A Review of Performance Enhancement and Optimization in Heterogeneous Networks

Sumit Chouksey[1], Akhilesh Bansiya[2]

[1]Computer Science Department, R.K.D.F University, Bhopal, M.P, India
[2] Computer Science Department, R.K.D.F University, Bhopal, M.P, India
[1] sumitchouksey2315@gmail.com, [2]akhilesh2483@gmail.com

* Corresponding Author: Akhilesh Bansiya Manuscript Received: Manuscript Accepted:

Abstract: *Smart and flexible wireless devices carry with them the never-ending task of figuring out the most effective way to use resources. The scope and avenues for increasing cellular network capability and coverage are constantly being investigated. The use of small cells such as microcells, pico cells, femto cells, hotspots, and relays to increase network coverage and bandwidth has proven to be an effective solution. However, the cost of installing and maintaining additional base stations offsets the improvements in efficiency. The use of user equipment with relaying support is another interesting approach for improving coverage and network performance.*

Keywords: *Heterogeneous Network, UE Relays, Coverage Optimization.*

I. Introduction

Wireless communication networks are widely used to provide a variety of communication services, including voice, video, packet data, messaging, broadcast, and so on. These wireless networks may be multiple-access networks that share network resources including bandwidth and transmit power to serve multiple users. Code Division Multiple Access networks, Time Division Multiple Access networks, Frequency Division Multiple Access networks, Orthogonal FDMA networks, Single-Carrier FDMA networks, Third Generation Partnership Project Long Term Evolution networks, and Long Term Evolution Advanced networks are examples of these multiple-access networks.

A wireless communication network may consist of several base stations capable of communicating with a variety of user equipment devices. The downlink and uplink are two ways a UE can communicate with a base station. The downlink or forward link is the communication link between the base station and the user equipment, while the uplink or reverse link is the communication link between the user equipment and the base station. On the downlink, a base station can send data and control information to a user equipment (UE), and on the uplink, the UE can send data and control information back to the base station. A single-input single-output, multiple input single-output, or multiple-input multiple-output device may be used to create this communication connection. A donor base station that communicates with wireless terminals through a relay node, such as a relay base station, is one example of a wireless communication device. A backhaul link connects the relay node to the donor base station, and an access link connects it to the terminals. In other words, the relay node will accept downlink messages over the backhaul link from the donor base station and relay them to the terminals over the access link. Similarly, the relay node may receive uplink messages from terminals over the access connection and relay them to the donor base station through the backhaul link. As a result, the relay node can be used to help fill coverage gaps by supplementing a coverage area.

II. LTE-Advanced and Relaying

II-A LTE-Advanced

The LTE-Advanced Release 10 is an evolution of LTE that is planned to meet the IMT-Advanced specifications and objectives. It aims to have peak data speeds of up to 1 Gbps for low mobility and 500 Mbps for DL and UL, respectively. When compared to LTE Release 8, LTE-Advanced is essential to reduce client and control-plane latencies. It aims to achieve top-of-the-line productivity of 30 bps/Hz in DL and 15 bps/Hz in UL, respectively.

To achieve a homogeneous client experience with the cell, LTE-Advanced increases the cell edge client throughput, or 5 percent -ile client throughput. Using a functioning recurrence band, it will improve the cell's mobility from 350 km/h to 500 km/h. The LTE-An is backward compatible with the existing LTE platform and helps to support current LTE-enabled devices. LTE-Advanced is expected to support more extensive transmission bandwidth up to 100 MHz and be adaptable in terms of data transfer capacity. For the existing combined and unpaired bands, it can also boost FDD and TDD duplexing.

It facilitates information exchange and handover with established heritage radio-access innovations. LTE-Advanced also considers a low-effort system organisation. It will allow backhauling over LTE to reduce the cost per bit.

Table 1: Comparison of LTE and LTE-Advanced Requirement

Parameter	LTE	LTE-Advanced
Peak Data Rates	100 Mbps in DL, 50-Mbps in UL	1Gbps in DL, 500-Mbps in UL
Spectrum efficiency	5-bps/Hz in DL, 2.5bps/Hz in UL	30 bps/Hz in DL, 15 bps/Hz in UL
Bandwidth	20 MHz	Up to 100 MHz
Latency	U-plane 5-ms, C–Plane 50/100ms	Improved, C-plane 10/50 ms

II-B Relaying in LTE-Advanced

A relay is a form of transceiver that repeats the signal from another base station in order to increase the network's effective coverage. Relays, as shown in Figure 1.1, are operator-deployed dbase stations located at strategic locations to enable connectivity to users across broad areas. The main goal of relay implementation is to increase network availability and coverage.

There are restrictions on the use of wireless spectrum since relay uses a wireless backhaul to connect with a nearby Macro cell Base Station or Donor MBS. The spectrum is used in a particular way by different types of relays. To communicate with its related consumer devices, an in-band relay uses the same spectrum as a donor MBS.

As a result of this spectrum sharing, adjacent users face more interference. The spectrum used by an out-of-band relay is orthogonal to the donor MBS. As a result, the interference is reduced, but the bandwidth demand for system-wide communication is increased.

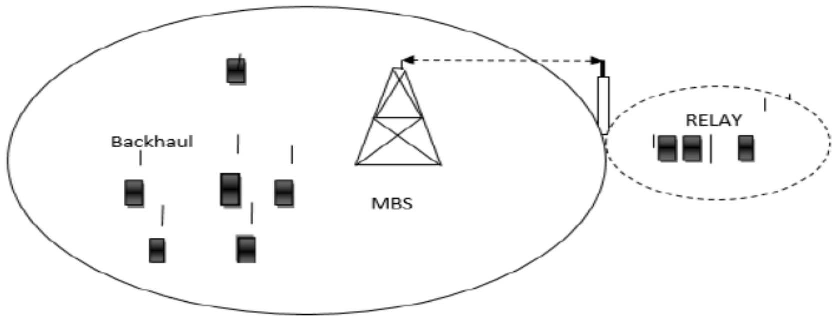

Figure 1: Relay node Network

II-C User Equipment Relays

The main aim of using a mobile phone as a hand-off device is to increase cell coverage while reducing base station capital expenditures.

An increase in framework limit and vitality efficiency of at least one is likely. The concept is inspired by the fact that if two devices are close to each other, they can communicate legitimately between themselves rather than relying on a large-scale cell/Pico cell base station to route the call.

As a result, this technique not only saves uplink and downlink band width, but also reduces macro cell load. Recommendations for such successful mobile phone to Device communication abound in the writing.

III. Challenges in Rue Deployments

The problems that arise when a UE serves as a relay for range-extended UEs in order to provide cellular connectivity are discussed here. The following are the main obstacles to the introduction and service of such devices:

III-A Implementation Challenge

A UE serves as a relay, performing the functions of a base station for the ERUEs to which it provides a network link. Also, refer to the UEs in the extended region as Extended Region User Equipment. This necessitates modifying the protocol stack implementations in UEs to provide this functionality.

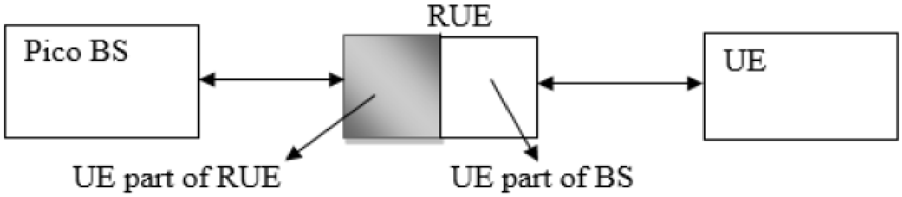

Figure 2: Relay UE Composition and Connection Model

Explains how to use [9] UEs as relays by enhancing their stacks. When associating ERUEs with RUEs, one task is to find sufficient discovery methods, and the second challenge is to figure out how to efficiently use the spectrum to minimise interference and maximize throughput. Consider two unlink transmission options: shared bandwidth and dedicated bandwidth, in order to examine this.

III-B Association/Discovery Challenge

When a UE becomes Relay Consumer Equipment and tells its donor base station that it is in relay mode RUE must also be discovered by other UEs as a potential base station for association.

- ***RUE as Base Station***
  The following conditions should be considered before any UE agrees to play the role of RUE. A RUE is a mobile device that has a small battery life. As a relay, RUE must use some of its energy to send or receive data from other UEs or donor BS. This necessitates the use of additional power in addition to RUE's self-data communication requirements. As a result, a UE can choose to act as an RUE whenever its power levels allow for additional data transmission. Mobility is another aspect to remember when it comes to RUEs. The fact that a UE is mobile makes it difficult to accommodate external devices. As a result, when a UE determines that its mobility will not interfere with the contact of associated REUEs, it may choose to play the position of RUE.
- **RUE as UE**
  When a UE chooses to play the role of an RUE, it should send out beacons on a regular basis so that neighbouring UEs can locate it. In order to preserve communication requirements, the protocol stack should also contain the following features.
  1. **Secured Environment:** A UE will function as an RUE if it has all of the requisite security safeguards in place to secure contact between the RUE and the REUE.
  2. **Access and Audit Control:** To allow approved UEs to connect to the network through RUE, all necessary functionalities must be present. This can also be used to monitor the amount of resources and bandwidth used by RUE on behalf of REUEs, which can be used to determine whether or not RUE should be reimbursed or given credit for delivering the RUE service.
  3. **Time bound Access:** The RUE can specify a service cycle duration, i.e. a period during which it acts as a relay for other UEs while continuing to function as a UE and enabling its own transmission during the remainder of the time. The duty cycle duration can be calculated by considering factors such as mobility, strength, and security.

IV. Conclusion

Relay User Equipment deployment in a heterogeneous network improves network coverage and capacity while also lowering energy consumption. While the current simulation uses a fixed nearly blank frame density, it can be modified to be dynamic based on device load and relay node availability.

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