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Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Coordinated multi-point operation for LTE with non-ideal backhaul (Release 12)

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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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  - 1 presented to TSG for information;
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- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
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1 Scope

This document is related to the technical report for the study item "Study on CoMP for LTE with Non-Ideal Backhaul" [1]. The purpose of this TR is to help TSG RAN WG1 to assess the performance benefits of CoMP operation involving multiple eNBs with non-ideal backhaul and the required specification support for the inter-eNB operation.

This activity involves the Radio Access work area of the 3GPP studies and has potential 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-130847, "Study on CoMP for LTE with Non-Ideal Backhaul".

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

[3] 3GPP TR 36.819: "Coordinated multi-point operation for LTE physical layer aspects".

[4] 3GPP TR 36.872: "Small cell enhancements for E-UTRA and E-UTRAN 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 defined in 3GPP TS 21.905 [2] and the following apply:

4 Introduction

[Editor's note: Capturing Justification and Objective sections of [1].]

At the 3GPP TSG RAN #60 meeting, the Study Item Description on "Study on CoMP for LTE with Non-Ideal Backhaul" was agreed for Release 12 [1]. Coordinated multi-point (CoMP) transmission and reception was introduced in 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 [3]. However, CoMP in Rel-11 did not address the specified support of CoMP involving multiple eNBs with non-ideal backhaul. Due to this limitation, the operators having non-ideal backhaul may not be able to take performance benefit from CoMP operation. Accordingly, this study item aims at evaluating the performance benefits and identifying potential standardization impacts for candidate CoMP techniques involving multiple eNBs with non-ideal backhaul. The detailed objectives are as follows.

- RAN1 evaluate coordinated scheduling and coordinated beamforming including semi-static point selection/muting as candidate techniques for CoMP involving multiple eNBs with non-ideal but typical backhaul and, if there is performance benefit, recommend for which CoMP technique(s) signalling for inter-eNB operation should be specified, considering potential impact on RAN3 work.
    - In the evaluations, consider the level of backhaul delay achievable with non-ideal backhaul.
    - Evaluation should be on the CoMP operation between macro eNBs (CoMP scenario 2 in [3] except for the backhaul assumptions), between macro eNB and small cell eNB (small cell enhancement (SCE) scenario 1 in [4] with non-ideal backhaul), and between small cell eNBs ((SCE) scenario 2a in [4] with non-ideal backhaul).
    - The study will take into account the outcome of the small cell enhancement study item and previous work on Rel-11 CoMP SI/WI.

5 Scenarios and CoMP Techniques

[Editor's note: This section will capture (1) network scenarios and (2) candidate CoMP techniques in consideration]

5.1 Network Deployment Scenarios

The scenarios for evaluation are described in this section.

- CoMP Scenario 2 in [3] with non-ideal backhaul (NIB):
    - CoMP operation between macro eNBs in homogeneous network with ISD = 500m
        - Number of cells in coordination: baseline is 9 (optional: 21) with the layout as in [3].
    - Backhaul assumption:
        - Non-ideal backhaul between eNB sites
    - Channel model: ITU UMa with macro indoor-outdoor modelling from SCE scenario 1 in [4]
- SCE scenario 1 in [4] with NIB:
    - CoMP operation between macro eNB and small cell eNBs in heterogeneous network
        - Number of macro cell areas in coordination: baseline is 3 intra-site macro cell areas (optional: 1 macro cell area)
    - Backhaul assumption:
        - Non-ideal backhaul between eNBs:
            - Between macro eNB and small cell eNBs within its coverage
            - Between small cell eNBs under the coverage of one macro cell
            - Between small cell eNBs of different cells in the same site
    - Channel model: ITU UMa for macro cell, ITU UMi for small cell as in [4]

- SCE scenario 2a in [4] with NIB:
  - CoMP operation between small cell eNBs in heterogeneous network
    - Number of macro cell areas in coordination: baseline is 3 intra-site macro cell areas (optional: 1 macro cell area)
  - Backhaul assumption:
    - Non-ideal backhaul between eNBs:
      - Between macro eNB and small cell eNBs within its coverage
      - Between small cell eNBs under the coverage of one macro cell
      - Between small cell eNBs of different cells in the same site
  - Channel model: ITU UMa for macro cell, ITU UMi for small cell as in [4]

5.2 Potential CoMP Techniques

[Editor's note: This section will describe candidate techniques for CoMP involving eNBs with non-ideal backhaul. For each evaluated scheme, information relating to a transmission to/from a serving node in a given subframe should be categorized in two group: the first group contains information which is considered valid for a longer than backhaul delay period and the second group contains information which is considered valid for a shorter than backhaul delay period.]

6 Evaluation Results

7 Network Signalling for Inter-eNB Operation

[Editor's note: This section will capture the study on network signalling needed to achieve the system level gain from candidate CoMP techniques]

8 Conclusion

[Editor's note: This section will capture the RAN1conclusion on potential CoMP techniques for specification support,and further recommend for which CoMP technique(s) signalling for inter-eNB operation should be specified, considering potential impact on RAN3 work]

Annex A: Evaluation Assumptions

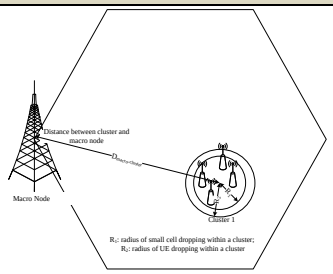
[Editor's note: This annex will capture the evaluation model agreed for performance evaluation in RAN WG1.]

A.1 CoMP Scenario 2 with NIB

	macro
Layout	Hexagonal grid, 3 sectors per site, 19 macro sites
Number of cells in coordination	Baseline is 9 (optional: 21) with the layout as in [3]
System bandwidth per carrier	10MHz
Carrier frequency	2.0GHz
Total BS TX power (Ptotal per carrier)	46dBm
Distance-dependent path loss	ITU UMa according to Table B.1.2.1-1in TR 36.814 [5] with 3D distance between an eNB and a UE applied (same as macro of SCE scenario 1 in [4])
Penetration loss	Same as macro of SCE scenario 1 in [4] (i.e., For outdoor UEs:0dB For indoor UEs: 20dB+0.5d_{in} (d_{in} : independent uniform random value between [0, min(25,d)] for each link))
Shadowing	ITU UMa according to Table A.1-1 of TR 36.819 [3] (same as macro of SCE scenario 1 in [4])
Antenna pattern	3D according to TR36.819 [3]
Antenna Height:	25m
UE antenna Height	1.5m
Antenna gain + connector loss	17 dBi
Antenna gain of UE	0 dBi
Fast fading channel between eNB and UE	ITU UMa according to Table A.1-1 of TR 36.819 [3]
Antenna configuration	- For FDD, • 4Tx, 2Rx in DL, cross-polarized • 2Tx, 2Rx in DL, cross-polarized • 1Tx, 2Rx in UL, cross-polarized - For TDD, • 8Tx, 2Rx in DL cross-polarized • 1Tx, 8Rx in UL, cross-polarized
Number of UEs	Variable per FTP model 1
UE dropping	20% UEs are outdoor and 80% UEs are indoor (same as SCE scenario 1 in [4])
Minimum distance	Macro - UE: 35m
Traffic model	- FTP model 1 as in TR 36.814 • Evaluate low, medium, and high load levels (e.g. RU 20%, 40%, 60% across all cells in the most loaded “layer” (i.e. macro and small cells) for the reference scheme)
UE receiver	MMSE-IRC (non-ideal DMRS channel estimation)
UE noise figure for DL	9 dB
eNB for UL	7 dB
UE speed	3km/h
Cell selection criteria	RSRP with cell common bias if CRE is applied
Handover margin	1 dB

Network synchronization	- 0us for co-sited cells - 3us for non-co-sited cells • How to model the network synchronization error is provided by each company
Backhaul assumption	- Non-ideal backhaul between eNB sites - Latency values: {5, 50}ms mandatory, {2, 10, 30}ms optional - Backhaul topology is to be described by each company • Baseline is same latency between any pair of nodes - Backhaul capacity limitation: • As per TR 36.932. Further details can be provided by each company
Performance metrics	Mean, 5%/50%/95% UPT at the given offered traffic
Considered transmission schemes from a single point	- DL: TM10 SU/MU-MIMO - UL: TM1 MU-MIMO
Coordination scheme	- Coordinated scheduling and/or coordinated beamforming • including semi-static point selection/muting - Note: Companies are to provide details of their coordination schemes
Reference scheme for performance comparison	The “best pre-release-12 scheme”, including: • Rel-11 intra-site CoMP between the 3 sectors of each macro • Rel-11 feICIC and other Rel-11 (and earlier) coordination signalling between cells where applicable • Rel-12 enhanced feedback • Further details of what each company believes to be the “best pre-release-12 scheme” to be provided by each company
Feedback assumption	- Non-ideal channel/interference estimation based on TM10 - CSI reporting: Rel-11 feedback and Rel-12 enhanced feedback - The assumed feedback should be described by companies in detail (e.g. PUSCH mode 3-2) - CSI feedback delay from measurement time to arrival at serving eNB: 5ms - Companies to give details of UL feedback rate/overhead
CRS interference	- CRS interference is modelled: • How CRS interference is modelled should be provided by each company

A.2 SCE Scenario 1 with NIB

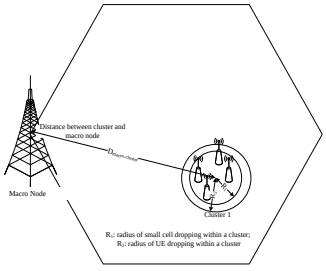
	macro cell	**small cell**
Layout	Hexagonal grid, 3 sectors per site, case 1 Both 19 Macro sites and 7 Macro sites can be used. Companies should indicate whether 19 or 7 sites are used when presenting the results.	 Clusters uniformly random within macro geographical area; small cells uniformly random dropping within cluster area
Number of macro cell areas in coordination*	baseline is 3 intra-site macro cell areas (optional: 1 macro cell area)	
System bandwidth per carrier	10MHz	
Carrier frequency	2.0GHz	
Carrier number	1	

Total BS TX power (Ptotal per carrier)	46dBm	30 dBm, Optional: 24dBm, 37dBm
Distance-dependent path loss	ITU UMa[referring to Table B.1.2.1-1 in TR36.814], with 3D distance between an eNB and a UE applied. Working assumption is that 3D distance is also used for: - break point distance - LOS probability	ITU UMi[referring toTableto Table B.1.2.1-1 in TR36.814], with 3D distance between an eNB and a UE applied. Working assumption is that 3D distance is also used for: -break point distance -LOS probability
Penetration loss	For outdoor UEs:0dB For indoor UEs: 20dB+0.5d_{in} (d_{in} : independent uniform random value between [0, min(25,d)] for each link)	
Shadowing	ITU UMa according to Table A.1-1 of 36.819 Working assumption is that 3D distance is used for shadowing correlation distance	ITU UMi [referring to Table B.1.2.1-4 in TR36.814] Working assumption is that 3D distance is used for shadowing correlation distance
Antenna pattern	3D according to TR36.819 [3]	2D Omni-directional is baseline; directional antenna is not precluded
Antenna Height:	25m	10m
UE antenna Height	1.5m	
Antenna gain + connector loss	17 dBi	5 dBi
Antenna gain of UE	0 dBi	
Fast fading channel between eNB and UE	ITU UMa according to Table A.1-1 of TR 36.819 [3]	ITU UMi
Antenna configuration*	- For FDD, • 4Tx, 2Rx in DL, cross-polarized • 2Tx, 2Rx in DL, cross-polarized • 1Tx, 2Rx in UL, cross-polarized - For TDD, • 8Tx, 2Rx in DL cross-polarized • 1Tx, 8Rx in UL, cross-polarized	- For FDD, • 4Tx, 2Rx in DL, cross-polarized • 2Tx, 2Rx in DL, cross-polarized • 1Tx, 2Rx in UL, cross-polarized - For TDD, • 2Tx, 2Rx in DL cross-polarized • 1Tx, 2Rx in UL, cross-polarized
Number of small cell clusters per macro cell area*	Baseline is 1 (optional: 2)	
Number of small cells per cluster	4, 10	
Number of small cells per macro cell	[4, 10]*Number of clusters per macro cell area	
Number of UEs*	Variable per FTP model 1	
UE dropping	Baseline: 2/3 UEs randomly and uniformly dropped within the clusters, 1/3 UEs randomly and uniformly dropped throughout the macro geographical area. 20% UEs are outdoor and 80% UEs are indoor.	
Radius for small cell dropping in a cluster	50m	
Radius for UE dropping in a cluster	70m	
Minimum distance (2D)	Small cell – small cell: 20m	
	Small cell – UE: 5m	
	Macro – small cell cluster center: 105m	
	Macro – UE: 35m	
	Cluster center – cluster center: 2*radius for small cell dropping in a cluster	
Traffic model*	- FTP model 1 as in TR 36.814 • Evaluate low, medium, and high load levels (e.g. RU 20%, 40%, 60% across all cells in the most loaded “layer” (i.e. macro and small cells) for the	

	reference scheme)
UE receiver	MMSE-IRC as baseline
UE noise figure for DL	9 dB
UE speed	3km/h
Cell selection criteria	Baseline: RSRP with cell common bias if CRE is applied.
Handover margin*	1dB
Network synchronization*	- 0us for co-sited cells - 3us for non-co-sited cells • How to model the network synchronization error is provided by each company
Backhaul assumption*	- Non-ideal backhaul between eNB sites - Latency values: {5, 50}ms mandatory, {2, 10, 30}ms optional - Backhaul topology is to be described by each company • Baseline is same latency between any pair of nodes - Backhaul capacity limitation: • As per TR 36.932. Further details can be provided by each company
Performance metrics	Mean, 5%/50%/95% UPT at the given offered traffic
Considered transmission schemes from a single point*	- DL: TM10 SU/MU-MIMO - UL: TM1 MU-MIMO
Coordination scheme*	- Coordinated scheduling and/or coordinated beamforming • including semi-static point selection/muting - Note: Companies are to provide details of their coordination schemes
Reference scheme for performance comparison*	The “best pre-release-12 scheme”, including: • Rel-11 intra-site CoMP between the 3 sectors of each macro • Rel-11 feICIC and other Rel-11 (and earlier) coordination signalling between cells where applicable • Rel-12 enhanced feedback • Further details of what each company believes to be the “best pre-release-12 scheme” to be provided by each company
Feedback assumption*	- Non-ideal channel/interference estimation based on TM10 - CSI reporting: Rel-11 feedback and Rel-12 enhanced feedback - The assumed feedback should be described by companies in detail (e.g. PUSCH mode 3-2) - CSI feedback delay from measurement time to arrival at serving eNB: 5ms - Companies to give details of UL feedback rate/overhead
CRS interference*	- CRS interference is modelled: • How CRS interference is modelled should be provided by each company

(*) Evaluation assumptions which are different from in Annex A of TR 36.872 [4]

A.3 SCE Scenario 2a with NIB

	macro cell	small cell
Layout	Hexagonal grid, 3 sectors per site, case 1 Both 19 Macro sites and 7 Macro sites can be used. Companies should indicate whether 19 or 7 sites are used when presenting the results.	

		Clusters uniformly random within macro geographical area; small cells uniformly random dropping within cluster area
Number of macro cell areas in coordination*	baseline is 3 intra-site macro cell areas (optional: 1 macro cell area)	
System bandwidth per carrier	10MHz	
Carrier frequency	2.0GHz	3.5GHz
Carrier number	1	1 or 2
Total BS TX power (Ptotal per carrier)	46dBm	30 dBm, Optional: 24dBm, 37dBm
Distance-dependent path loss	ITU UMa[referring to Table B.1.2.1-1 in TR36.814], with 3D distance between an eNB and a UE applied. Working assumption is that 3D distance is also used for: - break point distance - LOS probability	ITU UMi[referring toTableto Table B.1.2.1-1 in TR36.814], with 3D distance between an eNB and a UE applied. Working assumption is that 3D distance is also used for: -break point distance -LOS probability
Penetration loss	For outdoor UEs:0dB For indoor UEs: 20dB+0.5d_{in} (d_{in} : independent uniform random value between [0, min(25,d)] for each link)	
Shadowing	ITU UMa according to Table A.1-1 of 36.819 Working assumption is that 3D distance is used for shadowing correlation distance	ITU UMi [referring to Table B.1.2.1-4 in TR36.814] Working assumption is that 3D distance is used for shadowing correlation distance
Antenna pattern	3D according to TR36.819 [3]	2D Omni-directional is baseline; directional antenna is not precluded
Antenna Height:	25m	10m
UE antenna Height	1.5m	
Antenna gain + connector loss	17 dBi	5 dBi
Antenna gain of UE	0 dBi	
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Antenna configuration*	- For FDD, • 4Tx, 2Rx in DL, cross-polarized • 2Tx, 2Rx in DL, cross-polarized • 1Tx, 2Rx in UL, cross-polarized - For TDD, • 8Tx, 2Rx in DL cross-polarized • 1Tx, 8Rx in UL, cross-polarized	- For FDD, • 4Tx, 2Rx in DL, cross-polarized • 2Tx, 2Rx in DL, cross-polarized • 1Tx, 2Rx in UL, cross-polarized - For TDD, • 2Tx, 2Rx in DL cross-polarized • 1Tx, 2Rx in UL, cross-polarized
Number of small cell clusters per macro cell area*	Baseline is 1 (optional: 2)	
Number of small cells per cluster	4, 10	
Number of small cells per macro cell*	[4, 10]* Number of clusters per macro cell area	

Number of UEs*	Variable per FTP model 1
UE dropping	Baseline: 2/3 UEs randomly and uniformly dropped within the clusters, 1/3 UEs randomly and uniformly dropped throughout the macro geographical area. 20% UEs are outdoor and 80% UEs are indoor.
Radius for small cell dropping in a cluster	50m
Radius for UE dropping in a cluster	70m
Minimum distance (2D)	Small cell – small cell: 20m
	Small cell – UE: 5m
	Macro – small cell cluster center: 105m
	Macro – UE: 35m
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Traffic model*	- FTP model 1 as in TR 36.814 • Evaluate low, medium, and high load levels (e.g. RU 20%, 40%, 60% across all cells in the most loaded "layer" (i.e. macro and small cells) for the reference scheme)
UE receiver	MMSE-IRC as baseline
UE noise figure for DL	9 dB
UE speed	3km/h
Cell selection criteria	Baseline: RSRP for intra-frequency and RSRQ for inter-frequency, with cell common bias if CRE is applied.
Handover margin*	1dB
Network synchronization*	- 0us for co-sited cells - 3us for non-co-sited cells • How to model the network synchronization error is provided by each company
Backhaul assumption*	- Non-ideal backhaul between eNB sites - Latency values: {5, 50}ms mandatory, {2, 10, 30}ms optional - Backhaul topology is to be described by each company • Baseline is same latency between any pair of nodes - Backhaul capacity limitation: • As per TR 36.932. Further details can be provided by each company
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CRS interference*	- CRS interference is modelled: • How CRS interference is modelled should be provided by each company

(*) Evaluation assumptions which are different from in Annex A of TR 36.872 [4]

Annex B: Change history

Table B.1: Draft History

Change history					
Date	**TSG #**	**TSG Doc.**	**Subject/Comment**	**Old**	**New**
2013-08	RAN1#74	R1-133906	Skeleton TR		0.1.0
2013-08	RAN1#74	R1-134026	Inclusion of evaluation scenarios and assumptions	0.1.0	0.2.0
2013-09	RAN#61		Version 1.0.0 presented for information	0.2.0	1.0.0