International Journal of Modern Computer Science (IJMCS)
Volume 2, Issue 6, December, 2014
ISSN: 2320-7868 (Online)

Review on Moving Relay Nodes in LTE-Advanced

Anika Aneja
Department of ECE
Bharati Vidyapeeth's College of Engineering
New Delhi, India
E-mail: anika.aneja@gmail.com

Jolly Parikh
Ph.D. Scholar, Mewar University
Faculty, ECE
Bharati Vidyapeeth's College of Engineering
New Delhi, India
E-mail: jolly.parikh@bharatividyapeeth.edu

Anuradha Basu
HOD, ECE
Bharati Vidyapeeth's College of Engineering
New Delhi, India
E-mail: anuradha.basu@bharatividyapeeth.edu

Abstract: 3GPP aims to meet ITU (International Telecommunication Union) requirements for availing backward compatibility along with increased data rates and minimal data latency and losses. LTE-Advanced aims to achieve increased data rates for DL (upto 3Gbps) and UL (upto 1.5 Gbps), higher spectral efficiency, increased network capacity and improved cell-edge performance. The main new functionalities introduced in LTE-Advanced are Carrier Aggregation (CA), MIMO techniques and support for Relay Nodes (RN). Relay nodes ensure fair extended cell coverage and capacity. Moving Relay Nodes (MRN's) are RNs deployed on top of a moving public transportation vehicle. The use of MRNs is expected to enhance the performance of vehicular UEs. This paper reviews the work done on MRNs and investigations done up-till date. Paper also speaks about the possible solutions to overcome the challenges faced with MRNs so as to contribute towards an improved global communication system.

Keywords: Long Term Evolution-Advanced (LTE-A), Relay Nodes (RNs), Moving Relay Nodes (MRNs), Quality of Service (QoS), Donor eNodeB

I. INTRODUCTION

LTE (Long Term Evolution) was introduced in Release 8 of 3GPP (Third Generation Partnership Project) and the standard was adopted by ITU as international standards for wireless communications in the mobile network technology tree. The main objectives for LTE were increased downlink and uplink peak data rates, scalable bandwidth, improved spectral efficiency, user capacity. The global deployments during 2010 include GSM (Global System for Mobile Communication) & UMTS (Universal Mobile Telecommunication System) which used circuit switching techniques. Release 9 introduced the 3.9 G referred to as Pre-4G, but the system could not meet the ITU requirements of peak data rates, minimal data latency and reduced transmission errors. The 4G in addition to 3G services provides mobile broadband Internet access and also replaced the traditional voice calls with IP telephony. The successor, LTE-Advanced which was introduced in Release 10 of 3GPP, aims at both further improvement in the system capacity and improvement in the cell edge user experiences. Enhancements were provided by the collaboration of advanced network architecture with smart antenna technology. LTE-A uses packet switching techniques and the main new functionalities introduced in LTE-Advanced are Carrier Aggregation (CA) and addition of low power nodes to the topology. Release 11 and beyond aim for further enhancements of LTE-Advanced system functionality and specifications.

II. RELAYS

As the user moves away from the DeNB (Donor eNodeB), the Signal to Interference & Noise Ratio (SINR) drops with distance due to path loss and inter-cell interference as it moves closer to another eNB. Also, in urban areas, tall buildings block the signaling between UE and eNB; as shown in figure 1. This requires balancing for which relay nodes are placed on cell edges.

Addition of low power nodes in LTE-A heterogeneous networks is catalyzed by Relay Nodes. These are basically low-power Base Stations which are wirelessly connected to the donor cell. RNs utilize the backhaul link to extend the coverage area. The backhaul link uses the same air interface, same frequency as that for direct link between UE and server eNB.

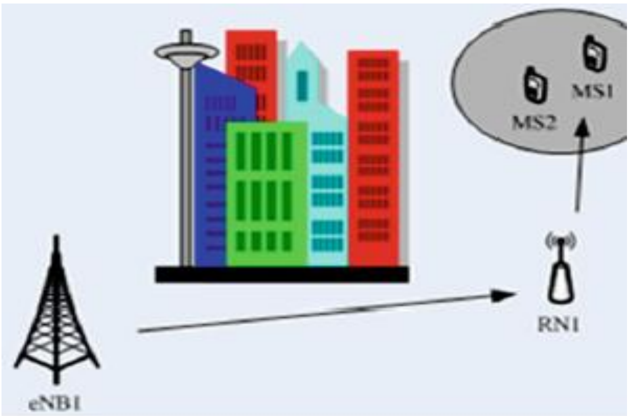

Figure1. Relaying Scenario

ISSN: 2320-7868 (Online)

But use of same frequency causes severe degradation of signal strength (may be in order of 100 dB); which is referred to as Isolation problem. Such RNs are called Inband Relays. In order to avoid isolation problems, Outband Relays were introduced which use different LTE frequencies for the two links, in case DeNB supports Carrier Aggregation [1].

RNs that use special configuration in order to avoid simultaneous transmission and reception on same frequency are also referred as Type-1 RNs. Outband Relays are Type-1a RNs and another kind of RNs which provide sufficiently strong isolation between transmission and reception frequency are Type-1b RNs.

III. TYPES OF RELAYS

A. Type-1 relays (Non-transparent RNs)

From the UE perspective, the RN appears the same way as a regular evolved NodeB (eNB). For communication with RN, UE uses control information in the normal manner. Whereas the RN behaves like a UE to the DeNB. Identification of an RN involves subsequent signaling. Each RN has its own cell ID, synchronization and control channels as well as retransmission and broadcast processes. In figure 2, the indirect link shows the connection between UE and eNB.

B. Type-2 relays (Transparent RNs)

From the UE perspective, the RN just extends the cell of DeNB. These do not have a separate cell ID, and should not be identifiable by UEs. These RNs are not allowed to transmit control and common reference signals, thus cannot be used for coverage extension but can be utilized for increasing the supported capacity and QoS increase within an existing cell. In figure2, the transparent linking is shown between UE and eNB.

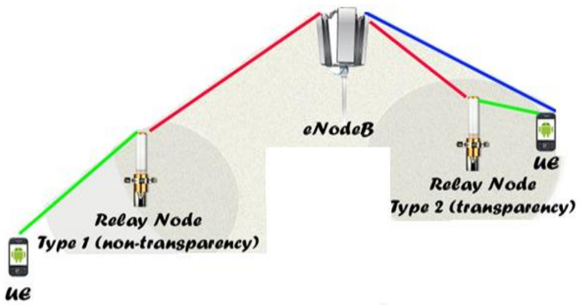

Figure 2. Types of Relay Nodes

IV. MOVING RELAY NODES

Voice and data communications on high speed vehicles encounter bad channel condition, high call drop rate, serious signaling congestion and excessive power consumption of UE. However, the design for fixed relay in LTE-A system cannot meet the requirements of mobile relay. The RN is positioned on top of a moving public transportation vehicle. The use of MRNs is expected to enhance the QoS for vehicular UEs providing higher data rates with reduced power consumption as a small cell is created within the vehicle effectively. In urban environments, a significant number of UEs use wireless broadband services within public transportation vehicles like buses or trains. A major factor that limits the achievable throughput for UEs inside vehicles is the vehicle penetration loss. Deploying MRNs pays off for the VPL increasing the UE throughput.

MRN is deployed on a vehicle and is connected to the DeNB through a relay-link and to the UE through an access-link as suggested in figure 3. MRNs have power supply provision making them reliable for constant transmission powers and possess processing capabilities [2].

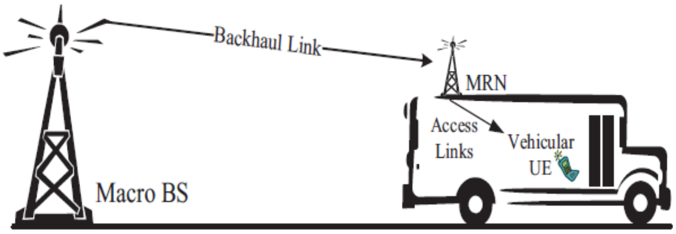

Figure 3. Moving Relay Scenario

V. CHALLENGES AND OPEN ISSUES

A. Speed of Vehicle

High speed UE's, as in figure 4, initiate more number of handovers. Handover decisions are dependent on the signal strength report. But high speed leads to lesser measurement samples, further decreasing the accuracy for decision making. This may lead to drop in HO success rate. HO failure causes drop in QoS [3] [4].

B. SNR

Signal to noise ratio (SNR) changes in accordance with the external environment (weather conditions), pathloss which increases with the distance of UE from DeNB and penetration loss. High SNR is desirable [5].

C. Power Balancing by MRN

Power required for transmission is low if UE is in near-area of the serving node as SNR is high. In such cases, concentration of power can be shifted to far-distant latched users. Thus, power balancing is achieved by mitigation of transmitted relay power [6].

D. Antennas

Advanced antenna solutions are capable of steering in accordance with the beam width or/and adaptively adjust with the beam width. Deployment of such antennas on-board improves the coverage and link quality. Also it prolongs the HO region by giving more time for successful completion of HOs [7] [8].

E. DeNB Identification

In urban areas with much complicated network deployment, two DeNBs providing backhaul access link, might have some overlapping coverage area. Or there may exist another non-Donor eNB causing an overlap-cover. So proper algorithm should be followed in order to identify the target DeNB offering good signal strength based on measurements [9].

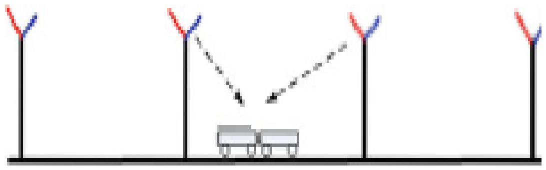

Figure4. High speed train passing a series of transmission points along the rail

F. PCI usage of Moving Relay

Changing of Physical Cell Id (PCI) is done to avoid PCI collision. PCI collision would occur in case PCI of relay is same as that of a nearby eNB on the route followed by UE. Here, the UE is not able to differentiate between the relay and stranger node causing loss of connection and reconnection might be delayed further causing disruption in packet delivery [10][11].

G. Number of Users being served by RN

If number of users on board is high, the Target DeNB might reject the HO request due to lack of enough resources. No eNB serves its 100% resources, thus, HO failures might occur if number of users using the common access-link is high as capacity can vary from node-to-node. Thus, proper admission control is required [12].

VI. DEPLOYMENTS & CURRENT SCENARIO

LTE-A features facilitate spectral reuse but improvement of backhaul links to meet the challenges due to user mobility still needs deep study. However, proper network planning is the key solution. MRNs do improve the user experience. In the global scenario where 4G is yet to find a position in market to meet demands for better connectivity for mobile users, dedicated deployment of MRNs is the best possible solution [13].

Yota, Russia was the first ever operator to launch the mobile technology commercially in 2011, but compatible handsets were available only after the first-half of 2013. South Korean companies unveiled the technology in 2013. Many other countries decided to upgrade to LTE-A.

Companies like Huawei, LG, Netgear, Samsung, and ZTE have produced LTE-A compatible devices, offering data rates upto 300Mbps [14].

VII. CONCLUSION

MRN is a potential solution to pay off the vehicular penetration loss, improve mobile user experience and thereby, contribute significantly to future mobile communication systems. The future expects a rise in number of data hungry vehicular users as on bus/train. So it is an important task to work over improvement of QoS for vehicular users. Further investigations can be done to overcome the challenges and meet ITU requirements.

REFERENCES

[1] M Kottkamp, A. Roessler, J. Schlienz, "LTE Advanced Technology", Introduction White Paper, August 2012.

[2] Y. Sui, J. Vihriälä, A. Papadogiannis, M. Sternad, W. Yang, and T. Svensson, "Moving Cells: A Promising Solution to Boost Performance for Vehicular Users", submitted to Special Issue on Heterogeneous and Small Cell Networks (HetSNets), IEEE Communications Magazine, Vol. 51, Issue 6, June 2013.

[3] R3-092738 "Architecture Options Comparison: UE Mobility Support", Jeju, Korea, Fujitsu, November 2009.

[4] R3-121152 "Proposed RAN3 Way Forward on Mobile Relays", Prague, Czech Republic, InterDigital Communications, May2012.

[5] Lin Chen, Ying Huang, Feng Xie, Yin Gao, Li Chu, Haigang He, Yunfeng Li, 'Mobile Relay in LTE-Advanced Systems', Feng Liang and Yifei Yuan,ZTE Corporation; IEEE Communications Magazine, November 2013.

[6] Jaafar A. Aldhaibani, Abid Yahya and R. Badlishah Ahmad, "Coverage Extension and Balancing the Transmitted Power of the Moving Relay Node at LTE-A Cellular Network", Hindawi, Published, 29 January 2014.

[7] R3-121281 "Antenna Impacts on Mobile Relay Scenarios", Prague, Czech Republic, Ericsson, May 2012.

[8] R3-121222 "Comparison of HO latencies for moving relays", Prague, Czech Republic, Mitsubishi Electric , May 2012.

[9] R3-121104 "DeNB identification in mobile relay handover procedure", Prague, Czech Republic, Potevio, May 2012.

[10] R3-121097 "PCI usage for mobile relay", Prague, Czech Republic, Nokia Siemens Networks, May 2012.

[11] R3-121051 "PCI Collision Issue for Mobile Relays", Prague, Czech Republic, Alcatel-Lucent Shanghai Bell, Alcatel-Lucent, May 2012.

[12] R3-121096 "Admission Control in Mobile Relay", Prague, Czech Republic, Nokia Siemens Networks, May 2012.

[13] Yutao Sui, "On the Benefits of Moving Relay Nodes in Wireless Networks", 2012.

[14] Editors of Fierce Wireless, "LTE-Advanced Status Report", June 2014.