7.1.1 for 3GPP case 1 channel model and 7.1.2 for ITU channel model. In both clauses, cross-polarized antenna deployment and ULA deployment are considered. As detailed in the Appendix A.1, 3GPP case 1 is considered as the baseline channel model and dual-polarized antenna deployments have higher priority over ULA deployments.

7.1.1 3GPP Case1 (3GPP spatial channel model)

7.1.1.1 FDD, Downlink

Table 7.1.1.1-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-1: Absolute performance of CS/CB in scenario 1 with full buffer [FDD,3GPP, cross-polarized deployment]

cross-polarized antenna		source 1	source 4	source 10	source 14	source 17	source 20
SU-MIMO 2x2	Cell avg	1.636		2.0534			
	Cell-edge	0.0488		0.0509			
SU-MIMO 4x2	Cell avg	1.937		2.5123		1.962	
	Cell-edge	0.06208		0.0684		0.0721	
MU-MIMO 2x2	Cell avg	1.797		1.5762	1.809		2.47
	Cell-edge	0.0437		0.0579	0.042		0.06
MU-MIMO 4x2	Cell avg	2.623	2.125	2.0381	2.824		2.48
	Cell-edge	0.0755	0.0469	0.0821	0.075		0.088
CS/CB SU-MIMO 2x2	Cell avg	1.696					
	Cell-edge	0.0535					
CS/CB SU-MIMO 4x2	Cell avg	1.9605				2.2411	
	Cell-edge	0.07211				0.1026	
CS/CB MU-MIMO 2x2	Cell avg			1.603	1.859		
	Cell-edge			0.0588	0.045		
CS/CB MU-MIMO 4x2	Cell avg		2.131	2.0835	2.752		2.58
	Cell-edge		0.0481	0.0845	0.073		0.1

Table 7.1.1.1-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-2: Absolute performance of JP in scenario 1 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna		source 1	source 3	source 4	source 10	source 11	source 12	source 14	source 20
MU-MIMO 2x2	Cell avg	1.797	2.24		1.5762	2.11	2.41	1.809	2.47
	Cell-edge	0.0437	0.07		0.0579	0.0532	0.043	0.042	0.06
MU-MIMO 4x2	Cell avg	2.623	2.77	2.125	2.0381	2.407	2.72	2.824	2.48
	Cell-edge	0.0755	0.11	0.0469	0.0821	0.0705	0.057	0.075	0.088
JT MU-MIMO 2x2	Cell avg	1.972	2.35		1.5683	2.19	2.58	1.681	2.49
	Cell-edge	0.0597	0.08		0.0677	0.0585	0.071	0.042	0.084
JT MU-MIMO 4x2	Cell avg	2.883	2.85	2.224	2.0255	2.66	2.86	2.462	
	Cell-edge	0.0977	0.12	0.055	0.0945	0.0827	0.092	0.07	

Table 7.1.1.1-3 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-3: Relative performance gain of DL CoMP in scenario 1 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna	number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 2x2 vs. SU-MIMO 2x2	1	Cell avg	3.67%	3.67%	3.67%
		Cell-edge	9.63%	9.63%	9.63%
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	2	Cell avg	7.72%	1.21%	14.23%
		Cell-edge	29.23%	16.16%	42.30%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	2	Cell avg	2.23%	1.70%	2.76%
		Cell-edge	4.35%	1.55%	7.14%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	4	Cell avg	1.00%	-2.55%	4.03%
		Cell-edge	4.11%	-2.67%	13.64%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	7	Cell avg	2.68%	-7.08%	9.74%
		Cell-edge	26.13%	0.00%	65.12%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	7	Cell avg	2.81%	-12.82%	10.51%
		Cell-edge	20.42%	-6.67%	61.40%

Table 7.1.1.1-4 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-4: Absolute performance of CS/CB in scenario 1 with full buffer [FDD,3GPP,ULA]

ULA		source 1	source 4	source 10	source 16
SU-MIMO 2x2	Cell avg	1.785		1.989	
	Cell-edge	0.055		0.0575	
SU-MIMO 4x2	Cell avg	2.0412		2.4529	
	Cell-edge	0.06443		0.0772	
MU-MIMO 2x2	Cell avg	2.067		1.8807	
	Cell-edge	0.0536		0.0654	
MU-MIMO 4x2	Cell avg	3.126	2.504	2.7408	2.868
	Cell-edge	0.0865	0.0617	0.1037	0.119
CS/CB SU-MIMO 2x2	Cell avg	1.877			
	Cell-edge	0.0614			
CS/CB SU-MIMO 4x2	Cell avg	2.0797			
	Cell-edge	0.07323			
CS/CB MU-MIMO 2x2	Cell avg			1.9796	
	Cell-edge			0.0714	
CS/CB MU-MIMO 4x2	Cell avg		2.521	2.8519	3.000
	Cell-edge		0.0635	0.1082	0.125

Table 7.1.1.1-5 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-5: Absolute performance of JP in scenario 1 with full buffer [FDD,3GPP,ULA]

ULA		source 1	source 3	source 4	source 10
MU-MIMO 2x2	Cell avg	2.067			1.8807
	Cell-edge	0.0536			0.0654
MU-MIMO 4x2	Cell avg	3.126	2.95	2.504	2.7408
	Cell-edge	0.0865	0.099	0.0617	0.1037
JT MU-MIMO 2x2	Cell avg	2.49	2.27		1.9728
	Cell-edge	0.078	0.095		0.0836
JT MU-MIMO 4x2	Cell avg	3.64	2.72	2.522	2.7165
	Cell-edge	0.1151	0.124	0.067	0.1199

Table 7.1.1.1-6 shows the relative gain of CoMP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-6: Relative performance gain of DL CoMP in scenario 1 with full buffer [FDD,3GPP,ULA]

ULA	number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 2x2 vs. SU-MIMO 2x2	1	Cell avg	5.15%	5.15%	5.15%
		Cell-edge	11.64%	11.64%	11.64%
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	1	Cell avg	1.89%	1.89%	1.89%
		Cell-edge	13.66%	13.66%	13.66%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	Cell avg	5.26%	5.26%	5.26%
		Cell-edge	9.17%	9.17%	9.17%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	3	Cell avg	3.11%	0.68%	4.60%
		Cell-edge	4.10%	2.92%	5.04%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	2	Cell avg	12.68%	4.90%	20.46%
		Cell-edge	36.68%	27.83%	45.52%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	4	Cell avg	2.12%	-7.80%	16.44%
		Cell-edge	20.63%	8.59%	33.06%

Table 7.1.1.1-7 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-7: Absolute performance of CS/CB in scenario 1 with non-full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna			source 14
MU-MIMO 4x2	RU (50%)	Cell avg	
		mean user	1.645
		5% cell-edge	0.498
	RU (25%)	Cell avg	
		mean user	2.506
		5% cell-edge	0.935
CS/CB MU-MIMO 4x2	RU (50%)	Cell avg	
		mean user	1.797
		5% cell-edge	0.532
	RU (25%)	Cell avg	
		mean user	2.644
		5% cell-edge	1

Table 7.1.1.1-8 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-8: Absolute performance of JP in scenario 1 with non-full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna			source 1	source 14
SU-MIMO 4x2	RU (50%)	Cell avg		
		mean user	2.05	
		5% cell-edge	0.46	
	RU (25%)	Cell avg		
		mean user	2.83	
		5% cell-edge	0.78	
MU-MIMO 4x2	RU (50%)	Cell avg		
		mean user		1.645
		5% cell-edge		0.498
	RU (25%)	Cell avg		
		mean user		2.506
		5% cell-edge		0.935
JT SU-MIMO 4x2	RU (50%)	Cell avg		
		mean user	2.4	
		5% cell-edge	0.641	
	RU (25%)	Cell avg		
		mean user	3.05	
		5% cell-edge	0.92	
JT MU-MIMO 4x2	RU (50%)	Cell avg		
		mean user		1.75
		5% cell-edge		0.496
	RU (25%)	Cell avg		
		mean user		2.68
		5% cell-edge		0.981

Table 7.1.1.1-9 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.1-9: Relative performance gain of DL CoMP in scenario 1 with non-full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna	number of sources			average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	1	RU (50%)	Cell avg			
			mean user	9.24%	9.24%	9.24%
			5% cell-edge	6.83%	6.83%	6.83%
		RU (25%)	Cell avg			
			mean user	5.51%	5.51%	5.51%
			5% cell-edge	6.95%	6.95%	6.95%
JT SU-MIMO 4x2 vs. SU-MIMO 4x2	1	RU (50%)	Cell avg			
			mean user	17.07%	17.07%	17.07%
			5% cell-edge	39.35%	39.35%	39.35%
		RU (25%)	Cell avg			
			mean user	7.77%	7.77%	7.77%
			5% cell-edge	17.95%	17.95%	17.95%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	1	RU (50%)	Cell avg			
			mean user	6.38%	6.38%	6.38%
			5% cell-edge	-0.40%	-0.40%	-0.40%
		RU (25%)	Cell avg			
			mean user	6.94%	6.94%	6.94%
			5% cell-edge	4.92%	4.92%	4.92%

7.1.1.2 TDD, Downlink

Table 7.1.1.2-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.2-1: Absolute performance of CS/CB in scenario 1 with full buffer [TDD,3GPP,cross-polarized deployment]

cross-polarized antenna		source 2	source 3	source 14
MU-MIMO 2x2	Cell avg	2.49	2.35	
	Cell-edge	0.0663	0.073	
MU-MIMO 4x2	Cell avg	3.43	2.98	
	Cell-edge	0.100	0.111	
MU-MIMO 8x2	Cell avg	4.29		4.256
	Cell-edge	0.151		0.106
CS/CB MU-MIMO 2x2	Cell avg	2.62	2.39	
	Cell-edge	0.0733	0.078	
CS/CB MU-MIMO 4x2	Cell avg	3.66	3.07	
	Cell-edge	0.116	0.12	
CS/CB MU-MIMO 8x2	Cell avg	4.76		4.061
	Cell-edge	0.181		0.107

Table 7.1.1.2-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.2-2: Absolute performance of JP in scenario 1 with full buffer [TDD,3GPP,cross-polarized deployment]

cross-polarized antenna		source 1	source 2	source 3	source 12	source 14	source 18
MU-MIMO 2x2	Cell avg	1.911	2.49	2.35	1.45		
	Cell-edge	0.0439	0.0663	0.073	0.045		
MU-MIMO 4x2	Cell avg	2.779	3.43	2.98			3.48
	Cell-edge	0.0763	0.100	0.111			0.102
MU-MIMO 8x2	Cell avg		4.29		4.21	4.256	5.46
	Cell-edge		0.151		0.134	0.106	0.183
JT MU-MIMO 2x2	Cell avg	2.419	2.79	2.46	2.01		
	Cell-edge	0.0672	0.0750	0.084	0.075		
JT MU-MIMO 4x2	Cell avg	3.596	3.93	2.98			3.89
	Cell-edge	0.112	0.123	0.12			0.142
JT MU-MIMO 8x2	Cell avg		4.80		5.18	3.577	6.15
	Cell-edge		0.172		0.164	0.11	0.227

Table 7.1.1.2-3 shows the relative gain of CoMP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.2-3: Relative performance gain of DL CoMP in scenario 1 with full buffer [TDD,3GPP,cross-polarized deployment]

cross-polarized antenna	number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	2	Cell avg	3.37%	1.70%	5.03%
		Cell-edge	8.66%	6.85%	10.48%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	2	Cell avg	4.92%	3.02%	6.82%
		Cell-edge	12.15%	8.11%	16.19%
CS/CB MU-MIMO 8x2 vs. MU-MIMO 8x2	2	Cell avg	3.27%	-4.58%	11.13%
		Cell-edge	10.51%	0.94%	20.08%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	4	Cell avg	20.45%	4.68%	38.62%
		Cell-edge	36.94%	12.97%	66.67%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	4	Cell avg	14.00%	0.00%	29.40%
		Cell-edge	29.37%	8.11%	46.79%
JT MU-MIMO 8x2 vs. MU-MIMO 8x2	4	Cell avg	7.94%	-15.95%	23.04%
		Cell-edge	16.09%	3.77%	24.04%

Table 7.1.1.2-4 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.2-4: Absolute performance of JP in scenario 1 with full buffer [TDD,3GPP,ULA]

ULA		source 1	source 3	source 12
MU-MIMO 2x2	Cell avg	2.069		1.86
	Cell-edge	0.0548		0.058
MU-MIMO 4x2	Cell avg	3.163	3.05	
	Cell-edge	0.0863	0.1	
MU-MIMO 8x2	Cell avg			4.5
	Cell-edge			0.151
JT MU-MIMO 2x2	Cell avg	2.711	2.38	2.49
	Cell-edge	0.078	0.1	0.095
JT MU-MIMO 4x2	Cell avg	4.075	2.85	
	Cell-edge	0.119	0.129	
JT MU-MIMO 8x2	Cell avg			5.66
	Cell-edge			0.188

Table 7.1.1.2-5 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.2-5: Relative performance gain of DL CoMP in scenario 1 with full buffer [TDD,3GPP,ULA]

ULA	number of sources		average relative gain	smallest relative gain	largest relative gain
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	2	Cell avg	32.45%	31.03%	33.87%
		Cell-edge	53.06%	42.34%	63.79%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	2	Cell avg	11.14%	-6.56%	28.83%
		Cell-edge	33.45%	29.00%	37.89%
JT MU-MIMO 8x2 vs. MU-MIMO 8x2	1	Cell avg	25.78%	25.78%	25.78%
		Cell-edge	24.50%	24.50%	24.50%

7.1.1.3 Uplink

Table 7.1.1.3-1 shows the spectral efficiency results of CoMP JR schemes versus single-cell schemes in scenario 1 FDD Uplink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.3-1: Absolute performance of JR in scenario 1 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna		source 1	source 12	source 18
SU-MIMO 1x2	Cell avg	1.156	1.7694	
	Cell-edge	0.0348	0.05822	
SU-MIMO 1x4	Cell avg	1.726		
	Cell-edge	0.06511		
MU-MIMO 1x8	Cell avg			3.96
	Cell-edge			0.06
JR SU-MIMO 1x2	Cell avg		2.1631	
	Cell-edge		0.0822	
JR MU-MIMO 1x2	Cell avg	1.193		
	Cell-edge	0.03796		
JR MU-MIMO 1x4	Cell avg	1.78		
	Cell-edge	0.06686		
JR MU-MIMO 1x8	Cell avg			4.76
	Cell-edge			0.075

Table 7.1.1.3-2 shows the relative gain of CoMP JR schemes versus single-cell schemes in scenario 1 FDD Uplink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.3-2: Relative performance gain of UL CoMP in scenario 1 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna	number of sources		average relative gain	smallest relative gain	largest relative gain
JR SU-MIMO 1x2 vs. SU-MIMO 1x2	1	Cell avg	22.25%	22.25%	22.25%
		Cell-edge	41.19%	41.19%	41.19%
JR MU-MIMO 1x8 vs. MU-MIMO 1x8	1	Cell avg	20.20%	20.20%	20.20%
		Cell-edge	25.00%	25.00%	25.00%

Table 7.1.1.3-3 shows the spectral efficiency results of CoMP JR schemes versus single-cell schemes in scenario 1 FDD Uplink with closely–spaced ULA antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.3-3: Absolute performance of JR in scenario 1 with full buffer [FDD,3GPP,ULA]

ULA		source 3
SU-MIMO 1x2	Cell avg	0.963
	Cell-edge	0.05
SU-MIMO 1x4	Cell avg	1.437
	Cell-edge	0.078
JR SU-MIMO 1x2	Cell avg	1.080
	Cell-edge	0.061
JR SU-MIMO 1x4	Cell avg	1.51
	Cell-edge	0.096

Table 7.1.1.3-4 shows the relative gains of CoMP JR schemes versus single-cell schemes in scenario 1 FDD Uplink with closely–spaced ULA antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.1.1.3-4: Relative performance gain of UL CoMP in scenario 1 with full buffer [FDD,3GPP,ULA]

ULA	number of sources		average relative gain	smallest relative gain	largest relative gain
JR SU-MIMO 1x2 vs. SU-MIMO 1x2	1	Cell avg	12.15%	12.15%	12.15%
		Cell-edge	22.00%	22.00%	22.00%
JR SU-MIMO 1x4 vs. SU-MIMO 1x4	1	Cell avg	5.08%	5.08%	5.08%
		Cell-edge	23.08%	23.08%	23.08%

7.1.2 ITU channel model

7.1.2.1 FDD, Downlink

Table 7.1.2.1-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.1-1: Absolute performance of CS/CB in scenario 1 with full buffer [FDD,ITU,cross-polarized deployment]

cross-polarized antenna		source 7	source 10	source 20
SU-MIMO 4x2	Cell avg	1.687	1.8285	
	Cell-edge	0.0671	0.0466	
MU-MIMO 2x2	Cell avg		1.6286	2.87
	Cell-edge		0.0415	0.07
MU-MIMO 4x2	Cell avg	1.935	1.8805	2.88
	Cell-edge	0.0829	0.0589	0.103
CS/CB SU-MIMO 4x2	Cell avg	2.141		
	Cell-edge	0.0923		
CS/CB MU-MIMO 2x2	Cell avg		1.7141	
	Cell-edge		0.0458	
CS/CB MU-MIMO 4x2	Cell avg		1.986	3.01
	Cell-edge		0.0644	0.117

Table 7.1.2.1-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.1-2: Absolute performance of JP in scenario 1 with full buffer [FDD,ITU,cross-polarized deployment]

cross-polarized antenna		source 1	source 10	source 11	source 20
MU-MIMO 2x2	Cell avg	1.732	1.6286	2.01	2.87
	Cell-edge	0.0354	0.0415	0.044	0.07
MU-MIMO 4x2	Cell avg	2.474	1.8805	2.199	2.88
	Cell-edge	0.0597	0.0589	0.0544	0.103
JT MU-MIMO 2x2	Cell avg	2.281	1.7464	2.155	2.9
	Cell-edge	0.0552	0.0582	0.0491	0.098
JT MU-MIMO 4x2	Cell avg	3.01	1.9782	2.434	
	Cell-edge	0.0786	0.0785	0.0665	

Table 7.1.2.1-3 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.1-3: Relative performance gain of DL CoMP in scenario 1 with full buffer [FDD,ITU,cross-polarized deployment]

cross-polarized antenna	number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	1	Cell avg	26.91%	26.91%	26.91%
		Cell-edge	37.56%	37.56%	37.56%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	Cell avg	5.25%	5.25%	5.25%
		Cell-edge	10.36%	10.36%	10.36%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	2	Cell avg	5.06%	4.51%	5.61%
		Cell-edge	11.47%	9.34%	13.59%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	4	Cell avg	11.80%	1.05%	31.70%
		Cell-edge	36.94%	11.59%	55.93%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	3	Cell avg	12.52%	5.20%	21.67%
		Cell-edge	29.06%	22.24%	33.28%

Table 7.1.2.1-4 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.1-4: Absolute performance of CS/CB in scenario 1 with full buffer [FDD,ITU,ULA]

ULA		source 7	source 10
SU-MIMO 4x2	Cell avg	1.544	1.8662
	Cell-edge	0.066	0.0537
MU-MIMO 2x2	Cell avg		1.5418
	Cell-edge		0.0481
MU-MIMO 4x2	Cell avg	1.837	2.2551
	Cell-edge	0.082	0.0725
CS/CB SU-MIMO 4x2	Cell avg	1.968	
	Cell-edge	0.091	
CS/CB MU-MIMO 2x2	Cell avg		1.6358
	Cell-edge		0.0515
CS/CB MU-MIMO 4x2	Cell avg		2.3749
	Cell-edge		0.0784

Table 7.1.2.1-5 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.1-5: Absolute performance of JP in scenario 1 with full buffer [FDD,ITU, ULA]

ULA		source 1	source 10
MU-MIMO 2x2	Cell avg	1.761	1.5418
	Cell-edge	0.0407	0.0481
MU-MIMO 4x2	Cell avg	2.636	2.2551
	Cell-edge	0.0625	0.0725
JT MU-MIMO 2x2	Cell avg	2.415	1.6888
	Cell-edge	0.0606	0.0662
JT MU-MIMO 4x2	Cell avg	3.113	2.3691
	Cell-edge	0.0854	0.0955

Table 7.1.2.1-6 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 1 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.1-6: Relative performance gain of DL CoMP in scenario 1 with full buffer [FDD, ITU, ULA]

ULA	number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	1	Cell avg	27.46%	27.46%	27.46%
		Cell-edge	37.88%	37.88%	37.88%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	Cell avg	6.10%	6.10%	6.10%
		Cell-edge	7.07%	7.07%	7.07%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	1	Cell avg	5.31%	5.31%	5.31%
		Cell-edge	8.14%	8.14%	8.14%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	2	Cell avg	23.34%	9.53%	37.14%
		Cell-edge	43.26%	37.63%	48.89%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	2	Cell avg	11.58%	5.06%	18.10%
		Cell-edge	34.18%	31.72%	36.64%

7.1.2.2 TDD, Downlink

Table 7.1.2.2-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.2-1: Absolute performance of CS/CB in scenario 1 with full buffer [TDD,ITU,cross-polarized deployment]

cross-polarized antenna		source 2
MU-MIMO 2x2	Cell avg	2.09
	Cell-edge	0.0669
MU-MIMO 4x2	Cell avg	2.86
	Cell-edge	0.0973
MU-MIMO 8x2	Cell avg	3.68
	Cell-edge	0.151
CS/CB MU-MIMO 2x2	Cell avg	2.33
	Cell-edge	0.0722
CS/CB MU-MIMO 4x2	Cell avg	3.26
	Cell-edge	0.119
CS/CB MU-MIMO 8x2	Cell avg	4.23
	Cell-edge	0.188

Table 7.1.2.2-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.2-2: Absolute performance of JP in scenario 1 with full buffer [TDD,ITU,cross-polarized deployment]

cross-polarized antenna		source 1	source 2	source 18
MU-MIMO 2x2	Cell avg	1.816	2.09	
	Cell-edge	0.0348	0.0669	
MU-MIMO 4x2	Cell avg	2.754	2.86	2.57
	Cell-edge	0.0596	0.0973	0.058
MU-MIMO 8x2	Cell avg		3.68	3.88
	Cell-edge		0.151	0.083
JT MU-MIMO 2x2	Cell avg	2.783	2.44	
	Cell-edge	0.0678	0.0857	
JT MU-MIMO 4x2	Cell avg	4.239	3.43	3.06
	Cell-edge	0.1016	0.107	0.083
JT MU-MIMO 8x2	Cell avg		4.51	4.84
	Cell-edge		0.203	0.138

Table 7.1.2.2-3 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.2-3: Relative performance gain of DL CoMP in scenario 1 with full buffer [TDD,ITU,cross-polarized deployment]

cross-polarized antenna	number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	Cell avg	11.63%	11.63%	11.63%
		Cell-edge	7.92%	7.92%	7.92%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	1	Cell avg	14.12%	14.12%	14.12%
		Cell-edge	21.91%	21.91%	21.91%
CS/CB MU-MIMO 8x2 vs. MU-MIMO 8x2	1	Cell avg	14.93%	14.93%	14.93%
		Cell-edge	24.30%	24.30%	24.30%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	2	Cell avg	35.01%	16.77%	53.25%
		Cell-edge	61.48%	28.12%	94.83%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	3	Cell avg	30.96%	19.07%	53.92%
		Cell-edge	41.04%	9.55%	70.47%
JT MU-MIMO 8x2 vs. MU-MIMO 8x2	2	Cell avg	23.67%	22.59%	24.74%
		Cell-edge	50.23%	34.19%	66.27%

Table 7.1.2.2-4 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.2-4: Absolute performance of JP in scenario 1 with full buffer [TDD,ITU,ULA]

ULA		source 1
MU-MIMO 2x2	Cell avg	1.766
	Cell-edge	0.0401
MU-MIMO 4x2	Cell avg	2.791
	Cell-edge	0.0631
JT MU-MIMO 2x2	Cell avg	2.802
	Cell-edge	0.068
JT MU-MIMO 4x2	Cell avg	4.232
	Cell-edge	0.104

Table 7.1.2.2-5 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 1 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.1.2.2-5: Relative performance gain of DL CoMP in scenario 1 with full buffer [TDD,ITU,ULA]

ULA	number of sources		average relative gain	smallest relative gain	largest relative gain
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	1	Cell avg	58.66%	58.66%	58.66%
		Cell-edge	69.58%	69.58%	69.58%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	1	Cell avg	51.63%	51.63%	51.63%
		Cell-edge	64.82%	64.82%	64.82%

7.2 Scenario 2: Homogeneous network with high Tx power RRHs

Performance evaluation for scenario2 is provided in Clause 7.2.1 for 3GPP case 1 channel model and 7.2.2 for ITU channel model. In both clauses, cross-polarized antenna deployment and ULA deployment are considered. As detailed in the Appendix A.1, 3GPP case 1 is considered as the baseline channel model and dual-polarized antenna deployments have higher priority over ULA deployments.

Performance is provided for 9 cells coordination (denoted as “9 cells”) and for more than 9 cells (denotes as “> 9 cells”) coordination. 9 cells coordination is considered as the baseline.

7.2.1 3GPP Case1 (3GPP spatial channel model)

7.2.1.1 FDD, Downlink

Table 7.2.1.1-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-1: Absolute performance of CS/CB in scenario 2 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna			source 1	source 4	source 5	source 9	source 10	source 11	source 13	source 14	source 17	source 20
SU-MIMO 2x2		Cell avg	1.636			2.397	2.0534		1.918			
		Cell-edge	0.0488			0.070	0.0509		0.0399			
SU-MIMO 4x2		Cell avg	1.937		2.395	2.891	2.5123		1.964		1.962	
		Cell-edge	0.06208		0.0654	0.090	0.0684		0.04084		0.0721	
MU-MIMO 2x2		Cell avg	1.797			2.171	1.5762	2.11		1.809		2.47
		Cell-edge	0.0437			0.071	0.0579	0.0532		0.042		0.06
MU-MIMO 4x2		Cell avg	2.623	2.125		2.435	2.0381	2.407	1.94	2.824		2.48
		Cell-edge	0.0755	0.0469		0.091	0.0821	0.0705	0.04076	0.075		0.088
CS/CB SU-MIMO 2x2	9 cells	Cell avg				2.432						
		Cell-edge				0.072						
CS/CB SU-MIMO 4x2	9 cells	Cell avg	1.9721		2.4793	3.058			2.079		2.1832	
		Cell-edge	0.07149		0.0675	0.096			0.05341		0.092	
CS/CB MU-MIMO 2x2	9 cells	Cell avg				2.225	1.6049			1.932		
		Cell-edge				0.074	0.0604			0.045		
	> 9 cells	Cell avg					1.6109	2.1				
		Cell-edge					0.0655	0.0624				
CS/CB MU-MIMO 4x2	9 cells	Cell avg		2.134		2.570	2.0909	2.393	2.076	2.914		2.66
		Cell-edge		0.0483		0.097	0.0864	0.0797	0.05143	0.084		0.102
	> 9 cells	Cell avg					2.1045	2.381				
		Cell-edge					0.0933	0.0853				

Table 7.2.1.1-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-2: Absolute performance of JP in scenario 2 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized			source 1	source 3	source 4	source 5	source 6	source 9	source 10	source 11	source 12	source 13	source 14	source 15	source 20
SU-MIMO 2x2		Cell avg	1.636	2.17			2.079	2.397	2.0534			1.918			
		Cell-edge	0.0488	0.069			0.074	0.070	0.0509			0.0399			
SU-MIMO 4x2		Cell avg	1.937	2.54		2.395	2.2076	2.891	2.5123			1.964		1.98	
		Cell-edge	0.06208	0.087		0.0654	0.0606	0.090	0.0684			0.04084		0.0638	
MU-MIMO 2x2		Cell avg	1.797	2.24				2.171	1.5762	2.11	2.41		1.809		2.47
		Cell-edge	0.0437	0.07				0.071	0.0579	0.0532	0.043		0.042		0.06
MU-MIMO 4x2		Cell avg	2.623	2.77	2.125			2.435	2.0381	2.407	2.72	1.94	2.824		2.48
		Cell-edge	0.0755	0.11	0.0469			0.091	0.0821	0.0705	0.057	0.04076	0.075		0.088
JT SU-MIMO 2x2	9 cells	Cell avg						2.498				1.921			
		Cell-edge						0.083				0.0443			
JT SU-MIMO 4x2	9 cells	Cell avg				2.3	2.2415	2.980				2.312		1.97	
		Cell-edge				0.0738	0.0647	0.106				0.0616		0.077	
JT MU-MIMO 2x2	9 cells	Cell avg	1.957					2.576	1.5424	2.24	2.49		1.707		2.45
		Cell-edge	0.0695					0.084	0.0734	0.062	0.081		0.046		0.1
	> 9 cells	Cell avg		2.32											
		Cell-edge		0.083											
JT MU-MIMO 4x2	9 cells	Cell avg	2.844		2.278			3.384	2.0082	2.71	2.82		2.585		
		Cell-edge	0.1115		0.0559			0.110	0.0991	0.0846	0.103		0.083		
	> 9 cells	Cell avg		2.96											
		Cell-edge		0.13											
DCS SU-MIMO 2x2	9 cells	Cell avg					2.144					1.923			
		Cell-edge					0.074					0.0415			
DCS SU-MIMO 4x2	9 cells	Cell avg										2.324			
		Cell-edge										0.0576			

Table 7.2.1.1-3 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-3: Relative performance gain of DL CoMP in scenario 2 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna		number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 2x2 vs. SU-MIMO 2x2		1	Cell avg	1.46%	1.46%	1.46%
			Cell-edge	2.86%	2.86%	2.86%
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2		5	Cell avg	5.65%	1.81%	11.27%
			Cell-edge	16.68%	3.21%	30.78%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	3	Cell avg	3.71%	1.82%	6.80%
			Cell-edge	5.17%	4.04%	7.14%
	> 9 cells	2	Cell avg	0.86%	-0.47%	2.20%
			Cell-edge	15.21%	13.13%	17.29%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	7	Cell avg	3.63%	-0.58%	7.26%
			Cell-edge	11.66%	2.99%	26.18%
	> 9 cells	2	Cell avg	1.09%	-1.08%	3.26%
			Cell-edge	17.32%	13.64%	20.99%
JT SU-MIMO 2x2 vs. SU-MIMO 2x2	9 cells	2	Cell avg	2.19%	0.16%	4.21%
			Cell-edge	14.80%	11.03%	18.57%
JT SU-MIMO 4x2 vs. SU-MIMO 4x2	9 cells	5	Cell avg	3.57%	-3.97%	17.72%
			Cell-edge	21.78%	6.77%	50.83%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	7	Cell avg	4.07%	-5.64%	18.68%
			Cell-edge	40.72%	9.52%	88.37%
	> 9 cells	1	Cell avg	3.57%	3.57%	3.57%
			Cell-edge	18.57%	18.57%	18.57%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	7	Cell avg	8.70%	-8.46%	38.96%
			Cell-edge	31.35%	10.67%	80.70%
	> 9 cells	1	Cell avg	6.86%	6.86%	6.86%
			Cell-edge	18.18%	18.18%	18.18%
DCS SU-MIMO 2x2 vs. SU-MIMO 2x2	9 cells	2	Cell avg	1.69%	0.26%	3.13%
			Cell-edge	2.01%	0.00%	4.01%
DCS SU-MIMO 4x2 vs. SU-MIMO 4x2	9 cells	1	Cell avg	18.33%	18.33%	18.33%
			Cell-edge	41.04%	41.04%	41.04%

Table 7.2.1.1-4 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-4: Absolute performance of CS/CB in scenario 2 with full buffer [FDD,3GPP,ULA]

ULA			source 1	source 4	source 5	source 9	source 10	source 11	source 13	source 16
SU-MIMO 2x2		Cell avg	1.785		1.9623	2.413	1.989			
		Cell-edge	0.055		0.0654	0.083	0.0575			
SU-MIMO 4x2		Cell avg	2.0412		2.321	2.888	2.4529		2.012	
		Cell-edge	0.06443		0.0781	0.101	0.0772		0.04624	
MU-MIMO 2x2		Cell avg	2.067			2.364	1.8807			
		Cell-edge	0.0536			0.083	0.0654			
MU-MIMO 4x2		Cell avg	3.126	2.504	2.90	2.608	2.7408	2.447	2.07	2.868
		Cell-edge	0.0865	0.0617	0.089	0.104	0.1037	0.0879	0.04965	0.119
CS/CB SU-MIMO 2x2	9 cells	Cell avg			2.078	2.465				
		Cell-edge			0.0696	0.085				
CS/CB SU-MIMO 4x2	9 cells	Cell avg	2.0961		2.4793	3.023			2.155	
		Cell-edge	0.07744		0.0865	0.107			0.06736	
CS/CB MU-MIMO 2x2	9 cells	Cell avg				2.429	1.9817			
		Cell-edge				0.087	0.0742			
	> 9 cells	Cell avg					1.9872			
		Cell-edge					0.0818			
CS/CB MU-MIMO 4x2	9 cells	Cell avg		2.579		2.734	2.8643	2.479	2.163	3.057
		Cell-edge		0.0653		0.111	0.1136	0.1028	0.06039	0.134
	> 9 cells	Cell avg					2.8845	2.431		
		Cell-edge					0.127	0.1064		

Table 7.2.1.1-5 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-5: Absolute performance of JP in scenario 2 with full buffer [FDD,3GPP,ULA]

ULA			source 1	source 3	source 4	source 5	source 9	source 10	source 15	source 19
SU-MIMO 2x2		Cell avg	1.785	1.97		1.9623	2.413	1.989		2.107
		Cell-edge	0.055	0.085		0.0654	0.083	0.0575		0.0607
SU-MIMO 4x2		Cell avg	2.0412	2.26		2.321	2.888	2.4529	2.19	
		Cell-edge	0.06443	0.096		0.0781	0.101	0.0772	0.0911	
MU-MIMO 2x2		Cell avg	2.067				2.364	1.8807		
		Cell-edge	0.0536				0.083	0.0654		
MU-MIMO 4x2		Cell avg	3.126	2.95	2.504	2.90	2.608	2.7408		
		Cell-edge	0.0865	0.099	0.0617	0.089	0.104	0.1037		
JT SU-MIMO 2x2	9 cells	Cell avg				1.9307	2.477			2.183
		Cell-edge				0.0738	0.097			0.0788
JT SU-MIMO 4x2	9 cells	Cell avg				2.2893	2.945		2.25	
		Cell-edge				0.0855	0.118		0.104	
JT MU-MIMO 2x2	9 cells	Cell avg	2.486				2.768	1.9411		
		Cell-edge	0.088				0.100	0.0898		
	> 9 cells	Cell avg		2.24						
		Cell-edge		0.097						
JT MU-MIMO 4x2	9 cells	Cell avg	3.581		2.544	3.05	3.580	2.6974		
		Cell-edge	0.1305		0.0676	0.118	0.133	0.128		
	> 9 cells	Cell avg		2.68						
		Cell-edge		0.133						

Table 7.2.1.1-6 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-6: Relative performance gain of DL CoMP in scenario 2 with full buffer [FDD,3GPP,ULA]

ULA		number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 2x2 vs. SU-MIMO 2x2	9 cells	2	Cell avg	4.03%	2.15%	5.90%
			Cell-edge	4.42%	2.41%	6.42%
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	9 cells	4	Cell avg	5.32%	2.69%	7.11%
			Cell-edge	20.64%	5.94%	45.67%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	2	Cell avg	4.07%	2.77%	5.37%
			Cell-edge	8.93%	4.40%	13.46%
	> 9 cells	1	Cell avg	5.66%	5.66%	5.66%
			Cell-edge	25.08%	25.08%	25.08%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	6	Cell avg	4.12%	1.31%	6.59%
			Cell-edge	12.22%	5.83%	21.63%
	> 9 cells	2	Cell avg	2.29%	-0.65%	5.24%
			Cell-edge	21.76%	21.05%	22.47%
JT SU-MIMO 2x2 vs. SU-MIMO 2x2	9 cells	3	Cell avg	1.55%	-1.61%	3.61%
			Cell-edge	19.84%	12.84%	29.82%
JT SU-MIMO 4x2 vs. SU-MIMO 4x2	9 cells	3	Cell avg	1.12%	-1.37%	2.74%
			Cell-edge	13.49%	9.48%	16.83%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	3	Cell avg	13.53%	3.21%	20.27%
			Cell-edge	40.50%	20.00%	64.18%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	5	Cell avg	11.40%	-1.58%	37.26%
			Cell-edge	28.87%	9.56%	50.87%
	> 9 cells	1	Cell avg	-9.15%	-9.15%	-9.15%
			Cell-edge	34.34%	34.34%	34.34%

Table 7.2.1.1-7 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-7: Absolute performance of CS/CB in scenario 2 with non-full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna				source 10	source 14
MU-MIMO 2x2		RU (50%)	Cell avg	0.6639	
			mean user	1.3263	
			5% cell-edge	0.3266	
		RU (25%)	Cell avg	0.3972	
			mean user	1.7772	
			5% cell-edge	0.5546	
MU-MIMO 4x2		RU (50%)	Cell avg	0.8465	
			mean user	1.454	1.645
			5% cell-edge	0.406	0.498
		RU (25%)	Cell avg	0.4778	
			mean user	1.9587	2.506
			5% cell-edge	0.6675	0.935
CS/CB MU-MIMO 2x2	9 cells	RU (50%)	Cell avg	0.6701	
			mean user	1.4597	
			5% cell-edge	0.3759	
		RU (25%)	Cell avg	0.3992	
			mean user	1.9333	
			5% cell-edge	0.602	
CS/CB MU-MIMO 4x2	9 cells	RU (50%)	Cell avg	0.853	
			mean user	1.5837	1.804
			5% cell-edge	0.4481	0.551
		RU (25%)	Cell avg	0.4798	
			mean user	2.1086	2.651
			5% cell-edge	0.737	1.01

Table 7.2.1.1-8 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-8: Absolute performance of JP in scenario 2 with non-full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna				source 6	source 9	source 10	source 13	source 14	source 15
SU-MIMO 2x2		RU (50%)	Cell avg	1.230	0.894	0.6712	0.773		
			mean user		1.629	1.6552	1.612		
			5% cell-edge	0.127	0.371	0.3458	0.318		
		RU (25%)	Cell avg	0.995	0.499	0.3984	0.458		
			mean user		2.421	2.0688	2.189		
			5% cell-edge	0.255	0.638	0.5544	0.585		
SU-MIMO 4x2		RU (50%)	Cell avg	0.781	1.122	0.8547	1.061		0.94
			mean user	1.290	2.057	1.9634	1.708		1.64
			5% cell-edge	0.357	0.474	0.4226	0.343		0.401
		RU (25%)	Cell avg	0.283	0.643	0.4775	0.616		0.572
			mean user	1.540	2.919	2.4704	2.461		2.35
			5% cell-edge	0.537	0.825	0.6929	0.688		0.876
MU-MIMO 2x2		RU (50%)	Cell avg		0.899	0.6639			
			mean user		1.630	1.3263			
			5% cell-edge		0.431	0.3266			
		RU (25%)	Cell avg		0.495	0.3972			
			mean user		2.589	1.7772			
			5% cell-edge		0.699	0.5546			
MU-MIMO 4x2		RU (50%)	Cell avg		1.117	0.8465			
			mean user		2.049	1.454		1.645	
			5% cell-edge		0.579	0.406		0.498	
		RU (25%)	Cell avg		0.639	0.4778			
			mean user		3.092	1.9587		2.506	
			5% cell-edge		0.878	0.6675		0.935	
JT SU-MIMO 2x2	9 cells	RU (50%)	Cell avg		0.896		0.776		
			mean user		2.410		1.97		
			5% cell-edge		0.645		0.435		
		RU (25%)	Cell avg		0.500		0.459		
			mean user		3.538		3.094		
			5% cell-edge		1.099		0.879		
JT SU-MIMO 4x2	9 cells	RU (50%)	Cell avg	0.793	1.124		1.063		0.943
			mean user	1.250	2.692		1.912		1.578
			5% cell-edge	0.361	0.771		0.401		0.414
		RU (25%)	Cell avg	0.283	0.640		0.618		0.578
			mean user	1.670	3.800		3.196		2.295
			5% cell-edge	0.698	1.317		0.993		0.859
JT MU-MIMO 2x2	9 cells	RU (50%)	Cell avg		0.898	0.6703			
			mean user		1.822	1.3837			
			5% cell-edge		0.571	0.3857			
		RU (25%)	Cell avg		0.500	0.4045			
			mean user		2.804	2.1315			
			5% cell-edge		0.868	0.7377			
JT MU-MIMO 4x2	9 cells	RU (50%)	Cell avg		1.127	0.8515			
			mean user		2.262	1.469		1.673	
			5% cell-edge		0.764	0.4591		0.498	
		RU (25%)	Cell avg		0.640	0.4837			
			mean user		3.313	2.2361		2.647	
			5% cell-edge		1.142	0.8806		1	
DCS SU-MIMO 2x2	9 cells	RU (50%)	Cell avg	1.243			0.775		
			mean user				1.954		
			5% cell-edge	0.143			0.417		
		RU (25%)	Cell avg	1.023			0.459		
			mean user				3.177		
			5% cell-edge	0.289			0.875		
DCS SU-MIMO 4x2	9 cells	RU (50%)	Cell avg				1.063		
			mean user				1.92		
			5% cell-edge				0.387		
		RU (25%)	Cell avg				0.618		
			mean user				3.255		
			5% cell-edge				0.998		

Table 7.2.1.1-9 shows relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-9: Relative performance gain of DL CoMP in scenario 2 with non-full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna	number of sources			average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	RU (50%)	Cell avg	0.93%	0.93%	0.93%
			mean user	10.06%	10.06%	10.06%
			5% cell-edge	15.09%	15.09%	15.09%
		RU (25%)	Cell avg	0.50%	0.50%	0.50%
			mean user	8.78%	8.78%	8.78%
			5% cell-edge	8.55%	8.55%	8.55%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	2	RU (50%)	Cell avg	0.77%	0.77%	0.77%
			mean user	9.29%	8.92%	9.67%
			5% cell-edge	10.51%	10.37%	10.64%
		RU (25%)	Cell avg	0.42%	0.42%	0.42%
			mean user	6.72%	5.79%	7.65%
			5% cell-edge	9.22%	8.02%	10.41%
JT SU-MIMO 2x2 vs. SU-MIMO 2x2	2	RU (50%)	Cell avg	0.29%	0.19%	0.39%
			mean user	35.06%	22.21%	47.92%
			5% cell-edge	55.32%	36.79%	73.85%
		RU (25%)	Cell avg	0.19%	0.17%	0.22%
			mean user	43.75%	41.34%	46.15%
			5% cell-edge	61.27%	50.26%	72.28%
JT SU-MIMO 4x2 vs. SU-MIMO 4x2	4	RU (50%)	Cell avg	0.57%	0.19%	1.54%
			mean user	8.99%	-3.78%	30.89%
			5% cell-edge	21.00%	1.12%	62.72%
		RU (25%)	Cell avg	0.21%	-0.52%	1.05%
			mean user	16.54%	-2.34%	30.19%
			5% cell-edge	33.01%	-1.94%	59.68%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	2	RU (50%)	Cell avg	0.44%	-0.09%	0.96%
			mean user	8.05%	4.33%	11.77%
			5% cell-edge	25.30%	18.10%	32.50%
		RU (25%)	Cell avg	1.43%	1.02%	1.84%
			mean user	14.10%	8.27%	19.94%
			5% cell-edge	28.63%	24.25%	33.01%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	2	RU (50%)	Cell avg	0.75%	0.59%	0.91%
			mean user	4.38%	1.03%	10.40%
			5% cell-edge	15.02%	0.00%	31.97%
		RU (25%)	Cell avg	0.68%	0.13%	1.23%
			mean user	8.98%	5.63%	14.16%
			5% cell-edge	22.97%	6.95%	31.93%
DCS SU-MIMO 2x2 vs. SU-MIMO 2x2	2	RU (50%)	Cell avg	0.66%	0.26%	1.05%
			mean user	21.22%	21.22%	21.22%
			5% cell-edge	21.77%	12.41%	31.13%
		RU (25%)	Cell avg	1.51%	0.22%	2.80%
			mean user	45.13%	45.13%	45.13%
			5% cell-edge	31.51%	13.45%	49.57%
DCS SU-MIMO 4x2 vs. SU-MIMO 4x2	1	RU (50%)	Cell avg	0.19%	0.19%	0.19%
			mean user	12.41%	12.41%	12.41%
			5% cell-edge	12.83%	12.83%	12.83%
		RU (25%)	Cell avg	0.32%	0.32%	0.32%
			mean user	32.26%	32.26%	32.26%
			5% cell-edge	45.06%	45.06%	45.06%

Table 7.2.1.1-10 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-10: Absolute performance of CS/CB in scenario 2 with non-full buffer [FDD,3GPP,ULA]

ULA				source 5	source 10
SU-MIMO 4x2		RU (50%)	Cell avg	1.0631	0.982
			mean user	1.6936	1.8185
			5% cell-edge	0.3453	0.4497
		RU (25%)	Cell avg		0.5271
			mean user		2.3291
			5% cell-edge		0.7859
MU-MIMO 2x2		RU (50%)	Cell avg		0.7933
			mean user		1.3908
			5% cell-edge		0.3526
		RU (25%)	Cell avg		0.4345
			mean user		1.8837
			5% cell-edge		0.6395
MU-MIMO 4x2		RU (50%)	Cell avg		0.9865
			mean user		1.637
			5% cell-edge		0.4888
		RU (25%)	Cell avg		0.529
			mean user		2.1008
			5% cell-edge		0.8425
CS/CB SU-MIMO 4x2	9 cells	RU (50%)	Cell avg	1.0817	
			mean user	1.7286	
			5% cell-edge	0.3742	
		RU (25%)	Cell avg		
			mean user		
			5% cell-edge		
CS/CB MU-MIMO 2x2	9 cells	RU (50%)	Cell avg		0.8014
			mean user		1.5435
			5% cell-edge		0.4153
		RU (25%)	Cell avg		0.4359
			mean user		2.0709
			5% cell-edge		0.735
CS/CB MU-MIMO 4x2	9 cells	RU (50%)	Cell avg		0.9915
			mean user		1.7773
			5% cell-edge		0.5598
		RU (25%)	Cell avg		0.5301
			mean user		2.26
			5% cell-edge		0.9091

Table 7.2.1.1-11 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-11: Absolute performance of JP in scenario 2 with non-full buffer [FDD,3GPP,ULA]

ULA				source 9	source 10	source 15
SU-MIMO 2x2		RU (50%)	Cell avg	0.891	0.798	
			mean user	1.675	1.4829	
			5% cell-edge	0.476	0.3675	
		RU (25%)	Cell avg	0.498	0.4342	
			mean user	2.282	1.9314	
			5% cell-edge	0.773	0.6444	
SU-MIMO 4x2		RU (50%)	Cell avg	1.126	0.982	1.091
			mean user	2.077	1.8185	1.705
			5% cell-edge	0.570	0.4497	0.455
		RU (25%)	Cell avg	0.643	0.5271	0.636
			mean user	2.856	2.3291	2.42
			5% cell-edge	0.938	0.7859	0.941
MU-MIMO 2x2		RU (50%)	Cell avg	0.893	0.7933	
			mean user	1.740	1.3908	
			5% cell-edge	0.570	0.3526	
		RU (25%)	Cell avg	0.499	0.4345	
			mean user	2.421	1.8837	
			5% cell-edge	0.848	0.6395	
MU-MIMO 4x2		RU (50%)	Cell avg	1.121	0.9865	
			mean user	2.148	1.637	
			5% cell-edge	0.737	0.4888	
		RU (25%)	Cell avg	0.641	0.529	
			mean user	3.049	2.1008	
			5% cell-edge	1.048	0.8425	
JT SU-MIMO 2x2	9 cells	RU (50%)	Cell avg	0.895		
			mean user	2.248		
			5% cell-edge	0.722		
		RU (25%)	Cell avg	0.501		
			mean user	3.191		
			5% cell-edge	1.242		
JT SU-MIMO 4x2	9 cells	RU (50%)	Cell avg	1.118		1.098
			mean user	2.642		1.681
			5% cell-edge	0.854		0.485
		RU (25%)	Cell avg	0.640		0.662
			mean user	3.656		2.38
			5% cell-edge	1.400		0.956
JT MU-MIMO 2x2	9 cells	RU (50%)	Cell avg	0.898	0.8011	
			mean user	1.871	1.4556	
			5% cell-edge	0.693	0.4322	
		RU (25%)	Cell avg	0.498	0.4374	
			mean user	2.607	2.2441	
			5% cell-edge	1.026	0.8743	
JT MU-MIMO 4x2	9 cells	RU (50%)	Cell avg	1.129	0.9918	
			mean user	2.288	1.6985	
			5% cell-edge	0.891	0.576	
		RU (25%)	Cell avg	0.637	0.5319	
			mean user	3.190	2.3846	
			5% cell-edge	1.280	1.0458	

Table 7.2.1.1-12 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and non-full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.1-12: Relative performance gain of DL CoMP in scenario 2 with non-full buffer [FDD,3GPP,ULA]

ULA	number of sources			average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	1	RU (50%)	Cell avg	1.75%	1.75%	1.75%
			mean user	2.07%	2.07%	2.07%
			5% cell-edge	8.37%	8.37%	8.37%
		RU (25%)	Cell avg			
			mean user			
			5% cell-edge			
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	RU (50%)	Cell avg	1.02%	1.02%	1.02%
			mean user	10.98%	10.98%	10.98%
			5% cell-edge	17.78%	17.78%	17.78%
		RU (25%)	Cell avg	0.32%	0.32%	0.32%
			mean user	9.94%	9.94%	9.94%
			5% cell-edge	14.93%	14.93%	14.93%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	1	RU (50%)	Cell avg	0.51%	0.51%	0.51%
			mean user	8.57%	8.57%	8.57%
			5% cell-edge	14.53%	14.53%	14.53%
		RU (25%)	Cell avg	0.21%	0.21%	0.21%
			mean user	7.58%	7.58%	7.58%
			5% cell-edge	7.91%	7.91%	7.91%
JT SU-MIMO 2x2 vs. SU-MIMO 2x2	1	RU (50%)	Cell avg	0.38%	0.38%	0.38%
			mean user	34.25%	34.25%	34.25%
			5% cell-edge	51.78%	51.78%	51.78%
		RU (25%)	Cell avg	0.68%	0.68%	0.68%
			mean user	39.86%	39.86%	39.86%
			5% cell-edge	60.69%	60.69%	60.69%
JT SU-MIMO 4x2 vs. SU-MIMO 4x2	2	RU (50%)	Cell avg	-0.01%	-0.67%	0.64%
			mean user	12.88%	-1.41%	27.17%
			5% cell-edge	28.23%	6.59%	49.87%
		RU (25%)	Cell avg	1.78%	-0.53%	4.09%
			mean user	13.18%	-1.65%	28.02%
			5% cell-edge	25.47%	1.59%	49.34%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	2	RU (50%)	Cell avg	0.77%	0.57%	0.98%
			mean user	6.09%	4.66%	7.52%
			5% cell-edge	22.01%	21.44%	22.58%
		RU (25%)	Cell avg	0.25%	-0.17%	0.67%
			mean user	13.40%	7.68%	19.13%
			5% cell-edge	28.83%	20.94%	36.72%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	2	RU (50%)	Cell avg	0.64%	0.54%	0.75%
			mean user	5.14%	3.76%	6.52%
			5% cell-edge	19.35%	17.84%	20.86%
		RU (25%)	Cell avg	-0.05%	-0.66%	0.55%
			mean user	9.06%	4.61%	13.51%
			5% cell-edge	23.13%	22.13%	24.13%

7.2.1.2 TDD, Downlink

Table 7.2.1.2-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.2-1: Absolute performance of CS/CB in scenario 2 with full buffer [TDD,3GPP,cross-polarized deployment]

cross-polarized antenna			source 2	source 3	source 11
MU-MIMO 2x2		Cell avg	2.49	2.35	
		Cell-edge	0.0663	0.073	
MU-MIMO 4x2		Cell avg	3.43	2.98	2.696
		Cell-edge	0.100	0.111	0.0883
MU-MIMO 8x2		Cell avg	4.29		3.401
		Cell-edge	0.151		0.125
CS/CB MU-MIMO 2x2	9 cells	Cell avg	2.58	2.4	
		Cell-edge	0.0767	0.078	
	> 9 cells	Cell avg		2.43	
		Cell-edge		0.082	
CS/CB MU-MIMO 4x2	9 cells	Cell avg	3.59	3.07	2.672
		Cell-edge	0.117	0.12	0.0944
	> 9 cells	Cell avg		3.1	2.599
		Cell-edge		0.13	0.1065
CS/CB MU-MIMO 8x2	9 cells	Cell avg	4.67		3.415
		Cell-edge	0.185		0.1475
	> 9 cells	Cell avg			3.391
		Cell-edge			0.1523

Table 7.2.1.2-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.2-2: Absolute performance of JP in scenario 2 with full buffer [TDD,3GPP,cross-polarized deployment]

cross-polarized antenna			source 1	source 2	source 3	source 12	source 18
MU-MIMO 2x2		Cell avg	1.911	2.49	2.35	1.45	
		Cell-edge	0.0439	0.0663	0.073	0.045	
MU-MIMO 4x2		Cell avg	2.779	3.43	2.98		3.48
		Cell-edge	0.0763	0.100	0.111		0.102
MU-MIMO 8x2		Cell avg		4.29		4.21	5.46
		Cell-edge		0.151		0.134	0.183
JT MU-MIMO 2x2	9 cells	Cell avg	2.431	2.83		2.31	
		Cell-edge	0.0786	0.0772		0.09	
	> 9 cells	Cell avg			2.43		
		Cell-edge			0.087		
JT MU-MIMO 4x2	9 cells	Cell avg	3.586	4.01			4.08
		Cell-edge	0.1336	0.133			0.161
	> 9 cells	Cell avg			3.1		
		Cell-edge			0.13		
JT MU-MIMO 8x2	9 cells	Cell avg		4.96		5.61	
		Cell-edge		0.176		0.185	

Table 7.2.1.2-3 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.2-3: Relative performance gain of DL CoMP in scenario 2 with full buffer [TDD,3GPP,cross-polarized deployment]

cross-polarized antenna		number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	2	Cell avg	2.68%	2.13%	3.24%
			Cell-edge	11.22%	6.85%	15.60%
	> 9 cells	1	Cell avg	3.40%	3.40%	3.40%
			Cell-edge	12.33%	12.33%	12.33%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	3	Cell avg	2.28%	-0.89%	4.72%
			Cell-edge	10.62%	6.91%	16.84%
	> 9 cells	2	Cell avg	0.21%	-3.60%	4.03%
			Cell-edge	18.86%	17.12%	20.61%
CS/CB MU-MIMO 8x2 vs. MU-MIMO 8x2	9 cells	2	Cell avg	4.63%	0.41%	8.84%
			Cell-edge	20.27%	18.00%	22.54%
	> 9 cells	1	Cell avg	-0.29%	-0.29%	-0.29%
			Cell-edge	21.84%	21.84%	21.84%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	3	Cell avg	33.26%	13.26%	59.31%
			Cell-edge	65.12%	16.31%	100.00%
	> 9 cells	1	Cell avg	3.40%	3.40%	3.40%
			Cell-edge	19.18%	19.18%	19.18%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	3	Cell avg	21.12%	17.09%	29.04%
			Cell-edge	55.26%	32.84%	75.10%
	> 9 cells	1	Cell avg	4.03%	4.03%	4.03%
			Cell-edge	17.12%	17.12%	17.12%
JT MU-MIMO 8x2 vs. MU-MIMO 8x2	9 cells	2	Cell avg	24.43%	15.60%	33.25%
			Cell-edge	27.38%	16.69%	38.06%

Table 7.2.1.2-4 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.2-4: Absolute performance of CS/CB in scenario 2 with full buffer [TDD,3GPP,ULA]

ULA			source 11
MU-MIMO 4x2		Cell avg	2.884
		Cell-edge	0.09
MU-MIMO 8x2		Cell avg	3.541
		Cell-edge	0.1168
CS/CB MU-MIMO 4x2	9 cells	Cell avg	2.875
		Cell-edge	0.1013
	> 9 cells	Cell avg	2.797
		Cell-edge	0.1134
CS/CB MU-MIMO 8x2	9 cells	Cell avg	3.555
		Cell-edge	0.1335
	> 9 cells	Cell avg	3.391
		Cell-edge	0.1538

Table 7.2.1.2-5 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.2-5: Absolute performance of JP in scenario 2 with full buffer [TDD,3GPP,ULA]

ULA			source 1	source 3	source 12
MU-MIMO 2x2		Cell avg	2.069		1.86
		Cell-edge	0.0548		0.058
MU-MIMO 4x2		Cell avg	3.163	3.05	
		Cell-edge	0.0863	0.1	
MU-MIMO 8x2		Cell avg			4.5
		Cell-edge			0.151
JT MU-MIMO 2x2	9 cells	Cell avg	2.713		2.77
		Cell-edge	0.0879		0.107
	> 9 cells	Cell avg		2.35	
		Cell-edge		0.102	
JT MU-MIMO 4x2	9 cells	Cell avg	4.028		
		Cell-edge	0.1368		
	> 9 cells	Cell avg		2.81	
		Cell-edge		0.139	
JT MU-MIMO 8x2	9 cells	Cell avg			6.11
		Cell-edge			0.207

Table 7.2.1.2-6 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.2-6: Relative performance gain of DL CoMP in scenario 2 with full buffer [TDD,3GPP,ULA]

ULA		number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	1	Cell avg	-0.31%	-0.31%	-0.31%
			Cell-edge	12.56%	12.56%	12.56%
	> 9 cells	1	Cell avg	-3.02%	-3.02%	-3.02%
			Cell-edge	26.00%	26.00%	26.00%
CS/CB MU-MIMO 8x2 vs. MU-MIMO 8x2	9 cells	1	Cell avg	0.40%	0.40%	0.40%
			Cell-edge	14.30%	14.30%	14.30%
	> 9 cells	1	Cell avg	-4.24%	-4.24%	-4.24%
			Cell-edge	31.68%	31.68%	31.68%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	2	Cell avg	40.03%	31.13%	48.92%
			Cell-edge	72.44%	60.40%	84.48%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	1	Cell avg	27.35%	27.35%	27.35%
			Cell-edge	58.52%	58.52%	58.52%
	> 9 cells	1	Cell avg	-7.87%	-7.87%	-7.87%
			Cell-edge	39.00%	39.00%	39.00%
JT MU-MIMO 8x2 vs. MU-MIMO 8x2	9 cells	1	Cell avg	35.78%	35.78%	35.78%
			Cell-edge	37.09%	37.09%	37.09%

7.2.1.3 Uplink

Table 7.2.1.3-1 shows the spectral efficiency results of CoMP JR schemes versus single-cell schemes in scenario 2 FDD Uplink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.3-1: Absolute performance of JR in scenario 2 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna			source 1	source 12
SU-MIMO 1x2		Cell avg	1.156	1.7694
		Cell-edge	0.0348	0.05822
SU-MIMO 1x4		Cell avg	1.726	
		Cell-edge	0.06511	
JR SU-MIMO 1x2	9 cells	Cell avg		2.3261
		Cell-edge		0.09658
JR MU-MIMO 1x2	9 cells	Cell avg	1.203	
		Cell-edge	0.0391	
JR MU-MIMO 1x4	9 cells	Cell avg	1.802	
		Cell-edge	0.0702	

Table 7.2.1.3-2 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Uplink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.3-2: Relative performance gain of UL CoMP in scenario 2 with full buffer [FDD,3GPP,cross-polarized deployment]

cross-polarized antenna	number of sources		average relative gain	smallest relative gain	largest relative gain
JR SU-MIMO 1x2 vs. SU-MIMO 1x2	1	Cell avg	31.46%	31.46%	31.46%
		Cell-edge	65.89%	65.89%	65.89%

Table 7.2.1.3-3 shows the spectral efficiency results of CoMP JR schemes versus single-cell schemes in scenario 2 FDD Uplink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.3-3: Absolute performance of JR in scenario 2 with full buffer [FDD,3GPP,ULA]

ULA			source 3	source 5
SU-MIMO 1x2		Cell avg	0.963	
		Cell-edge	0.05	
SU-MIMO 1x4		Cell avg	1.437	
		Cell-edge	0.078	
MU-MIMO 2x4		Cell avg		1.91
		Cell-edge		0.065
JR SU-MIMO 1x2	9 cells	Cell avg	1.090	
		Cell-edge	0.066	
JR SU-MIMO 1x4	9 cells	Cell avg	1.51	
		Cell-edge	0.106	
JR MU-MIMO 2x4	9 cells	Cell avg		2.15
		Cell-edge		0.086

Table 7.2.1.3-4 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Uplink with closely–spaced ULA deployment and full buffer traffic model for 3GPP case 1 channel model.

Table 7.2.1.3-4: Relative performance gain of UL CoMP in scenario 2 with full buffer [FDD,3GPP,ULA]

ULA	number of sources		average relative gain	smallest relative gain	largest relative gain
JR SU-MIMO 1x2 vs. SU-MIMO 1x2	1	Cell avg	13.19%	13.19%	13.19%
		Cell-edge	32.00%	32.00%	32.00%
JR SU-MIMO 1x4 vs. SU-MIMO 1x4	1	Cell avg	5.08%	5.08%	5.08%
		Cell-edge	35.90%	35.90%	35.90%
JR MU-MIMO 2x4 vs. MU-MIMO 2x4	1	Cell avg	12.57%	12.57%	12.57%
		Cell-edge	32.31%	32.31%	32.31%

7.2.2 ITU channel model

7.2.2.1 FDD, Downlink

Table 7.2.2.1-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.1-1: Absolute performance of CS/CB in scenario 2 with full buffer [FDD,ITU,cross-polarized deployment]

cross-polarized antenna			source 8	source 10	source 11	source 20
SU-MIMO 4x2		Cell avg	1.78	1.8285		
		Cell-edge	0.052	0.0466		
MU-MIMO 2x2		Cell avg		1.6286	2.01	2.87
		Cell-edge		0.0415	0.044	0.07
MU-MIMO 4x2		Cell avg		1.8805	2.199	2.88
		Cell-edge		0.0589	0.0544	0.103
CS/CB SU-MIMO 4x2	9 cells	Cell avg	1.75			
		Cell-edge	0.054			
CS/CB MU-MIMO 2x2	9 cells	Cell avg		1.72		
		Cell-edge		0.0476		
	> 9 cells	Cell avg		1.7539		
		Cell-edge		0.0547		
CS/CB MU-MIMO 4x2	9 cells	Cell avg		1.9925	2.206	3.11
		Cell-edge		0.0667	0.0609	0.12
	> 9 cells	Cell avg		2.0246	2.172	
		Cell-edge		0.0736	0.0674	

Table 7.2.2.1-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.1-2: Absolute performance of JP in scenario 2 with full buffer [FDD, ITU,cross-polarized deployment]

cross-polarized antenna			source 1	source 8	source 10	source 11	source 20
SU-MIMO 2x2		Cell avg		1.5	1.4604		
		Cell-edge		0.043	0.0347		
SU-MIMO 4x2		Cell avg		1.78	1.8285		
		Cell-edge		0.052	0.0466		
MU-MIMO 2x2		Cell avg	1.732		1.6286	2.01	2.87
		Cell-edge	0.0354		0.0415	0.044	0.07
MU-MIMO 4x2		Cell avg	2.474		1.8805	2.199	2.88
		Cell-edge	0.0597		0.0589	0.0544	0.103
JT SU-MIMO 2x2	9 cells	Cell avg		1.62			
		Cell-edge		0.048			
JT SU-MIMO 4x2	9 cells	Cell avg		1.85			
		Cell-edge		0.054			
JT MU-MIMO 2x2	9 cells	Cell avg	2.276		1.7256	2.22	2.85
		Cell-edge	0.0641		0.0638	0.055	0.116
JT MU-MIMO 4x2	9 cells	Cell avg	2.957		1.9691	2.49	
		Cell-edge	0.0946		0.0837	0.0691	
DCS SU-MIMO 2x2	9 cells	Cell avg		1.51			
		Cell-edge		0.044			
DCS SU-MIMO 4x2	9 cells	Cell avg		1.79			
		Cell-edge		0.053			

Table 7.2.2.1-3 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.1-3: Relative performance gain of DL CoMP in scenario 2 with full buffer [FDD, ITU,cross-polarized deployment]

cross-polarized antenna		number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	9 cells	1	Cell avg	-1.69%	-1.69%	-1.69%
			Cell-edge	3.85%	3.85%	3.85%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	1	Cell avg	5.61%	5.61%	5.61%
			Cell-edge	14.70%	14.70%	14.70%
	> 9 cells	1	Cell avg	7.69%	7.69%	7.69%
			Cell-edge	31.81%	31.81%	31.81%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	3	Cell avg	4.75%	0.32%	7.99%
			Cell-edge	13.90%	11.95%	16.50%
	> 9 cells	2	Cell avg	3.22%	-1.23%	7.66%
			Cell-edge	24.43%	23.90%	24.96%
JT SU-MIMO 2x2 vs. SU-MIMO 2x2	9 cells	1	Cell avg	0.08	0.08	0.08
			Cell-edge	11.63%	11.63%	11.63%
JT SU-MIMO 4x2 vs. SU-MIMO 4x2	9 cells	1	Cell avg	3.93%	3.93%	3.93%
			Cell-edge	3.85%	3.85%	3.85%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	4	Cell avg	11.78%	-0.70%	31.41%
			Cell-edge	56.38%	25.00%	81.07%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	3	Cell avg	12.49%	4.71%	19.52%
			Cell-edge	42.53%	27.02%	58.46%
DCS SU-MIMO 2x2 vs. SU-MIMO 2x2	9 cells	1	Cell avg	0.67%	0.67%	0.67%
			Cell-edge	2.33%	2.33%	2.33%
DCS SU-MIMO 4x2 vs. SU-MIMO 4x2	9 cells	1	Cell avg	0.56%	0.56%	0.56%
			Cell-edge	1.92%	1.92%	1.92%

Table 7.2.2.1-4 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.1-4: Absolute performance of CS/CB in scenario 2 with full buffer [FDD,ITU,ULA]

ULA			source 10	source 11
MU-MIMO 2x2		Cell avg	1.5418	
		Cell-edge	0.0481	
MU-MIMO 4x2		Cell avg	2.2551	2.063
		Cell-edge	0.0725	0.0401
CS/CB MU-MIMO 2x2	9 cells	Cell avg	1.6393	
		Cell-edge	0.0529	
	> 9 cells	Cell avg	1.6502	
		Cell-edge	0.0595	
CS/CB MU-MIMO 4x2	9 cells	Cell avg	2.3843	2.051
		Cell-edge	0.079	0.0449
	> 9 cells	Cell avg	2.4137	2.04
		Cell-edge	0.0878	0.0535

Table 7.2.2.1-5 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.1-5: Absolute performance of JP in scenario 2 with full buffer [FDD, ITU, ULA]

ULA			source 1	source 10
MU-MIMO 2x2		Cell avg	1.761	1.5418
		Cell-edge	0.0407	0.0481
MU-MIMO 4x2		Cell avg	2.636	2.2551
		Cell-edge	0.0625	0.0725
JT MU-MIMO 2x2	9 cells	Cell avg	2.406	1.6682
		Cell-edge	0.0691	0.0716
JT MU-MIMO 4x2	9 cells	Cell avg	3.045	2.36
		Cell-edge	0.0923	0.1023

Table 7.2.2.1-6 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.1-6: Relative performance gain of DL CoMP in scenario 2 with full buffer [FDD, ITU, ULA]

ULA		number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	1	Cell avg	6.32%	6.32%	6.32%
			Cell-edge	9.98%	9.98%	9.98%
	> 9 cells	1	Cell avg	7.03%	7.03%	7.03%
			Cell-edge	23.70%	23.70%	23.70%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	2	Cell avg	2.57%	-0.58%	5.73%
			Cell-edge	10.47%	8.97%	11.97%
	> 9 cells	2	Cell avg	2.96%	-1.11%	7.03%
			Cell-edge	27.26%	21.10%	33.42%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	2	Cell avg	22.41%	8.20%	36.63%
			Cell-edge	59.32%	48.86%	69.78%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	2	Cell avg	10.08%	4.65%	15.52%
			Cell-edge	44.39%	41.10%	47.68%

Table 7.2.2.1-7 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for ITU channel model.

Table 7.2.2.1-7: Absolute performance of CS/CB in scenario 2 with non-full buffer [FDD,ITU,cross-polarized deployment]

cross-polarized antenna				source 8	source 10
SU-MIMO 4x2		RU (50%)	Cell avg	0.813	0.6876
			mean user	1.531	1.5638
			5% cell-edge	0.509	0.3238
		RU (25%)	Cell avg	0.442	0.3861
			mean user	2.196	2.0062
			5% cell-edge	0.811	0.5263
MU-MIMO 2x2		RU (50%)	Cell avg		0.531
			mean user		1.2775
			5% cell-edge		0.28
		RU (25%)	Cell avg		0.3173
			mean user		1.6513
			5% cell-edge		0.4494
MU-MIMO 4x2		RU (50%)	Cell avg		0.6882
			mean user		1.3957
			5% cell-edge		0.3484
		RU (25%)	Cell avg		0.3852
			mean user		1.8138
			5% cell-edge		0.568
CS/CB SU-MIMO 4x2	9 cells	RU (50%)	Cell avg	0.993	
			mean user	1.856	
			5% cell-edge	0.643	
		RU (25%)	Cell avg	0.523	
			mean user	2.621	
			5% cell-edge	0.872	
CS/CB MU-MIMO 2x2	9 cells	RU (50%)	Cell avg		0.5385
			mean user		1.5021
			5% cell-edge		0.3401
		RU (25%)	Cell avg		0.3194
			mean user		1.886
			5% cell-edge		0.5342
CS/CB MU-MIMO 4x2	9 cells	RU (50%)	Cell avg		0.6993
			mean user		1.5825
			5% cell-edge		0.4037
		RU (25%)	Cell avg		0.3881
			mean user		2.0246
			5% cell-edge		0.656

Table 7.2.2.1-8 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for ITU channel model.

Table 7.2.2.1-8: Absolute performance of JP in scenario 2 with non-full buffer [FDD,ITU,cross-polarized deployment]

cross-polarized antenna				source 8	source 10
SU-MIMO 2x2		RU (50%)	Cell avg	0.641	0.5254
			mean user	1.275	1.3096
			5% cell-edge	0.399	0.2499
		RU (25%)	Cell avg	0.355	0.3163
			mean user	1.823	1.6966
			5% cell-edge	0.614	0.4098
SU-MIMO 4x2		RU (50%)	Cell avg	0.813	0.6876
			mean user	1.531	1.5638
			5% cell-edge	0.509	0.3238
		RU (25%)	Cell avg	0.442	0.3861
			mean user	2.196	2.0062
			5% cell-edge	0.811	0.5263
MU-MIMO 2x2		RU (50%)	Cell avg		0.531
			mean user		1.2775
			5% cell-edge		0.28
		RU (25%)	Cell avg		0.3173
			mean user		1.6513
			5% cell-edge		0.4494
MU-MIMO 4x2		RU (50%)	Cell avg		0.6882
			mean user		1.3957
			5% cell-edge		0.3484
		RU (25%)	Cell avg		0.3852
			mean user		1.8138
			5% cell-edge		0.568
JT SU-MIMO 2x2	9 cells	RU (50%)	Cell avg	0.645	
			mean user	1.653	
			5% cell-edge	0.589	
		RU (25%)	Cell avg	0.355	
			mean user	2.206	
			5% cell-edge	0.759	
JT SU-MIMO 4x2	9 cells	RU (50%)	Cell avg	0.826	
			mean user	1.641	
			5% cell-edge	0.656	
		RU (25%)	Cell avg	0.448	
			mean user	2.286	
			5% cell-edge	0.904	
JT MU-MIMO 2x2	9 cells	RU (50%)	Cell avg		0.545
			mean user		1.6403
			5% cell-edge		0.4602
		RU (25%)	Cell avg		0.323
			mean user		2.2099
			5% cell-edge		0.8081
JT MU-MIMO 4x2	9 cells	RU (50%)	Cell avg		0.7018
			mean user		1.6044
			5% cell-edge		0.4702
		RU (25%)	Cell avg		0.3908
			mean user		2.2559
			5% cell-edge		0.8914
DCS SU-MIMO 2x2	9 cells	RU (50%)	Cell avg	0.632	
			mean user	1.305	
			5% cell-edge	0.421	
		RU (25%)	Cell avg	0.355	
			mean user	1.853	
			5% cell-edge	0.634	
DCS SU-MIMO 4x2	9 cells	RU (50%)	Cell avg	0.809	
			mean user	1.545	
			5% cell-edge	0.553	
		RU (25%)	Cell avg	0.443	
			mean user	2.21	
			5% cell-edge	0.819	

Table 7.2.2.1-9 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced cross-polarized antenna deployment and non-full buffer traffic model for ITU channel model.

Table 7.2.2.1-9: Relative performance gain of DL CoMP in scenario 2 with non-full buffer [FDD,ITU,cross-polarized deployment]

cross-polarized antenna	number of sources			average relative gain	smallest relative gain	largest relative gain
CS/CB SU-MIMO 4x2 vs. SU-MIMO 4x2	1	RU (50%)	Cell avg	22.14%	22.14%	22.14%
			mean user	21.23%	21.23%	21.23%
			5% cell-edge	26.33%	26.33%	26.33%
		RU (25%)	Cell avg	18.33%	18.33%	18.33%
			mean user	19.35%	19.35%	19.35%
			5% cell-edge	7.52%	7.52%	7.52%
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	RU (50%)	Cell avg	1.41%	1.41%	1.41%
			mean user	17.58%	17.58%	17.58%
			5% cell-edge	21.46%	21.46%	21.46%
		RU (25%)	Cell avg	0.66%	0.66%	0.66%
			mean user	14.21%	14.21%	14.21%
			5% cell-edge	18.87%	18.87%	18.87%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	1	RU (50%)	Cell avg	1.61%	1.61%	1.61%
			mean user	13.38%	13.38%	13.38%
			5% cell-edge	15.87%	15.87%	15.87%
		RU (25%)	Cell avg	0.75%	0.75%	0.75%
			mean user	11.62%	11.62%	11.62%
			5% cell-edge	15.49%	15.49%	15.49%
JT SU-MIMO 2x2 vs. SU-MIMO 2x2	1	RU (50%)	Cell avg	0.62%	0.62%	0.62%
			mean user	29.65%	29.65%	29.65%
			5% cell-edge	47.62%	47.62%	47.62%
		RU (25%)	Cell avg	0.00%	0.00%	0.00%
			mean user	21.01%	21.01%	21.01%
			5% cell-edge	23.62%	23.62%	23.62%
JT SU-MIMO 4x2 vs. SU-MIMO 4x2	1	RU (50%)	Cell avg	1.60%	1.60%	1.60%
			mean user	7.18%	7.18%	7.18%
			5% cell-edge	28.88%	28.88%	28.88%
		RU (25%)	Cell avg	1.36%	1.36%	1.36%
			mean user	4.10%	4.10%	4.10%
			5% cell-edge	11.47%	11.47%	11.47%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	1	RU (50%)	Cell avg	2.64%	2.64%	2.64%
			mean user	28.40%	28.40%	28.40%
			5% cell-edge	64.36%	64.36%	64.36%
		RU (25%)	Cell avg	1.80%	1.80%	1.80%
			mean user	33.83%	33.83%	33.83%
			5% cell-edge	79.82%	79.82%	79.82%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	1	RU (50%)	Cell avg	1.98%	1.98%	1.98%
			mean user	14.95%	14.95%	14.95%
			5% cell-edge	34.96%	34.96%	34.96%
		RU (25%)	Cell avg	1.45%	1.45%	1.45%
			mean user	24.37%	24.37%	24.37%
			5% cell-edge	56.94%	56.94%	56.94%
DCS SU-MIMO 2x2 vs. SU-MIMO 2x2	1	RU (50%)	Cell avg	-1.40%	-1.40%	-1.40%
			mean user	2.35%	2.35%	2.35%
			5% cell-edge	5.51%	5.51%	5.51%
		RU (25%)	Cell avg	0.00%	0.00%	0.00%
			mean user	1.65%	1.65%	1.65%
			5% cell-edge	3.26%	3.26%	3.26%
DCS SU-MIMO 4x2 vs. SU-MIMO 4x2	1	RU (50%)	Cell avg	-0.49%	-0.49%	-0.49%
			mean user	0.91%	0.91%	0.91%
			5% cell-edge	8.64%	8.64%	8.64%
		RU (25%)	Cell avg	0.23%	0.23%	0.23%
			mean user	0.64%	0.64%	0.64%
			5% cell-edge	0.99%	0.99%	0.99%

Table 7.2.2.1-10 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and non-full buffer traffic model for ITU channel model.

Table 7.2.2.1-10: Absolute performance of CS/CB in scenario 2 with non-full buffer [FDD,ITU,ULA]

ULA				source 10
SU-MIMO 2x2		RU (50%)	Cell avg	0.6478
			mean user	1.2548
			5% cell-edge	0.2809
		RU (25%)	Cell avg	0.3846
			mean user	1.6433
			5% cell-edge	0.5213
SU-MIMO 4x2		RU (50%)	Cell avg	0.8309
			mean user	1.5157
			5% cell-edge	0.3546
		RU (25%)	Cell avg	0.4664
			mean user	1.9954
			5% cell-edge	0.6731
MU-MIMO 2x2		RU (50%)	Cell avg	0.6495
			mean user	1.2462
			5% cell-edge	0.2837
		RU (25%)	Cell avg	0.3849
			mean user	1.6941
			5% cell-edge	0.5302
MU-MIMO 4x2		RU (50%)	Cell avg	0.836
			mean user	1.5354
			5% cell-edge	0.4093
		RU (25%)	Cell avg	0.4667
			mean user	1.9852
			5% cell-edge	0.721
CS/CB MU-MIMO 2x2	9 cells	RU (50%)	Cell avg	0.6592
			mean user	1.4244
			5% cell-edge	0.3409
		RU (25%)	Cell avg	0.3872
			mean user	1.9281
			5% cell-edge	0.6095
CS/CB MU-MIMO 4x2	9 cells	RU (50%)	Cell avg	0.8416
			mean user	1.7009
			5% cell-edge	0.4766
		RU (25%)	Cell avg	0.4696
			mean user	2.1789
			5% cell-edge	0.8093

Table 7.2.2.1-11 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and non-full buffer traffic model for ITU channel model.

Table 7.2.2.1-11: Absolute performance of JP in scenario 2 with non-full buffer [FDD,ITU,ULA]

ULA				source 10
SU-MIMO 2x2		RU (50%)	Cell avg	0.6478
			mean user	1.2548
			5% cell-edge	0.2809
		RU (25%)	Cell avg	0.3846
			mean user	1.6433
			5% cell-edge	0.5213
SU-MIMO 4x2		RU (50%)	Cell avg	0.8309
			mean user	1.5157
			5% cell-edge	0.3546
		RU (25%)	Cell avg	0.4664
			mean user	1.9954
			5% cell-edge	0.6731
MU-MIMO 2x2		RU (50%)	Cell avg	0.6495
			mean user	1.2462
			5% cell-edge	0.2837
		RU (25%)	Cell avg	0.3849
			mean user	1.6941
			5% cell-edge	0.5302
MU-MIMO 4x2		RU (50%)	Cell avg	0.836
			mean user	1.5354
			5% cell-edge	0.4093
		RU (25%)	Cell avg	0.4667
			mean user	1.9852
			5% cell-edge	0.721
JT MU-MIMO 2x2	9 cells	RU (50%)	Cell avg	0.6621
			mean user	1.4648
			5% cell-edge	0.4158
		RU (25%)	Cell avg	0.3892
			mean user	2.1649
			5% cell-edge	0.7882
JT MU-MIMO 4x2	9 cells	RU (50%)	Cell avg	0.8449
			mean user	1.7027
			5% cell-edge	0.5487
		RU (25%)	Cell avg	0.4714
			mean user	2.3475
			5% cell-edge	0.9615

Table 7.2.2.1-12 shows the relative gains of CoMP CS/CB schemes versus single-cell schemes in scenario 2 FDD Downlink with closely–spaced ULA deployment and non-full buffer traffic model for ITU channel model.

Table 7.2.2.1-12: Relative performance gain of DL CoMP in scenario 2 with non-full buffer [FDD,ITU,ULA]

ULA	number of sources			average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	1	RU (50%)	Cell avg	1.49%	1.49%	1.49%
			mean user	14.30%	14.30%	14.30%
			5% cell-edge	20.16%	20.16%	20.16%
		RU (25%)	Cell avg	0.60%	0.60%	0.60%
			mean user	13.81%	13.81%	13.81%
			5% cell-edge	14.96%	14.96%	14.96%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	1	RU (50%)	Cell avg	0.67%	0.67%	0.67%
			mean user	10.78%	10.78%	10.78%
			5% cell-edge	16.44%	16.44%	16.44%
		RU (25%)	Cell avg	0.62%	0.62%	0.62%
			mean user	9.76%	9.76%	9.76%
			5% cell-edge	12.25%	12.25%	12.25%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	1	RU (50%)	Cell avg	1.94%	1.94%	1.94%
			mean user	17.54%	17.54%	17.54%
			5% cell-edge	46.56%	46.56%	46.56%
		RU (25%)	Cell avg	1.12%	1.12%	1.12%
			mean user	27.79%	27.79%	27.79%
			5% cell-edge	48.66%	48.66%	48.66%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	1	RU (50%)	Cell avg	1.06%	1.06%	1.06%
			mean user	10.90%	10.90%	10.90%
			5% cell-edge	34.06%	34.06%	34.06%
		RU (25%)	Cell avg	1.01%	1.01%	1.01%
			mean user	18.25%	18.25%	18.25%
			5% cell-edge	33.36%	33.36%	33.36%

7.2.2.2 TDD, Downlink

Table 7.2.2.2-1 shows the spectral efficiency results of CoMP CS/CB schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.2-1: Absolute performance of CS/CB in scenario 2 with full buffer [TDD,ITU,cross-polarized deployment]

cross-polarized antenna			source 2
MU-MIMO 2x2		Cell avg	2.09
		Cell-edge	0.0669
MU-MIMO 4x2		Cell avg	2.86
		Cell-edge	0.0973
MU-MIMO 8x2		Cell avg	3.68
		Cell-edge	0.151
CS/CB MU-MIMO 2x2	9 cells	Cell avg	2.35
		Cell-edge	0.0743
CS/CB MU-MIMO 4x2	9 cells	Cell avg	3.19
		Cell-edge	0.116
CS/CB MU-MIMO 8x2	9 cells	Cell avg	4.15
		Cell-edge	0.179

Table 7.2.2.2-2 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.2-2: Absolute performance of JP in scenario 2 with full buffer [TDD, ITU,cross-polarized deployment]

cross-polarized antenna			source 1	source 2	source 18
MU-MIMO 2x2		Cell avg	1.816	2.09	
		Cell-edge	0.0348	0.0669	
MU-MIMO 4x2		Cell avg	2.754	2.86	2.57
		Cell-edge	0.0596	0.0973	0.058
MU-MIMO 8x2		Cell avg		3.68	3.88
		Cell-edge		0.151	0.083
JT MU-MIMO 2x2	9 cells	Cell avg	2.774	2.48	
		Cell-edge	0.0765	0.0883	
JT MU-MIMO 4x2	9 cells	Cell avg	4.213	3.51	3.18
		Cell-edge	0.1161	0.112	0.09
JT MU-MIMO 8x2	9 cells	Cell avg		4.70	
		Cell-edge		0.214	

Table 7.2.2.2-3 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced cross-polarized antenna deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.2-3: Relative performance gain of DL CoMP in scenario 2 with full buffer [TDD, ITU,cross-polarized deployment]

cross-polarized antenna		number of sources		average relative gain	smallest relative gain	largest relative gain
CS/CB MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	1	Cell avg	12.48%	12.48%	12.48%
			Cell-edge	11.04%	11.04%	11.04%
CS/CB MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	1	Cell avg	11.46%	11.46%	11.46%
			Cell-edge	19.22%	19.22%	19.22%
CS/CB MU-MIMO 8x2 vs. MU-MIMO 8x2	9 cells	1	Cell avg	12.74%	12.74%	12.74%
			Cell-edge	18.43%	18.43%	18.43%
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	9 cells	2	Cell avg	35.80%	18.85%	52.75%
			Cell-edge	75.90%	31.98%	119.83%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	9 cells	3	Cell avg	33.20%	22.88%	52.98%
			Cell-edge	55.16%	15.52%	94.80%
JT MU-MIMO 8x2 vs. MU-MIMO 8x2	9 cells	1	Cell avg	27.57%	27.57%	27.57%
			Cell-edge	41.62%	41.62%	41.62%

Table 7.2.2.2-4 shows the spectral efficiency results of CoMP JP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.2-4: Absolute performance of JP in scenario 2 with full buffer [TDD,ITU,ULA]

ULA			source 1
MU-MIMO 2x2		Cell avg	1.766
		Cell-edge	0.0401
MU-MIMO 4x2		Cell avg	2.791
		Cell-edge	0.0631
JT MU-MIMO 2x2	9 cells	Cell avg	2.855
		Cell-edge	0.0781
JT MU-MIMO 4x2	9 cells	Cell avg	4.262
		Cell-edge	0.1202

Table 7.2.2.2-5 shows the relative gains of CoMP schemes versus single-cell schemes in scenario 2 TDD Downlink with closely–spaced ULA deployment and full buffer traffic model for ITU channel model.

Table 7.2.2.2-5: Relative performance gain of DL CoMP in scenario 2 with full buffer [TDD, ITU,ULA]

ULA	number of sources		average relative gain	lowest relative gain	highest relative gain
JT MU-MIMO 2x2 vs. MU-MIMO 2x2	1	Cell avg	61.66%	61.66%	61.66%
		Cell-edge	94.76%	94.76%	94.76%
JT MU-MIMO 4x2 vs. MU-MIMO 4x2	1	Cell avg	52.71%	52.71%	52.71%
		Cell-edge	90.49%	90.49%	90.49%

7.3 Scenario 3 and 4: Heterogeneous network with low power RRHs within the macrocell coverage

The relative performance gains of scenario3 and scenario4 over HetNet without eICIC and HetNet with eICIC are provided in this clause. The relative performance gains of scenario3 and scenario4 are provided in Clause 7.3.1 for FDD downlink, Clause 7.3.2 for FDD uplink, and Clause 7.3.3 for TDD downlink. The relative performance gains in Clause 7.3.1, Clause 7.3.2, Clause 7.3.3 were obtained by averaging the submitted relative performance gains for both scenario3 and scenario4.

Disclaimer: Results for different cases and different schemes in Clause 7.3.1, Clause 7.3.2, Clause 7.3.3 are not comparable due to averaging over different companies and different set of schemes including different antenna configurations.

7.3.1 FDD Downlink

Clause 7.3.1.1 provides evaluation results for the full buffer traffic model and Clause 7.3.1.2 provides evaluation results for the FTP traffic model

7.3.1.1 Full Buffer Traffic Model

Table 7.3.1.1-1 provides the relative performance gain of downlink CoMP in scenarios 3 and 4 with full buffer traffic model for the uniform UE distribution case (configuration 1).

Table 7.3.1.1-1: Relative performance gain of downlink CoMP in scenarios 3 and 4 with full buffer traffic model for configuration 1

FDD DL Full Buffer	CoMP JP Scn3/4 Gains		CoMP CS/CB Scn3/4 Gains	
	Macro Cell Area Avg	5% Worst User	Macro Cell Area Avg	5% Worst User
Relative Gain vs HetNet without eICIC	3.0%	24.1%	5.1%	24.8%
Relative Gain vs HetNet with eICIC	3.3%	52.8%	2.7%	19.7%

Table 7.3.1.1-2 provides the relative performance gain of downlink CoMP in scenarios 3 and 4 with full buffer traffic model for the clustered UE distribution case (configuration 4b).

Table 7.3.1.1-2: Relative performance gain of downlink CoMP in scenarios 3 and 4 with full buffer traffic model for configuration 4b

FDD DL Full Buffer	CoMP JP Scn3/4 Gains		CoMP CS/CB Scn3/4 Gains	
	Macro Cell Area Avg	5% Worst User	Macro Cell Area Avg	5% Worst User

Relative Gain vs HetNet without eICIC	6.2%	28.8%	5.2%	30.1%
Relative Gain vs HetNet with eICIC	2.3%	42.9%	1.6%	17.6%

7.3.1.2 FTP Traffic Model

Table 7.3.1.2-1 provides the relative performance gain of FDD downlink CoMP in scenarios 3 and 4 with FTP traffic model for the uniform UE distribution case (configuration 1) when the resource utilization is below 35%.

Table 7.3.1.2-1: Relative performance gain of downlink CoMP in scenarios 3 and 4 with FTP traffic model for configuration 1 (resource utilization<35%)

FDD DL FTP	**CoMP JP Scn3/4 Gains**			**CoMP CS/CB Scn3/4 Gains**		
	Macro Cell Area Avg	**Mean User**	**5% Worst User**	**Macro Cell Area Avg**	**Mean User**	**5% Worst User**
Relative Gain vs HetNet without eICIC	-0.5%	9.0%	26.7%	0.2%	3.1%	12.1%
Relative Gain vs HetNet with eICIC	1.3%	11.4%	16.6%	0.3%	7.4%	11.3%

Table 7.3.1.2-2 provides the relative performance gain of FDD downlink CoMP in scenarios 3 and 4 with FTP traffic model for the uniform UE distribution case (configuration 1) when the resource utilization is 35% or higher.

Table 7.3.1.2-2: Relative performance gain of downlink CoMP in scenarios 3 and 4 with FTP traffic model for configuration 1 (resource utilization≥35%)

FDD DL FTP	**CoMP JP Scn3/4 Gains**			**CoMP CS/CB Scn3/4 Gains**		
	Macro Cell Area Avg	**Mean User**	**5% Worst User**	**Macro Cell Area Avg**	**Mean User**	**5% Worst User**
Relative Gain vs HetNet without eICIC	4.0%	10.2%	39.6%	0.4%	5.1%	20.6%
Relative Gain vs HetNet with eICIC	3.3%	11.1%	16.4%	0.3%	8.6%	26.0%

Table 7.3.1.2-3 provides the relative performance gain of FDD downlink CoMP in scenarios 3 and 4 with FTP traffic model for the clustered UE distribution case (configuration 4b) when the resource utilization is below 35%.

Table 7.3.1.2-3: Relative performance gain of downlink CoMP in scenarios 3 and 4 with FTP traffic model for configuration 4b (resource utilization<35%)

FDD DL FTP	**CoMP JP Scn3/4 Gains**			**CoMP CS/CB Scn3/4 Gains**		
	Macro Cell Area Avg	**Mean User**	**5% Worst User**	**Macro Cell Area Avg**	**Mean User**	**5% Worst User**

Relative Gain vs HetNet without eICIC	2.4%	5.8%	17.0%	0.1%	2.7%	10.1%
Relative Gain vs HetNet with eICIC	4.9%	19.8%	34.1%	0.0%	18.2%	35.3%

Table 7.3.1.2-4 provides the relative performance gain of FDD downlink CoMP in scenarios 3 and 4 with FTP traffic model for the clustered UE distribution case (configuration 4b) when the resource utilization is 35% or higher.

Table 7.3.1.2-4: Relative performance gain of downlink CoMP in scenarios 3 and 4 with FTP traffic model for configuration 4b (resource utilization≥35%)

FDD DL FTP	CoMP JP Scn3/4 Gains			CoMP CS/CB Scn3/4 Gains		
	Macro Cell Area Avg	Mean User	5% Worst User	Macro Cell Area Avg	Mean User	5% Worst User
Relative Gain vs HetNet without eICIC	13.5%	16.9%	39.7%	0.0%	18.2%	54.2%
Relative Gain vs HetNet with eICIC	5.5%	10.3%	16.7%	0.0%	13.3%	13.6%

7.3.2 FDD Uplink

Table 7.3.2-1 provides the relative performance gain of FDD uplink CoMP in scenarios 3 and 4 with full buffer traffic model for the uniform UE distribution case (configuration 1).

Table 7.3.2-1: Relative performance gain of FDD uplink CoMP in scenarios 3 and 4 with full buffer traffic model for configuration 1

FDD UL Full Buffer	CoMP JR Scn3/4 Gains	
	Macro Cell Area Avg	5% Worst User
Relative Gain vs HetNet without eICIC	13.5%	39.7%

Table 7.3.2-2 provides the relative performance gain of FDD uplink CoMP in scenarios 3 and 4 with full buffer traffic model for the clustered UE distribution case (configuration 4b).

Table 7.3.2-2: Relative performance gain of FDD uplink CoMP in scenarios 3 and 4 with full buffer traffic model for configuration 4b

FDD UL Full Buffer	CoMP JR Scn3/4 Gains	
	Macro Cell Area Avg	5% Worst User
Relative Gain vs HetNet without eICIC	15.2%	45.0%

7.3.3 TDD Downlink

Table 7.3.3-1 provides the relative performance gain of TDD downlink CoMP in scenarios 3 and 4 with full buffer traffic model for the uniform UE distribution case (configuration 1).

Table 7.3.3-1: Relative performance gain of TDD downlink CoMP in scenarios 3 and 4 with full buffer traffic model for configuration 1

TDD DL Full Buffer	CoMP JP Scn3/4 Gains		CoMP CS/CB Scn3/4 Gains	
	Macro Cell Area Avg	5% Worst User	Macro Cell Area Avg	5% Worst User
Relative Gain vs HetNet without eICIC	9.5%	24.6%	6.4%	17.8%
Relative Gain vs HetNet with eICIC	10.6%	11.4%	7.0%	5.2%

Table 7.3.3-2 provides the relative performance gain of TDD downlink CoMP in scenarios 3 and 4 with full buffer traffic model for the clustered UE distribution case (configuration 4b).

Table 7.3.3-2: Relative performance gain of TDD downlink CoMP in scenarios 3 and 4 with full buffer traffic model for configuration 4b

TDD DL Full Buffer	CoMP JP Scn3/4 Gains		CoMP CS/CB Scn3/4 Gains	
	Macro Cell Area Avg	5% Worst User	Macro Cell Area Avg	5% Worst User
Relative Gain vs HetNet without eICIC	12.8%	33.2%	10.2%	27.8%
Relative Gain vs HetNet with eICIC	6.5%	7.4%	2.8%	2.5%

7.4 Impact of constraints from lower capacity/higher latency communication between points

The impact of constraints from lower capacity/higher latency communication between transmission points are provided in this clause. The evaluation results were obtained for CoMP in a homogeneous network.

Table 7.4-1 provides the performance evaluation results for CS/CB with varying levels of backhaul delay.

Table 7.4-1 9: Cell CSCB performance evaluation with varying total CSI feedback delay

Transmission scheme	CSI feedback delay + backhaul delay	Sector Tput [kbps]	Gain[%]	UE Tput (5%) [kbps]	Gain[%]
SU-MIMO with CSCB	5ms + 0ms	19147	-	538	-

SU-MIMO with CSCB	5ms + 5ms	18484	-3.5%	516	-4.1%
SU-MIMO with CSCB	5ms + 10ms	17759	-7.2%	477	-11.3%
SU-MIMO with CSCB	5ms + 15ms	17030	-11.1%	443	-17.7%

Table 7.4-2 provides the performance evaluation results for JT with varying levels backhaul delay.

Table 7.4-2 9: Cell JT performance evaluation with varying total CSI feedback delay

Transmission scheme	CSI feedback delay + backhaul delay	Sector Tput [kbps]	Gain[%]	UE Tput (5%) [kbps]	Gain[%]
MU-MIMO with JT	5ms + 0ms	19706	-	828	-
MU-MIMO with JT	5ms + 5ms	18830	-4.4%	776	-6.3%
MU-MIMO with JT	5ms + 10ms	17931	-9.0%	699	-15.6%
MU-MIMO with JT	5ms + 15ms	16944	-14.0%	608	-26.6%

Figure 7.4-1 provides the impact of delayed availability of CSI on the performance of coherent joint transmission operating over 3 intra-site cells.

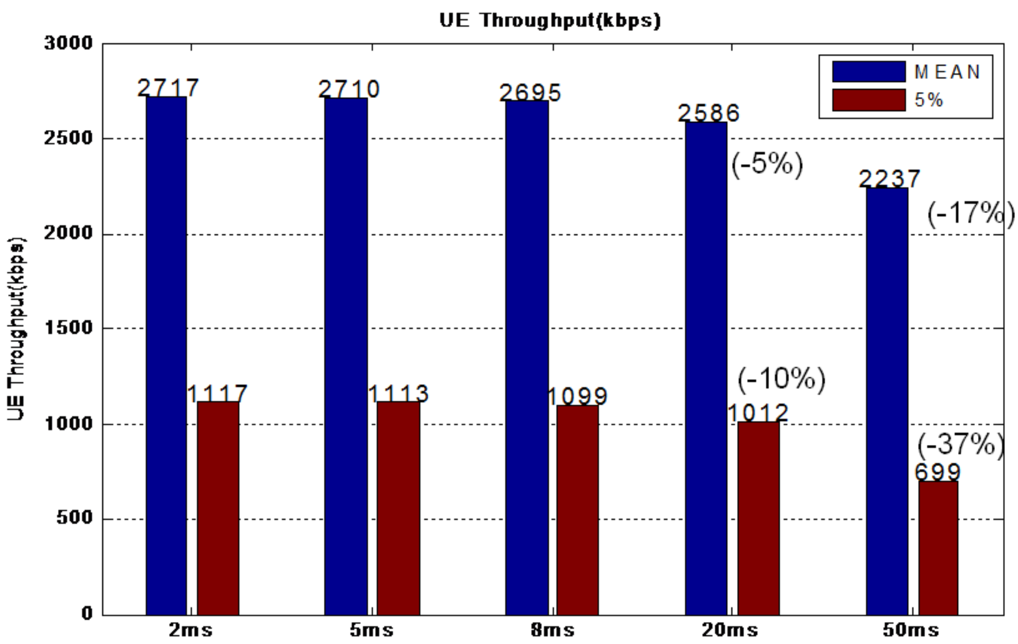


Figure 7.4-1: UE average and cell edge throughput for different feedback delays

Table 7.4-3 provides the full buffer performance evaluation results for JT with varying levels of latency.

Table 7.4-3: FDD JP Results with latency – DL Full Buffer

Channel	Antenna	Single Cell/JP	Cell average	Cell edge spectral

Model	Configuration		spectral efficiency	efficiency
3GPP-Case1	2x2 XPOL	Single Cell	2.11	0.0532
		JT in scenario 2	2.24(+6.1%)	0.062(+16.5%)
		JT with 2ms latency in scenario 2	2.218(+5.1%)	0.057 (+7.1%)

Table 7.4-4 provides the full buffer performance evaluation results for CS/CB with varying levels of latency.

Table 7.4-4: FDD CS/CB Results with latency – DL Full Buffer

Channel Model	Antenna Configuration	Single Cell/CSCB	Cell average spectral efficiency	Cell edge spectral efficiency
3GPP-Case1	4x2 XPOL	Single Cell	2.407	0.0705
		CS/CB (9-cell cluster)	2.393 (-0.6%)	0.0797 (+13%)
		CS/CB (21-cell cluster)	2.381 (-1.1%)	0.0853 (+21%)
		CS/CB with 10ms latency	2.375 (-1.3%)	0.0769 (9%)
		CS/CB with 2ms latency	2.3424(-2.7%)	0.0839(19%)
	4x2 ULA	Single Cell	2.447	0.0879
		CS/CB (9-cell cluster)	2.479 (1.3%)	0.1028 (+17%)
		CS/CB	2.431(-0.6%)	0.1064 (+21%)
		CS/CB with 10ms latency	2.4152(-1.3%)	0.0945(7.5%)
		CS/CB with 2ms latency	2.3872(-2.4%)	0.1044(18.77%)
ITU UMi	4x2 XPOL	Single Cell	2.199	0.0544
		CS/CB (9-cell cluster)	2.206 (+0.3%)	0.0609(+12%)
		CS/CB (21-cell cluster)	2.172 (-1.2%)	0.0674(+24%)
		CS/CB with 10ms latency	2.1790(-0.9%)	0.0598(9.9%)
		CS/CB with 2ms latency	2.1574(-1.9%)	0.0660(21.32%)
	4x2 ULA	Single Cell	2.063	0.0401
		CS/CB (9-cell cluster)	2.051 (-0.6%)	0.0449 (+12%)
		CS/CB (21-cell cluster)	2.040 (-1.4%)	0.0535 (+34%)
		CS/CB with 10ms latency	2.0405（-1.1%）	0.0448(11.74%)
		CS/CB with 2ms latency	2.0202(-2.07%)	0.0521(29.9%)

7.5 Observations

7.5.1 Scenarios 1 and 2

It is observed from the evaluation results for scenarios 1 and 2 that

- for DL, CoMP can offer performance benefits in homogeneous networks
- for UL, considerable gain is achievable with CoMP JR for scenarios 1 and 2.

The following observations are made based on submitted performance numbers, although the observations do not take into account that the following assumptions (channel estimation error modelling, channel reciprocity modelling, feedback / SRS mechanisms, scheduler, receiver, performance baseline) may vary among sources

- The results are based on ideal and non ideal assumptions.

The relative CoMP performance gain over No CoMP

- is increased for the ITU UMi scenario compared to 3GPP case 1 for DL CoMP
- is decreased for high load compared to low load for SU-JP in non-full buffer

Simulated CoMP schemes are different in terms of level of standardization impact,as described in Clause 5.2 and 6.1

7.5.2 Scenarios 3 and 4

It is observed from the evaluation results for scenarios 3 and 4 that CoMP provides performance benefits in heterogeneous networks. The following observations were made for CoMP DL based on submitted performance numbers.

- CoMP gain is seen both with full buffer and FTP traffic
- CoMP shows performance benefits in scenarios 3 and 4

The following observations were made for CoMP UL based on submitted performance numbers.

- For CoMP JR, considerable gain is achievable for scenarios 3 and 4

7.5.3 Impact of constraints from lower capacity/higher latency communication between points

Based on the evaluation results, following observations were made on the impact of constraints from lower capacity/higher latency communication between points:

- Performance of CoMP schemes relying on spatial information exchange is sensitive to the delay between two transmission points.
- Level of sensitivity depends on the CoMP schemes.

8 Conclusion

According to the discussions and the performance evaluation results captured in the previous clauses, the following conclusion is made:

- CoMP can offer performance benefits in homogeneous networks (scenarios 1 and 2).
- CoMP shows performance benefits in heterogeneous networks (scenarios 3 and 4).
- Performance of CoMP schemes relying on spatial information exchange is sensitive to the delay between two transmission points.

- Level of sensitivity depends on the CoMP schemes.

In view of the observed results, it is recommended to specify support for DL CoMP operation and to investigate the extent to which specified support is needed for UL CoMP.

Following the observations on CoMP performance benefits, which are based on the evaluations of coherent joint transmission, coordinated scheduling/beamforming, dynamic point selection, and dynamic point blanking, the work for specifying CoMP support in Rel-11 should focus on

- Joint transmission
- Dynamic point selection, including dynamic point blanking
- Coordinated scheduling/beamforming, including dynamic point blanking

All schemes will be developed assuming that the UE reports CSI feedback based on the assumption of single-user transmission for the work specifying CoMP. This assumption causes no restriction on the SU/MU scheduling decision at the eNB when the PDSCH is demodulated based on UE-specific RS.

Annex A: Simulation model

Editor's note: This annex will capture the evaluation model agreed for performance evaluation of CoMP in RAN WG1. The text colored in yellow will be updated based on RAN1 decisions.

A.1 CoMP system-level simulation assumptions

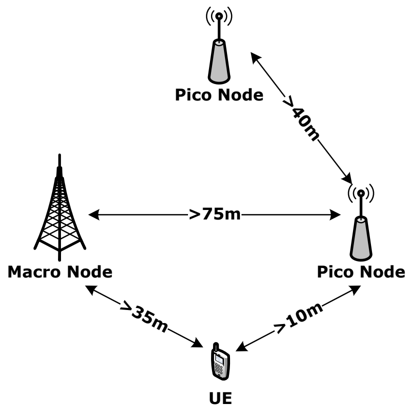
The system simulation baseline parameters for the homogeneous and heterogeneous deployment models are as specified in [TR 36.814], with Table A.2.3-1 modified as Table A.1-1. For Uplink CoMP, some additional simulation assumptions are provided in Table A.1-2.

Table A.1-1: System simulation parameters for CoMP Evaluation

Parameter	Values used for evaluation
Performance metrics	• Full buffer traffic: Cell capacity, Cell-edge user throughput • Non full buffer traffic as defined in Clause A.2.1.3.2 in [TR 36.814] • Jain Index may be provided for information. $J = \frac{\overline{T}^2}{\overline{T}^2 + \mathrm{var}[T]}$

Deployment scenarios	1. **Scenario 1:** Homogeneous network with intra-site CoMP, as illustrated in Figure A.1-1
	2. **Scenario 2:** Homogeneous network with high Tx power RRHs, as illustrated in Figure A.1-2
	    • The central entity can coordinate 9 cells as a baseline, with the reference layout as in Figure A.1-3
	    Choose between 3, 19, 21 cells as a potential optional value. Interested reader can refer to [R1-110585] for some layout examples.
	    Method for modelling of the out-of-coordinated area interference is to be described
	3. **Scenario 3:** Heterogeneous network with low power RRHs within the macrocell coverage (Figure A.1-4).
	    • transmission/reception points created by the RRHs have different cell IDs as the macro cell
	    • Coordination area includes:
	      - 1 cell with N low-power nodes as starting point
	      - 3 intra-site cells with 3*N low-power nodes
	    • Benchmark is non-CoMP Rel. 10 eICIC framework with the different cell ID
	4. **Scenario 4:** Network with low power RRHs within the macrocell coverage where the transmission/reception points created by the RRHs have the same cell IDs as the macro cell (Figure A.1-4).
	    • Coordination area includes:
	      - 1 cell with N low-power nodes as starting point
	      - 3 intra-site cells with 3*N low-power nodes
	    • Benchmark is non-CoMP Rel. 10 eICIC framework with the different cell ID
	
	Baseline for association bias values,
	0 dB only applied for RSRP as baseline
	Any other values applied either for RSRP or RSRQ as optional
	These association values are applied for non-CoMP simulation and those for CoMP simulation can be decided independently

Simulation case	**Deployment scenarios 1, 2:** Baseline: 3GPP-Case1 Recommended: ITU UMi channel model (200m ISD) with eNB/high power RRH Tx power (Ptotal) as 41/44 dBm in a 10/20 MHz carrier **Deployment scenarios 3, 4:** Baseline: ITU UMa for Macro, UMi for low power node • UMa

	- UE speed : 3km/hr - No outdoor in-car penetration loss • UMi - Carrier Frequency : 2GHz - 100% UE dropped outdoors - No outdoor to indoor penetration loss • Antenna Height: Applied for ITU UMa (Macro), ITU UMi (LPN) • 10m for RRH/Hotzone Node • 25m for Macro Node • 3D antenna tilt for calibration (for 25m) : 12 degrees • UE noise figure: Applicable to all the channel models • 9dB • Minimum Distance: Applicable to all the channel models • Macro – RRH/Hotzone: >75m • Macro – UE : >35m • RRH/Hotzone – RRH/Hotzone: >40m • RRH/Hotzone – UE : >10m  • Modeling Conventions • Distance measure 1. Distance *d* is measured in 2 dimensions ▪ Applies to both path loss formula, as well as minimum Node/UE distances • Introduce an efficiency loss parameter, Peff, that is appended to the path-loss of all deployment layers 2. Enables modeling of coverage limited scenarios 3. Default value of Peff is 0 dB 4. Optional value of Peff is 7 dB, corresponding to a coverage limited deployment ▪ This can also be implemented by increasing the UE noise figure accordingly • Additional Clarifications - ITU UMa and UMi penetration, pathloss, and shadowing generation methodology is used for Macro to UE and Pico/RRH to UE repectively - Do not use values in TR36.814 for pathloss, penetration and shadowing Optional enhancement: • Indoor-outdoor modeling • Indoor/Outdoor UE distribution 1. 80% of users are dropped indoor 2. Applies to both UE placing configuration 1 and 4b • Indoor penetration loss for UMa 1. Reuse the model from UMi 2. $PL_{O-I}(d) = PL_{LOS/NLOS}(d) + PL_{penetration}(d_{in})$ 3. $PL_{penetration}(d_{in}) = 20 + 0.5 * d_{in}$ 4. d : distance between UE and transmission node 5. d_{in} : independent uniform random value between [0, min(25,d)] for each link

6. $PL_{LOS/NLOS}$: pathloss of LOS or NLOS computed using the LOS probability for the given link.
   - Note that ITU UMi LOS probability (to the wall) is also used for indoor users.

- Channel Model Parameters for UMa O-to-I
  - Reuse Channel Model Parameters of UMa NLOS for UMa O-to-I
    1. To be used as starting point
    2. Some parameters, including delay spread, standard deviation of shadow fading, number of clusters, cluster ASA, may need to be revised, based on measurements and other observations
  - Chanel Model Parameters of extended UMa are given in the following tables.

Scenarios		UMi			UMa		
		LoS	NLoS	O–to–I	LoS	NLoS	Proposed O-to-I
Delay spread (DS) $\log_{10}$(s)	μ	–7.19	–6.89	–6.62	–7.03	–6.44	–6.44
	σ	0.40	0.54	0.32	0.66	0.39	0.39
AoD spread (ASD) $\log_{10}$(degrees)	μ	1.20	1.41	1.25	1.15	1.41	1.41
	σ	0.43	0.17	0.42	0.28	0.28	0.28
AoA spread (ASA) $\log_{10}$(degrees)	μ	1.75	1.84	1.76	1.81	1.87	1.87
	σ	0.19	0.15	0.16	0.20	0.11	0.11
Shadow fading (SF) (dB)	σ	3	4	7	4	6	6
K–factor (*K*) (dB)	μ	9	N/A	N/A	9	N/A	N/A
	σ	5	N/A	N/A	3.5	N/A	N/A
Cross–correlations*	ASD vs DS	0.5	0	0.4	0.4	0.4	0.4
	ASA vs DS	0.8	0.4	0.4	0.8	0.6	0.6
	ASA vs SF	–0.4	–0.4	0	–0.5	0	0
	ASD vs SF	–0.5	0	0.2	–0.5	–0.6	–0.6
	DS vs SF	–0.4	–0.7	–0.5	–0.4	–0.4	–0.4
	ASD vs ASA	0.4	0	0	0	0.4	0.4
	ASD vs *K*	–0.2	N/A	N/A	0	N/A	N/A
	ASA vs *K*	–0.3	N/A	N/A	–0.2	N/A	N/A
	DS vs *K*	–0.7	N/A	N/A	–0.4	N/A	N/A
	SF vs *K*	0.5	N/A	N/A	0	N/A	N/A
Delay distribution		Exp	Exp	Exp	Exp	Exp	Exp
AoD and AoA distribution		Wrapped Gaussian			Wrapped Gaussian		

Scenarios		UMi			UMa		
		LoS	NLoS	O–to–I	LoS	NLoS	Proposed O-to-I
Delay scaling parameter r_τ		3.2	3	2.2	2.5	2.3	2.3
XPR (dB)	μ	9	8.0	9	8	7	7
Number of clusters		12	19	12	12	20	20
Number of rays per cluster		20	20	20	20	20	20
Cluster ASD		3	10	5	5	2	2
Cluster ASA		17	22	8	11	15	15
Per cluster shadowing std ζ (dB)		3	3	4	3	3	3
Correlation distance (m)	DS	7	10	10	30	40	40
	ASD	8	10	11	18	50	50
	ASA	8	9	17	15	50	50
	SF	10	13	7	37	50	50
	K	15	N/A	N/A	12	N/A	N/A

Optional:
3GPP Case 1 Model1 for TR36.814, SCME Urban Macro 15 degrees angle spread for fast fading (both Macro-to-UE and low power node-to-UE)

Number of low power node per macro-cell	Configuration #4b [TR 36.814] with N low power nodes per macro cell Configuration #1 [TR 36.814] with N low power nodes per macro cell Baseline: N = 4 Optional: N = 1, 2, 10
High power RRH Tx power (Ptotal)	46/49dBm in a 10/20MHz carrier
Low power node TX power (Ptotal)	30 dBm and 37 dBm for both FDD and TDD in 10MHz carrier, with higher priority for 30 dBm
Number of UEs per cell	Full buffer traffic model: 10 for Homogeneous networks; dependent on the targeted resource utilization for non-full-buffer traffic model. Same as TR 36.814 for Heterogeneous networks
System bandwidth	10 MHz, 20MHz
Possible transmission schemes in DL	• SU-MIMO • MU-MIMO • SU-MIMO with intra-eNB CS/CB • MU-MIMO with intra-eNB CS/CB • SU-MIMO with intra-eNB JP-CoMP • MU-MIMO with intra-eNB JP-CoMP
Impairments modelling	The following impairments are modelled. The modelling needs to be described. - impairments of JP-CoMP - Collision between CRS and PDSCH - Different control regions - Modeling of actual propagation delay differences depending on UE location would need to be included as a multipath effect Baseline timing error is 0us; recommended to provide results for additional case with non-zero timing error, for which the details of the timing error modeling are to be described Methods that offset the propagation delay are not precluded - Frequency offset sensitivity analysys is recommended - Analysis of PDCCH and SRS overhead/capacity is recommended
Network synchronization	Synchronized
Number of antennas at transmission point	Macro and high Tx power RRH: 1, 2, 4, 8 (2 and 4 antennas are baseline for FDD, 2 and 8 antennas are baseline for TDD) Low power node: 1, 2, 4 (2 and 4 antennas are baseline). Values for combinations (number of antennas at macro node, number of antennas at low-power node) are (2, 2), (4, 4) for FDD, (2, 2), (8, 2) for TDD as baseline, (2, 4) for FDD, (4, 2) for TDD as optional
Number of antennas at UE	2, 4, with higher priority for 2 antennas.
Antenna configuration	For macro eNB and high power RRH, in priority order for each number of antennas: • 2 Tx antennas 1. 1 column, cross-polarized: X 2. 2 columns, closely-spaced vertically-polarized: || • 4 Tx antennas 1. 2 columns, cross-polarized on each column, closely-spaced: X X 2. 2 columns, cross-polarized on each column, widely-spaced: X X 3. 4 columns, vertically-polarized, closely-spaced: |||| • 8 Tx antennas 1. 4 columns, cross-polarized on each column, closely-spaced: X X X X 2. 4 columns, cross-polarized on each column, 2 widely-spaced sets of closely-spaced columns: X X X X 3. 8 columns, vertically-polarized, closely-spaced: |||||||| For low power node • 1 Tx antenna: vertically-polarized • 2 Tx antennas: 1. cross-polarized: X 2. vertically-polarized: || • 4 Tx antennas: 1. 1. 0.5 λ-spaced cross-polarized: X X 2. 2. 0.5 λ-spaced vertically-polarized: |||| Array orientation needs to be defined (e.g., random for 4 Tx) When cross-polarized antenna configuration is applied to transmission point, it is also applied to the receiver. When co-polarized antenna configuration is applied to

	transmission point, it is also applied to the receiver. For scenarios 3 and 4 and more that 1 antenna at the low power node, when cross-polarized antenna configuration is applied at the macro, it is also applied at the low power node; when co-polarized antenna configuration is applied at the macro, it is also applied at the low power node
Antenna pattern	For macro eNB and high-power RRH: 3D as baseline and 2D as additional Follow Annex A 2.1.1.1 Table A.2.1.1-2 in TR36.814 For low-power node: 2D as baseline and 3D as optional Horizontal plane: omnidirectional Vertical plane: $$A_V(\theta) = -\min\left[12\left(\frac{\theta-\theta_{etilt}}{\theta_{3dB}}\right)^2, SLA_v\right]$$ θ_{3dB} = 40 degrees, SLA_v = 20 dB
eNB Antenna tilt	For macro eNB and high-power RRH: Different downtilt values may be evaluated. For low-power node: 0 or 10 degrees
Antenna gain + connector loss	For macro eNB and high-power RRH: 17 dBi in ITU, 14 dBi in 3GPP Case 1 For low power node: 5 dBi
Feedback scheme (e.g. CQI/PMI/RI/SRS)	Overhead is to be reported The following benchmarks may be used: • Rel-10 feedback (baseline) (with overhead as close as possible to overhead of CoMP scheme) • If CoMP scheme requires more feedback overhead than is possible in Rel-10, benchmark is a single-transmission/reception-point scheme (to be fully described) with same feedback overhead as CoMP scheme Baseline: Per-transmission-point feedback is implicit Inter-cell information feedback mechanism to be described
Channel estimation	Non-ideal Clarify in detail the following on CoMP evaluation: - CSI knowledge of eNB - Feedback scheme and/or UL sounding scheme - Accuracy of CSI . Quantization error . Channel estimation error based on CSI-RS and SRS 1. Describe the way to model the CSI channel estimation errors 2. K different CDF curves are provided, where K = number of transmission points in the CoMP cluster. A curve corresponds to statistics over all UEs of average SINR of the estimated channel for the k:th strongest transmission point for a UE - Try to capture common mis-calibration modelling for TDD by June 3rd Until RAN1 #65, no antennas mis-calibration for UL-DL channel reciprocity as mandatory and antennas mis-calibration for UL-DL channel reciprocity as recommended for TDD - Antennas mis-calibration for DL Tx antennas with 0.5λ spacing as optional for FDD - Channel estimation error for demodulation - Any channel reciprocity modelling to be described. - Any antenna calibration mechanism to be described
UE receiver	Mandatory (in context of the simulations): 'MMSE receiver' Recommended: 'Advanced MMSE receiver and/or IRC receiver' Description for the 'MMSE receiver' assumption • DM-RS Channel estimation o only across layers in which the UE being scheduled o No knowledge of channel estimate coefficients of other co-scheduled DM-RS ports • Assume that the total interference (i.e. including all signals other than the intended data signal) has diagonal covariance matrix

	For more 'advanced MMSE receiver and/or IRC receiver', the MMSE/IRC modeling should be described in detail • Details such as covariance matrix, and frequency selectivity of the covariance matrix, etc More details are described in [R1-110586]
DL overhead assumption	Should be clarified for each transmission scheme, taking into account CSI-RS and PDSCH muting overhead, as well as PDCCH overhead corresponding to scheduling
Placing of UEs	Uniform distribution for homogeneous networks For heterogeneous networks, placement according to the configuration.
Traffic model	Full buffer Non-full-buffer according to Clause A.2.1.3.1 in TR36.814, with the following modifications: • Model 1 with file size of 2 Mbytes is preferred, however Model 1 with file size of 0.5 Mbytes and Model 2 with file size of 0.5 Mbytes can be evaluated instead • Simulations are run for various λ (for model 1) or K (for model 2) that lead to covering at least the range [10 - 70]% of RU (See A.2.1.3.2) in non-CoMP SU-MIMO, and the metrics described in A.2.1.3.2 are computed for each λ (for model 1) or K (for model 2) value • The RU is computed over the entire network, i.e. the RU is the average of the RUs per transmission point For full buffer traffic model and non-full buffer traffic model 2 - Fix the total number of users, N_{users}, dropped within each macro geographical area, where N_{users} is 30 or 60 in fading scenarios and 60 in non-fading scenarios. - Randomly and uniformly drop the configured number of low power nodes, N, within each macro geographical area (the same number N for every macro geographical area, where N may take values from {1, 2, 4, 10}). - Randomly and uniformly drop N_{users_lpn} users within a 40 m radius of each low power node, where $N_{users\_lpn} = \lfloor P^{hotspot} \cdot N_{users}/N \rfloor$ with $P^{hotspot}$ defined in Table A.2.1.1.2-5, where $P^{hotspot}$ is the fraction of all hotspot users over the total number of users in the network. - Randomly and uniformly drop the remaining users, N_{users} - N_{users_lpn}*N, to the entire macro geographical area of the given macro cell (including the low power node user dropping area). For non-full buffer traffic model 1 - Randomly and uniformly drop the configured number of low power nodes, N, within each macro geographical area (the same number N for every macro geographical area, where N may take values from {1, 2, 4, 10}). • -Generate users based on traffic load. Chose the geographical area in which user will be dropped randomly and with probability of $P^{hotspot}$ for the low power node geographical area, and 1- $P^{hotspot}$ for the the entire macro cell geographical area (including the low power node user dropping area).
Backhaul assumptions	For deployment scenarios 1, 2, 3, and 4: Step 1: [point-to-point fiber, zero] latency and infinite capacity Step 2: higher latency and limited capacity for scenarios 2 and 3 • The latency values used for CoMP evaluation are {0ms,2ms,10ms} • The latency value here refers to the one-way delay incurred when a message is conveyed from one node to another The capacity requirement associated with the proposed scheme should be indicated
Link adaptation	Non-ideal; details to be provided

The objective of uplink CoMP evaluation is to clarify the performance gain of intra-site and inter-site CoMP schemes over single reception point schemes.

Same assumptions for scenarios, UE dropping, antenna configuration, and channel model, etc. as for downlink CoMP evaluation (Table A.1-1) are applied. In addition, the assumptions in Table A.1-2 apply.

Table A.1-2: System simulation parameters for UL CoMP Evaluation

Parameter	Values used for evaluation
Access scheme	SC-FDMA (mandatory), Clustered DFT-S-OFDM (optional)
Number of Tx antenna at the UE	1, 2, 4, with higher priority to 1 antenna
Number of Rx antenna at the eNB/RRH/Pico nodes	• Macro: 2, 4, 8 (2 and 4 antennas are baseline for FDD, 2 and 8 antennas are baseline for TDD) • Low Tx power RRH/Pico (in applicable scenarios) : 2, 4
UL power control	• Power control parameters (P0 and alpha) are chosen according to the deployment scenario. (IoT reported with simulation results.) o Details of the power control formula used in evaluations are to be supplied together with the evaluation results. • Total maximum transmission power (sum over all Tx antennas): 23 dBm • Companies to state: alpha value, P0 value, open or close loop, K_s value (Macro and pico may use different values) • α =1.0, P0=-106 for both macro & pico UEs (suggested value for calibration and/or benchmarking)
UL receiver type	specify the modelling of the receiver type
UL overhead assumption	• SRS overhead according to UL scheduler and transmission scheme • 4 PRBs for PUCCH
Channel estimation for DMRS & SRS	Non-ideal (mandatory) Ideal (for calibration)
HARQ scheme	Specify the HARQ scheme
Scheduling algorithm	Specify the scheduling algorithm
SRS setting	Specify the SRS setting
Downlink cell selection (CRE)	[0, 6] dB (mandatory) [16] dB (optional) Note: downlink cell selection decides the PCI used by each UE.
Reception point/s selection	Specified as part of CoMP scheme
Backhaul assumption	Zero delay
CoMP scheme	Specify the detailed information, e.g. # of coordinated eNBs, JR or CS etc.

Performance metrics	• User throughput CDF
	• Scenarios 3 and 4
	    o macro area throughput [bps/Hz/(1macro+4LPNs)]
	    o cell edge UE throughput (5% worst user throughput over the macro area)
	    o pico cell/receive point throughput [bps/Hz/LPN]
	• Additional information, which may be provided, is as follows:
	    o Macro cell IoT [dB]: mean and variance of effective IoT (36.814)
	        • Linear scale
	    o Pico cell IoT [dB]: mean and variance of effective IoT
	        • Linear scale
	    o Macro UE ratio (%)

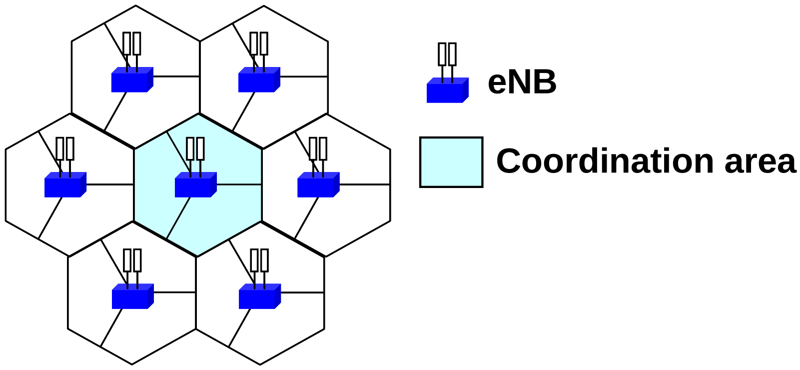


Figure A.1-1: Scenario 1 - Homogeneous network with intra-site CoMP

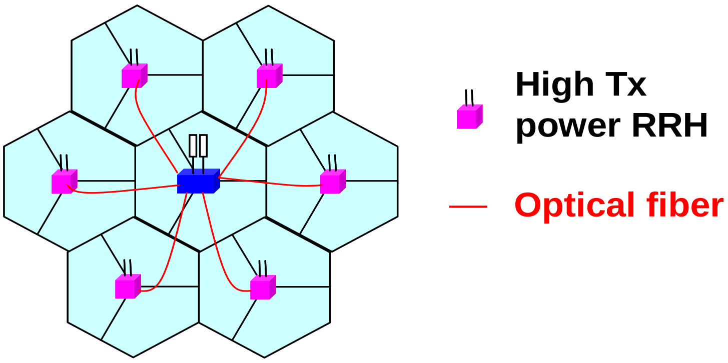


Figure A.1-2: Scenario 2 - Homogeneous network with high Tx power RRHs

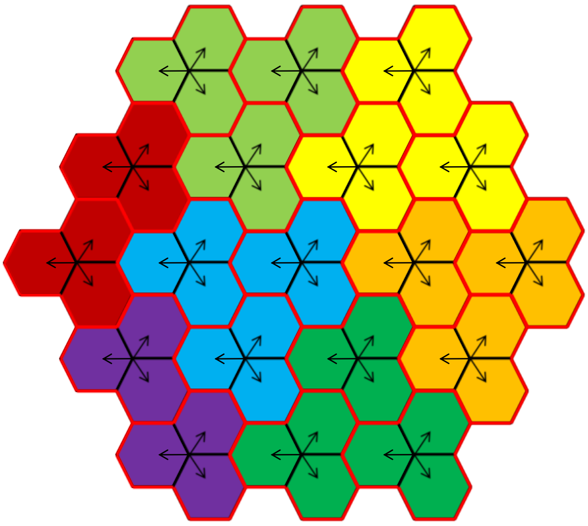


Figure A.1-3- Reference CoMP Coordination Cell Layout for Scenario 2

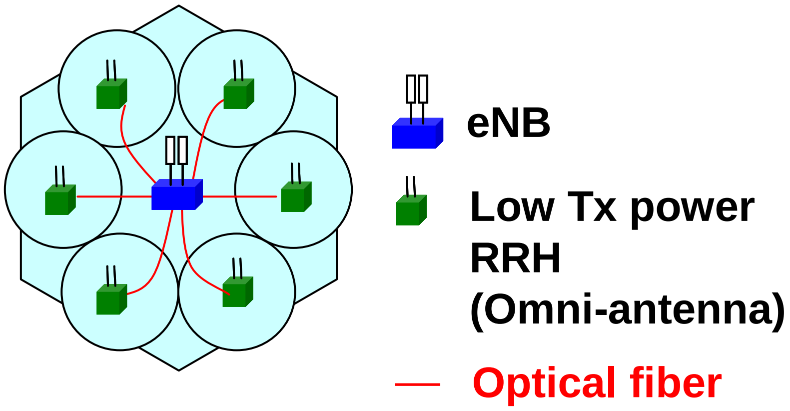


Figure A.1-4: Scenario 3/4 - Network with low power RRHs within the macrocell coverage

A.2 References

[1] 3GPP TR 36.814: "Further Advancements for E-UTRA, Physical Layer Aspects".

[2] R1-110585: "Proposal for CoMP Coordination Cell Layout for Scenario 1 and 2".

[3] R1-110586: "Proposal for UE receiver assumption in CoMP simulations".

[4] R1-111922: "RAN1 Phase 1 CoMP results".

[5] R1-112811: "RAN1 Phase 2 CoMP results".

Annex B: Change history

Table B.1: Change History

Change history					
Date	**TSG #**	**TSG Doc.**	**Subject/Comment**	**Old**	**New**
	R1#64	R1-111167	Draft skeleton TR		0.0.1
	R1#65	R1-111977	Inclusion of agreed evaluation methodology and Phase 1 (Scenarios 1/2)simulation results	0.0.1	0.0.2
	R1#65	R1-111999	Version 0.0.2 approved in RAN1	0.0.2	0.1.0
	RP#52	RP-110631	Version 1.0.0 presented for information in RAN plenary #52	0.1.0	1.0.0
	R1#66	R1-112865	Version 1.1.0 capturing the evaluation phase 2 results, the specification impacts, and the conclusion	1.0.0	1.1.0
	R1#66	R1-112882	Version 1.2.0 capturing the design principle in the conclusion	1.1.0	1.2.0
	RP#53	RP-111240	Version 2.0.0 presented for approval in RAN plenary #53	1.2.0	2.0.0
2011-09	RP#53	RP-111240	Go under change control as version 11.0.0 according to plenary decision	2.0.0	11.0.0
2011-12	RP#54	RP-111673	Update of UL CoMP simulation assumption	11.0.0	11.1.0
2013-09	RP#61	RP-131251	CR for DL CoMP deployment implication	11.1.0	11.2.0