Handoff in Various Mobile Network Technologies

Ekaterina Otsetova-Dudin[1]

[1]Department of Information Technologies, University of Telecommunications and Post, Sofia, 1700, Bulgaria

Abstract Mobile cellular networks are an indispensable part of modern life, where the need for customer satisfaction in the use of many different services by consumers is constantly increasing. The requirements for higher transmission speed, lossless transmission, reliability, efficiency, low latency, mass connectivity, guarantee of high Quality of Service criteria are repeatedly increasing. All this requires the continuous development of the used technologies as well as the introduction of new generations of networks.

Handover mechanism is extremely important in cellular network because of the cellular architecture employed to maximize spectrum utilization.

To ensure the quality of service in wireless cellular networks, the report proposes the use of a Horizontal Handoff Priority Scheme. Simulation experiments have been carried out, the probability parameters of the scheme have been evaluated and the probabilities of losses occurrence have been classified as rare events.

The proposed material are various algorithms and techniques for the implementation of Vertical and Horizontal Handoff in 3G, 4G and fifth-generation networks to provide the required QoS for mobile users with Ultra-High Definition.

Keywords Handoff, 3G, 4G and 5G, Quality of Service

JEL L86, L96

1. Introduction

Mobile cellular networks are an integral part of modern life. In order to ensure high levels of consumer satisfaction, the requirements for high speed, reliability and efficiency, low latency and performance, energy savings, mass connectivity, lossless transmission and Quality of Service (QoS) guarantee are repeatedly increased. All this leads to the need for continuous development and improvement of the technologies used and the introduction of new generations of networks.

Mobility management is a priority issue in today's mobile networks. A high real-time loss rate compromises QoS. The challenge for all networks is data transmission to be carried out without loss [3, 12].

For these reasons, in order to meet the QoS criteria, it is necessary to classify losses as rare events. These events are described in the literature as events with a probability of occurrence much smaller than 10^{-6} [3, 4].

2. Third Generation Wireless Network

The third generation of digital mobile cellular systems provide a transition from narrowband to broadband mobile networks through voice, data and / or mobile Internet transmission.

Wireless Local Area Networks (WLANs) and third generation (3G) as broadband technologies, have their specific weaknesses that impede their full potential.

For example: Wireless networks are characterized by the limited capacity and small scope of Base Station (BS), while 3G systems are limited by the low bandwidth and high cost of building their infrastructure.

This requires the implementation of new standards for broadband access.

The application of WiMAX technology in wireless local networks, based on IEEE 802.16, 802.16a, 16d and 16e standards, successfully removes the gap between LAN and WAN technologies.

3G wireless technology represents the convergence of various 2G wireless telecommunications systems into a single global system that includes both terrestrial and satellite components. One of the most important aspects of 3G wireless technologies is its ability to unify existing cellular standards, such as CDMA, GSM, and TDMA. The speeds of 3G can be up to 2Mbps [1].

In the technologies described above, maintaining mobility of users is a priority, along with ensuring certain QoS parameters.

The process of transferring a signal when changing a cell or reducing the signal during an active user connection is known in the literature as Handoff (HO) [1, 3].

Transport and Communications, 2019; Vol. II.
ISSN: 1339-5130
DOI: 10.26552/tac.C.2019.2.6

In typical wireless cellular systems, the handover mechanism involves reassigning an ongoing session handled by one cell into another.

Handoff is a progression in mobile communications and telecommunications in which a connected a data session, or cellular call is transferred from one cell site (Base Station, BS) to another without disconnecting the session. It lets users create connect phone or data sessions calls on the move. This process keeps the calls and data sessions connected even if users move from one cell position to another.

There are different concepts for Handoff types [1, 16, 17].

For networks with adaptive protocols and set priorities, implemented and designed according to the IEEE802.16 and IEEE802.11 standards, two main types are considered: Vertical Handover (VHO) и Horizontal Handoff (HHO).

HHO is a symmetric process that occurs in the same access technology or a device that change/handover the cells within the same network technology to maintain its continuity. VHO is an asymmetric process that occurs between different base stations belong to different network.

Table 1 presents the types of HO across different generations of networks.

Table 1. HO across different generations of networks

Technology	2G/2,5G	3G	4G	5G
Service	Digital voice, Short messages/ Packetized data	Higher Quality audio, video, voice and data	Dynamic Information, Access, Wearable device	Dynamic Information, Access, Wearable device with IA capabilities
Handoff	HHO	HHO	HHO and VHO	HHO and VHO

When implementing HO different solutions are used (Figure 1):

- Hard Handover (HHO) - the connection between the device and the antenna is disconnected before connecting to a new cell;
- Soft Handover (SHO) - the connection to the new cell is made before the previous one is interrupted.

Soft Handover techniques include:

- Macro Diversity Handover (MDHO) and
- Fast Base Station Switching (FBSS) [16].

Figure 1 shows the Handoff realized through Relative Signal Strength (RSS).

In this scheme are measured over time and the base station BTS with the strongest signal is chosen to Handoff.

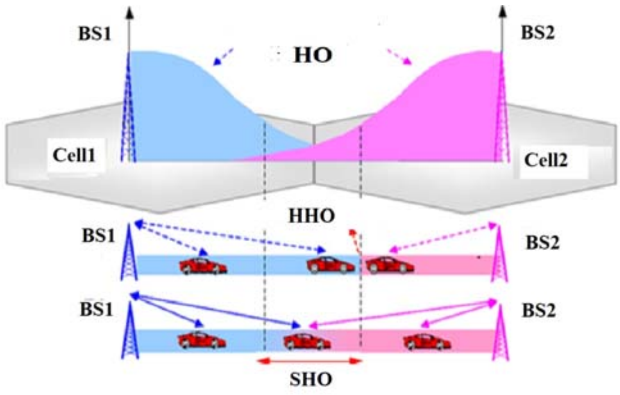

Figure 1. Types of Handoffs

Other methods for Handoff are described in [17]:

- Relative Signal Strength with Threshold,
- Relative Signal Strength with Hystersis and
- Threshold prediction Approaches.

HO initiation timing is not clearly defined and unnecessary neighbouring BS scanning and association are performed before and during HO process. These redundant processes cause a long HO operation time, which makes severe degradation in system performance. The following algorithms are offered to solve these problems [2]:

- Fast Handover Algorithm for IEEE 802.16e Broadband Wireless Access System - achieves a reduction in the loss of wireless channel resources and delays and increases system throughput and efficiency. This algorithm selects the Target Base Station (TBS) by performing Fast Synchronization, Association (FSA) and Optimized Handoff Initiation Time (OHIT), which increases the system throughput and verifies the efficiency of the proposed algorithm.
- Fast Base Station Switching in Soft Handover - one BS is selected from a wide variety of base stations. These stations can be selected as Target Base Station (TBS).

Many algorithms have been proposed for VHO mechanism based on a number of criteria, namely, the Received Signal Strength (RSS), available bandwidth, connection cost, Signal to Interference Noise Ratio (SINR), mobile station's velocity, handover delay, battery consumption and Quality of Service guarantee.

In [17] is discuss nonpreemptive and preemptive priority handoff schemes for a multiple traffic system, such as an integrated voice and data system or integrated real-time and nonreal-time systeme. The proposed traffic model was used in 3. The authors propose a methodology for estimating the probabilistic parameters of QoS. The signaling scheme is implemented with four priority two-queue scheme - for data traffic and voice calls. Based on this model, effective values of probabilities of occurrence of non-served voice calls and data loss due to overflow of the queues of the handover and channels of BS are determined.

This prioritization schemes for handover in GSM cellular wireless network provide improved performance at the expense of the increased call blocking probability.

Using the proposed methodology and programming environment, simulation experiments were conducted with different traffic systems.

During the simulation, experiments with a Non-Markovian type of traffic system were conducted.

With P_0 and P_R are marked probability of packet loss data and unserved voice calls under the following input parameters of the system: MN - data queue lengths, MR - voice calls, N - total cell counts in BS.

The results are summarized, processed and presented at Figure 2.

Qos probability parameters are found to be less than 10^{-8} , therefore they are classified as rare events (dark green sections of Figure.2 and Figure. 3).

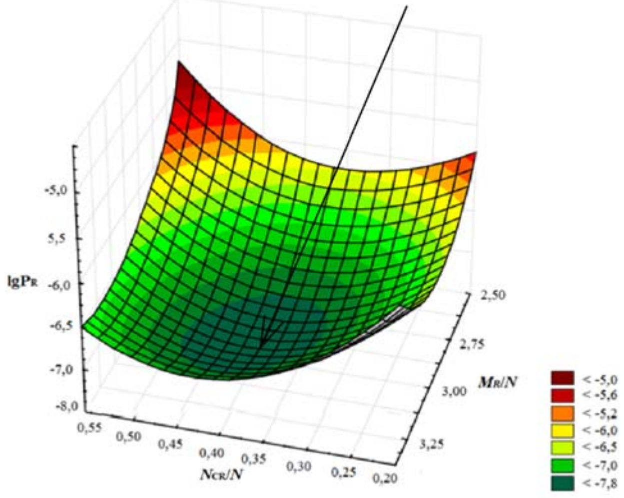

Figure 2. The probability of losing voice calls P_R

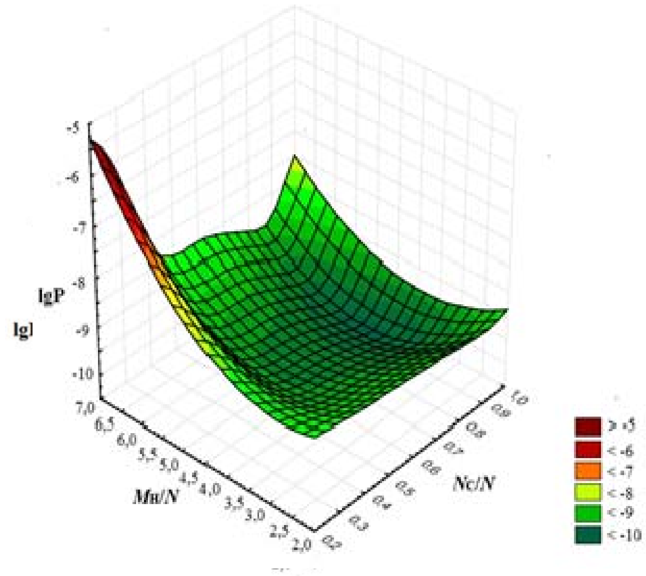

Figure 3. The probability of losing data packets P

With the development of new technologies, it has been found that traditional methods of implementing Handoff based on signal strength estimation (Figure. 1) are not sufficient.

3. Types of Handoffs in 4G Networks

The structure of 4G packet-based technology for data transfer allows call or online sessions to be routed to 2G (UMTS or GSM) and 3G networks, as well as easy and seamless integration with WI-FI and Internet networks.

4G can support at least 100 Mbps peak rates in full-mobility wide area coverage and 1Gbps in low-mobility local area coverage.

The challenge for these technologies is to meet different criteria and the level of QoS.

Mobility is a very important feature of these wireless networks. For this reason, Mobile Terminals choose the best network available, including WLAN, WiMAX and satellite systems, before performing HO.

4G technologies offer an adaptive and intelligent vertical transmission approach. The challenge for these technologies is to meet the different criteria and level of QoS arising from the requirements for cost, security, power consumption, latency and speed of the mobile terminal [4, 7].

Example: In order to minimize transmission delays and meet quality of service requirements, HO schemes are developed to be offered and analyzed by different standards - IEEE 802.16m, 3GPP, etc. [13, 14].

Different techniques of Handoff Parameter Optimization (HPO) are applied to achieve QoS:

- Load balancing (LB) - increases the rate of transmission of intermediate cells, increasing the possibility of interruptions of HO;
- Dynamic Hysteresis Adjusting (DHA) – Increases transmission efficiency and number of completed users on Long Term Evolution (LTE) networks.

LTE is a standard for 4G wireless broadband technology that offers increased network capacity and speed to mobile device users. LTE technology supports handover and roaming with second- and third-generation cellular networks, enabling their compatibility.

Figure 4 presents the VHO on the LTE Network, where ENodeB, MME and S-GW are common elements for the network, and S1 and Z2 are the used interfaces [5, 11,13].

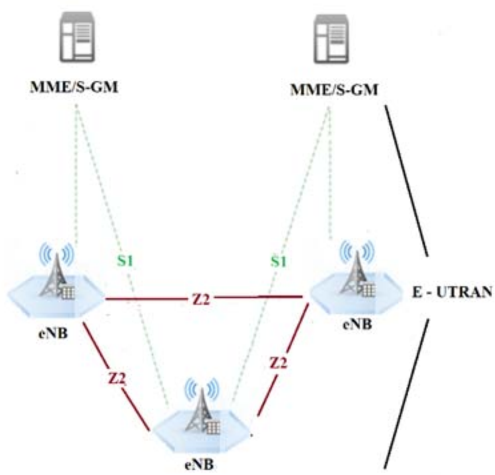

Figure 4. VHO, standard LTE Network

The IEEE 802.21 Media Independent Handover (MIH) standard provides seamless roaming among various wireless technologies, consisting of GSM, UMTS, WLAN, WiMAX and Bluetooth [10].

To achieve successful Handovers in Mobile WiMAX, two serving base station (SBS) and one Target Base Station (TBS) are used.

Hard handover allows only low speed mobility. For higher speed mobility were FBSS and MDHO implemented. MDHO and FBSS belong to the group of the SHO.

The main difference between MDHO and FBSS is, that in MDHO is applied the selection diversity and diversity combining in uplink and downlink, respectively. In FBSS all data traffic is processed only in the anchor BS [6].

4. Types of Handoffs in 5G Technology

The rapidly growing number of mobile devices, the avalanche of ever-expanding data transfer, and services require the development of a new generation of heterogeneous networks integrating 3G, heterogeneous wireless 4G, Wi-Fi and other technologies. They implement applications for analysing, predicting traffic, and exploring the entire network in order to save time, ensure high efficiency and network intelligence [9].

The basic requirements for these technologies are [7]:

- Increasing data transmission and transmission rates - 1 Gbit / s for end user in each cell of the network and at any time (20 Gbit / s peak transfer rate).
- Reducing network latency (1ms radio latency one way from the base station to the user or 10ms end-to-end latency.
- Mass connectivity (density of 106 mobile connections per square kilometre).
- High lossless transmission reliability.
- High efficiency and performance (10 Mbps per square meter).

The architecture of fifth generation networks requires the construction of ultra-dense networks with huge numbers of heterogeneous cells (Het-Nets), which requires the introduction of an automated procedure for their management.

5G technologies face a number of challenges in providing Handoff - network compaction, high mobility, reduced interference level, zero latency, multi-RAT access, and inability to provide effective load balancing for BS in current cellular networks.

There are two types of Handoffs in the new generation of networks:

- Inter-Macrocell Handoff - transfer between two small cells operating under different mobile base station (MBS)
- Multi-RATs Handoff - can be optimized to the similar process with intra-frequency LTE HO.

In a 5G environment, the blend different wireless technologies and service providers that share an IP-based core network, will offer the possibility to the mobile devices of switching between providers and technologies, for maintaining a high level of Quality of Service. Fast Vertical Handoffand the general openness of the network make the devises susceptible to several vulnerabilities like access control, communication security, data confidentiality, availability and privacy. Furthermore, since the 5G environment is IP-based, it will suffer from all the vulnerabilities that are to IP-specific. Based on these findings, it is obvious that guaranteeing a high level of security and privacy will be one of important aspects for the successful deployment of 5G networks [8].

5. Conclusions

The challenge for new mobile networks is the provision of a wide range of applications and services with many different technologies, in parallel with different QoS requirements. Another problem is consumer mobility.

Handoff is the process of transferring connection of a mobile user from one node to another, when the previous node cannot provide proper service. Handover mechanism is extremely important in cellular network because of the cellular architecture employed to maximize spectrum utilization.

Handover is the key technology in the research of the next generation of wireless mobile communication systems. It can improve the validity and reliability of the whole communication system. In 5G application scenarios, the handover decision algorithm and handover executing mechanism are the key factors that affect the performance of handover technology.

Network compaction, high speed and mobility, zero latency, minimal interference and lossless transmission are challenges that require combining existing ones and developing new algorithms and standards for Handoff implementation.

REFERENCES

[1] Fagbohuni Ol., Comparative studies on 3G, 4G and 5G wireless technology, Journal of Electronics and Communication Engineering, Volume 9, Issue 3, Ver. I, pp. 88-94, 2014.

[2] Feras Z., Suhaidi H., Adib H., Vertical Handover in Wireless Heterogeneous Networks, Journal of Telecommunication, Electronic and Computer Engineering, Vol. 9 No. 1-2, pp. 81-85, 2017.

[3] Otsetova-Dudin E., Kurtev I., Siarova S., Simulation Algorithm to Determine the Number of Un-Served Calls when Transferring the Signal in Broadband Cellular Networks, Journal Information Technologies and Control Vol 14(3), pp. 18-23, 2016.

[4] Becvar Z., Zelenka J., Handovers in the Mobile WiMAX, : https://www.researchgate.net/publication/22904939, 2019.

[5] Badry Z. Saadane R., Wahbi M., Mbarki S., Handover management scheme in LTE femtocell networks, International Journal of Computer Science & Information Technology Vol 5, No 3, pp.89-100, June, 2013.

[6] Yajnanarayana V., Ryde´n H., He´vizi, Jauhari A.,, Cirkic M., 5G Handover using Reinforcement Learning, https://arxiv.org/pdf/1904.02572.pdf, 2019.

[7] Jo, J., & Cho, J., Cross-layer optimized vertical handover schemes between mobile WiMAX and 3G networks. KSII Transactions on Internet and Information Systems, 2(4), 171–183, 2008.

[8] Ferrag M.,, Maglaras L., Argyriou A., Kosmanos D., Janick H., Security for 4G and 5G Cellular Networks: A Survey of Existing Authentication and Privacy-preserving Schemes, 2017, https://arxiv.org/pdf/1708.04027.pdf, 2019.

[9] Road to 5G: Introduction and Migration, GSMA, 2018, https://www.gsma.com/futurenetworks/wp-content/uploads/2018/04/Road-to-5G-Introduction-and-Migration_FINAL.pdf, 2019.

[10] IEEE 802.21 WG. (2009, January). IEEE standard for local and metropolitan area networks. Part 21: Media Independent Handover Services. IEEE Standard 802.21 GSMA Intelligence, Definitive data and analysis for the mobile industry, available at: www.gsmaintelligence.com, 2019.

[11] Abubakar M., Mahamod I., Rosdiadee N., Vertical Handover Solutions Over LTE-Advanced Wireless Networks, Article in Wireless Personal Communications · August 2014, https://www.researchgate.net/publication/317166638, 2019.

[12] Kim J., Lee T., Handover in UMTS Networks with Hybrid Access Femtocells", the 12th International Conference Advanced Communication Technology, vol.1, pp.904-907, 2010.

[13] 3GPP TS 25.467 V9.2.0 (2010-03), UTRAN architecture for 3G Home Node B (HNB); Stage 2.

[14] 3GPP TS 36.331 V12.2.0, "Radio Resource Control (RRC) Protocol specification," 2014.

[15] Luan L., Wu M., Shen J., Ye J., and He X., Optimization of handover algorithms in lte high-speed railway networks, International Journal of Digital Content Technology and its Applications, vol. 6, no. 5, Mar. 2012.

[16] https://softhandover.wordpress.com/category/5g/

[17] Zeng Q., Agrawal D., Handbook of Wireless Networks and Mobile Computing, Chapter 1, pp. 1-25, John Wiley & Sons, Inc., 2002.