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Available Bandwidth and RSRP Based Handover Algorithm for LTE/LTE-Advanced Networks Tested in LTE-Sim Simulator

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***Abstract*—In this paper, we propose a new algorithm that improves the performance of the operation of Handover (HO) in LTE-Advanced (LTE-A) networks. As recognized, Mobility Management (MM) is an important pillar in LTE/LTE-A systems to provide high quality of service to users on the move. The handover algorithms define the method and the steps to follow to ensure a reliable transfer of the UEs from one cell to another without interruption or degradation of the services offered by the network. In this paper, the authors proposed a new handover algorithm for LTE/LTE-A networks based on the measurement and calculation of two important parameters, namely the available bandwidth and the Received Power (RSRP) at the level of eNodeBs. The proposed scheme named LTE Available Bandwidth and RSRP Based Handover Algorithm (LABRBHA) was tested in comparison with well-known algorithms in the literature as the LHHA, LHHAARC and the INTEGRATOR scheme using the open source simulator LTE-Sim. Finally, the network performances were investigated via three indicators: the number of lost packets during the handover operation, the latency as well as the maximum system throughput. The results reported that our algorithm shows remarkable improvements over other transfer schemes.**

***Keywords*—mobility management, handover, LTE, lte-sim, available bandwidth, RSRP**

I. Introduction

THE number of mobile internet users continues to increase exponentially from year to year. New technologies have emerged, while others are experiencing continuous improvements. As a result, new versions of these standards have been defined. LTE-Advanced will be the continuation of the series of networks of the 4th generation (4G). This technology is considered as the switch to the exploitation of the 5th generation (5G) networks.

In the horizon of 2020, the number of smartphones and also users of cellular networks will explode, which explains the forecasts on the number of 4G networks exploitable in this period. The operators then invest in high-speed mobile networks given the huge demand for Internet users [1].

LTE-Advanced (Release 10(R10) and belong) was developed by the Third Generation Partnership Project (3GPP) with improvements over the LTE standard, introducing new features and services. LTE-A is a pure IP-Switched system that delivers a peak data rate of up to 3 Gbps in Downlink (DL), and 1.5 Gbps in Uplink (UL). This standard has a higher spectral efficiency with a maximum of 30 bps/Hz in R10. In addition to the improvement that has affected multiple-input and multiple-output (MIMO) and carrier aggregation (CA) techniques; the total number of active subscribers simultaneously has been greatly increased [2].

LTE-Advanced continues to evolve. Several versions have emerged, introducing new improvements for the system. Providing superior capacity was the important point to migrate from LTE to LTE-Advanced.

MIMO, Carrier Aggregation, Relay Nodes, Coordinated Multi Point (CoMP), 4 band Carrier Aggregation, the inter-band Carrier Aggregation and LTE support for V2x services were treated as new features in the different releases of LTE-A. Those releases continue to offer new enhancements as well as new techniques for the benefit of users [2] [3] [4].

For data transmission, a reliable connection must be maintained when the user moves from one area to another. One of the important benefits of cellular technologies is the management of user mobility. LTE-A uses mobility management to ensure continuity of service to the user while moving, regardless of whether the User Equipment(UE) can connect to multiple eNodeBs (eNBs) in a very short time [5] [6].

Mobility in LTE-A can be divided into two basic categories depending on the user's situation: when there is no valid Radio Resource Control (RRC) link with an eNB, the mobility is called in Idle mode. When the UE has an RRC connection with a given eNB, mobility is known as connected mode [5].

3GPP has defined several measurement quantities made by the user and reported to the eNB for the purpose of measuring the quality of the physical layer in an efficient manner. The base station uses these values to decide on the quality of service (QoS) offered to the UE in the served cell. If the service is poor, it is up to the eNB to decide and trigger a HO to a better cell [5].

Several parameters allowing a total collection of the information on the quality of receiving signals on the side of the UE were introduced, thus allowing a better management of mobility of the users. The performance indicators used in LTE-Advanced are:

Reference Signal Receiver Power (RSRP): it is a data used for cell reselection and handover decision. It is a value that defines the strength of the specific signal generated in a cell. RSRP is defined as the average of the powers (in Watts) of resource elements (REs) transmitting signals in a predefined

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bandwidth [7]. For power control calculations, RSRP is important for estimating path loss [8].

Received Signal Strength Indicator (RSSI): for a defined channel, this value indicates the total power received. It is defined as the linear average of the total power received only for Orthogonal Frequency Division Multiplexing (OFDM) symbols bearing reference symbols by the UE from all sources [7].

Reference Signal Received Quality (RSRQ): as explained in 3GPP specifications, it is not directly measured from the signal, but is calculated from measured RSRP and RSSI values. It is defined as the ratio between the number of Physical Resource Blocks (PRBs), RSRP and RSSI as detailed in the following formula [9]:

$$RSRQ = PRBs * \left(\frac{RSRP}{RSSI}\right) \quad (1)$$

These two parameters LTE-A RSRQ and LTE-A RSRP are used in mobility management operations such as cell selection, cell re-selection and handover [8].

Signal-to-Interference-and-Noise-Ratio (SINR): this parameter is measured by the user, allowing the choice of the most appropriate Modulation and Coding Scheme (MCS) for the transmission of data. It is calculated on each RB, converted to Channel Quality Indicator (CQI) by the UE, and then reported to the eNB [7]. It is expressed according to the following equation, Where S, I and N are respectively the Signal, Interference and the Noise:

$$SINR = \frac{S}{(I+N)} \quad [5](2)$$

This article discusses the big topic of mobility management at the LTE-Advanced level, and more specifically the Handover decision for every user on the move. We study, analyse and critique the different classical algorithms defined in the literature, and we propose a new algorithm based on the multi-parameterization. We demonstrate afterwards, by simulation, that the proposed algorithm offers better performance compared to the most well-known schemes.

For the rest of our paper, serving eNodeB(Cell), served eNodeB(Cell), current eNodeB(Cell) or source eNodeB(Cell) means the LTE base station(or Cell) to which the active UE is currently attached. While the candidate eNodeB (cell), target eNodeB (cell) or neighbouring eNodeB (cell) considered as the Base Station (cell) that can accommodate a UE after validating and executing a handover.

II. Mobility Management and Handover in LTE-A

The Handover consists of all the steps and procedures of preparation, decision, execution and signalling required, allowing, in all fluency and transparency, the transfer of the connections of any user from the cell to which it is linked, to a new cell more better in QoS, while keeping the continuity of the services offered by the network [10].

LTE-Advanced supports mobility over cellular networks with improvements compared to LTE. The mobility management (MM) is made for different speeds of 15, 30, 120 and 300Km/h with high performance, and it can also support the speed of 500Km/h in specific frequency bands. LTE-Advanced also supports some mechanisms for optimizing delays and packet loss during an intra-system HO. As a result, the influence of intra-system handovers at LTE-A level on the quality of service (for example, the interruption time) is less than that provided by the LTE standard [11].

A. Handover mechanisms, Handover types and Handover procedures

In general, two types of HO mechanisms have been defined, namely the hard handover, or Break-Before-Connect (BBC) handover and the soft handover, also known as Connect-Before-Break (CBB) handover:

Soft HO is a mechanism allowing to a moving UE, by adding and removing radio links, to keep at least one active communication link in the mobile cellular network, as a result, the mobile user is linked at a given time to two different cells. While the Hard HO (which is the default mechanism used in LTE-A) requires breaking the current connection (source cell) even before establishing the new link with the target cell. Given the flat IP architecture of LTE-A systems and also the lack of a centralized system controller, 3GPP has adopted the Hard HO for this standard [12].

Two classifications of Handover according to the type, then exist, the proactive/reactive HO and the horizontal/vertical HO.

The Proactive one estimates the values triggering the HO even before they have reached the threshold, and then it triggers the HO. This reduces the Packet Drop. For the Reactive, the approach adopted by this type is to delay as much as possible the triggering of the HO, the change to the new cell is then done only after the loss of the signal with the first.

The horizontal HO is the process of ensuring the continuity of the service of a UE that moves with any speed, while handing this task to a cell of the same technology as the old one. In other words, the target cell is the same radio type as the source cell. Whereas the HO vertical consists of a transmission of the service, to a target cell whose type of technology is different from that of the source cell [13].

When the client sends or receives packets to or from the network kernel, regardless of the type of flows, it is said that it is in active mode. While the UE is in active mode, the LTE-A system differentiates between two handover procedures in the downlink: X2 and S1 [14].

The name of each procedure is derived from the type of the interface used for the preparation and execution of all the steps of an HO operation, either S1 or X2. The HO using the X2 interface does not involve the Evolved Packet Core (EPC) in its process, the communication between the two target and source cells is done to ensure the transfer of the user. Whereas in the S1 procedure, the interface between eNB and EPC called S1 is used; but only when the connection of the X2 interface has failed for some reason [9].

The X2 procedure is then introduced to manage user mobility by allowing neighbouring eNBs to execute the HO without the involvement of the core network. Several research articles have tried to compare these two procedures in terms of EPC signalling load. The results showed that when using the X2 interface to execute the HO, the EPC signalling load can be reduced more than six times compared to the S1 transfer. X2 is normally used for inter-eNodeB transfer in order to balance the network load and prevent interference [15].

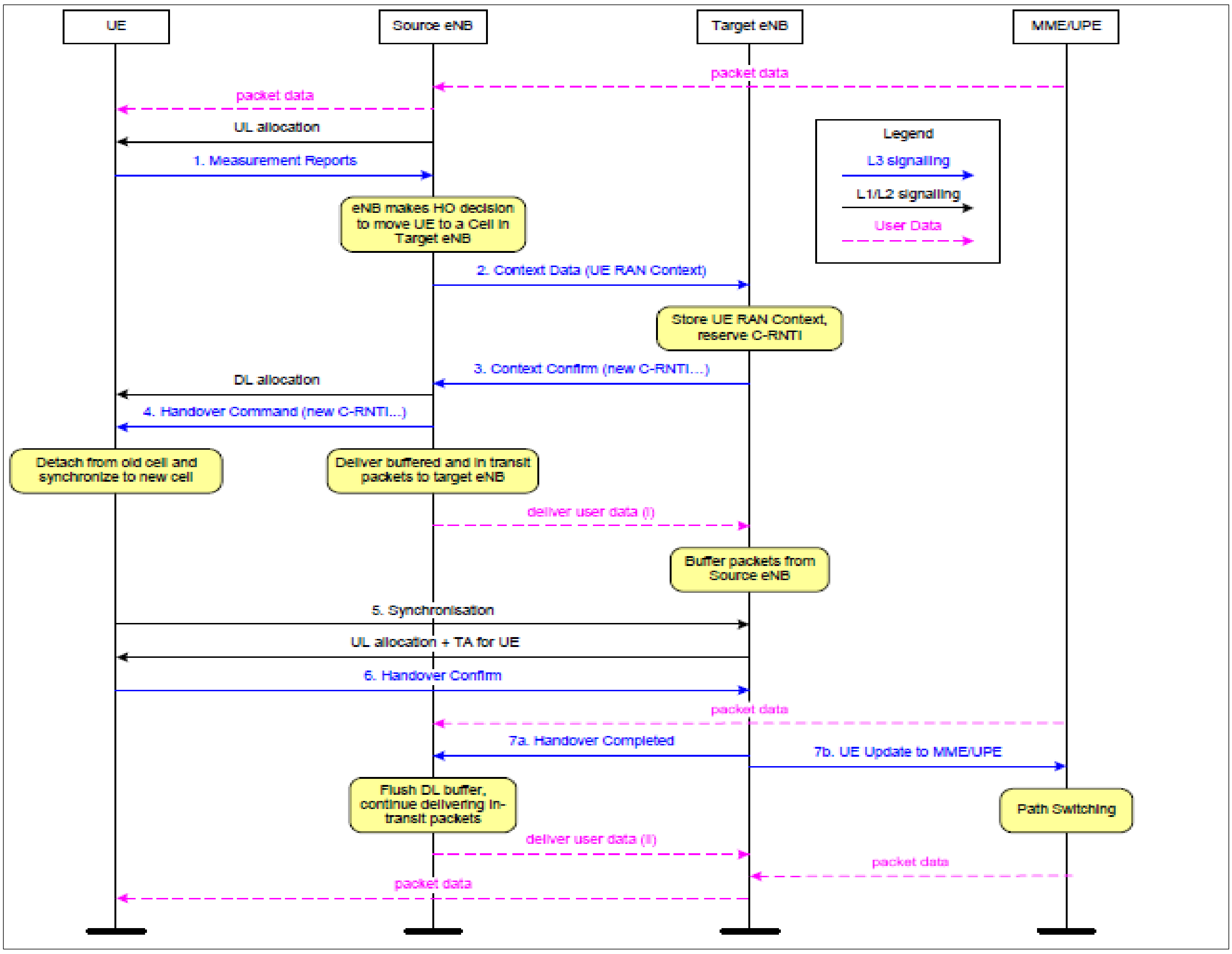

Fig. 1. The complete scenario of the execution of a handover operation in LTE

B. LTE-A handover Process

Known as "break-before-connect", the Hard Handover is adopted by the 3GPP to be used in LTE-A. The connection of a UE to a new eNb is established after an HO decision, judging that the new station offers a better QoS than the one offered by the old eNB. Three well-defined steps compose the various operations of a handover procedure, namely, the preparation, execution, and completion of the HO [16]. Fig. 1 shows all the steps and commands exchanged between the UE, Serving eNB, Target eNB, and the Mobility Management Entity/Serving Gateway (MME / S-GW) to transfer a moving user from one eNB to another [17].

While communication normally takes place between the UE, which is in full motion, and the Serving eNB via packets sent and received in both directions DL and UL, the UE continues to send a measurement report to the base station to which it is attached, containing the different QoS parameters, namely the RSSI and the signal quality. The eNB analyses each report and determines the appropriate time to perform the handover. The serving eNB cooperates with the target eNB to prepare the signalling data and invoke its transfer algorithm. The HO decision is then taken. All this operation represents the preparation step. [16] [17].

The two steps in the execution and completion of the HO begin with a HANDOVER_REQUEST command sent by the serving eNB to the target eNB containing information necessary for that one. A check performed by the target station on the availability of resources must be done, the resources reserved for the UE must be sent to the source eNB with an acknowledgment command HANDOVER_REQUEST_ACK. This command activates the HO operation. The UE synchronizes with the new eNB, after detaching itself from the old station. After confirming the HO between the UE and the target eNB, this one exchange messages with the MME/S-GW to change the path of the downlink data to the target side via both command PATH_SWITCH_REQUEST and PATH_SWITCH_REQUEST_ACK. While the MME sends its acknowledgement, the eNB target completes the HO procedure, and this after the serving eNB re-raises the radio links and control of the used associated resources [16] [17].

C. Problems related to HO

The main objectives that must be ensured by the cellular system during a HO operation should not just provide better QoS before and after the handover, but also during the transfer. In addition, the latency must be minimal to ensure the continuity of service. The Handover must not also evacuate the battery of the UE equipment [18].

On the other hand, if those objectives are not achieved, it's because of several problems encountered during the transfer to a new eNB; among these problems we can mention:

- Handover Failure: An inappropriate parameter during the transfer stage may cause the handover failure. Three cases are then defined below [19]:

• Handover to Wrong Cell: When the UE is at the edge of the eNBs, an overlap of signals can occur, causing a wrong choice of the target station;

• Too Early Handover: low Time to Trigger (TTT) value can cause radio link failure;

• Too Late Handover: a high value of the TTT may cause the radio link to fail.

- Ping Pong Handover: when the user moves in a zone where the neighbouring eNbs have quality parameters almost the same, the UE detaches itself and attaches to several eNbs in a very short period of time. This causes unnecessary handovers [12].

III. LTE-Advanced Handover Decision Algorithms

Using the hard handover in LTE-A systems (whether S1 or X2 interface) reduces the complexity of the network architecture. However, hard transfer can degrade performance (i.e. decreasing throughput, increasing delay and Packet Loss Rate (PLR), and increasing the number of handovers). Therefore, the need for an efficient handover algorithm to improve system performance is strongly recommended [14].

Handover algorithms are programmed at the eNB level, as it is the case for the scheduling algorithms. They are used to make the decision to trigger a handover, at a given time, for any user, when several conditions specified by this algorithm are satisfied. Since the mobile UE is still in an active mode, it is necessary to use an efficient handover scheme to ensure a smooth and reliable transfer to the new eNB [20].

Several parameters are used for handover trigger decision making, which results in a large number of algorithms presented and tested in the literature.

A. Power based HO scheme

The most basic handover algorithm uses the generated power in a specific cell. The UE performs these power measurements for all the neighbouring eNBs, the decision to trigger a handover is taken by the serving eNB when the field level coming from another station is higher than that of the current station (equation 3).

$$RSRP_T(t) > RSRP_S(t) \qquad (3)$$

B. LTE Hard Handover Algorithm (LHHA Scheme)

The LHHA, also known as "Power Budget Handover Algorithm" is a simple algorithm based mainly on two parameters, namely: handover margin (HOM) and Time to Trigger (TTT) timer. By using these two variables, the LHHA can thus reduce the Ping-Pong effect represented by useless handovers causing a degradation of the performances [14].

Fig. 2 shows the triggering of a Handover between two cells, using the LHHA scheme. The measurement period Tm is defined as the time interval that, when it ends, the transfer condition is verified. Handover Margin (HOM) represents the hysteresis at the signal received by the UE, between the two source and target eNBs, while the time interval during which the HOM condition is satisfied is called TTT [12]. In [19], several TTT values have been specified: 0, 40, 64, 80, 100, 128, 160, 256,320, 480, 512, 640, 1024, 1280, 2560 and 5120ms.

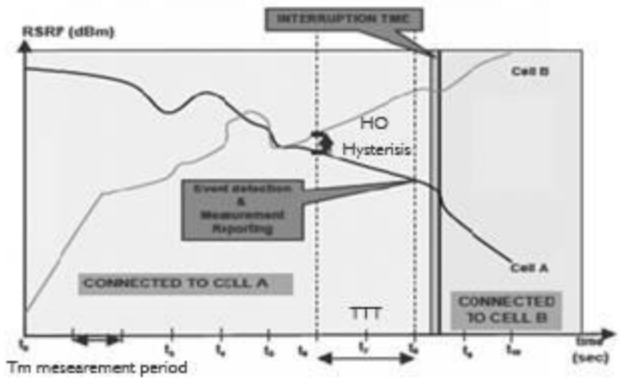

Fig. 2. Triggering of a Handover between tow cells using TTT and HOM parameters

Two filtering steps are defined in the LHHA algorithm: a test on the validation of the difference between the two RSRP values (source and target) by a HOM gap (equation 4), and then the test on the TTT value (launched after the validation of the first condition), if it is well passed (equation 5). The execution of the handover operation, then begins [fig. 3].

$$RSRP_T(t) > RSRP_S(t) + HOM \qquad (4)$$

$$HO_{Trigger} > TTT \qquad (5)$$

C. Integrator Handover Scheme

Proposed in 2008, similar to the “Received Signal Strength based TTT Window Algorithm” [14], the Integrator is based on the data history of differences in signal strength level.

Fig. 4 shows the detailed flow chart of this algorithm. A measurement of the power at the two eNBs (source and target) for the user j to deduct the difference DIFs_j (t) will be the first step (equation 6). Then, the filtered RSRP difference FDIFs_j is calculated, with the value of the variable α is: 0 <α <1 (Equation 7). α is the variable that defines the weight of the difference of powers DIFs_j (t) and its filtered value FDIFs_j. FDIFs_j depends on the value of the difference DIFs_j at the current moment, as well as the history of the filtered difference, while varying the parameter α [14]. The handover is then started if the calculated value of FDIFs_j is superior to a predefined threshold FDIFThreshold (equation 8).

$$DIF_{s\_j}(t) = RSRP_T(t) - RSRP_S(t) \qquad (6)$$

$$FDIF_{s\_j}(t) = (1-\alpha)FDIF_{s\_j}(t-1) + \alpha DIF_{s\_j}(t) \qquad (7)$$

$$FDIF_{s\_j}(t) > FDIF_{Threshold} \qquad (8)$$

D. LTE Hard Handover Algorithm with Average RSRP Constraint (LHHAARC Scheme)

This algorithm is proposed based on the LHHA algorithm previously explained, with one more condition on the average RSRP. The new version can effectively improve network performance by decreasing the delay, the number of handovers and the number of lost packets, as well as increasing the total system throughput [14].

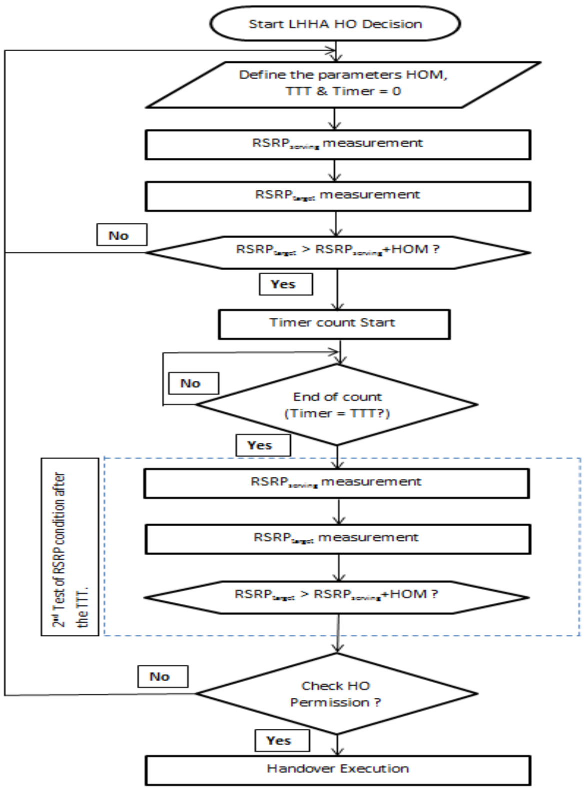

Fig. 3. LHHA handover execution flowchart

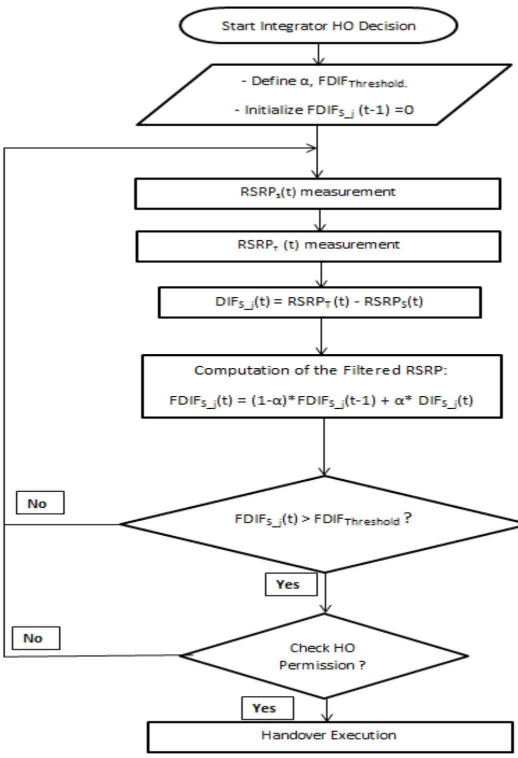

Fig. 4. Flowchart presenting the steps of a handover for the INTEGRATOR algorithm

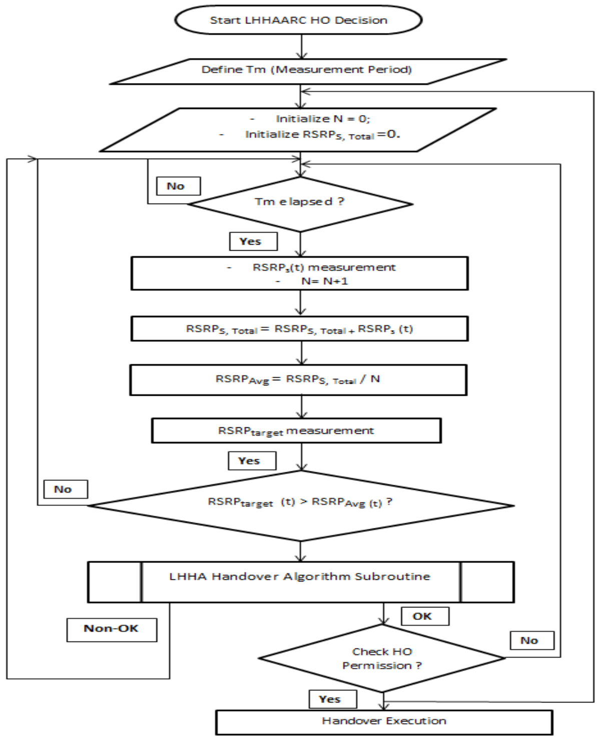

Fig. 5. LHHAARC handover algorithm flowchart

In Fig. 5, the various steps of this algorithm were presented by order of execution: after each time period Tm, the power measurement operation at the serving station RSRPs will be executed. This measured power is added to the RSRPs_total, the accumulation of the RSRPs already measured is accompanied with an automatic incrementing of an integer parameter N. the average of the powers is then calculated as the ratio between RSRPs,total and N (equation 9).

If then the value measured at the target eNB is higher than the average calculated at the current eNB (equation 10), a new test will be made on the same conditions (equations 4 and 5) proposed by the LHHA algorithm (Subroutine shown in Fig. 5 and detailed in Fig. 3).

$$RSRP_{avg\ S\_j} = \frac{\sum_{n=1}^{N} RSRP_{S\_j}(nT_m)}{N} \qquad (9)$$

$$RSRP_T(t) > RSRP_{Avg\ S\_j}(t) \qquad (10)$$

IV. THE PROPOSED LABRBHA SCHEME (LTE AVAILABLE BANDWIDTH AND RSRP BASED HANDOVER ALGORITHM)

Most of the algorithms proposed in the literature use a well-defined parameter for decision-making for triggering a handover operation in LTE/LTE-A networks. Even the algorithms using a multitude of parameters, are based on the procedure of filtering by stages. It means that, for a scheme using several variables for the handover decision, the test on the condition ensured by the parameter K, starts only after that the condition ensured by parameter K-1 is validated [10].

In this part, a first introduction to the proposed algorithm will be presented, followed by sequential modelling by the C++ computer language under the LTE-Sim simulator.

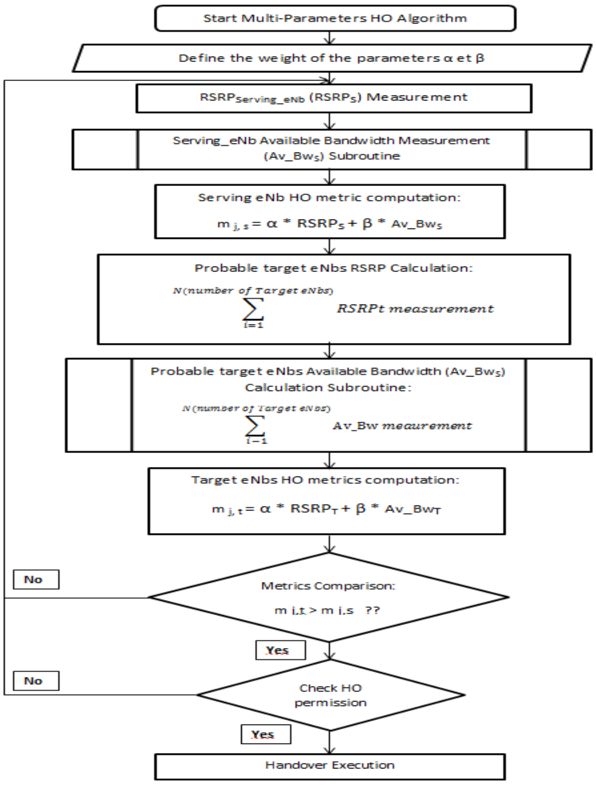

Fig. 6. The new LABRBHA handover algorithm based on RSRP and Available Bandwidth

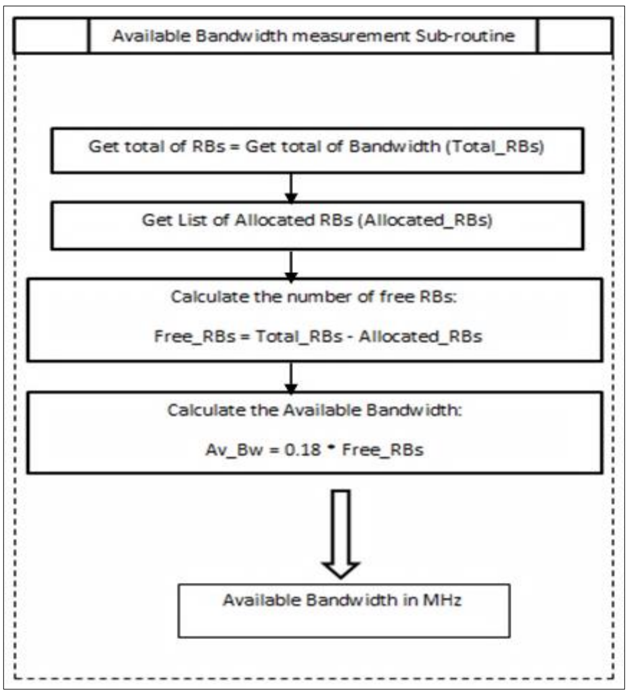

Fig. 7. The subroutine of the Available Bandwidth prediction at the base station for the LABRBHA algorithm

The principle and the strong point of our idea is that our algorithm use several parameters measured at the same time (in this article we use two variables: available bandwidth and received power). Each of these parameters is characterized by a weight (α or β) defining its importance in the decision-making equation.

Our algorithm is RSRP and Available_Bandwidth based. The first parameter is the RSRP received power and it characterizes the level of fields received by the UE, for the current station as well as for neighbouring stations around the UE. The second parameter is the free bandwidth at the serving station as well as at the different candidate stations to accommodate the user in question. These two parameters are measured at the UE, and transmitted periodically to the base station.

This approach is the strong point of this new scheme. It benefits from measurements of the two parameters mentioned above. The proposed algorithm then analyses the quality of service offered by the current eNB by calculating the metric mj,s characterizing the UE j attached to the source station s, and it compares it with the metrics of the different target eNBs mj,t. The handover is launched when the target station will offer a better QoS ($m_{j,s} < m_{j,t}$).

The calculation details as well as the operations performed to define the triggering or not of a handover using the LABRBHA algorithm are presented in the flowchart in Fig. 6. The steps are listed as follows:

- First, we define the weight of each parameter by the two variables α and β, with: $0 < \alpha < 1$ and $0 < \beta < 1$ and $\alpha + \beta = 1$;
- The power at the source station $RSRP_S$ is measured;
- The subprogram Measuring the available bandwidth at the source station Av_Bw_s is then started (this subroutine is detailed in Fig. 7): We define a Resource Block (RB), which is the smallest unit of resources that can be rented to a user, with a bandwidth of 180 Khz in frequency and 0.5ms in a unit of time. A bandwidth of 10 MHz is composed, for example, of 50 RBs.

The next sentences explain how the available bandwidth in an eNodeB is meseared using the LTE-Sim tool.

- Using the function “`targetNode->GetPhy()->GetBandwidthManager()->GetDlSubChannels().size()`” (GetPhy, GetBandwidthManager and GetDlSubChannels are functions of the targetNode class), we can calculate the total number of existing RBs.
- We can also detect the number of used RBs (Allocated RBs in Fig.7) based on the function “`GetListOfAllocatedRBs()->size()`” located in the `PacketScheduler` class.
- The free RBs in the station in question can be deducted: Total_RBs – Allocated_RBs.
- The next equation shows the calculation of the available bandwidth (0.18 is the width of a RB explained previously: 180 KHz).

$$Av\_Bw_s = 0.18 * Free\_RB_s \qquad (11)$$

- The metric mj,s is then calculated for the current station using the two parameters measured previously.

$$m_{j,s} = \alpha * RSRP_s + \beta * Av\_BW_s \qquad (12)$$

- For all target stations, the RSRP power is measured, the Available bandwidth is calculated (following the same method for the current station). Subsequently the metric mj,t is deduced.

$$m_{j,t} = \alpha * RSRP_t + \beta * Av\_BW_s \qquad (13)$$

- The comparison between the two metrics mj,s and mj,t is the last step. The HO is triggered when the new station will offer a better QoS (mj,s <mj,t).

V. Simulation Results and Discussion

A. Simulating tools and parameters

Many free and open source tools have been introduced to simulate a complete model of LTE/LTE-A networks. Each of these simulators has its limitations.

The two most powerful tools used in the literature are NS-3 and LTE-SIM. The LTE module of NS3 was developed as part of the LENA project and it allows the simulation of handover algorithms based on RSRP and RSRQ measurement in different events [21].

The literature is also rich of other simulators like OMNet++ and OPNET, in addition to the dedicated LTE module in the MATLAB tool.

In our work we chose to use LTE-Sim which contains a model of the handover procedures as well as the user mobility modelling.

The sub-folder "Src -> protocolStack -> rrc -> ho" contains two simple default algorithms (position based and power based). We have programmed via the C ++ language our new algorithm as well as the different schemes presented previously for the purpose of comparison.

The influence of these algorithms on the signalling and network capacity or on energy consumption (battery management) is not generally studied in most researches carried out on this topic [10].

The architecture proposed to be simulated considers the case of a multi-cell scenario with interference. An environment with a number of 105 UEs distributed over 7 cells (15 users per cell) is chosen. Each hexagonal cell contains an eNB and it has a radius of 1.2 Km. Users are in random mobility, according to the RANDOM_DIRECTION mobility model with a fixed speed of 120 Km/h. Each UE receives a VOIP stream encoded using the G.729 codec with a speed of 8.8 Kbps. Table I shows the different parameters used for this simulation.

The parameter values for obtaining the best results for the four simulated algorithms are shown in Table II.

Three important parameters will be inspected to validate the performance of a handover algorithm. For a mobile user, the number of packets lost during the handover operation will give us an idea of the quality of the used HO algorithm. The system throughput and the latency will be influenced by the cell change for each user, so they must be investigated too.

B. Results and Discussion

In this part, the different values of the three processed parameters were presented, for the real-time VOIP flows, for a number of users set at 105 UEs.

TABLE I
SIMULATION PARAMETERS

Parameters	Value
Frame structure	FDD
Cell radius	1 Km
Bandwidth	5 MHz
Slot duration	0.5 s
TTI duration	1 ms
Speed of UE	120 Km/h
Maximum delay	0.1 ms
Video bit-rate	242 kbps
VOIP bit-rate	8.8 kbps
Cells number	7
UEs number	105 (15 per cell)
Scheduling Algorithm	PF

In Fig. 8, the latency of the different schemes is compared. With the exception of the LHHA standard (which shows a high delay due to the fixed value of the TTT), the other three algorithms have very similar values. We can note that our algorithm has a gain of about 20 ms compared to the best of the other three algorithms (LHHAARC). The simplicity of our proposed scheme allows the HO operation to run in an easy way, allowing users to benefit from minimizing delay after linking to the new radio link (the new cell).

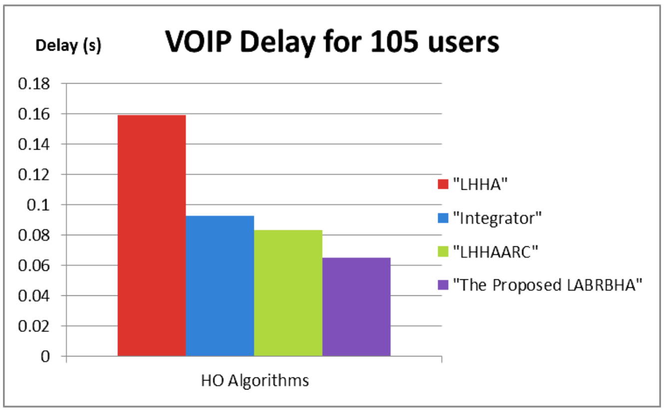

Fig. 8. The VOIP delay for different HO algorithms

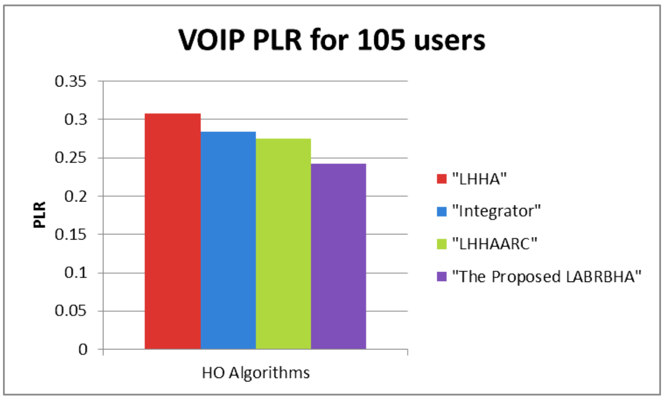

Fig. 9. Packet Loss Ratio (PLR) for different HO algorithms

TABLE II
VALUES OF HANDOVER ALGORITHMS VARIABLES FOR OBTAINING BEST RESULTS

HO ALGORITHMS	LHHA	INTEGRATOR	LHHAARC	LABRBHA
VARIABLES VALUES	HOM= 7DB TTT= 5 MS	A = 0.25 $FDIF_{THRESHOLD}$ = 6 DB	HOM= 10DB TTT= 1 MS	A = 0.9 B = 0.1

TABLE III
VALUES OF DIFFERENT SIMULATED PARAMETERS OF THE HO ALGORITHMS AND THE AMELIORATION EARNED BY THE PROPOSED LHHAARC

ALGORITHMS / SIMULATED PARAMETERS	LHHA	INTEGRATOR	LHHAARC	LABRBHA	BROUGHT GAIN (COMPARED TO LHHAARC)
DELAY(S)	0.15929	0.09255	0.08309	0.06518	- 21.55%
PLR	0.30742	0.28405	0.27481	0.24296	- 11.58%
THROUGHPUT (MBPS)	23.987	24.708	24.996	26.182	+ 4.74 %

The percentage of the number of lost packets PLR during the execution of a handover operation by using the different algorithms can be observed in Fig. 9. We can notice that the four schemes have close values (variation between 0.23 and 0.3). The proposed algorithm LABRBHA then shows its efficiency by decreasing the value of the PLR with about 12% related to the LHHAARC one. It can be seen that the Integrator appears better than the standard LHHA algorithm, but at the same time it is poorer compared to LHHAARC, since LHHAARC uses the average of the RSRP measured values.

As can be seen in Fig. 10, the system rates with the different HO algorithm for user mobility management were well presented. Note that the new LABRBHA scheme shows a significant increase of about 1.2 Mbps compared to LHHAARC. In addition to that, our multi-parameters method has a gain of 10% when compared with the standard LHHA algorithm. The Integrator and LHHAARC both have close values, but the LHHAARC algorithm, and as it is the case for latency and PLR, showed better value.

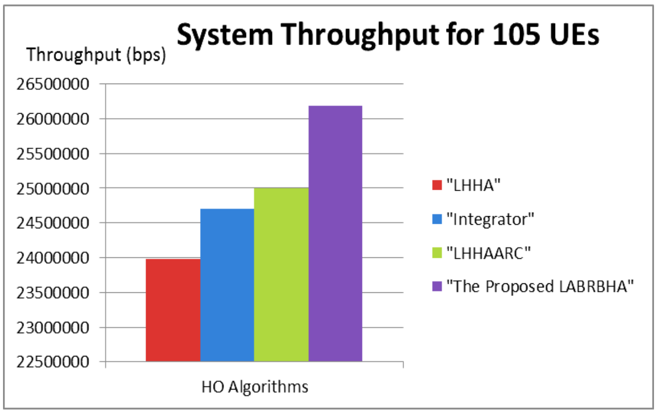

Fig. 10. VOIP System Throughput for different HO algorithms

Table III illustrates in percentage the earned gain when we use the proposed LABRBHA algorithm compared to the other schemes, for the three evaluated indicators (latency, PLR and system throughput).

As shown in Table III, our algorithm gives good results for the three simulated parameters: decrease in system delay, increase in transmission rate and decrease in the number of lost packets during the handover operation. This significant improvements brought by the new LABRBHA are due to the multi-parameter processing of several factors involved in the decision to trigger a handover. In addition to measuring the RSRP power at each station, the proposed algorithm detects the number of free RBs at all the stations nearby. It then benefits from the measurement and the use of the free bandwidth (available bandwidth) at the level of each cell.

VI. CONCLUSION

In this article, we first studied and analyzed the principle of mobility management in LTE-Advanced networks. Secondly, we implemented the best known handover algorithms in the literature, after developing their organizational charts. In third action, we proposed a new algorithm based on the collection of information about a multiple of parameters. The new scheme named LABRBHA (LTE Available Bandwidth and RSRP Based Handover Algorithm) was designed using two parameters with different weights, namely the RSRP and the Available bandwidth, measured at different base stations around the UE for making a decision to trigger or no a handover operation. The comparison of this new method with the other HO algorithms was made in the LTE-Sim Simulator for three main indicators: latency, PLR and system throughput. The proposed improvements have been well noticed, thus demonstrating the effectiveness of our new scheme. An evolved version of this algorithm by adding other parameters like the SINR remains the idea of our future work.

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