4G LTE CoMP, Coordinated Multipoint Tutorial

- 4G LTE Advanced CoMP, coordinated multipoint is used to send and receive data to and from a UE from several points to ensure the optimum performance is achieved even at cell edges.

LTE CoMP or Coordinated Multipoint is a facility that is being developed for LTE Advanced - many of the facilities are still under development and may change as the standards define the different elements of CoMP more specifically.

LTE Coordinated Multipoint is essentially a range of different techniques that enable the dynamic coordination of transmission and reception over a variety of different base stations. The aim is to improve overall quality for the user as well as improving the utilisation of the network.

Essentially, LTE Advanced CoMP turns the inter-cell interference, ICI, into useful signal, especially at the cell borders where performance may be degraded.

Over the years the importance of inter-cell interference, ICI has been recognised, and various techniques used from the days of GSM to mitigate its effects. Here interference averaging techniques such as frequency hopping were utilised. However as technology has advanced, much tighter and more effective methods of combating and utilising the interference have gained support.

LTE CoMP and 3GPP

The concepts for Coordinated Multipoint, CoMP, have been the focus of many studies by 3GPP for LTE-Advanced as well as the IEEE for their WiMAX, 802.16 standards. For 3GPP there are studies that have focussed on the techniques involved, but no conclusion has been reached regarding the full implementation of the scheme. However basic concepts have been established and these are described below.

CoMP has not been included in Rel.10 of the 3GPP standards, but as work is on-going, CoMP is likely to reach a greater level of consensus. When this occurs it will be included in future releases of the standards.

Despite the fact that Rel.10 does not provide any specific support for CoMP, some schemes can be implemented in LTE Rel.10 networks in a proprietary manner. This may enable a simpler upgrade when standardisation is finally agreed.

LTE CoMP - the advantages

Although LTE Advanced CoMP, Coordinated Multipoint is a complex set of techniques, it brings many advantages to the user as well as the network operator.

* ***Makes better utilisation of network:***   By providing connections to several base stations at once, using CoMP, data can be passed through least loaded base stations for better resource utilisation.
* ***Provides enhanced reception performance:***   Using several cell sites for each connection means that overall reception will be improved and the number of dropped calls should be reduced.
* ***Multiple site reception increases received power:***   The joint reception from multiple base stations or sites using LTE Coordinated Multipoint techniques enables the overall received power at the handset to be increased.
* ***Interference reduction:***   By using specialised combining techniques it is possible to utilise the interference constructively rather than destructively, thereby reducing interference levels.

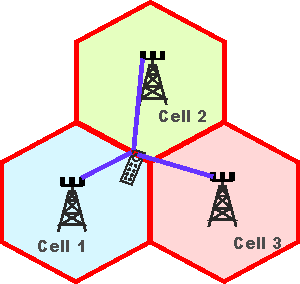
What is LTE CoMP? - the basics

Coordinated multipoint transmission and reception actually refers to a wide range of techniques that enable dynamic coordination or transmission and reception with multiple geographically separated eNBs. Its aim is to enhance the overall system performance, utilise the resources more effectively and improve the end user service quality.

One of the key parameters for LTE as a whole, and in particular 4G LTE Advanced is the high data rates that are achievable. These data rates are relatively easy to maintain close to the base station, but as distances increase they become more difficult to maintain.

Obviously the cell edges are the most challenging. Not only is the signal lower in strength because of the distance from the base station (eNB), but also interference levels from neighbouring eNBs are likely to be higher as the UE will be closer to them.

4G LTE CoMP, Coordinated Multipoint requires close coordination between a number of geographically separated eNBs. They dynamically coordinate to provide joint scheduling and transmissions as well as proving joint processing of the received signals. In this way a UE at the edge of a cell is able to be served by two or more eNBs to improve signals reception / transmission and increase throughput particularly under cell edge conditions.

  
**Concept of LTE Advanced CoMP - Coordinated Multipoint**

In essence, 4G LTE CoMP, Coordinated Multipoint falls into two major categories:

* ***Joint processing:***   Joint processing occurs where there is coordination between multiple entities - base stations - that are simultaneously transmitting or receiving to or from UEs.
* ***Coordinated scheduling or beamforming:***   This often referred to as CS/CB (coordinated scheduling / coordinated beamforming) is a form of coordination where a UE is transmitting with a single transmission or reception point - base station. However the communication is made with an exchange of control among several coordinated entities.

To achieve either of these modes, highly detailed feedback is required on the channel properties in a fast manner so that the changes can be made. The other requirement is for very close coordination between the eNBs to facilitate the combination of data or fast switching of the cells.

The techniques used for coordinated multipoint, CoMP are very different for the uplink and downlink. This results from the fact that the eNBs are in a network, connected to other eNBs, whereas the handsets or UEs are individual elements.

Downlink LTE CoMP

The downlink LTE CoMP requires dynamic coordination amongst several geographically separated eNBs transmitting to the UE. The two formats of coordinated multipoint can be divided for the downlink:

* ***Joint processing schemes for transmitting in the downlink :***   Using this element of LTE CoMP, data is transmitted to the UE simultaneously from a number of different eNBs. The aim is to improve the received signal quality and strength. It may also have the aim of actively cancelling interference from transmissions that are intended for other UEs.  
    
  This form of coordinated multipoint places a high demand onto the backhaul network because the data to be transmitted to the UE needs to be sent to each eNB that will be transmitting it to the UE. This may easily double or triple the amount of data in the network dependent upon how many eNBs will be sending the data. In addition to this, joint processing data needs to be sent between all eNBs involved in the CoMP area.
* ***Coordinated scheduling and or beamforming:***   Using this concept, data to a single UE is transmitted from one eNB. The scheduling decisions as well as any beams are coordinated to control the interference that may be generated.  
    
  The advantage of this approach is that the requirements for coordination across the backhaul network are considerably reduced for two reasons:  
    
  + UE data does not need to be transmitted from multiple eNBs, and therefore only needs to be directed to one eNB.
  + Only scheduling decisions and details of beams needs to be coordinated between multiple eNBs.

Uplink LTE CoMP

* ***Joint reception and processing:***   The basic concept behind this format is to utilise antennas at different sites. By coordinating between the different eNBs it is possible to form a virtual antenna array. The signals received by the eNBs are then combined and processed to produce the final output signal. This technique allows for signals that are very low in strength, or masked by interference in some areas to be receiving with few errors.  
    
  The main disadvantage with this technique is that large amounts of data need to be transferred between the eNBs for it to operate.
* ***Coordinated scheduling:***   This scheme operates by coordinating the scheduling decisions amongst the ENBs to minimise interference.  
    
  As in the case of the downlink, this format provides a much reduced load in the backhaul network because only the scheduling data needs to be transferred between the different eNBs that are coordinating with each other.

Overall requirements for LTE CoMP

One of the key requirements for LTE is that it should be able to provide a very low level of latency. The additional processing required for multiple site reception and transmission could add significantly to any delays. This could result from the need for the additional processing as well as the communication between the different sites.

To overcome this, it is anticipated that the different sites may be connected together in a form of centralised RAN, or C-RAN.

<http://www.radio-electronics.com/info/cellulartelecomms/lte-long-term-evolution/4g-lte-advanced-comp-coordinated-multipoint.php>