

LTE-ADVANCED AND 4G WIRELESS
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Coordinated Multipoint Transmission and Reception in LTE-Advanced: Deployment Scenarios and Operational Challenges

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ABSTRACT

3GPP has completed a study on coordinated multipoint transmission and reception techniques to facilitate cooperative communications across multiple transmission and reception points (e.g., cells) for the LTE-Advanced system. In CoMP operation, multiple points coordinate with each other in such a way that the transmission signals from/to other points do not incur serious interference or even can be exploited as a meaningful signal. The goal of the study is to evaluate the potential performance benefits of CoMP techniques and the implementation aspects including the complexity of the standards support for CoMP. This article discusses some of the deployment scenarios in which CoMP techniques will likely be most beneficial and provides an overview of CoMP schemes that might be supported in LTE-Advanced given the modern silicon/DSP technologies and backhaul designs available today. In addition, practical implementation and operational challenges are discussed. We also assess the performance benefits of CoMP in these deployment scenarios with traffic varying from low to high load.

INTRODUCTION

The trend of increasing demand for high quality of service at the user terminal or user equipment (UE), coupled with the shortage of wireless spectrum, requires more advanced wireless communication techniques to mitigate intercell interference and increase the cell edge throughput. Coordinated multipoint (CoMP) transmission

and reception techniques utilize multiple transmit and receive antennas from multiple antenna site locations, which may or may not belong to the same physical cell, to enhance the received signal quality as well as decrease the received spatial interference. This article is an overview of potential CoMP technologies and their key deployment scenarios, which have been identified during the CoMP study performed by the Third Generation Partnership Project (3GPP) for the Long Term Evolution (LTE)-Advanced standard development. The article also discusses practical implementation aspects as well as operational challenges for CoMP. The focus of the article is on the downlink CoMP aspects since uplink CoMP technologies tend to have less standard impact; indeed, the receiver processing at the network side can be performed in a more transparent way to the UE. Note that the mechanisms discussed in this article apply to both frequency-division duplex (FDD) and time-division duplex (TDD) modes of operation.

DEPLOYMENT SCENARIOS FOR COMP TECHNOLOGY BEING CONSIDERED FOR LTE-ADVANCED

Today's deployed LTE networks are mostly based on macrocells only, as depicted on Fig. 1a. Such networks are said to be *homogeneous* because all the base stations belong to the same type and power class. In Release 8 of LTE, the multiple-input multiple-output (MIMO) transmission in each cell is controlled independent of

that of its neighbors. Intercell interference coordination (ICIC) is supported by means of coordination message exchanges between base stations via a standardized interface named X2. The goal of ICIC is to provide the scheduler at one cell with information about the current or prospective interference situation at its neighbors. However, the latency, or delay with which these coordination messages can be exchanged, depends on the backhaul technology used to carry X2. This latency cannot be guaranteed to be low, as discussed in more detail later. While ICIC techniques are primarily designed for semi-static coordination, CoMP techniques target more dynamic coordination and may require much lower latency.

While macrocells constitute the basis of a mobile network's coverage, the deployment of low-power nodes (e.g., pico- or femtocells, or relay nodes) within the macrocell is foreseen as a widely used solution in the future to cope with the ever increasing mobile traffic demands. Such networks, called *heterogeneous networks*, are characterized by harsh intercell interference between the macro and the low-power nodes, due to their closer proximity and different power classes. Heterogeneous deployments are illustrated in Fig. 1b. The intercell interference effect is even more detrimental when the effective cell size of the low-power node is expanded to balance the traffic load between the macro and the low-power node cell, so UE may be associated with a cell that does not provide the strongest received signal power [1].

One recent deployment trend foreseen to be widely applied for LTE consists of splitting the base station functionalities into a baseband unit (BBU), which performs in particular the scheduling and the baseband processing, and a remote radio head (RRH), responsible for all the radio frequency (RF) operations (e.g., carrier frequency transposition, filtering, power amplification). The BBU is typically placed in a technical room (e.g., in the basement of a building) while the RRH is located close to the antenna, potentially hundreds of meters away from the BBU, both units being connected via optical fiber. In addition to suppressing the feeder loss (since the power amplifier is immediately close to the antenna), this approach allows BBUs managing different radio sites to be gathered in the same place, thereby reducing the site cost and easing site maintenance. Moreover, having geographically separated RRHs controlled from the same location enables either centralized BBUs jointly managing the operation of several radio sites or the exchange of very low-latency coordination messages between BBUs responsible for their own site. RRH deployments therefore facilitate the fast coordination between transmission/reception points that is required for CoMP.

The applicability of the CoMP functionality indeed depends to a great extent on the backhaul characteristics (latency and capacity), which condition the type of CoMP processing that can be applied and the associated performance. In order to account for the various possible network topologies and backhaul characteristics, the study of CoMP in 3GPP has focused on the following scenarios:

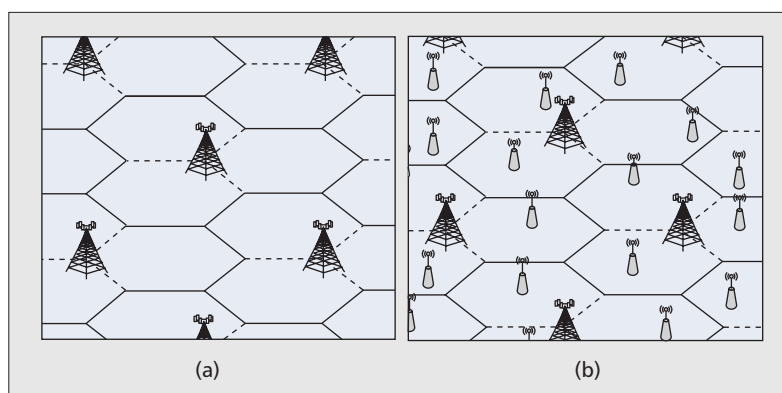


Figure 1. Deployment scenarios under consideration for CoMP technology: a) homogeneous networks; b) heterogeneous networks.

- Coordination between the cells (sectors) controlled by the same macro base station (where no backhaul connection is needed)
- Coordination between cells belonging to different radio sites from a macro network
- Coordination between a macrocell and low-power transmit/receive points within its coverage, each point controlling its own cell (with its own cell identity)
- The same deployment as the latter, except that the low-power transmit/receive points constitute distributed antennas (via RRHs) of the macrocell, and are thus all associated with the macrocell identity

Scenarios 1 and 2 are targeted for homogeneous scenarios (Fig. 1a), and scenarios 3 and 4 are targeted for heterogeneous scenarios (Fig. 1b). Note that different operators will have different priorities regarding the CoMP deployment scenarios, leading to different implementation considerations.

OVERVIEW OF GENERAL CoMP TECHNIQUES

Conventionally, a set of geographically collocated antennas that correspond to a particular sectorization are configured as a cell. A UE terminal is connected to a single cell at a given time based on associated maximum received signal power. This cell then becomes its serving cell. Given the new definitions of CoMP scenarios as introduced earlier, the antennas configured as a cell may not be geographically collocated. The term *transmission point* (TP) can then be used to refer to a set of collocated antennas, and a cell can correspond to one or more of such TPs. Note that a single geographical site location may contain multiple TPs in case of sectorization, with one TP corresponding to one sector. CoMP techniques can also be defined in a more straightforward manner as the coordination between TPs.

CoMP studies performed in 3GPP generally categorized three different types of CoMP techniques depending on the required constraints on the backhaul link between coordinated points and the level of scheduling complexity. These types of CoMP techniques can be broadly classified into coordinated scheduling and coordinat-

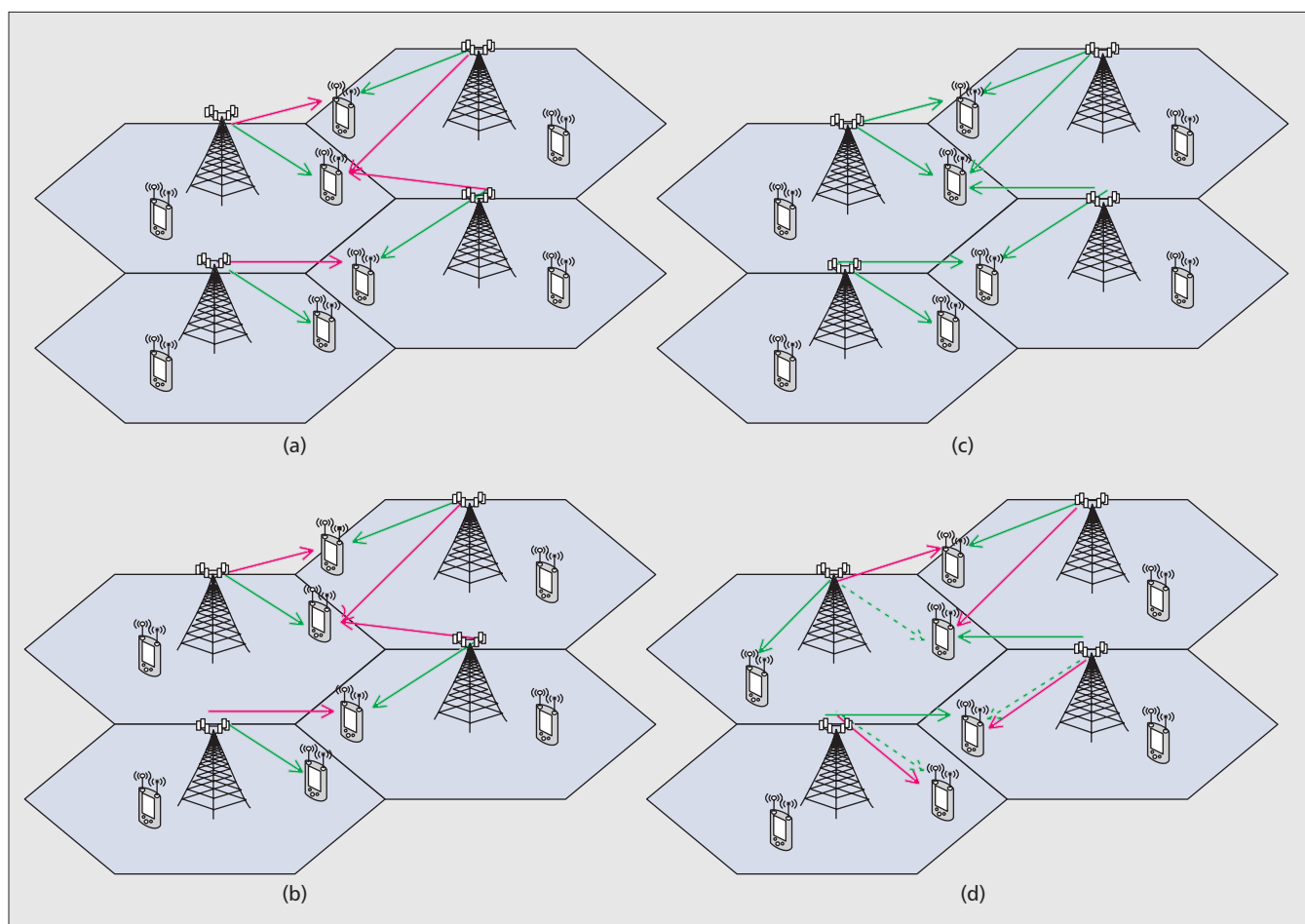


Figure 2. General classification of CoMP techniques.

ed beamforming (CS/CB), joint transmission (JT), and TP selection (TPS).

CS/CB can be characterized by multiple coordinated TPs sharing only channel state information (CSI) for multiple UE terminals, while data packets that need to be conveyed to a UE terminal are available only at one TP. JT can be characterized by the same data transmission from multiple coordinated TPs with appropriate beamforming weights. TPS can be regarded as a special form of JT, where transmission of beamformed data for a given UE terminal is performed at a single TP at each time instance, while the data is available at multiple coordinated TPs.

Figure 2 illustrates the principles of CoMP CS/CB, JT, and TPS. A solid red arrow refers to the strong interference incurred by the transmission in a neighboring cell, whereas dotted red lines represent relatively lower interference achieved with coordination. CS/CB reduces the interference level experienced by a UE terminal by appropriately selecting the beamforming weights of interfering points to steer the interference toward the null space of the interfered UE as represented by the dotted red arrow. JT allows one or more neighboring points to transmit the desired signal rather than interference signals from the point of view of the selected UE. TPS enables UE to be dynamically scheduled by the most appropriate TP by exploiting changes in

the channel fading conditions. A dotted green arrow refers to an interfering cell that could potentially be transmitting desired signals to the UE in subsequent timeframes. Hybrid methods may also be implemented in a network to cope with different types of interference.

COORDINATED SCHEDULING AND COORDINATED BEAMFORMING

The idea of CB emerged in the mid-nineties, mainly targeting a so-called signal-to-interference-plus-noise ratio (SINR) leveling problem [2], in which the power levels and the beamforming coefficients are calculated to achieve some common SINRs in the system or to maximize the minimum SINR. CS is a relatively newer idea. The first studies [3] mainly divide the entire network in clusters and apply centralized scheduling within each cluster in order to determine which TPs in the cluster should transmit in each time slot and to which UE. Later studies jointly use CS/CB as a tool to reduce multi-user and multicell interference.

Different approaches jointly combining CS and CB have been studied in LTE-Advanced, which can be classified by increasing order of complexity and requirements in terms of CSI feedback and CSI sharing.

Coordinated beam pattern is a low feedback

overhead approach targeting highly loaded cells that consists of coordinating the precoders (beamforming matrices) in the cooperating TPs in a pre-defined manner in order to reduce interference variation and enable accurate link adaptation, while avoiding spatial CSI feedback from the UE. Relying on a TP-specific beam pattern in the time and/or frequency domain, the TPs cycle through the fixed set of beams where the cycling period is decided by a central controller and conveyed to the TPs. Based on reports of the best resources and associated channel quality in each cycling period, the UE can be scheduled in the subframes or subbands where the coordinated beams provide the best channel conditions.

Precoding matrix indicator (PMI) coordination mitigates the inter-TP interference based on the report of a restricted or recommended PMI, which corresponds to a potential precoder at an interfering TP. Assuming that the UE and base stations have knowledge of a codebook composed of quantized precoders, PMI restriction and PMI recommendation techniques constrain the interfering TPs to use only those precoders that belong to a subset of the codebook in order to enhance cell edge performance. In the case of PMI restriction (or recommendation), the cell edge UE calculates and reports to their serving cell the restricted (or recommended) PMIs, defined as the PMIs that create the highest (or lowest) interference if used as a precoder in the interfering TPs. With these techniques, transmitters may be constrained to use a specific quantized PMI in the codebook as the actual precoder in a downlink transmission.

Interference suppression-based coordinated beamforming refers to a coordinated selection of the transmit precoders in each TP that aims at eliminating or reducing the effect of inter-TP interference. Contrary to the PMI coordination, the base stations compute a new transmit filter based on the CSI feedback from the serving and interfering TPs, relying typically on zero-forcing beamforming (ZFBB) or joint leakage suppression (JLS) criteria. While ZFBB filter is designed by forcing the interference from a reference TP to UEs served by other TPs to zero, JLS filter is obtained by maximizing the signal-to-leakage-plus-noise ratio (SLNR) of the UE served by the reference TP. Interference-suppression-based CB provides more design flexibility than PMI coordination, but is more demanding in terms of complexity, CSI accuracy, feedback overhead, backhaul overhead, and scheduling coordination.

JOINT TRANSMISSION

Joint transmission can be broadly described as a simultaneous transmission of data to a UE terminal from multiple cooperating TPs. The transmission could be coherent or non-coherent and aims to improve the overall system throughput or a similar system-wide performance metric. It is particularly helpful to improve cell edge performance by converting an interfering signal to a desired signal. With dense small cell deployments and heterogeneous networks with low-power nodes, there could be many UE terminals that receive significant signal strength simultaneously from multiple TPs. Furthermore, in RRH

deployments, a single BBU controlling multiple TPs can enable very low-latency coordination among them and allow joint scheduler implementations. A joint scheduler allows resource pooling, by dynamically adapting to short-term channel conditions and different traffic loads experienced across the control area of the BBU. In general, large cluster sizes improve these gains. However, the backhaul constraints in real deployments may limit the cluster size over which joint transmission and scheduling may be performed, or it could also be constrained by the network to simplify scheduler operation. The centralized scheduler can be implemented for each such cluster.

Non-coherent JT may use techniques like single-frequency network (SFN) or cyclic delay diversity (CDD) schemes, which target diversity gains and also enable increased transmit power to the UE. On the other hand, coherent transmission could be based on spatial CSI feedback relative to two or more TPs, which can be used to perform MIMO transmissions from the corresponding antennas. However, better synchronization and much smaller timing error differences between transmission points are needed to realize the full potential gains of coherent JT schemes, which may limit their applicability only to TPs connected by a fast backhaul.

The information theoretic bounds with ideal CSI predict significant gains with multi-TP coordination schemes [4]. However, the CSI available at the transmitter is often limited by the feedback currently supported on the uplink channels. For 3GPP specifications, the focus has been on enabling linear precoding techniques at the transmitter, and extensions of codebook-based PMI feedback that are currently supported for single-TP MIMO are the most likely candidates for multi-TP feedback.

To enable JT, the UE may report a PMI and corresponding channel quality indicator (CQI) with the assumption of JT from a set of aggregated antennas corresponding to the JT TPs. The TPs for JT may be set up semi-statically by the network. On the other hand, using more TPs incurs a network resource cost not known to the UE, since it may depend on dynamic conditions introduced due to traffic load, quality of service (QoS), and fairness at the network level. More flexibility can be achieved if the UE could feedback PMI/CQI corresponding to multiple JT transmission hypothesis. Clearly, there is a trade-off between flexibility and overhead. One approach is to design codebooks with a hierarchical approach. With this approach, precoding matrix codebook may be used for single TP transmission to derive the PMI/CQI of each TP. For multi-TP joint transmission, JT CQI and PMI can be derived by concatenating each TP's CQI and PMI with inter-TP co-phasing information. More generally, multi-user JT schemes can also be used where the JT PMI received from multiple UE terminals can be used to perform multi-TP ZFBB. In a typical operation, the centralized scheduler controlling a cluster of TPs obtains the PMI/CQI corresponding to joint transmission hypothesis from UE in the cluster and assigns UE to TPs such that a certain metric (e.g., sum proportional rate) is maximized.

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In its most compact form, CoMP transmission and reception applied to the sectors of a single site can just be realized by an upgrade of the scheduling and processing algorithms since these functions are already co-located.

TRANSMISSION POINT SELECTION (TPS)

In LTE-Advanced, transmission point selection (TPS) is investigated by extending to an orthogonal frequency-division multiplexing (OFDM) system the idea of site selection diversity transmission power control proposed for high-speed HSDPA [5]. With TP selection, the signal to a given UE is transmitted from a single transmission point within the CoMP cooperating set on a certain time-frequency resource. The UE basically reports the index of its preferred TP (e.g. the TP with the highest received SINR) and corresponding CSI, which is subsequently used for transmission. The selected TP may dynamically change from one subframe, which is the minimum signal transmit time unit equivalent to 1ms, to another subframe via time-frequency domain dynamic scheduling. In addition, if the neighboring TPs remain silent by not transmitting any data, the received SINR of the UE can be further improved.

CONSIDERATIONS FOR THE STANDARD AND IMPLEMENTATION

IMPLEMENTATION CONSIDERATIONS AT THE NETWORK

The deployment of CoMP techniques requires some changes in the implementation of the network. As emphasized earlier, fiber connections among distributed cooperating points and regrouping the scheduling and processing functions at a central BBU allow harnessing the highest CoMP gains. In its most compact form, CoMP transmission and reception applied to the sectors of a single site can just be realized by an upgrade of the scheduling and processing algorithms since these functions are already co-located. Since the scheduling and processing complexity increases with the number of cooperating TPs, a balance needs to be found between the performance gains and the cost of the network upgrade.

Additional considerations for the deployment of CoMP in the network pertain to the propagation environment and the expected traffic load. For deployments with the same sites topology, backhaul latency and capacity, and scheduling and processing capabilities, the configuration of the TPs also has an impact on the performance of CoMP. In the heterogeneous scenarios 3 and 4, where pico-cells or RRHs may be deployed in hotspots or coverage holes, configuring the cooperating TPs with the same or different physical cell identities (cell ID) offers certain trade-offs.

When a macrocell and the picocells in its coverage are configured with different cell IDs (scenario 3) with a frequency reuse factor of one, each cell has its own pool of resources for the transmission and reception of control channels and its own set of reference signals. Interference among these channels and signals is mitigated by scrambling sequences and by assigning orthogonal resources for reference signals from different cells. This cell splitting gain (or area splitting gain) enables a large number of connections

within the coverage area of the macro-cell, so this type of network configuration is appropriate with high traffic load. But this gain comes at a cost of spectral efficiency since data channels of one cell collide with the reference signals or control channels of another cell. This limits the applicability of CoMP techniques since JT cannot be applied on resource elements where such collisions occur, and CoMP gains can only be achieved on a limited number of resource elements.

On the other hand, configuring the macro-cell and RRHs in its coverage with the same cell ID allows all the cooperating TPs to share the same set of control channels and reference signals, by aligning the resources used for the transmission of data. This configuration comes at the cost of a lower control channel capacity and is therefore more appropriate in lightly loaded environments. Note that the cell splitting loss may be potentially recovered by designing control channels relying on user specific reference signals and transmitted only on a subset of coordinated TPs. Additional considerations should be given to the performance of legacy terminals which are not aware of the distributed nature of the antennas within the same cell. Some resources may need to be reserved for legacy terminals that are compliant with earlier versions of the specifications that do not support CoMP.

Finally, the network must make sure that the quality of channel estimation is sufficiently accurate to enable CoMP techniques. A CoMP terminal needs not only to measure the channel from its strongest TP, but also from TPs that are farther away. The reference signals used for CSI estimation transmitted from the far-away TPs may be interfered by reference signals and data transmissions from closer TPs. In order to avoid this situation, orthogonal resources are assigned to reference signals transmitted by cooperating TPs, and these resources cannot be used for data transmissions. This loss of spectral efficiency for the data is minimal given the sparse transmission of CSI reference signals (CSI-RS) in time/frequency and is further compensated for by the gains achieved in resource elements used for CoMP transmission of the data.

The deployment of CoMP sets some constraints on the backhaul when distant radio sites are coordinated. Regarding backhaul aspects, two categories of radio nodes have to be distinguished, as introduced earlier: base stations (macro, pico) and RRHs. Base stations are interconnected via the standardized X2 interface, carried over the backhaul network, whereas RRHs are connected to a BBU via point-to-point optical fiber. The backhaul capacity required by CoMP, even for JT, depends very much on the system bandwidth, the number of UEs served in a CoMP way, the size of the cluster and the network topology (e.g. ring or star). The backhaul latency is driven by the transport technology (e.g. optical fiber, microwave or copper-based technologies), the network topology (in particular the number of routers between two nodes) and the need to employ a security protocol over the backhaul, which all taken together can lead the latency to vary from hundreds of microseconds to 10–20 milliseconds [6]. As a result, the

applicability of CoMP between neighbor base stations depends very much on the local backhaul network deployment. In contrast, CoMP between RRHs controlled by a centralized BBU or co-located inter-connected BBUs seems the most favorable deployment for CoMP across geographically separated radio sites, because point-to-point fiber exhibits both very low latency and high capacity. At last, coordination between the cells controlled by the same base station remains the most straightforward CoMP deployment scenario.

In addition, CoMP requires the TPs to be tightly time and frequency synchronized. This constraint again mostly affects CoMP between base stations, because some additional solution is needed to provide accurate phase synchronization (e.g. based on Global Navigation Satellite System), which is not needed otherwise (unless for TDD mode and multicast/broadcast service).

IMPLEMENTATION CONSIDERATIONS AT THE USER TERMINAL

One aspect that needs to be considered at the UE is how to measure the channel quality to the TPs in the network in which CoMP is being operated. Here, the measurement can include long term signal strength for tracking the user mobility and the short term CSI measurements for link adaptation. The main purpose of the long term measurements in a conventional network is to prepare the handover, i.e. to report the signal strength received from each neighboring cell. Regarding the CSI measurement, all the neighboring signals are treated as interference in calculating the suitable PMI and CQI. In contrast, in a CoMP operating network, there are multiple TPs (cells) that are involved in the communication to a given UE, and it is possible for a neighboring cell (from the conventional network point of view) to transmit the desired signal. For a functional CoMP operation, this difference in the network measurement needs to be considered in the UE implementation. In addition, networks deploying advanced CoMP techniques may have multiple TPs which are associated with the same cell. In such deployments, long term measurements may be taken between TPs belonging to the same "cell."

The long term measurements can be used to identify the UEs that will benefit from CoMP transmissions and to trigger an appropriate CoMP scheme. With the long term measurements reported by UEs, the base station is able to identify the severity of the interference created by neighboring TPs. The CoMP measurement set of a given UE, defined as the set of TPs about which the CSI related to their link to the UE is reported, can be decided based on such measurements.

Depending on the supported CoMP schemes, a UE may be required to measure and report short term feedback corresponding to the channel observed from multiple TPs. A UE is expected to derive PMI feedback for multiple TPs (either per-TP PMI or a single PMI for multiple TPs) and CQI assuming multiple transmission hypotheses, where a transmission hypothesis corresponds to an assumption in the UE link adap-

tation block about the TPs transmitting to the UE and the TPs that constitute interference. If transmission hypothesis are restricted with semi-static setup by the network or by down selection at the UE, complexity may be reduced with acceptable performance loss.

CoMP terminals should be able to measure an appropriate interference which fits the targeted CoMP operation in deriving CQI. Differently from the conventional network where all the neighboring cells are the source of interference, some coordinating cells may not cause any interference in CoMP operation by transmitting only the CoMP terminal signal (JT) or nullifying its signal into the CoMP terminal direction (CS/CB). It is obvious that the conventional interference measurement will lead to an overestimation of interference because the contribution from the coordinated cells, which usually occupies a large portion in the inter-TP interference, will be removed or mitigated in the actual CoMP transmission. Thus, it is required for the network to ensure that a CoMP terminal can measure an appropriate interference level, for example, by measuring only the interference outside of the coordinated set. Even after this consideration, residual interference may remain after CS/CB operation due to the imperfect PMI feedback, so this effect also needs to be taken into consideration in performing the interference measurement.

PERFORMANCE EVALUATIONS FOR CoMP

3GPP Radio Access Network Working Group 1 has conducted a simulation campaign to evaluate the performance of the CoMP techniques described in this article. The detailed simulation assumptions and simulation modeling used in this campaign is described in the 3GPP Technical Report for LTE-Advanced CoMP [7]. The evaluation results presented in this article have been performed for a specific set of assumptions [8] such that they only represent one example of the performance achievable with CoMP. CoMP performance results can vary depending on the assumptions on e.g. impairments modeling and scheduler implementation.

Figure 3 and Fig. 4 show the relative performance gain of example CS/CB and JT CoMP implementations compared to Multi-User MIMO (MU-MIMO) in a non-CoMP network, for full-buffer and a simplified FTP traffic model [7] respectively. MU-MIMO is a spatial transmission technique where more than one user is scheduled using the same time-frequency resource from a transmission point, where co-channel separation between users is achieved by means of proper precoding and receive processing. The FTP traffic model allows various load factors to be modeled, and naturally leads to unequal loads in neighboring cells. Note that performance results between homogeneous networks and heterogeneous networks cannot be compared due to different layout and simulation parameters such as number of UEs, etc. The evaluated Heterogeneous Network is based on Scenario 3. For Scenario 4 the cell through-

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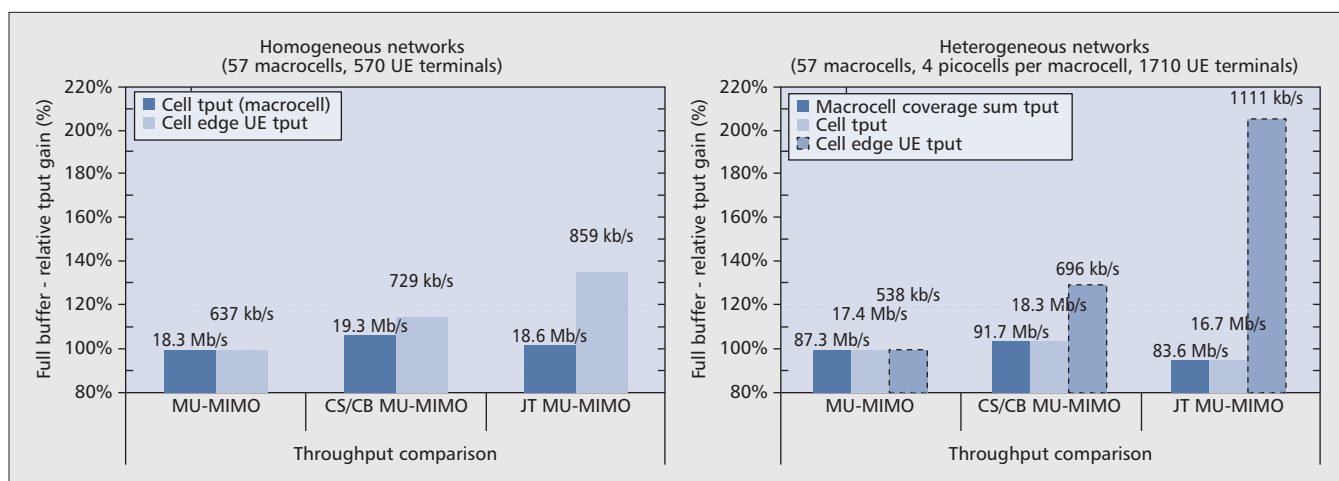


Figure 3. Example homogeneous and heterogeneous networks (Scenario 3) evaluation for full buffer traffic.

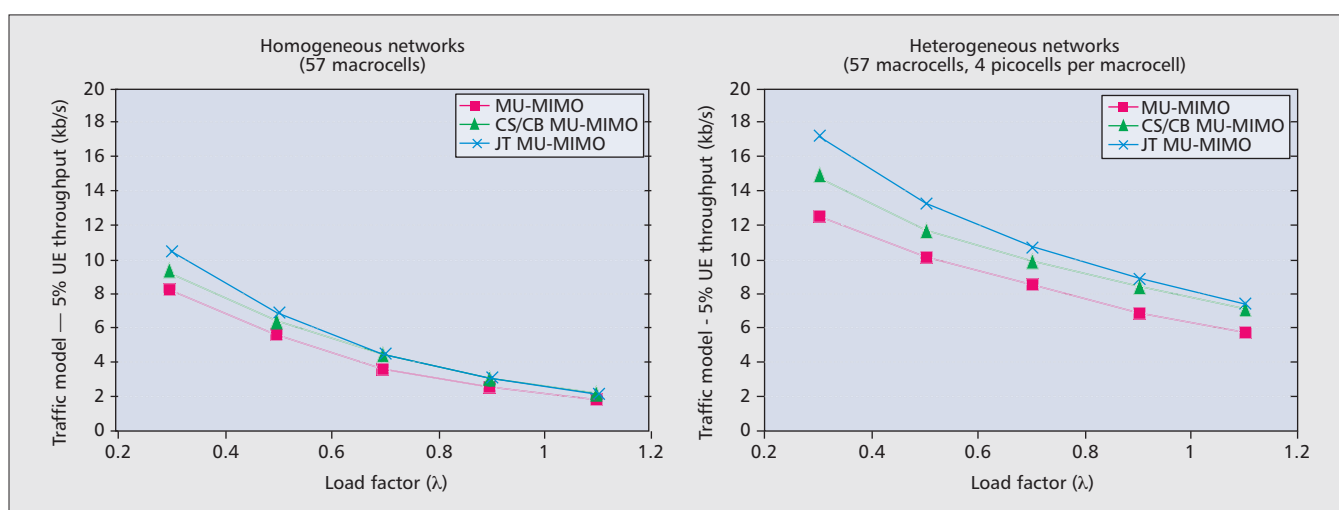


Figure 4. Example homogeneous and heterogeneous networks (Scenario 3) evaluation for FTP traffic.

put and the Macro-cell coverage sum throughput would have been identical. “Cell Tput” and “Cell-edge UE Tput” in Fig. 3 depict the average throughput of the entire cell and the throughput of users in the lower 5 percent-tile throughput distribution of the users in the network respectively. “Macrocell coverage sum Tput” in Fig. 3 depicts the sum of all cell throughput in the macrocell area, which includes picocells deployed in the macrocell. The load factor in Fig. 4 is the parameter, which is used to control the traffic load of the network; further detailed description of the load factor is in [7].

In addition to the results given in [9], the evaluation results in this article show that CoMP gains over the traditional single cell approach are obtained in both homogeneous and heterogeneous networks. CoMP gains are observed for UEs severely affected by interference. These UEs are typically found at cell edges in homogeneous networks. In heterogeneous networks, the numerous pico-cells create more cell boundaries, and the overlay of macro and pico-cells with different transmission powers enlarges the interference zone. Thus more UEs become eligible to

benefit from CoMP in heterogeneous networks. JT CoMP techniques generally give larger performance benefits than CS/CB CoMP, but at the cost of larger backhaul overheads as JT requires TPs to share the data packet to be transmitted to a particular UE. Note that the average cell throughput of JT CoMP in the heterogeneous scenario seems to be lower than for the non-CoMP case, but this is due to the fact that different scheduler algorithms were implemented and simulated. Indeed, due to the nature of the JT CoMP operation the same scheduler as the single cell operations cannot be used in the simulations. However, note that the performance benefits shown by JT CoMP cannot be achieved by changing the scheduler parameters in single cell operations.

These observations show that CoMP techniques are a promising technology for LTE-Advanced networks, especially where the cellular deployment is not very regular and uniform but has rather complex cellular boundaries with varying user distributions. CoMP will thereby contribute to providing to the end user a more uniform experience of mobile broadband across the network coverage.

CONCLUSIONS

In this article, we have discussed CoMP techniques and the target deployment scenarios being considered as part of the LTE-Advanced radio technology standard development. Evaluation studies have shown that CoMP can greatly improve the cell-edge user experience. Similar conclusions were made in the LTE Advanced CoMP study item report, where CoMP performance benefits were observed in both homogeneous and heterogeneous networks [7]. The interest for the CoMP technology is expected to grow as new network topologies (e.g., heterogeneous networks) and geographically distributed antennas for single logical cell further demand solutions for interference mitigation. Lower cost radio nodes, improved backhaul connection links, faster processors at the base stations as well as user terminals, now allow CoMP to be considered as a viable technology for practical implementation and deployment.

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Lower cost radio nodes, improved backhaul connection links, faster processors at the base stations as well as user terminals, now allow CoMP to be considered as a viable technology for practical implementation and deployment.