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# Advanced Handover Techniques in 5G LTE-A Networks

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## ABSTRACT

In High-speed and seamless access is the goal of next-generation mobile communication systems, especially for VoIP and multimedia services. The supported mobile speeds are expected to reach 500 km/h in the Fifth Generation Networks (5G), lead to the handover will take place continuously as the mobile user moves through the cells. Therefore, efficient radio resource management, including the handover, load balancing technologies is vital problems. In this work, we perform a comprehensive survey of advanced handover techniques in the next-generation mobile communication system (5G) as well as requirements and features for the LTE-Advanced system. In the LTE-Advanced system, Fractional Soft Handover (FSHO) with 5 CCs improves latency and better handover quantity when not using CA. Currently, the proposed handover techniques have many advantages but have not yet resolved important issues in the handover process. Therefore, new handover techniques are required to support a fast and seamless handover process in the LTE-Advanced system. As a result, an advanced transfer technique proposed by combining FSHO, SSHO techniques can reduce latency, enhance efficiency and reliability, especially in the border areas between the cells.

**Key words:** LTE-Advanced, Handover, 5G.

## 1. INTRODUCTION

With along the increasing number of mobile devices, while the new generation mobile information system requires support for high-speed mobile access devices [1]. As a result, the number of handover in the system will increase rapidly. In cellular communication networks, handover can be defined as the process of establishing a wireless connection from the source cell to the target cell on the base station (BS), ensuring seamless the call. Mobile users are not interrupted while moving from the coverage area of a source cell to the coverage area of a target cell, Figure 1.

The quality of the handover depends on the quality of the signal made to both the uplinks and downlinks direction of the radio link, even when the subscriber is still within the coverage of a cell but due to the subscriber density of this cell is so large lead to this call may be routed to a lower density adjacent cell to ensure good call quality. During a call, there can be many handovers, this number depends on the mobility speed of the mobile user. So handover is an important issue, is the key to mobile technologies. If the handover problem cannot be solved, there will be no mobility world.

Fast and seamless connection with minimal delay in handover process under different mobility speeds of different terminals is one of the significant problems of new generation mobile communication systems.

With the development of multimedia services and broadband wireless applications, it will require higher data rates and wider coverage. As a result, fast and robust handover is always required in all mobile communication systems. The LTE-Advanced system is initiated and standardized into the next-generation communication system of 5G networks.

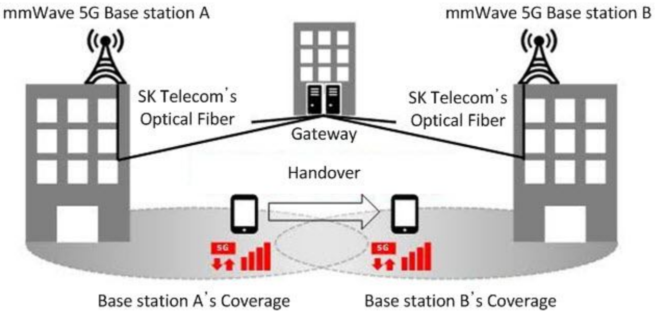

**Figure 1:** Illustration of Handover in 5G

The LTE-Advanced system is expected to meet and exceed the requirements proposed by the ITU. Support for high-speed mobility is one of the requirements that must be achieved in 5G. The LTE-Advanced system can support mobility speeds up to 500 km / h. Furthermore, LTE-Advanced will support high data rates up to 1Gbps with downlink (DL) and up to 500Mbps with uplink (UL). In addition, the antenna specifications in the LTE-Advanced system are enhanced by the handover mechanism in the link layer, allowing for reduced handover interruptions [2].

Nowadays, The handover techniques in the LTE-Advanced system are based entirely on hard handover. This technique is simpler and less complicated than the soft and softer handover technique. However, hard handover has some limitations such as the high probability of data loss, time of interruption and high probability of power failure, carrier interference. As a result, this technique has difficulty maintaining the quality of service (QoS) in networks with very high terminals moving at very high mobility due to high delay during handover [3].

Meanwhile, the fast and seamless data transfer with minimal latency is one of the main goals to be achieved in the LTE-Advanced system. This can be achieved by supporting the handover from the source cell (eNB) to the target eNB [5]. At this point, there are several handover techniques that allow for partial handover softening in the LTE-Advanced system. Several studies have been proposed in references [3]-[8]. However, these techniques are not enough to solve complicated problems in hard handover. Therefore, new handover techniques are to be studied. This paper gives an overview of the handover of cellular radio communications systems, advanced handover techniques in LTE-Advanced systems, and hybrid handover techniques.

## 2. HANDOVER TECHNIQUES

Handover is one of the most important features of a cellular radio communication system. Normally, continuous service will be achieved with the assistance of handover between cells. Handover is the process of switching channels (frequency, time slot, spread code or their combination) related to the active connection while the call is in progress.

The handover occurs when the power of the MS (Mobile Station) received from the neighbouring BS is greater than the power that the MS receives from the current BS. This value is called the handover threshold. For a successful handover, the channel must be ensured for the handover request before the power received by the MS reaches the threshold.

Handover requires network resources to reroute calls from the current BS to the new BS. One handover problem is the time delay. If handover does not proceed quickly, the quality of network service may decrease. Therefore, the handover delay is important for the QoS guarantee of the cellular mobile communication system. Therefore, mobile communication networks such as GSM, GPRS, 3G, LTE, 4G and 5G are especially interested in handover delay when considering QoS solutions.

In the 5G mobile communication network, there exist networks with different technologies such as UMTS, Wifi, Wimax, LTE. A key requirement in the 5G network is to ensure that calls are maintained through layers of technology without interruption, so in addition to the hard handover mechanisms in mobile communication systems already exist, Soft and softer handover in 4G, there are Horizontal and Vertical Handover mechanisms.

Horizontal handover is performed in a mobile radio communication network layer of the same technology, for example, between two cells of the same LTE network [9]. While vertical handover occurs between different radio communication technologies, for example, handover from an LTE cellular network to a WiMax network or vice versa. Handover techniques are divided into two main techniques: hard handover and soft handover.

### 2.1 Hard Handover

The hard handover (HHO) concept refers to the old connection being disconnected before the new connection is made, Figure 2. That means, after disconnecting from the source eNB, a new connection is established and activated to the destination eNB. The handover confirmation threshold is when the signal strength from the target eNB is greater than the signal strength of the source eNB, then HO is performed.

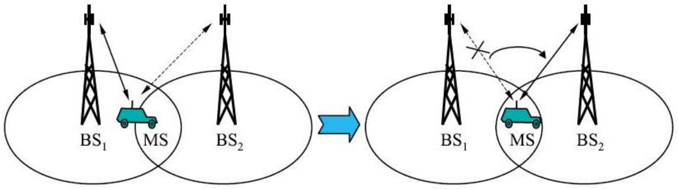

**Figure 2**: Illustration Hard handover (HHO) Technique

### 2.2. Soft Handover - SHO

The SHO method for creating a new connection before the old connection is dropped. This means that a new wireless connection to the target eNB is established while the old connection to the source eNB is maintained. The MS concurrently receives all service data from the active eNBs [3], [10]. Only after successfully connecting to the target eNB does the MS disconnect from the source eNB. SHOs are divided into two categories: Macro Diversity Handover (MDHO) and Fast Base Station Switching (FBSS).

#### 2.2.1. Macro Diversity Handover - MDHO

In the MDHO, Figure 3, a list of BS is maintained by both the MS and the BS, this set of BS is called the Active Set. In this technique, the MS can communicate with all BS in Active Set. According to, during the download process, MS received data from all BS in the list, during the upload process, all All BS received data from MS. Furthermore, neighbouring BS may receive the signal from MS, but the signal strength is not strong enough for neighbouring BS to be admitted to BS Active set. MDHO technology makes the handover process fast and seamless.

However, the MDHO technique is more complex in architecture and handover process than HHO. Accordingly, MDHO can overload as well as cause a waste of system resources. This technique is used in UMTS or WiMAX systems [10]-[11].

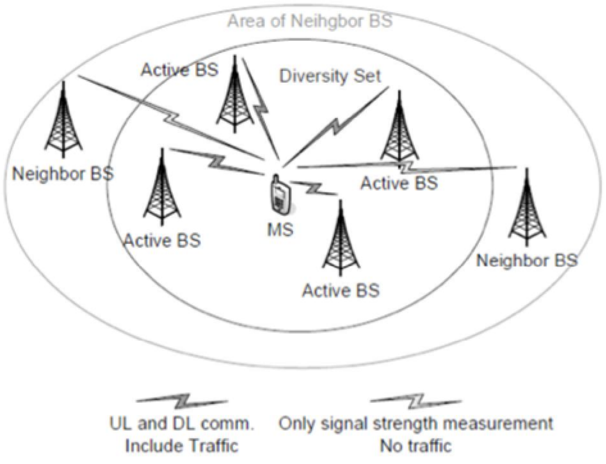

**Figure 3**: Macro Diversity Handover

### 2.2.2. Fast Base Station Switching - FBSS

In the FBSS technique, Figure 4, MS and BS maintain a set of active BS, similar to MDHO technique. MS constantly checks the active BS Set and selects only one central BS, called Anchor BS based on signal strength.

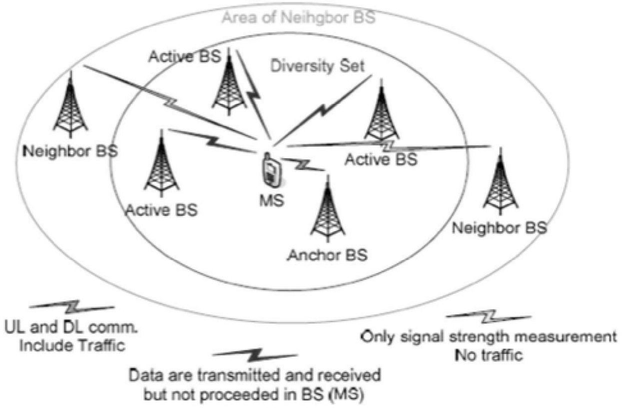

**Figure 4**: Fast Base Station Switching

MS can transfer data with both download and upload link with Anchor BS as shown in Figure 3(subsection 2.2.1). This handover type allows a smooth handover of data from source eNB to destination eNB and limits system overload than MDHO technique. However, FBSS has a higher probability of data loss as well as a higher probability of power loss than the MDHO technique.

## 3. ADVANCED HANDOVER TECHNIQUES IN LTE-A

At the time of performing this work, the handover techniques in the LTE-Advanced system are only supported by HHO [3]. In practice, HHO has some benefits over MDHO and FBSS, but HHO also has some limitations as shown in Section 1. Fast and seamless access is one of the most important problems that should be achieved in the LTE-Advanced system, especially for high-speed services. Therefore, some technical handover has been applied to solve these problems in the LTE-Advanced system. In the studies [3]-[4], [5]-[15] have proposed innovative solutions to solve these problems.

### 3.1. Fractional Soft Handover - FSHO

The FSHO technique has been proposed in the LTE-Advanced system based on Carrier Aggregation (CA) techniques. The main idea of FSHO technique is to implement soft handover for VoIP service. This technique divides network services into VoIP and non-VoIP. During the handover, the VoIP service is transmitted from both the source eNB and the target eNB, while the non-VoIP service is only transmitted by the source eNB or the target eNB. From theoretical analysis and simulation results, studies have shown that FSHO improves call drop probability compared to SHO technique by saving radio resource and power consumption. Furthermore, the FSHO technique maintains the QoS of the VoIP service and improves spectral efficiency. Finally, the proposed FSHO technique is backwards compatible with the handover procedure in LTE. Therefore, FSHO is a choice to improve performance in the LTE-Advanced system [3].

### 3.2 Semi-Soft Handover - SSHO

The SSHO technique using the Macro Diversity approach introduced in Section 2. This technique allows for retaining the advantages of both the HHO and SHO techniques for multicarrier based broadband services. This hybrid handover technique is also known as SSDT (Site Selection Diversity Transmission). This technique is the solution for multicarrier systems. The basic concept of SSDT is to selectively transmit each type of data down a different channel from each BS [4].

In [4], the authors propose a hybrid SSDT handover method for OFDM-based broadband networks called SSHO. This technique overcomes the limitations associated with both HHO and SHO. Analysis of simulation results shows that SSHO improves the power failure probability compared to both traditional HHO and SHO. SSHO is expected to use high-speed multimedia services over widely broadband based on OFDM.

### 3.3. Multicarrier Handover

Multicarrier handover is a new technique used in the LTE-Advanced system by using multiple carriers to support high-speed service and increase mobility. In addition, MS with multicarrier can perform fast and seamless handover by keeping two tasks in parallel: (1) connecting to the server eNB, and (2) handover at the target eNB [13].

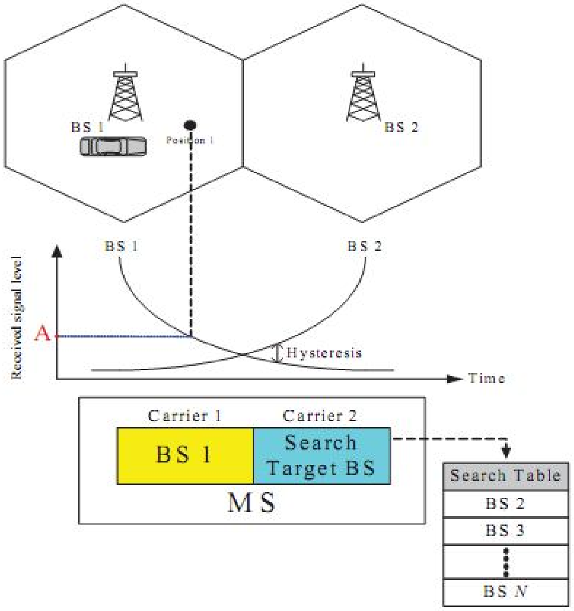

**Figure 5**: Multicarrier Handover

Figure 5 illustrates the multicarrier handover technique. When the MS moves from BS1 to Position 1, MS receives weak signal strength from BS1. It initializes Carrier 1 to activate Carrier 2 ready for the handover process. Carrier 2 then search for the target BS in the neighbourhood in the table BS active.

When the MS moves to the position between the two BSs. The MS receives the same signal strength from BS1 and BS2, so Carrier 2 is activated to execute the handover. When Carrier 2 receives the trigger signal from BS1, it starts to execute the handover. Carrier 2 selects the target BS from the search in the BS table. After Carrier 2 completes the handover process, carrier 1 terminates its connection with BS1. When the MS has reached the limit delay, it starts to hand over from BS1 to BS2 by Carrier 2 [14].

## 4. SIMULATION AND ANALYTICAL RESULTS

### 4.1 Simulation Scenarios

In this simulation, we use 19 eNB with the indoor isotropic antenna. The base station is located in the centre of each cell (hexagonal shape) with a radius of 1000 m per cell. Meanwhile, 40 MS were randomly generated in the source cell (eNB 1). In addition, each MS has the ability to move up to six cells around the source cell with random direction selection. Frequency Reuse Factor (FRF) is seen as one way to enhance the capabilities of LTE-Advanced.

The CA-based FSHO with 5 CCs is implemented in DL direction from eNB to MS, where each user has the ability to communicate with the served eNB through all OFDMA based CCs. LTE-Advanced is capable of serving up to 30 concurrent users in each cell when the frequency band is reused based on CA with 5 CCs. Conversely, in the absence of a CA, the number of users served is reduced. Furthermore, all parameters used in our simulation are based on the LTE-Advanced system environment at the time of the study.

### 4.2 Performance Evaluation

In this simulation, we use the physical structure of the frame introduced in several studies [11-15]. On that basis, the throughput per cell can be computed for each subcarrier MS side. It is measured in all simulations and then averaged across all active MSs in the cell. Performance evaluation is based on the Shannon formula defined in [16], which can be rewritten as follows:

$$Data_a = \frac{BW}{a} x(BW_{eff} x \log_2(1 + \frac{SINR_\alpha}{SINR_{eff}})) \qquad (1)$$

Where, $BW$ is the total system bandwidth (in Hz), $BW_{eff}$ is the system bandwidth efficiency, introduced in [15], is the achieved signal strength, $\alpha$ is the frequency reuse factor, assumed to be 1 ($\alpha = 1$), which means only $1/\alpha^{th}$ spectrum can be used by a cell and $SINR_{eff}$ is the signal strength efficient as follows:

$$SINR_{eff} = -\beta x \ln(\frac{1}{N}\sum_{k=1}^{N} e^{-\frac{SINR_k}{\beta}}) \qquad (2)$$

Where, $SINR_k$ denotes the $SINR$ of subcarrier $i^{th}$ and parameter $\beta$ is the value obtained from the bonding level simulation and adjusted for each individual MCS. $N$ represents the number of active OFDM subcarriers. The handover numbers in our simulation are tested through all simulation times to see the effect of CA on LTE-Advanced network during the handover process.

### 4.3 Simulation Results

In this section, a performance evaluation of the CA-based FSHO implementation with 5 CCs in the LTE-Advanced system is performed. The simulation results show that with the throughput factor and average handover for each MS during simulation from source eNB to target eNB as follows:

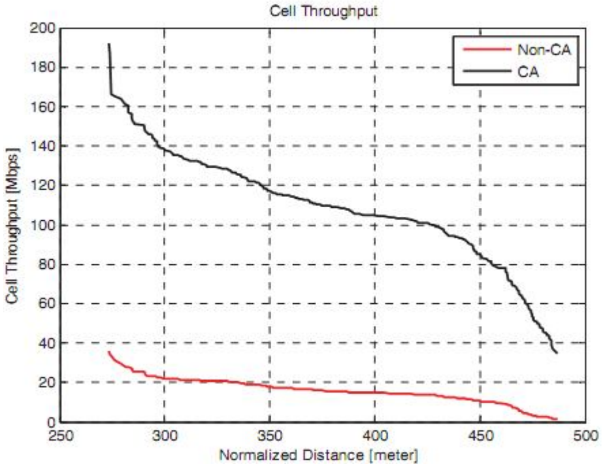

**Figure 6**: Cell Throughput per MS

Figure 6 shows that the impact of implementing the CA technique in the LTE-Advanced system, which provides the user with higher throughput everywhere in the cell compared with the absence of CA technique (*Non-CA*) about 87.5%. The simulation results also showed that implementing CA in LTE-Advanced system not only improves the throughput of each cell but also leads to a decrease in the number of MS handed over at the edge of the serving eNB.

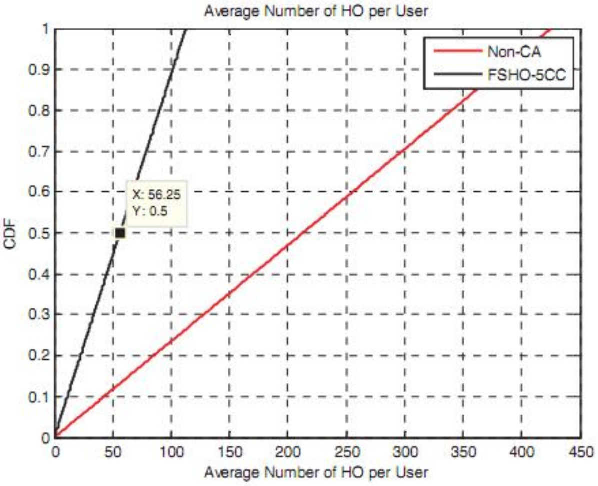

**Figure 7**: Average Number of Handover per MS

Figure 7 shows that the benefit of implementing CA engineering in the LTE-Advanced system according to the number of handover criteria is performed. FSHO reduced the number of handovers per MS by 73.5% compared with the absence of using the CA technique.

## 5. CONCLUSIONS

Currently, the HHO handover techniques are being used in the LTE-Advanced system. HHO has a less complex handover architecture and procedures but also has some implementation limitations such as high latency, unreliable handover procedures, high probability of call drops and data loss rates. In this work, we present an overview of handover techniques used in LTE / LTE-Advanced systems. A hybrid handover technique based on a combination of FSHA and SSHO is proposed to address the limitations of existing methods. This technique is expected to improve system performance, reduce latency, probability of power outages, and decrease interruption time and increase reliability during handover especially in the edge area between cells. In addition, the combination can reduce the overload at the serve cells, balancing the traffic load whole the LTE-A system.

## AUTHOR CONTRIBUTIONS

We have conducted the research, analyzed the data, and performed simulations together. All authors had approved the final version. Corresponding Author is Vu Khanh Quy.

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## REFERENCES

1. Vu Khanh Quy, Nguyen Tien Ban, Vi Hoai Nam, Dao Minh Tuan, and Nguyen Dinh Han. **Survey of Recent Routing Metrics and Protocols for Mobile Ad-Hoc Networks**, *Journal of Communications*, vol. 14, no. 2, pp. 110-120, 2019.
2. W. Tsai, C. Liou, Z. Peng and S. Mao. **Wide-Bandwidth and High-Linearity Envelope- Tracking Front-End Module for LTE-A Carrier Aggregation Applications**, *IEEE Transactions on Microwave Theory and Techniques*, vol. 65, no. 11, pp. 4657-4668, 2017.
3. I. Jouli, K. Hassine and M. Frikha. **Improved Version of Extended Soft Handover for Real-Time Service in LTE-A System**, *Global Summit on Computer & Information Technology (GSCIT)*, pp. 86-90, 2016.
4. I. Shayea, M. Ismail and R. Nordin. **Advanced handover techniques in LTE- Advanced system**, *International Conference on Computer and Communication Engineering (ICCCE)*, pp. 74-79, 2012.
5. D. Castro-Hernandez and R. Paranjape. **Optimization of Handover Parameters for LTE/LTE-A in-Building Systems**, *IEEE Transactions on Vehicular Technology*, vol. 67, no. 6, pp. 5260-5273, 2018.
6. N. K. Panigrahy and S. C. Ghosh. **Analyzing the Effect of Soft Handover on Handover Performance Evaluation Metrics Under Load Condition**, *IEEE Transactions on Vehicular Technology*, vol. 67, no. 4, pp. 3612-3624, 2018.
7. N. Mouawad, R. Naja and S. Tohme. **SDN Based Fast and Soft Handover (FSH) For a Shuttle Bus Monitoring System**, *IEEE Symposium on Computers and Communications (ISCC)*, pp. 1-6, 2019.
8. I. Shayea, M. Ergen, A. Azizan, M. Ismail and Y. I. Daradkeh. **Individualistic Dynamic Handover Parameter Self-Optimization Algorithm for 5G Networks Based on Automatic Weight Function**, *IEEE Access*, vol. 8, pp. 214392-214412, 2020.
9. M. Tayyab, X. Gelabert and R. Jäntti. **A Simulation Study on Handover in LTE Ultra-Small Cell Deployment: A 5G Challenge**, *IEEE 5G World Forum (5GWF)*, pp. 388-392, 2019.
10. J. Sultan, N. Misran, M. Ismail, M. T. Islam and H. Mohamad. **Performance evaluation of macro diversity handover technique for multi-hop relay cellular networks**, *Asia-Pacific Conference on Communications (APCC)*, pp. 363-367, 2010.
11. E. Lee, C. Choi and P. Kim. **Intelligent Handover Scheme for Drone Using Fuzzy Inference Systems**, *IEEE Access*, vol. 5, pp. 13712-13719, 2017.
12. S. Sambare, M. U. Kharat and A. Zatke. **Modified Efficient Handover Mechanism for WiFi-WiMAX Heterogeneous Network Environment**, *International Conference on Computing Communication Control and Automation (ICCUBEA)*, pp. 1-6, 2018,
13. Q. Fan et al.. **Reducing the Impact of Handovers in Ground-to-Train Free Space Optical Communications**, *IEEE Transactions on Vehicular Technology*, vol. 67, no. 2, pp. 1292-1301, 2018.
14. Z. Chen, G. Cui, C. Zhai, W. Wang, Y. Zhang and X. Li. **Component Carrier Selection Based on User Mobility for LTE-Advanced Systems**, *IEEE 78th Vehicular Technology Conference (VTC Fall)*, pp. 1-5, 2013.
15. L. Huang, L. Lu and W. Hua. **A Survey on Next-Cell Prediction in Cellular Networks: Schemes and Applications**, *IEEE Access*, vol. 8, pp. 201468-201485, 2020.
16. S. M. Shahid, Y. T. Seyoum, S. H. Won and S. Kwon. **Load Balancing for 5G Integrated Satellite Terrestrial Networks**, *IEEE Access*, vol. 8, pp. 132144-132156, 2020.