Exploration on Relay Selection Schemes for LTE-Advanced System

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Abstract-- The advancement of Long Term Evolution, LTE to LTE-A involves new technologies to be deployed to provide significant improvement in the performance of the network. One such new technology which aids the LTE-A environment is the relay node usage. Relay nodes will increase the range of coverage and ensure that speeds are good. The optimal allocation of the relay node enhances the system revenue, lifetime and the overall network capacity. Selecting an appropriate relay node for the communication is very challenging and a dynamic area of research. The paper provides an impression on LTE-A network, relaying technologies involved in the system and various relay selection algorithms aiming at boosting the system efficiency.

Keywords: Relay Selection, LTE Advanced System

I. INTRODUCTION

As the world today almost uses wireless technologies for the communication there is always an increasing demand over the enhancement of the network technologies. With the introduction of 2G system the network could able to handle the text messaging services and small amount of data over protocol known as MMS. Then rolled out the 3G networks replacing the 2G networks where larger data formats became much more accessible, which includes videos, and music. In March 2008, the standards for 4G communication set by ITU-R, requires all the services which are meant to be 4G services should hold on to a set of connection and speed standards [7]. It is given that for the usage with mobile nodes, the link speeds should have a maximum of at least 100 megabits per second, and for the immobile uses which include mobile hotspots, the link speeds should be at least 1 gigabit per second. The networks that have been established as 3G formerly is said to be enhanced to the point that they can be classified as 4G. The minimum speeds set by the ITU-R for 4G connectivity, were quite unreachable at the early period. LTE stands for Long Term Evolution is path followed to achieve 4G speeds. Now, the new technologies and features are being established focusing on expansion of the capabilities of LTE, and to support trendy ways of deploying and operating network environments ensuring finest supply of services with LTE-A[10].

II. LTE-A NETWORK

LTE-A includes enhancements from LTE with the technologies like uplink and downlink multi-antenna (MIMO), extension of bandwidth with carrier aggregation (CA), coordinated multi-cell transmission and reception (CoMP) , deployment of heterogeneous network (Hetnet) and relay nodes (RN)/relay station (RS). The paper focuses on the relaying technology for the LTE-A system. An LTE-A system model is depicted in figure 1.

A. Relaying

For the 4G LTE advanced systems among the various features being proposed relaying is said to be an important and interesting feature which requires further research investigation. The main aim of LTE relay service is to improve the coverage and the overall network capacity. Relaying service is said to lessen the troubles being experienced at the cell edges [6],[8],[9].

![Figure 1: LTE-A network scenario with numerous RSs and UE units](image)

LTE relay nodes are said to work in either of the two scenarios:

1. **Half-Duplex:** For LTE relay, Half-Duplex is achieved by careful scheduling. It requires the resource allocation for the RN should be in accordance with that of the UE nodes in the uplink and the assigned eNB in the downlinks.

2. **Full Duplex:** For full duplex, LTE relay nodes mostly work on the same frequency. The reception and the transmission of the signals by the LTE relay nodes carried out in the same frequency with minimal delay after processing it.

LTE relay functioning is continued in any of the following two methods:

1. **Inband:** In the Inband communication the frequency used between the eNb and the relay station/relay node will be the same as that of the frequency used between the relaying node and the terminal UE node.

2. **Outband:** In the Outband communication the frequency used between the eNb and the relay station/relay node will be of different frequency that is being used by the relaying node and the terminal UE node link.

For the LTE relay nodes themselves there are two basic types which are mentioned below

1. **Type 1 LTE relay nodes:** If the relay node is of type 1, the relay node will be a usual base station where all the communication protocols end. The type 1 relay node has its ID of the cell to where it belongs, controlling and
2. Type 2 LTE relay nodes: The type-2 LTE relaying nodes are said to be similar to the main base stations without their cell ID and it is difficult to distinguish between the main eNB and the relay node.

III. RELAY SELECTION SCHEMES

LTE-Advanced is of 100 MHz bandwidth is said to consist of five component carriers (CC), and each CC is said to have a bandwidth of 20 MHz. For the heuristic relay allocation in [1], a system with an eNB and UEs’ is considered. It is also assumed that there is no direct link between the eNB and UE, and the intermediate CPEs which is the customer premise equipment acts as the relay node between these eNB and UE. It is assumed that each CPE can use only one CC for relaying.

In this algorithm the third node called the CBS cognitive radiobase station is involved in selecting the CC with higher gain channels and allocates one CC to each secondary terminal CPE. This algorithm involves an iterative approach in which an available CC with the good gain in comparison with the preceding iterations is recognized for several CPEs, and the channel is allocated to the CPE with the highest gain. The above mentioned procedure is said to continue until a channel has been allocated to N CPEs. Now these CPEs acts as the relay nodes for the given UE.

The best relay in the approach mentioned in [2], will be the relay node with the highest metric, where each relay nodes’ metric is computed using local channel knowledge. In this approach the user node will be involved in the election of the relay node. In the Selection phase at the beginning it is assumed that a relay node transmits if its metrics is said to lie in between their lower and upper threshold. User node will choose the best relay node according to the Metrics, number of user equipments connected, Carrier-noise ratio, QoS provided by relay nodes and the Power consumed by relay nodes.

In paper [3], a distributed joint relay node (RN) selection and power allocation scheme for an LTE-Advanced network aiming at increasing the achievable data rate and prolonging the network lifetime is designed. The system model assumptions includes considering Rayleigh block-fading channels with half- duplex decode-and-forward (DF) relaying strategy. It is also assumed that eNB and UE have the perfect knowledge of channel gains. The RN selection and power allocation mechanism is done in two the off-line stage and the on-line stage. In the off-line stage the priority-indices and the equivalent reward is computed with the help of channel estimation and residual energy states. This information is stored in the form of an index-table. For the on-line selection process the candidate RNs shares their indices and each RN arranges indices in ascending order. The node with its index in the first place is selected as the best relay node.

In paper [4] an auction-based approach is considered using game theory. The system with the UEs in close immediacy is said to form a cluster to appeal for the same data from eNB. The UEs within a cluster could communicate with every other UE with the aid of D2D links. The UEs that can successfully receive data (ACK-UEs) are employed as relays to forward the received data to those UEs which could not receive the data (NACK-UEs) from the eNB. In this iterative combinatorial auction where multiple NACK-UEs can be served by ACK-UE relay, NACK-UEs will be the bidders who bid to get an ACK-UE and the eNB servers as the auctioneer. Allocation choices are determined by an iterative process with an approximate solution enhancing the system revenue is designed.

In a centralized pairing scheme mentioned in [5], every RN will be identifying a set of UE nodes for which it can serve for with the details of the channel conditions between the nodes involved in the network. The main objective of this centralized pairing scheme is to get the most out of the number of served UE units. A matrix representing the achievable data rate over the transmission with the i\textsuperscript{th} RN serving for the j\textsuperscript{th} UE is recorded. The UE node which has only one RN in their coverage is given first priority. If several such high-priority UE nodes are conflicting for the single RN, then the UE node with the highest attainable data rate is elected.

The distributed scheme based on contention mentioned in [5] reduces the periodic information exchange overhead as in the centralized relay allocation scheme. In the first round of pairing the RNs with one-UE service set will randomly select a time slot from the give N slots to broadcast its paired UE - ID. If multiple RNs choose the same time slot, then collision is said to occur and those colliding RN will be trying in the next pairing sections and will independently select their own time slot. This process is repeated until every remaining unpaired RN will pick a UE node and declare its final pairing selection at a random time slot.

CONCLUSION

The paper gives an overview 3GPP LTE Advanced communications systems. The importance of relaying in a network with various technologies has been discussed. Since the relay nodes are said to extend the coverage services and throughput, a novel selection on relay node is essential to improve the system capacity and the overall network lifetime. An overview of various relay selection algorithms is provided in this article. While various relay selection algorithms has been established for LTE-A networks, there are still many challenges to be resolved with an extra effort from researchers.  

References


