A Review on Soft Handover Schemes in LTE Cellular Networks

Shreedhar K V M
Department of Computer Science and Engineering
R V College of Engineering
Bengaluru, India - 560095

Vinay V Hegde
Department of Computer Science and Engineering
R V College of Engineering
Bengaluru, India - 560095

Abstract **- Long Term Evolution (LTE) is an upgraded version of 3G UMTS to meet the more demanding user requirements such as high speed data access and better Quality of Service (QoS). 3GPP standard introduces handover mechanism to meet the additional user requirement of handling seamless mobility across different cellular regions. During handover, there is a challenge to meet the better QoS especially for real time services such as voice call. Handover occurs more frequently in a high speed mobility. This is also the case when end user is at the edge of the cell. However, there are different techniques that exist to allow for efficient handover to happen without affecting the service experienced by the end user. In this paper, we study the architecture of LTE system and survey the handover techniques.**

Keywords – OFDMA, carrier aggregation, multipath fading, MIMO

I. INTRODUCTION

Mobile networks provide end user with wireless services such as voice call, data access, etc. Today's LTE system is evolved from 3G system. Cellular network is composed of radio network and core network. Radio network interfaces User Equipment (UE) with the controller and core network interfaces controller with external IP network. Each generation of cellular network uses different radio access technology for its radio access network. Table I presents the summary of the each generation techniques.

Time Division Multiple Access (TDMA) used in 2G allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit the data in rapid succession, one after the other. Each user uses its own time slot. This allows multiple mobile stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity.

TABLE I Cellular Network Generations

Generation	Radio Access Technology	Architecture
2G	TDMA	Circuit Switched
2.5G	TDMA	Circuit Switched + Packed Switched
3G	CDMA	Circuit Switched + Packed Switched
4G	OFDMA	Packed Switched

3G employs Code Division Multiple Access (CDMA) for multiple access using which several transmitters can send the information simultaneously over a common communication channel. This mechanism allows multiple users to share same band of frequencies. To permit this without causing interference between the users, CDMA employs spread-spectrum technology and a special coding scheme where each transmitter is assigned a unique code.

4G system supports only Internet Protocol (IP) based communication such as IP telephony. This is opposed to earlier generations such as 3G where circuit switched telephone service is provided for voice calls. The spread spectrum radio technology used in 3G systems, is replaced by Orthogonal Frequency Division Multiple Access (OFDMA) multi-carrier transmission and other Frequency Domain Equalization (FDE) schemes. This make it possible to transfer very high bit rates despite extensive multi-path radio propagations (echoes). The peak bit rate is further improved by smart antenna arrays for Multiple Input Multiple Output (MIMO) communications. Also, there is a better spectral efficiency with OFDMA technology. Use of OFDMA increases the number of users per cell and has the other advantages of bandwidth reliability, carrier aggregation and low inter symbol interference.

II. ARCHITECTURE OF LTE SYSTEM

3GPP introduced Evolved Packet Core (EPC) which is the core network of the LTE system in Release 8 of the standard specifications. The standards make it is a flat architecture compared to UMTS to handle the payload efficiently from performance and cost perspective. Signaling data and user data are made separate to allow for independent scaling in future. The operators can dimension and adapt their network easily. Basic EPS architecture is shown in the Fig. 1. Evolved NodeB is the base station in LTE networks for transmission of LTE radio. User Equipment (UE) is connected to EPC over E-UTRAN. EPC is composed of four network elements - the Serving Gateway (Serving GW), the PDN Gateway (PDN GW), the Mobility Management Entity (MME) and Host Subscriber Server (HSS). External networks consisting of IP Multimedia Subsystem (IMS) is connected to EPC.

A. Host Subscriber Server

HSS is a database server that stores both user related and subscriber related information. It assists in support functionality such as call and session setup, mobility management, authentication of user and access authorization.

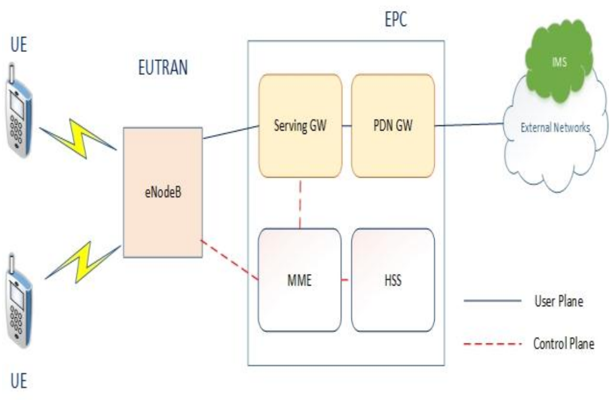

Fig. 1 Basic EPS Architecture with E-UTRAN Access

B. Serving GW and PDN GW

The Serving Gateway (GW) and Packet Data Network Gateway (PDN GW) are part of the user plane. IP data traffic is transported by these gateways between external networks and the User Equipment (UE). The Serving GW interfaces the radio network with EPC. This gateway serves the user equipment by routing both incoming and outgoing IP packages. It is the anchor point for intra LTE mobility and between LTE and other 3gpp radio access technologies. PDN GW interfaces Serving GW with external networks.

The PDN GW is the only point of interconnection between the external IP networks and the EPC. These networks are called PDN (Packet Data Network), hence the name.

The PDN GW routes packets to and from the PDNs. The PDN GW performs various other functions such as allocation of IP address/IP prefix, policy control and charging. As per 3GPP standard specifications these gateways are independent of each other, however, in practice, these gateways may be combined in a single 'box" by network vendors.

C. Mobility Management Entity

Mobility Management Entity (MME) deals with the control plane. Its functionalities include handling of the signaling related to mobility management and security for accessing E-UTRAN. It is also responsible for tracking and paging of UE in idle-mode.

III. HANDOVER IN LTE SYSTEM

Handover is the mechanism by which UE moves from one cell to the other. Handover is triggered when the serving cell signal strength is below a certain threshold and neighboring cell signal strength is better than serving cell signal strength. Handover is of two types - soft handover and hard handover. Software handover involves first establishing the connection with the target eNodeB and then breaking the existing connection with source eNodeB. Hard handover (shown in Fig. 2) follows break and then make approach. LTE standard specifies only hard handover. Handovers can also be classified as horizontal handover and vertical handover. Horizontal handover involves handover of the UE to the Radio Access Technology (RAT) while vertical handover involves handover of the UE to different RAT. This involves handover to and from existing GSM and UMTS systems.

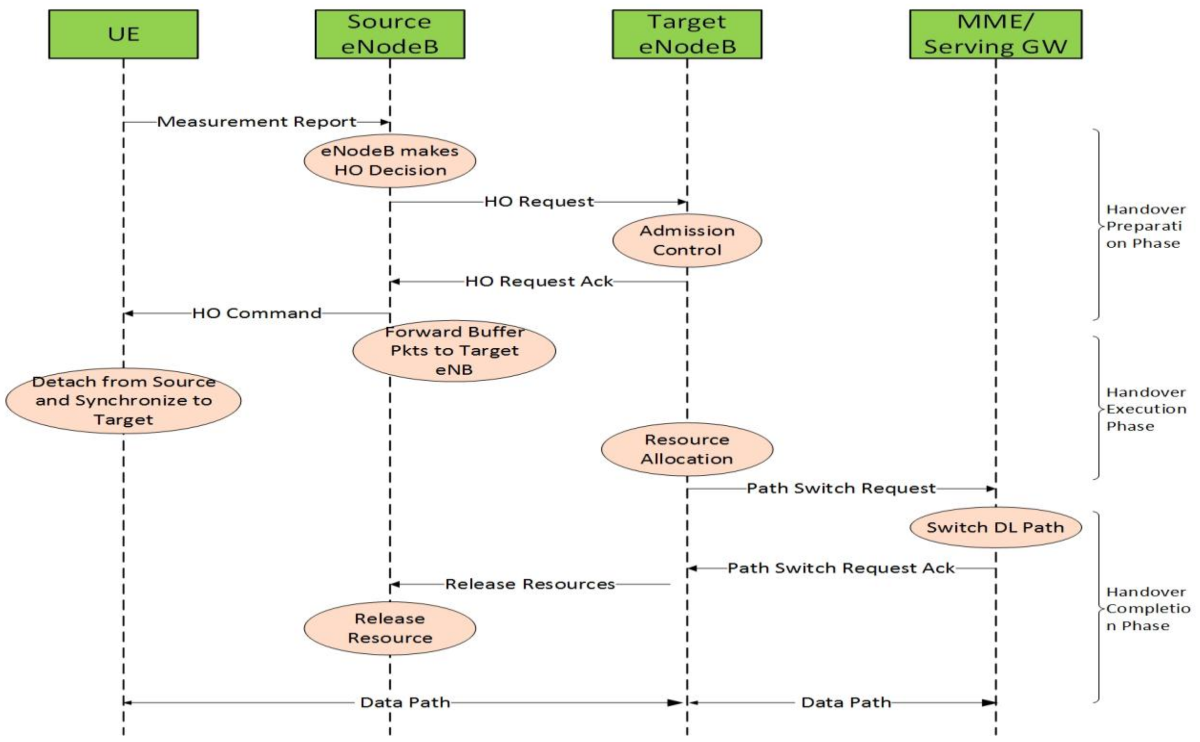

Fig. 2 LTE Handover Procedure [1]

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

A. MEASUREMENT BASED HANDOVER TRIGGER

Handover is triggered to target cell mainly based on the measurements reports received by the serving eNodeB from UE. After UE establishes the connection with the eNodeB, UE is configured by eNodeB to trigger measurement reports periodically. UE reports the signal strength of the serving eNodeB and other eNodeBs depending upon the configuration. After eNodeB receives measurement report, it decides whether to trigger handover or not. There are different type of measurement reports based on the events configured by eNodeB. Standard defines intra-system and inter-system measurement reporting events. The list of measurement events are listed in Table II.

TABLE II LTE Measurement Events

Event Type	Description
Event A1	Serving cell strength becomes better than certain threshold
Event A2	Serving cell strength becomes worse than certain threshold
Event A3	Neighbor cell strength becomes offset better than serving cell
Event A4	Neighbor cell becomes better than certain threshold
Event A5	Serving cell becomes worse than threshold1 and neighbor cell becomes better than threshold2
Event A6	Neighbor cell offset becomes better than serving cell
Event B1	Inter RAT neighbor cell becomes better than certain threshold
Event B2	Serving cell becomes worse than threshold1 and inter RAT neighbor cell becomes better than threshold2

IV. SOFT HANDOVER TECHNIQUES

The advantage of standard specified hard handover for LTE system is that it keeps the architecture and the design simple making the system cost effective for both service provider and service user, but there is certainly a cost involved with it. End user is subjected to experience the discontinuity in the data service access for small duration of time. Also, there is a possibility of complete service disconnection if there are no resources available at the target cell after mobile station disconnects from the source eNodeB.

In this paper, we present the research works on the soft handover which overcome the disadvantages of the hard handover. In the first section that follows is the standard mechanism used for triggering the handover.

A. FRACTIONAL SOFT HANDOVER (FSHO)

Chang et al [2] present fractional soft handover approach. In this scheme, UE periodically measures the pilot signal strength of each component carrier of neighboring eNodeBs and then reports these to eNodeBs. The source eNodeB based on the measurement report, selects the component carrier as the FSHO carrier and negotiates it with the target eNodeB in the handover preparation phase (see Fig. 3). In the handover execution phase, UE needs reestablishing the RRC connection with target eNodeB using the chosen FSHO carrier. Once RRC connection establishment with target eNodeB is completed, the serving gateway bi-casts the VoIP packets to target eNodeB and source eNodeB. As a result, VoIP packets are simultaneously transmitted to UE by target eNodeB and source. However, non-VoIP packets are transmitted by either target eNodeB or source eNodeB. This approach can be easily implemented using the carrier aggregation technology in LTE-Advanced system.

Several component carriers are aggregated to form larger system bandwidth. Carrier aggregation is popular in LTE-advanced systems to get larger bandwidth than 20MHz. It requires UE to have several FFT modules or a larger FFT module. This facilitates or assists UE for simultaneously receiving the signal from different component carriers using several FFT modules or the different parts of the larger FFT module. For implementing the improved handover scheme, Chang et al. [2] set one component carrier as the special carrier for UE to establish RRC connection with the target eNodeB during handover procedure and other carriers maintain the communication with source eNodeB. Chang et al. [2] name this proposed handover scheme as Fractional Soft Handover (FSHO) and call the special component carrier used by UE for establishing the RRC connection with the target eNodeB during the handover procedure as the FSHO carrier.

B. SEMI SOFT HANDOVER (SSHO)

In this scheme [3], each mobile station maintains multiple control signals with active eNodeBs over the handover region, but the user data signal is selectively received from a signal eNodeB whose pilot signal strength is the largest [3]. Signaling procedure for the semi soft handover scheme is shown in the Fig. 4. As the MS moves towards BS2 from BS1, it reaches the handover region where it establishes a connection with the BS2. Home BS (BS1) copies the packets received from the core network and forward them to Base Station 2 (BS2). It is the Mobile Station (MS) that selects one of these two BSs for user data transmission based on the signal strength of pilot signals of different controllers.

The process of BS selection results in relatively reduced number of users anchored to each BS when compared to soft handover case. The additional advantage is the small handover delay associated with the approach. This is because, MS simultaneously communicates with both BSs using two control channels and BSs are in a position to transmit user data during semi-soft handover. The delay is much smaller when compared to hard handover case.

From the perspective of delay and interference, the semisoft handover technique has much greater advantages for the high speed real-time data services compared to other handover techniques.

C. MULTI CARRIER HANDOVER (MCHO)

As per this scheme, MS with multi carrier capability maintains the connection with serving BS at the time of performing the handover to the target BS [4]. With the multi carrier capability, MS can operate over multiple carriers upon a common Medium Access Control (MAC) layer for high data rate service. The feature allows zero tolerant data interruption time during handover.

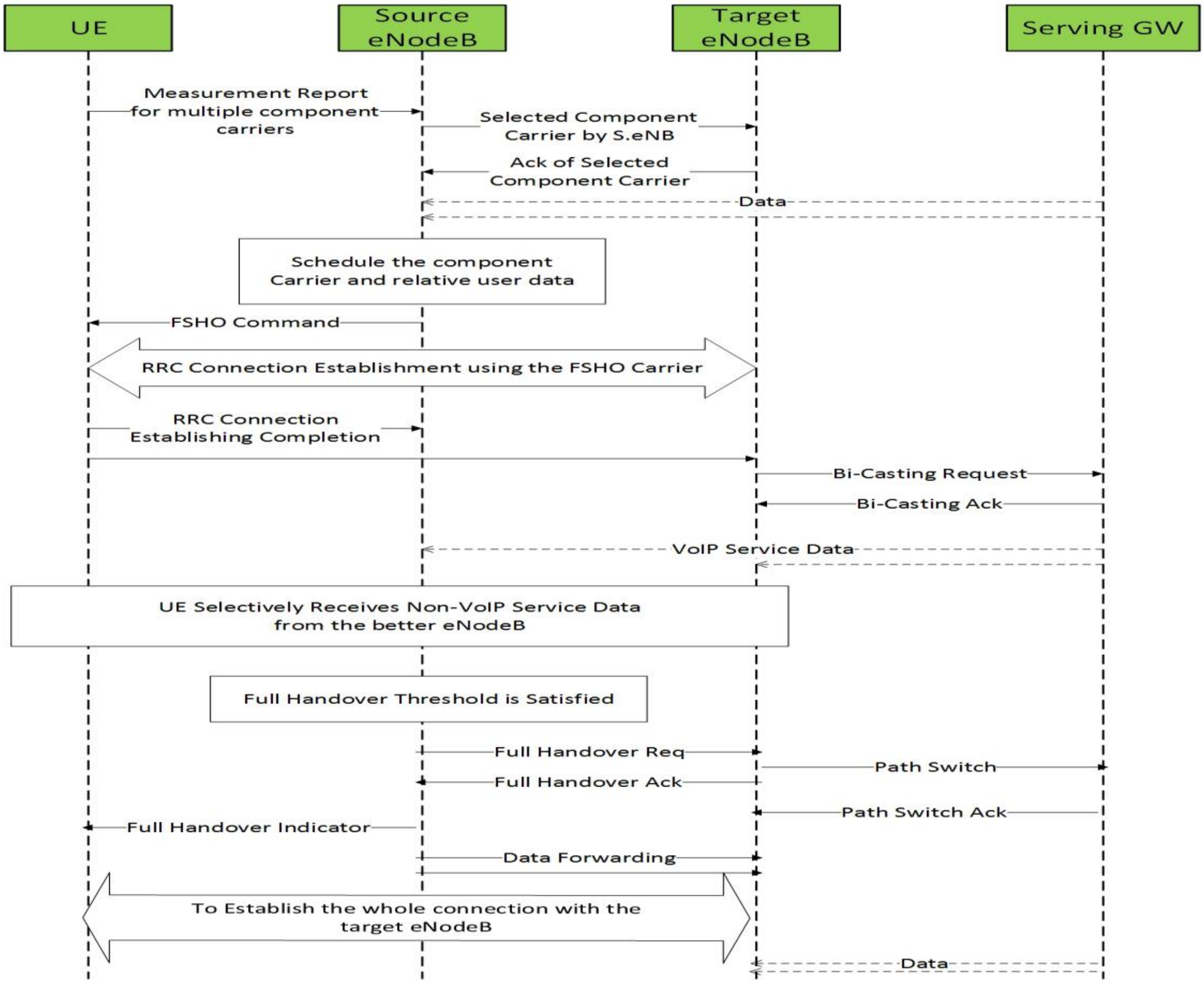

Fig. 3 Message chart of the FSHO in LTE-Advanced system [2]

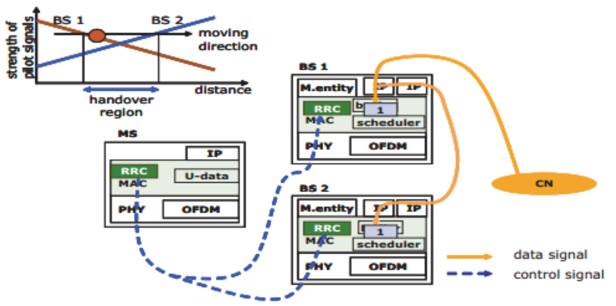

Fig. 4 The signaling procedure for site selection diversity [3]

D. FUZZY LOGIC TECHNIQUE

Fuzzy logic technique for optimizing the hard handover in LTE networks is introduced in [5]. Standard specifies only hard handover. Hard handover has the advantage that it is less complex in nature. However, it has inefficient LTE performance as it decreases the system throughput and increasing the service access delay. Therefore, an efficient handover technique is required.

Saeed et al. [5] introduce a new handover optimized technique based on the fuzzy logic controller, with the objective of minimizing the number of handovers and maximizing the total system throughput. It finds the Optimum Handover Margin (OHM) that is required for handover process and finding appropriate Time-to-Trigger (TTT) to perform successful handover using funzzy logic

E. COORDINATE MULTIPLE POINT TRANSMISSION

Luo et al. [6] introduce a Coordinate Multiple Point (CoMP) soft handover technique for LTE systems in high speed railway. Standard specified hard handover encounters two challenges under high speed moving environment. Handover delay associated with the hard handover is relatively large. The handover procedure cannot be accomplished timely as the high speed moving train passes through the overlapping areas or regions at a very high speed. As a result this, optimal handover position is tend to be missed. This mainly degrades the probability of successful handover. In order to overcome the challenges mentioned above, the existing handover scheme of LTE should be optimized to improve the handover success probability in high-speed movement circumstance.

Coordinated multiple point transmission (CoMP) transmission and reception allows geographically separated base stations to jointly sending the data to one terminal and jointly receiving the data from one terminal, by which the inter-cell interference could be reduced and the system frequency spectral efficiency would be improved. In order to take full advantage of the multiple base stations cooperation feature of CoMP systems under high speed scenarios, [6] proposes a seamless soft handover scheme based on CoMP, that allows the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

moving train to receive signals from both adjacent base stations when the train travels through the overlapping areas. This results in the degradation of the handover failure rate and the reliability of train to ground communication is guaranteed.

F. HANDOVER IN LTE FEMTO CELLS

Handover in the case of Femto cells is different from that of the macro cells considered in the previous sections. The main reason is that region served by the Femto cell is in the order of 10m to 30 meters. As a result, there is a high probability of frequent handovers among femtocells. Also, transmission power of femtocell is much lower than that of macro cell leading to increase in the probability of frequent handovers to macro cells. Energy-Efficient method for Handover in LTE femtocell networks.

V. CONCLUSION

Soft handover mechanisms promise to be better handling of the service discontinuity associated with the hard handover. Most of the research works make use of maintaining multiple connections one with each controller. This has the advantage but at the cost of the mobile station transmission power.

REFERENCES

[1] Yun Li, Bin Cao, Chonggang Wang, "Handover schemes in heterogeneous LTE networks: challenges and opportunities", Published in: IEEE Wireless Communications, Vol. 23(2), 2016, Pages: 112 – 117
[2] J. Chang, Y. Li ,S. Feng ,H. Wang , C. Sun , P. Zhang"A Fractional Soft Handover Scheme for 3GPP LTE Advanced System," in Communications Workshops, 2009. ICC Workshops 2009. IEEE International Conference on, 2009, Pages: 1-5
[3] Hyungkeuk Lee, Hyukmin Son, Sanghoon Lee, “OFDM-based semi-soft handover for high data rate service”, IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, (IEEE PIMRC 2007), Athene, Greece, 3-7 Sep. 2007
[4] Ronny Yongho Kim, Inuk Jung, Xiangying Yang, Chao-Chin Chou, "Advanced Handover Schemes in IMT-Advanced Systems", IEEE Communications Magazine, Volume: 48, Issue: 8, Pages: 78 - 85
[5] Mohamed Saeed; Hanan Kamal; Mona El-Ghoneimy, "A new fuzzy logic technique for handover parameters optimization in LTE", 2016 28th International Conference on Microelectronics (ICM) Year: 2016 Pages: 53 – 56
[6] Wantuan Luo, Ruiqiang Zhang, Xuming Fang, “A CoMP soft handover scheme for LTE systems inhigh speed railway”, EURASIP Journal on Wireless Communications and Networking 2012
[7] http://www.3gpp.org/technologies/keywords-acronyms/98-lte