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A Comparative Study Coverage Optimization in Heterogeneous Networks

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ABSTRACT:- Smart and versatile wireless devices brings with them, an ever continuing challenge of finding efficient means for resource usage. Scope and avenues for capacity and coverage improvement in cellular networks are constantly explored. Deployment of small cells such as microcells, picocells, hotspots, and relays proved an effective solution to improve network coverage and capacity. However, this increases in performance occurs with the cost of deployment and maintenance of additional base stations. Another interesting solution to improve coverage and network capacity is the use of user equipment with relaying support.

KEYWORDS:- Heterogeneous Network, UE Relays, Coverage Optimization.

INTRODUCTION

Wireless communication networks are broadly deployed to provide different communication services such as voice, video, packet data, messaging, broadcast, etc. These wireless networks may be multiple-access networks capable of supporting multiple users by sharing the available network resources e.g., bandwidth and transmit power. Examples of such multiple-access networks include Code Division Multiple Access networks, Time Division Multiple Access works, 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.

A wireless communication network may include a number of base stations that can support communication with a number of user equipment devices. A UE may communicate with a base station via the downlink and uplink. The downlink or forward link refers to the communication link from the base station to the UE, and the uplink or reverse link refers to the communication link from the UE to the base station. A base station may transmit data and control information on the downlink to a UE and or may receive data and control information on the uplink from the UE.

This communication link may be established via a single-input single-output, multiple-input single-output or a multiple-input multiple-output system. Wireless communication systems may comprise a donor base station that communicates with wireless terminals via a relay node, such as a relay base station. The relay node may communicate with the donor base station via a backhaul link and with the terminals via an access link. In other words, the relay node may receive downlink messages from the donor base station over the backhaul link and relay these messages to the terminals over the access link. Similarly, the relay node may receive uplink messages from the terminals over the access link and relay these messages to the donor base station over the backhaul link. The relay node may, thus, be used to supplement a coverage area and help fill coverage holes.

LTE-ADVANCED AND RELAYING

LTE-Advanced

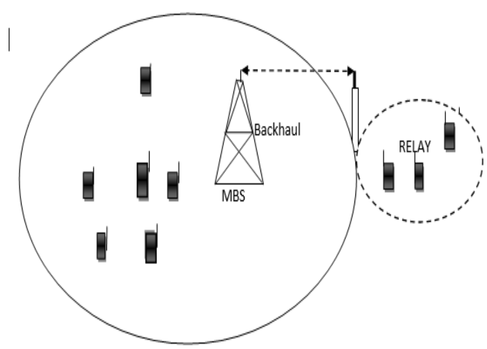
The LTE-Advanced Release 10 is an evolution of LTE, which is to compliant with the IMT-Advanced requirements and targets. It aims to provide peak data rates of up to 1 Gbps for low mobility and 500 Mbps in DL and UL respectively. LTE-Advanced is required to reduce the user- and control-plane latencies as compared to LTE Release 8. It targets to achieve peak spectrum efficiency of 30 bps/Hz and 15 bps/Hz in DL and UL respectively.

LTE-Advanced enhances the cell edge user throughput or 5%-ile user throughput in order to achieve a homogeneous user experience in cell. It will support the mobility across the cell from 350 km/h to 500 km/h depending on operating frequency band [1]. The LTE-A is backward compatible with existing LTE system and support the existing LTE enabled UEs. LTE-Advanced is expected to be bandwidth scalable and support wider bandwidth up to 100 MHz .It should also support the FDD and TDD duplexing for the existing paired and unpaired band, respectively.

It enables network sharing and handover with existing legacy radio-access technologies. LTE-Advanced also considers a low cost infrastructure deployment. It will allow the backhauling using LTE spectrum in order to reduce the cost per bit.

Relaying in LTE-Advanced

A relay is a specific kind of transceiver which repeats the signal of another base station usually to extend the effective coverage of the network. In fig. 1.1 relays are operator deployed dbase stations positioned at strategic locations as to enable communication to users in extended regions. The primary aim of relay deployment is to improve capacity and coverage of heterogeneous networks.
Since, relay uses a wireless backhaul to communicate with nearby Macro cell Base Station or Donor MBS, there exists a constraints on usage of wireless spectrum. A different kind of relay uses the spectrum differently. An in-band relay uses the same spectrum as donor MBS to communicate with its associated user equipment's.
This sharing of the spectrum results in increased interference to neighboring users. An out-of-band relay uses the spectrum that is orthogonal to the donor MBS. Consequently, this lowers the interference, but imposes a higher bandwidth requirement for system wide communication.



User Equipment Relays

The primary objective to use mobile device as relay is to extend cellular coverage whilst saving capital expenditure of base station deployment. An additional improvement in system capacity and energy efficiency is a plus. The motivation comes from the fact that if two devices are close to each other, they can communicate directly between themselves instead of involving macrocell/picocell base station to route the call.

Hence, this approach not only save additional bandwidth required at uplink and downlink but also reduces load on macrocell. Literature is abounding with proposals for such efficient mobile Device to Device communication.

Relaying Advantages and Disadvantages

Advantages

a) The main purpose of relaying is to provide peak data rates in order to support high data services. Results show that Relay Enhanced Cell network has better downlink performance in terms of UE throughput as compared with single-hop eNB-only network [2].

b) RNs enhance the overall network throughput by efficiently utilizing the network resources. Results have shown that UE experiencing good propagation conditions towards RNs. It invoke the UEs to perform handover towards RNs especially at the cell edge, therefore, increasing the network capacity as well as improve the resource fairness to UEs. It also provides good performance at cell edge by enabling a network coverage extension [3] - [4].

c) RNs being a cost efficient deployment solution, gained the network operator interest. Due to less complex site planning, acquisition, cost-efficient and low power requirements, they can be easily mounted on structures like street lamp posts. Therefore, with low CAPEX/OPEX cost, REC networks outperform the eNB-only deployed network [5].

d) RN yields a remarkable SINR gains on the relay link through proper site planning. It also reduces the shadow fading impact by selecting best site location for RN deployment [6].

Disadvantages

a). In relaying, the DeNB utilizes the same radio resource pool among three links namely direct, relay and access links. Moreover, in inband relaying, the relay and access link utilize the same radio resources through time-division multiplexing, therefore, limiting the RN performance. It creates high competition for the available radio resources at the DeNB, which requires an efficient and complex resource scheduling techniques [7].

b). RN possess small coverage area due to its low transmit power, low antenna gains and high path-loss exponent. Thus, less number of UEs will be connected to RNs, lead to inefficient utilization of resources as well as load imbalance between RN and macro base station. Moreover, RN-served UEs may also experience interference from high power transmission of macro base station [8].

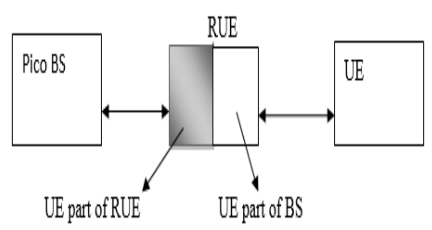
CHALLENGES IN RUE DEPLOYMENTS

Here is discussing the challenges that exits when a UE acts as a relay for range extended UEs as to provide cellular connectivity. The major challenges that exists in implementation and operation of such devices are,

Implementation Challenge

A UE acts as a relay, it has to play the functionality of a base station for the E UEs to which it serves a connection to the network. And call those UEs in the extended region as Extended Region User Equipments. For this, the protocol stack implementations in UEs need to be modified to provide this functionality.

Work in [9] explains the stack enhancements that can be done in UEs as to use them as relay. In fig 1.2 While associating ERUEs with the RUE, suitable discovery mechanisms is one challenge, and the second challenge is how to effectively use the spectrum that can results in less interference and higher throughput. To analyse this, consider two options for unlink transmission viz. shared bandwidth and dedicated bandwidth



ASSOCIATION/DISCOVERY CHALLENGE

In this section is discuss when a UE should start playing the role of Relay User Equipment and indicates its donor base station that it is in relay mode. Some discovery mechanism is also required to indicate availability of RUE to other UEs as a possible base station for association.

RUE as Base Station

Before any UE decides to play the role of RUE, following criteria should be considered. A RUE is a mobile device with limited battery constraints. Being a relay requires RUE to expend its energy consumption to transmit or receive data from other UEs or donor BS. This involves additional power to be expended on top of RUE's self-data communication requirements. Hence a UE can decided to play the role of a RUE whenever its power levels can support additional data transmission. Another criteria need to be considered for RUEs is mobility. A UE being mobile in nature poses a challenge to support additional devices. Hence a UE can decide to play the role of RUE when it could determine that its mobility will not hamper the communication of associated REUEs.

RUE as UE

Once a UE decides to play the role of a RUE, it should periodically transmit beacons that would enable nearby UEs to discover the RUE. Additionally, following features should be implemented in the protocol stack to maintain communication standards.

I) Secured Environment

A UE can act as a RUE if it satisfies that all the necessary security protections are in place to protect the communication between RUE and REUE.

II) Access and Audit Control

All necessary functionalities are required to support authorized UEs to access the network through RUE. This can also help in tracking the amount of resources and bandwidth expended by RUE on behalf of REUEs and can be used for suitable reimbursement or credit for providing the RUE service.

III) Time bound Access

The RUE can define a duty cycle period, i.e. a period during which it would act as a relay to other UEs, while in the remaining time continue to behave as a UE and enable its own transmission. The period of duty cycle can be decided based on the factors such as mobility, power, security etc.

BACKGROUND

A. Damnjanovic, J. Montojo, [11] say that the main goal of this article is to provide an overview of the topology and the deployment options for heterogeneous networks. Deployment of small, low power, low cost cellular base stations provides an efficient mean to handle this ever increasing demand of data. Heterogeneous cellular network consists of macro cells overlaid with microcells, Pico cells, relays, and hotspots helps improving network capacity and coverage by efficient reuse of available wireless spectrum.

Pico cells are regular eNBs with the only difference of having lower transmit power than traditional macro cells. Their transmit power ranges from 250 mW to approximately 2 W for outdoor deployments, while it is typically 100 mW or less for indoor deployments.

Femto cells or HeNBs are typically consumer deployed (unplanned) network nodes for indoor application with a network backhaul facilitated by the consumer's home digital subscriber line or cable modem. Femtocells are typically equipped with omni directional antennas, and their transmit power is 100 mW or less.

An RN is a network node without a wired backhaul. The backhaul, which provides the attachment of the RN to the rest of the network, is wireless and uses the air interface resources of the wireless system in question. In case the backhaul communication takes place in the same frequency as the communication to/from UE on DL/UL, respectively, the relays are denoted as in-band.

Durgamalladi qualcomminc [12] say that on the uplink, femto UE and macro UE could create high interference, which can lead to high interference variation. Due to the downlink power mismatch, UE that receives similar signal strength from the macro- and femtocells is much closer to the femtocell than the macrocell. In the case of nominal transmit power of the macro base station at 43 dBm and femto at 20 dBm, the received power difference on uplink would be as high as 23 dB i.e., the received power at the femtocell is 23 dB higher than the received power at the macrocell. If this UE is served by the macrocell with a targeted received signal-to noise ratio of 5 dB, the interference caused by this UE would be 28 dB above the thermal at the femtocell when this UE starts transmitting.

J. Andrews, H. Claussen,[13] say that however, it has been seen that even with more bandwidth, better modulation and coding techniques in heterogeneous cellular networks, operators still facing problem to fulfil users' data demands. Nevertheless, these infrastructure incurs very high capital and operational expenditure and still unable to solve indoor coverage problem. Recently, use of miniature indoor cellular base stations called femtocell is suggested for indoor users.

J. Kim,K. Vanganuru,Z. Shi, and I. Katzela [14,15,16,17] say that femtocell provide huge performance improvement to users inside homes/offices by efficiently reusing the available spectrum Femtocell eliminate wall penetration loss to indoor users, and hence able to provide users with better coverage and bit rates. However, dense femtocell deployment may lead to additional co-channel interference to neighbouring users. Various researches are ongoing to mitigate the interference from such dense deployment scenario. One of the best approaches is to bring transmitter and receiver spatially closer to each other so as to improve received signal strength from target base station. Another approach is planning reuse of frequency sub channels in an effective manner as to avoid interference completely. Frequency partitioning surly allows service providers to enable high quality user experience, but deteriorate spectral efficiency of the system. Most research exists in literature focus on improving capacity and coverage of cellular networks by optimization of transmit power and sub channel allocation policy.

CONCLUSION

Deployment of Relay User Equipment's in a heterogeneous network not only shows improvement in coverage and capacity of the network, but also helps in decreasing networks' energy consumption. While the current simulation is done with fixed almost blank frame density, the same can be made dynamic based on system load and relay node availability.

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