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Timer Decision Algorithm for Ping-Pong Handover Control on High-Speed Train in LTE Networks 1800 MHz

Hasanah Putri, Atik Novianti, Tri Nopiani Damayanti

School of Applied Science, Telkom University, Bandung, Indonesia

Abstract: The initial drive test on the Padalarang-Kasugihan railway in Ciroyom road, Andir subdistrict, indicated a handover failure categorized as the ping-pong handover. It is a condition where User Equipment (UE) experiences repeated handovers in a very short time because there is no dominant service. This makes the signal quality received by the user not optimal. This research aims to reduce the effect of ping-pong using a timer decision algorithm in two optimization approaches, namely physical tuning and macrocell. These two optimization methods are considered in the proposed system to evaluate the system handover performance. Timer decision algorithm proposed in high-speed train in LTE Network to control the ping-pong handover effect. This algorithm makes KPI system performance obtained such as Handover Success Rate (HOSR) and Advanced Timing Parameters. Reference Signal Received Power (RSRP), Signal for Interference Noise Ratio (SINR), and throughput more efficient. In the bad spot areas, i.e., where the ping-pong handover occurs, site 2152147 sectors two and site 100539 sectors 3 have the RSRP values of each adjacent sector of -85.97 dBm -87.64 dBm, respectively. After applying these two methods, the physical tuning method is better at eliminating ping-pong handovers. After applying physical tuning to sector two sites 2152147, the RSRP value of each sector becomes -83.25 dBm and -77.73 dBm. Thus, when the user makes a handover from sector three site 100539, there is no ping-pong handover because sector three site 100539 has a more dominant RSRP value. Numerical results show that the parameters in the system have increased. RSRP has increased 19%, SINR has increased 90%, and throughput has increased 17%.

Keywords: timer decision algorithm, ping-pong handover, physical tuning, macrocell, high-speed train.

800 兆赫移動通信標準。网络中高速火车乒乓切换控制的计时器决策算法

摘要: 在安迪尔街道铁路上进行的初始路试表明，移交失败归类为乒乓移交。这是用户设备由于没有主导服务而在很短的时间内经历重复切换的情况。这使得用户接收的信号质量不是最佳的。本研究旨在通过两种优化方法，即物理调谐和宏蜂窝，使用定时器决策算法来减少乒乓效应。这两种优化方法被考虑到所提出的系统中以评估系统切换性能。网络中高速列车中提出的定时器决策算法能够控制乒乓切换效应。该算法的使用使得获得的关键绩效指标系统性能，如切换成功率 、高级定时参数、参考信号接收功率 、信号干扰噪声比 和吞吐量更高效。在坏点区域，即发生乒乓切换的区域，站点 2152147 扇区 2 和站点 100539 扇区 3 的每个相邻扇区的值分别为和。应用这两种方法后，发现物理调谐方法更能消除乒乓切换。对扇区 2 站点 2152147 进行物理调谐后，每个扇区的值变为-83.25 分貝和-77.73 分貝。因此， 当用户从扇区 3 站点 100539 进行切换时，不存在乒乓切换，因为扇区 3 站点 100539 具有更占优势的值。数值结果表明系统中的参数有所增加。增加了 19%，增加了 90%，吞吐量增加了 17%。

关键词：计时器决策算法, 乒乓切换, 物理调整, 宏小区, 高速列车.

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About the authors: Hasanah Putri, Atik Novianti, Tri Nopiani Damayanti, School of Applied Science, Telkom University, Bandung, Indonesia

1. Introduction

Ping-pong handover is a condition where the EU experiences repeated handovers in a very short time. One of the factors that cause ping-pong handover is that there is no dominant server related to the signal strength value [1]. The signal strength of the cells providing network services in areas does not have a dominant server. In this case, when the UE makes a call, there will be problems such as drop calls or block calls due to ping-pong handovers [2]. The coverage, user movement, and speed parameters serve as the main considerations for ping-pong handover [3]. The scheme and the process of ping-pong handover are shown in Figure 1.

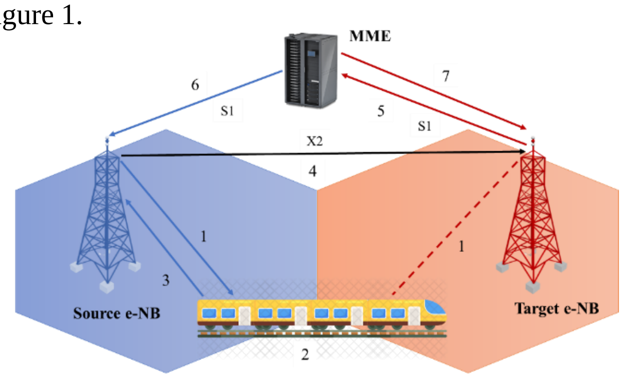

Fig. 1 Ping-pong handover

(1) The handover process begins with the UE receiving a signal strength value from the source eNodeB and the target eNodeB, which then (2) the UE will compare it to get a more dominant signal strength value. Next, (3) the UE will send information that it is going to make a handover to the target eNodeB because it has a higher signal strength, (4) the source eNodeB will prepare a handover on the target eNodeB via the X2 interface, and (5) the target eNodeB sends a request to MME if UE will make a handover via the S1 interface. After receiving the target eNodeB's request, (6) the MME will send information via the S1 interface on the source eNodeB to release the UE for the UE to perform a handover. The handover will be successful if (7) the target eNodeB acknowledges approval once the EU has handover on the target eNodeB. The ping-pong handover occurs when the UE receives a signal strength value adjacent between the source eNodeB and the target eNodeB, so when the UE has performed a handover, it will send a handover request back in a very short time [4].

The ping-pong handover can be optimized with physical tuning to adjust the transmission direction and antenna coverage so the source eNodeB and the target eNodeB can have more dominant signal strength. When the user receives signal strength from the two eNodeBs, it will hand over the eNodeB with a stronger power value. Besides physical tuning, ping-pong handover can also be optimized by increasing or decreasing the gain on the antenna since this will affect the coverage transmitted by the antenna. Ping-pong handover can also be optimized by changing the threshold parameter and setting the time to trigger the algorithm's handover [5]. Changing the threshold parameter can be done by setting the signal strength value, i.e., howmuch eNodeB can serve the user.

Therefore, if the value of signal strength received by the user exceeds the threshold, the user must perform a handover on the target eNodeB [6]-[7]. In addition to some of the optimizations already mentioned, ping-pong handover can also be optimized using the Mobility Robustness Optimization with Self Optimizing Network by analyzing the inter-eNodeB handover algorithm through the X2 interface [8]. This method can identify the number of probabilities of handover failure and ping-pong handover with a certain user speed [9].

This paper will compare two optimization methods, namely physical tuning and macrocell, on the Padalarang- Kasugihan railway line. Physical tuning is done by adjusting several antenna parameters, including antenna azimuth and tilting and antenna height. Meanwhile, macrocells are the widest form of cell coverage obtained by increasing the transmit power of the antenna. Both methods can be used as a ping-pong handover solution. However, when viewed from the procedure performed by each method, optimization-using macrocells has a lower success rate than physical tuning. This is because when the transmit power of the antenna is increased or decreased, it only affects the coverage area of the cell.

Meanwhile, the initial problem was the ping-pong handover, where the factors causing the problem were not identical to the cell coverage area, but because there were no dominant eNodeB transmitting signals (providing services), the handover process went back and forth. Physical tuning is more effective because several antenna parameter settings support eNodeB-transmitting signals in a specific direction. This, of course, affects the signal strength transmitted, where the eNodeB has a dominant signal strength when it is in coverage and weakens when it leaves the service area to minimize the occurrence of ping-pong handovers. Apart from using these two methods, it also uses a timer decision algorithm to reduce the ping-pong effect. This timer decision algorithm uses the computed Received Signal Strength (RSS) value to determine the appropriate timer value to control Ping Pong due to handovers.

2. Materials and Methods

2.1. Spot Identification

The first thing to optimize the LTE network is to identify the area and survey the location. This aims to comprehend the conditions and characteristics of the area to be optimized and determine the starting and ending points of the data collection process [10]. In this study, the data collection was conducted on the Jakarta-Bandung railway line on January 17, 2020. The physical tuning optimization and macrocell planning were performed on the Jakarta-Bandung railway line, especially in Ciroyom road and the Andir subdistrict, along the Padalarang-Kasugihan railway. This area was chosen since it had the ping-pong handover, which caused the network quality below the three operator standards.

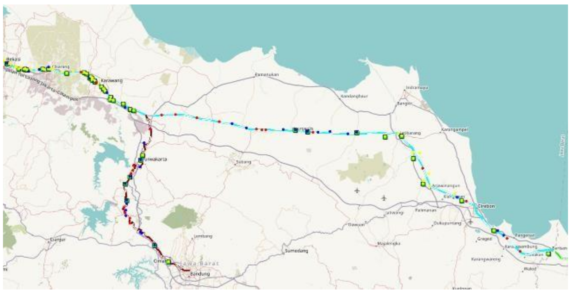

Fig. 2 The Jakarta-Bandung railway

The next step was the initial drive test, which was conducted to collect data and identify the real performance in the determined area [11]. This initial drive test was performed along the Jakarta- Bandung railway line using the TEMS Pocket software and USIM card of three operators. According to the initial drive test, a ping-pong handover occurred on the Padalarang-Kasugihan railway line along Ciroyom road, Andir subdistrict.

Figure 3 shows a ping-pong handover on the Padalarang-Kasugihan railway along Ciroyom road, Andir subdistrict, indicated by green Tosca for PCI 114 and brown for PCI 81. A repeated PCI shows the ping-pong handover in the area.

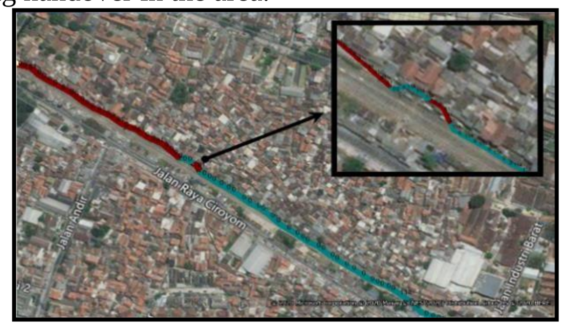

Fig. 3 Initial drive test results

The next step was the existing site identification. The existing site is a transmitter that already exists and is located around the planning area. The existing site data was obtained from a cellular network operator's engineering parameter, i.e., a collection of information regarding the identity and specifications of a site [12]. This physical tuning optimization involved several existing sites in the area where ping-pong handovers occurred. The conditions of the existing site where ping-pong handover occurred in several areas on the Padalarang-Kasugihan railway line are shown in Table 1.

2.2. Identification of Bad Spot and Solution Tracker

Cellular operators use the data on the bad spot and solution tracker to identify areas with bad networks, thus needing optimization [13]. The data contains an analysis of the performance of a network, spot categories, and site conditions before and after optimization, optimization solutions offered, etc. Based on identifying the bad spot data and solution tracker that has been carried out, ten bad spot points along the Jakarta-Bandung railway line need network optimization. The following is the longitude and latitude coordinate data, and the areas where bad spots occur are shown in Table 2.

Table 2 indicates that three bad spots are in line with the results of the initial drive test in Bandung, Purwakarta, and Padalarang areas, which are marked with spot numbers 6, 8, and 9. Each bad spot has a different analysis and optimization solution. According to the operator's tracker data for bad spots 2 and 3, optimization has been performed as marked with the optimization status being asked 'closed optim', while bad spot 1 has the 'open optim' optimization status.

Table 1 Existing sites in bad spots

Site id	Transmitter name	Azimuth	Mechanical	Electrical	PCI
2542147	Salamrojo_4G-1	60	4	4	80
2542147	Salamrojo_4G-2	205	0	6	81
2542147	Salamrojo_4G-3	330	3	5	82
100539	Arjuna_NTS_Site_4G-1	60	6	6	116
100539	Arjuna_NTS_Site_4G-2	210	4	3	115
100539	Arjuna_NTS_Site_4G-3	300	4	3	114
102397	SASAKSAAT_4G-1	40	3	2	106
102397	SASAKSAAT_4G-2	190	8	2	105
102397	SASAKSAAT_4G-3	270	4	2	107
101773	Cikubang_Nyalindung_Cipatat_4G-1	50	3	2	395
101773	Cikubang_Nyalindung_Cipatat_4G-2	120	4	2	394
101773	Cikubang_Nyalindung_Cipatat_4G-3	240	6	2	393
102035	Basuki_Rahmat_Indosat_Sharing_4G-1	100	2	6	389
102035	Basuki_Rahmat_Indosat_Sharing_4G-2	230	2	2	388
102035	Basuki_Rahmat_Indosat_Sharing_4G-3	330	4	3	387

603260	CIGANEA_BUNDER_4G-21	0	2	2	213
603260	CIGANEA_BUNDER_4G-22	150	2	2	214
603260	CIGANEA_BUNDER_4G-23	270	3	2	215

Table 2 Bad spot latitude and longitude

Route	**City name**	**Spot number**	**Spot latitude**	**Spot longitude**
Bandung - Cikampek	Bandung	Spot#6	-6,910727	107,583761
Bandung - Cikampek	Cimahi	Spot#7	-6,782652	107,434531
Bandung - Cikampek	Padalarang	Spot#8	-6,306087	107,12496
Bandung - Cikampek	Purwakarta	Spot#9	-6,331114	107,171496
Cipularang (Cikampek - Pasteur)	Karawang	Spot#1	-6,430982	107,441422
Cipularang (Cikampek - Pasteur)	Karawang	Spot#2	-6,445378	107,430594
Cipularang (Cikampek - Pasteur)	Karawang	Spot#3	-6,509626	107,439134
Cipularang (Cikampek - Pasteur)	Karawang	Spot#4	-6,603482	107,426934
Cipularang (Cikampek - Pasteur)	Karawang	Spot#5	-6,654124	107,427268
Cipularang (Cikampek - Pasteur)	Karawang	Spot#6	-6,654124	107,427268

For analysis results, the optimization solution and optimization status can be seen in Table 3. The table shows that some optimization solutions are suitable, and some optimization statuses are already performed. Four bad spots have not been optimized in the tracker data, and six bad spots have been optimized. Bad spot one or the Padalarang-Kasugihan railway line in Ciroyom road, Andir subdistrict, has not been optimized.

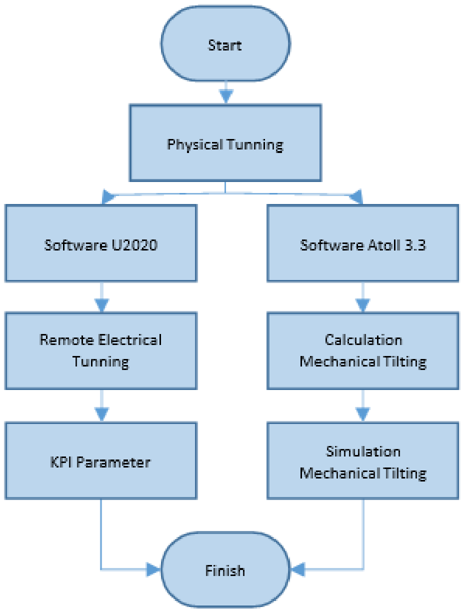

Fig. 4 Physical tuning flow chart

2.3. Physical Tuning Simulation

After the area identification, the next step was to simulate the existing site data before network optimization. The initial condition is needed to know how to simulate the initial conditions of the LTE network on the railroad where ping-pong handover occurs [13]. Figure 4 illustrates an optimization flow using the physical tuning method. The initial simulation was performed using Atoll 3.3 and U2020 software. The simulation using Atoll 3.3 software was done by preparing simulated area boundaries that varied depending on the coverage of areas with the ping-pong handover.

Table 3 Bad spot & solution tracker Jakarta-Bandung railway

Spot number	**Spot location**	**Analysis**	**Solution**	**Status**
Spot#6	Jl. Ciroyom	Ho Failure, Poor coverage due to no dominance serving cell 2542147_2 dist 353 100539_3 dist 527	Newsite	Open Optim
Spot#7	Cimahi	Poor Coverage and Poor Throuhput due to poor SINR when served from site 100201_Galaxi_Raya_Jakasampurna_4G-	Newsite	Closed Optim
Spot#8	Jalur Cikampek-Padalarang	Ho Failure, Poor Throuhgput due to poor SINR When served by site 101773_1	Newsite	Closed Optim
Spot#9	Jatiluhur (Purwakarta)	Ho failure, Poor coverage due to far distance serving cell 104397_2 dist 782	Physical tuning	Closed Optim
Spot#1	Toll Jakarta Cikampek	Poor Throuhgput due to poor SINR When served by site 602322_KM39TolCikampek_	Newsite	Closed Optim
Spot#2	Toll Jakarta Cikampek	Poor Throuhgput due high site to site distance When served by site 103026_CNANGKACKMPK_4G	Newsite	Open Optim
Spot#3	Toll Jakarta Cikampek	Poor Throughput due to unbalance user when served by the site 101654_Margajaya_Sarbini	Physical Tuning	Open Optim
Spot#4	Toll Jakarta Cikampek	Poor Coverage and Poor Throughput when served by cell 102166_Cikampek64_4G-3	Physical Tuning	Open Optim
Spot#5	Toll Jakarta Cikampek	Ho failure, Poor Coverage when served by cell 104673_GANTIONO_4G-2	New site	Closed Optim

Spot#6	Toll Jakarta Cikampek	Poor Coverage due to Poor SINR when served by cell 103766_Kosambi_VIP_4G-	New site	Closed Optim

Only site radiation that occurs with ping-pong is within the boundary [14]. The boundary on Atoll 3.3 software is marked with a red line called the computation zone, while in the U2020 software, HOSR and TA Key Performance Indicator (KPI) data are collected by entering the query data menu [7].

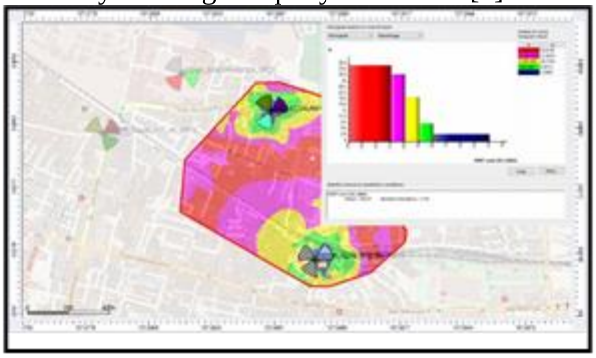

Fig. 5 Initial simulation results for RSRP parameters

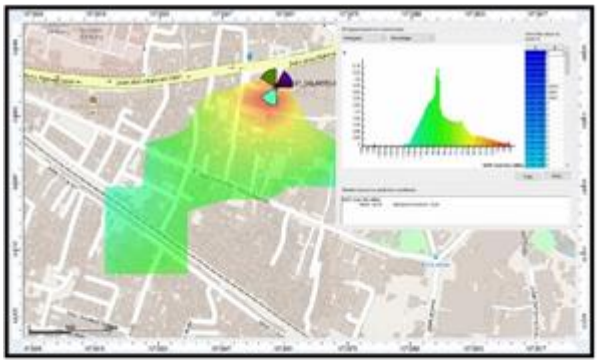

Fig. 6 RSRP of site 2542147 sectors 2

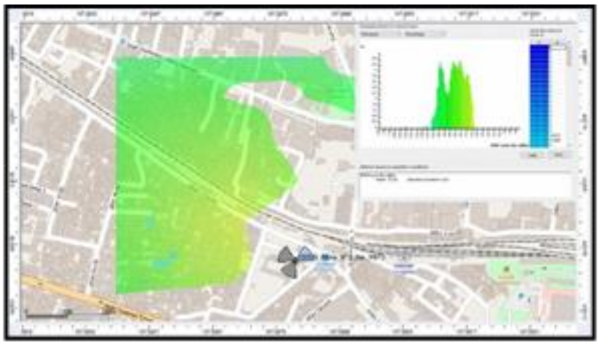

Fig. 7 RSRP of site 100539 sectors 3

According to Figures 5 - 7, the sites experiencing ping-pong handover are site 2542147 sectors 2 with PCI 81 and site 100539 sector 3 with PCI 141. From the initial simulation results, the average RSRP in the computation zone is -104.37 dBm with the highest percentage, 35.8%, in the range -110 to -140. Meanwhile, the result of RSRP site 2542147 sector 2 is -85.97 dBm, while the result of RSRP of site 100539 sectors 3 is -87.64 dBm.

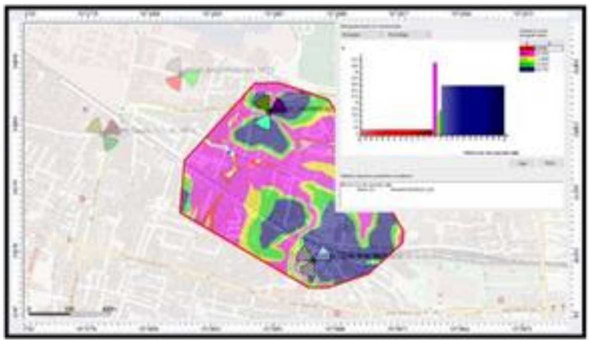

Fig. 8 Initial simulation results for SINR parameters

Figure 8 indicates the highest presentation of around 42.1%, the coverage in the range of 0 to 6 dB, and the average simulation value of the SINR parameter of 9.4 dB.

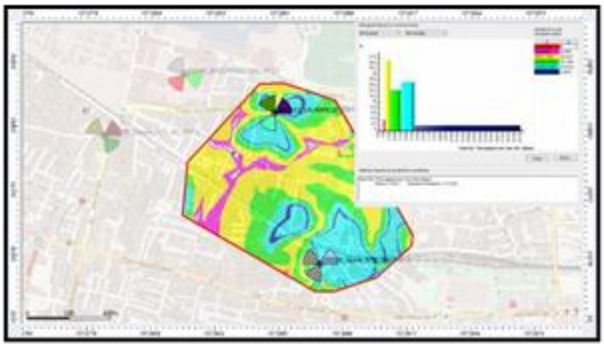

Fig. 9 Initial simulation results for throughput parameters

Figure 9 indicates the highest percentage of around 40.2%, coverage in the range of 800 to 1500 Kbps, and the average simulation value of throughput parameters of 2319 Kbps, categorized as bad according to KPI operator standards.

2.4. Mechanical Tilt

Physical tuning is an optimization method done by changing or managing physical devices on the network in the field. Physical tuning can be done by tilting, height adjustment or resetting antenna height, antenna azimuth adjustment, etc. Tilting is a directional elevation angle on the antenna [15]. Figure 10 below is an illustration of the mechanical tilt method.

To calculate the antenna tilting needs an antenna with a height (Hb) of 22 m, a receiver with a height (Hm) of 2 m, the distance from the site to the bad spot of 435 m, and an antenna datasheet.

$$\text{Tilting Antenna} = \tan^{-1}\left(\frac{H_b - H_m}{\text{Distance (m)}}\right)$$

$$\text{Tilting Antenna} = \tan^{-1}\left(\frac{22 - 2}{436}\right)$$

$$\text{Tilting Antenna} = 2.6^{\circ} \approx 3^{\circ}$$

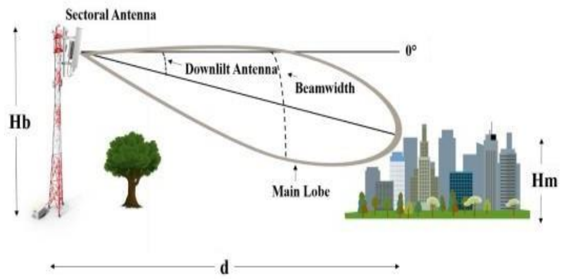

Fig. 10 Mechanical tilt

This study covered bad spot one by sector two site 2542147 and sector three sites 100539. The sites optimized for physical tuning included sites with the smallest RSRP, i.e., site 2542147 sectors 2.

From the calculation using the antenna tilting formula above, the optimization recommendation for sector two sites 2542147 was 3°. Each sector antenna had a mechanical down tilt of 3° and azimuth of 0°, 150°, and 255°, respectively. Then, the power used was 38 dBm based on the conventional base station standards for macrocell.

The next step was a simulation using the U2020 software to determine the HOSR and TA values at this spot. Figures 10 and 11 show the HOSR and TA values.

Figure 11 shows the HOSR chart from July 1, 2020, to July 3, 2020. Only sector 1 has a handover rate of 100%, while sectors 2 and 3 have an average handover success rate of 99.75%. From Figure 12, it can be seen that the highest sector radius distance occurs in sector two and sector 3, i.e., on July 2, 2020, with a distance of 480 m and 650 m.

Fig. 11 HOSR initial parameter

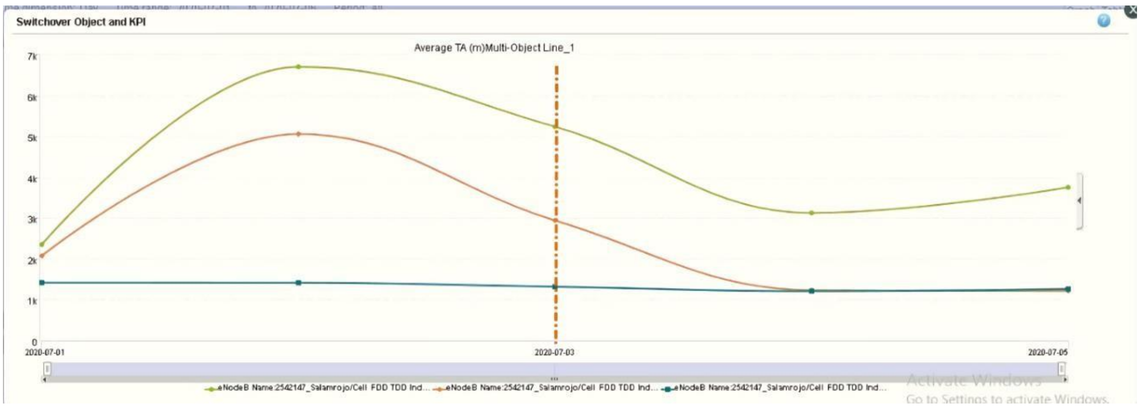

Fig. 12 TA initial parameter

2.5. Macrocell Planning Simulation

At this step, macrocell planning was performed using the coverage planning approach [13]. Figure 13 illustrates the steps in macrocell planning.

This approach was used to obtain the number of macrocell sites based on the planning area. This calculation goes through several stages, such as determining the coverage of the planning area, identifying the planning area, determining the frequency of work, determining the use of propagation models, preparing MAPL standards, and calculating site requirements [16]. Table 4 shows the required calculation specifications.

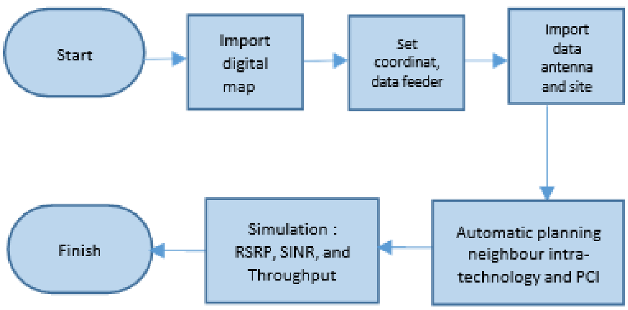

Fig. 13 Macrocell planning flow chart

Table 4 Specifications for coverage planning calculation

Parameter	Variable	Unit	Value

Propagation Model	-	-	Cost-231
Planning Area Classification	-	-	Urban
Planning Area Coverage	L	Km²	0.68
Frequency of work	f	MHz	1800
Antenna BS Height	Hb	m	30
Antenna MS Height	Hm	m	1.5
MAPL	PL	dB	UL: 127.526 & DL: 132.097
Power Correction Factor	cm	dB	0

The next step was calculating the number of required sites based on the coverage planning approach.

$a(hm)=(1.1 \log(f) - 0.7)\, hm - (1.56 \log(f) - 0.8)$ (2)

$=(1.1 \log(1800) - 0.7)\ 1.5 - (1.56 \log(1800) - 0.8)$

$=4.321 - 4.278$

$=0.043$

The following is the PL calculation on the uplink side.

PL UL $= 46.33 + 33.9 \log(f) - 13.82 \log(hb) - a(hm) + [44.9 - 6.55 \log(hb)] \log d + cm$ (3)

$= 46.33 + 33.9 \log(1800) - 13.82 \log(30) - 0.043 + [44.9 - 6.55 \log(30)] \log d$

$= 46.33 + 33.9 (3.255) - 13.82 (1.477) - 0.043 + [44.9 - 6.55 (1.477)] \log d$

$= 156.674 - 20.412 - 0.043 + 35.226 \log d$

$127.526 = 136.219 + 35.226 \log d$

$-0.246 = \log d$

$d = 0.567$ km

Lmacrocell = 3 x 1.95 x d2 (4)
Lmacrocell = 3 x 0.626
Lmacrocell = 1.883 km2

$$\sum \text{macrocell} = \frac{\text{area}}{\text{cell}} = \frac{0.680}{1.883} = 0.36 \approx 1\text{macrocell}$$

After that, the PL calculation on the downlink side was performed.

PL DL $= 46.33 + 33.9 \log(f) - 13.82 \log(h_b) - a(h_m) + [44.9 - 6.55 \log(h_b)] \log d + cm$ (5)

$= 46.33 + 33.9 \log(1800) - 13.82 \log(30) - 0.043 + [44.9 - 6.55 \log(30)] \log d$

$= 46.33 + 33.9 (3.255) - 13.82 (1.477) - 0.043 + [44.9 - 6.55 (1.477)] \log d$

$= 156.674 - 20.412 - 0.043 + 35.226 \log d$

$132.097 = 136.219 + 35.226 \log d$

$-0.117 = \log d$

$d = 0.765$ km

$L_{macrocell} = 3 \times 1.95 \times d^2$
$L_{macrocell} = 3 \times 1.136$
$L_{macrocell} = 3\ 3.424\ km^2$

$$\sum \text{macrocell} = \frac{\text{area}}{\text{cell}} = \frac{0.680}{3.423} = 0.19 \approx 1\text{macrocell}$$

2.6. Ping-Pong Timer Decision

Ping-pong timer decision controls the ping-pong effect caused by the handover, especially when the UE or SS moves at high speed. The algorithm uses two function values obtained: the user RSS value, throughput value, cell load, SINR received by the user, and the power consumption of the cell and the user. Our proposed algorithm will try to initiate the HO procedure as soon as the received signal strength from the target is bigger than that from the source, and the completion of the HO procedure will not perform until the timer value is expired (Figure 14).

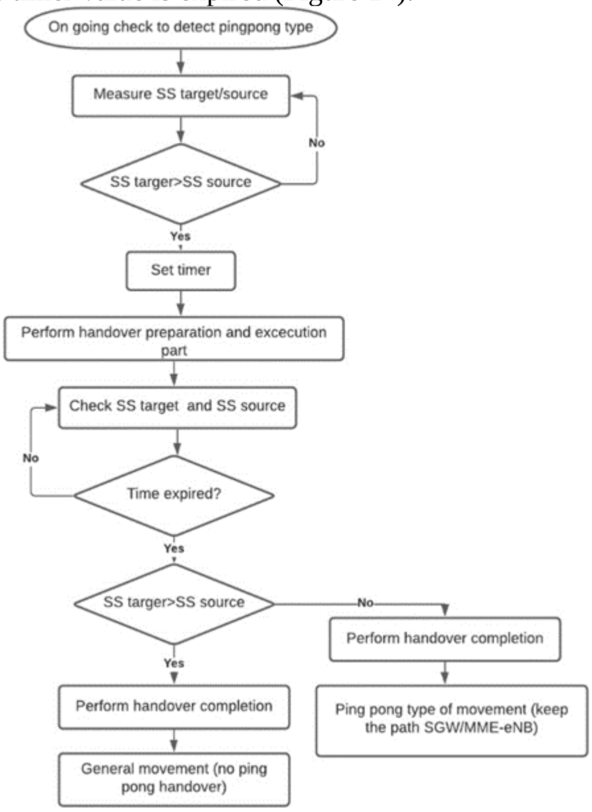

Fig. 14 The ping-pong detection algorithm proposed to reduce the number of ping-pong HOs in LTE networks

3. Results and Discussion

By the physical tuning method, in sector two site 2542147_Salamrojo that leads to the bad spot area, the tilt was changed, affecting the cell coverage area. This scenario was performed because, in the bad spot area, the ping-pong handover was covered by sector two site 2542147_Salamrojo.

Fig. 15 Results of physical tuning computation and focus zone

After knowing the site that covered the area, a physical tuning optimization simulation was performed according to the calculation of the antenna tilt value, which was previously obtained. The physical tuning optimization was performed by changing the electrical tilt value of the antenna using the U2020 software, while the simulation optimization was done by changing the mechanical tilt value of the antenna using the Atoll 3.3 software. Table 5 below is the sector 2 data site 2542147_Salamrojo.

Table 5 Data on sector two sites 2542147_Salamrojo

DATA ON SECTOR 2 SITE 2542147_Salamrojo		
Parameter	**Value before**	**Value after**
Antenna Height	22 m	22 m
Azimuth	205°	205°
Mechanical Tilt	0°	3°
Electrical Tilt	2°	6°

Different results are obtained based on the physical tuning simulation results, but they are still quite close. The comparison of the prediction results from the simulation of the existing site and physical tuning is shown in Tables 6 - 8.

By applying the physical tuning method, the RSRP parameter in the computation zone shows the highest percentage of 33.13%, the coverage ranging from -80 to -40 dBm. The average RSRP value is -84.85 dBm and is in a good category according to three operator standards. Furthermore, the RSRP value per sector at site 2542147 sector 2 is -83.28 dBm, while at site 100,539, sector three is -77.73 dBm. The average RSRP is categorized as very good for sector three and good for sector two according to 3 operator standards.

Table 6 RSRP comparison of the existing site and physical tuning

Value (dBm)	**Scenario**			
	Category	**Color**	**Existing site**	**Physical tuning**
> -80 to -40	Very good		3.38%	33.13%
> -90 to -80	Good		8.42%	30.26%
> -110 to -90	Fairly good		20.77%	26.16%
> -110 to -100	Fairly bad		31.60%	8.05%
> -140 to -110	Bad		35.81%	2.42%
Simulation Results Average (dBm)			-104.37	-84.85
KPI Target 70% > -90 dBm			32.57%	89.55%

By applying the physical tuning method, the SINR parameters in the computation zone indicate the highest percentage of 66.1% and the coverage in the range of > 12 dB. In addition, the average SINR simulation value is

17.83 dB and is in the very good category according to threeoperator standards.

Table 7 SINR comparison of the existing site and physical tuning

Value (dBm)	**Category**	**Color**	**Scenario**	
			Existing site	**Physical tuning**
> 12	Very good		28.77%	6.12%
> 8 to 12	Good		14.42%	25.81%
> 5 to 8	Fairly good		11.66%	5.82%
> 0 to 5	Fairly bad		42.15%	2.23%
< 0	Bad		2.97%	0%
Simulation Results Average (dB)			9.4	17.83
KPI Target 70% > 5 dB			54.85%	97.75%

Furthermore, the throughput parameter in the computation zone shows the highest percentage of 55% and the coverage in the range of 3000 to 5000 Kbps. In addition, the average throughput simulation value is around 2,704 Kbps and is in a good category according to three operator standards.

Table 8 Throughput comparison of the existing site and physical tuning

Value (dBm)	**Scenario**			
	Category	**Color**	**Existing site**	**Physical tuning**
> 5000 to 20000	2.80%		2.80%	0%
> 3,000 to 5000	27.81%		27.81%	55%
> 1500 to 3000	23.14%		23.14%	33.82%
> 800 to 1500	40.20%		40.20%	11.11%
> 500 to 800	20.67%		20.67%	0%
	0 to 500 Kbps		6.03%	0%
Simulation Results Average (Kbps)			2319	2704

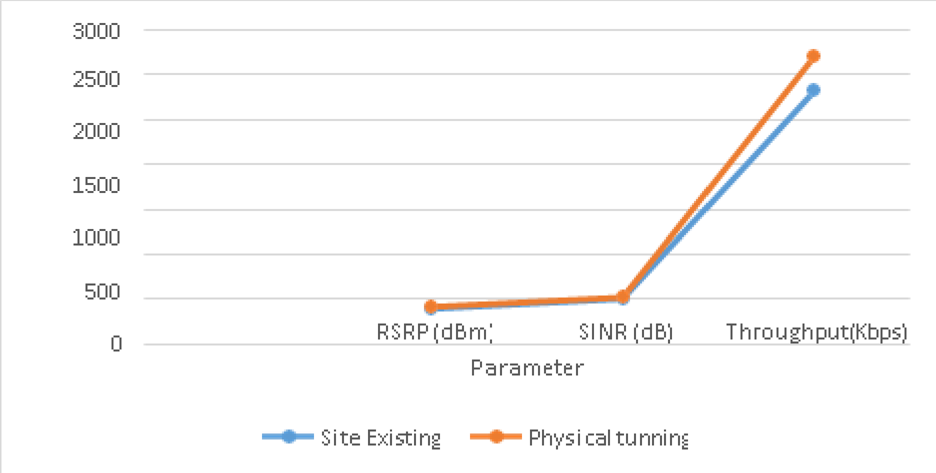

Fig. 16 Comparison of improvements between the existing site and physical tuning

All the three parameters show a value increase, i.e. RSRP > -90 dBm, SINR > 5 dB, and throughput > 800 kbps, for each user. An increase also occurs in each sector that leads to the bad spot area. The RSRP value experiences significant improvement, i.e., sector two sites 2542147 got an RSRP value of -83.25 dBm, while sector three site 100539 got an RSRP value of -77.73 dBm using the physical tuning method. From the value of these parameters, sector three site 100539 has a more dominant RSRP value than sector 2.

Figure 16 shows the comparison results of the existing site before and after the optimization using physical tuning. After physical tuning, all parameters (RSRP, SINR, and throughput) are improved.

The optimization using physical tuning can affect the quality of signal strength in the optimized site area. It is because changing the transmission direction or the inclination angle will affect the transmission direction of the site. In addition to changes in signal strength in bad spot areas, other areas also experience changes in signal strength quality. In this simulation, two boundary zones are used, namely the computation zone and the focus zone. At a distance of 200 m from the bad spot area, the RSRP value before the optimization of physical tuning is -103 dBm (categorized as fairly bad), while the RSRP value after the optimization is -100 dBm (categorized as fairly good). For a distance of 210 m from the bad spot area, the RSRP value before the optimization is -92 dBm (categorized as fairly good), while the RSRP value after the optimization is -112 dBm (categorized as fairly bad). Figures 17 and 18 are graphs comparing the initial and final HOSR parameters and the initial and final TA parameters obtained from the simulation using the U2020 software.

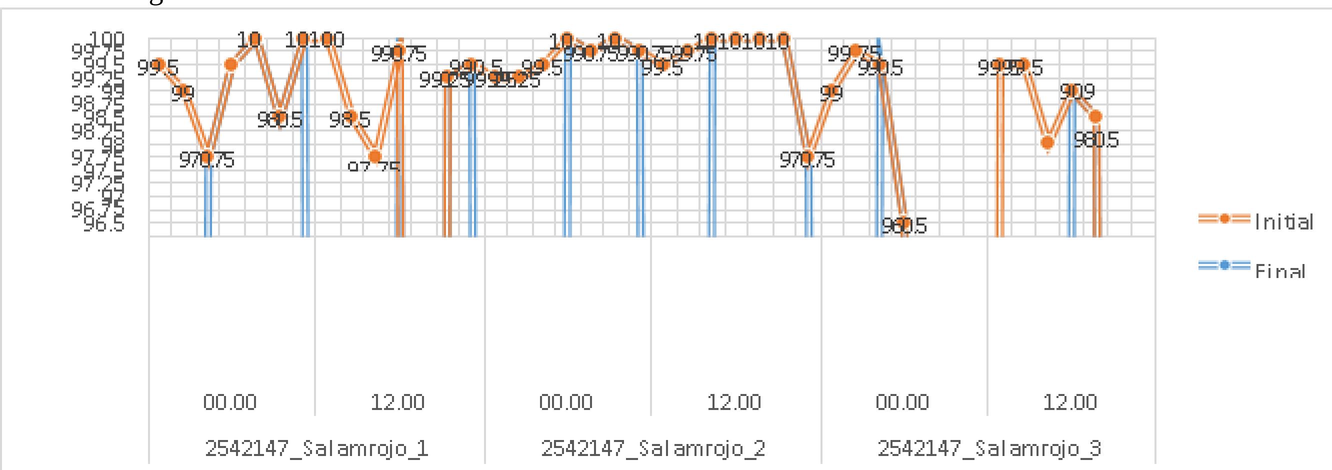

Fig. 17 Comparison of the initial and final HOSR values

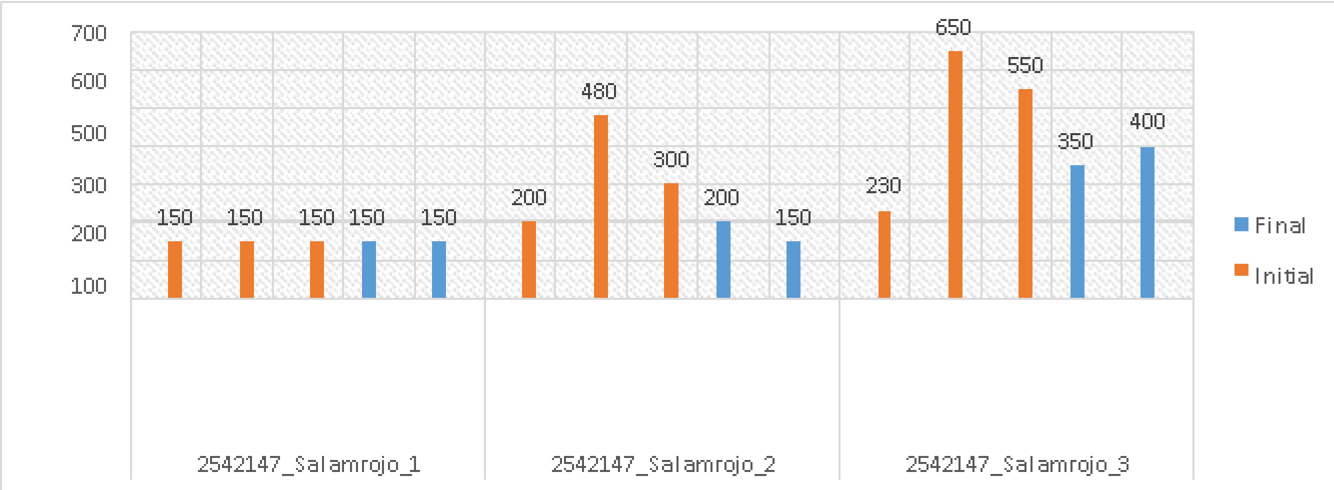

Fig. 18 Comparison of the initial and final time advance values

Based on these comparison graphs, there is an increase in the value of the HOSR parameter in sector two sites 2542147, i.e., reaching 100%, which results in a very good communication relationship without a handover failure, and a decrease in the radius of the sector from 650 m to 150 m so that the user will get good network quality because it is covered by sites that are not too far away.

4. Conclusion

In this paper, we propose a decision-timer algorithm to control ping-pong handover in the LTE network. The developed algorithm can control the ping-pong handover when the UE is moving at high speed based on the evaluation of the timer decisions with the physical tuning optimization approach and the new site macrocell. Timer decision algorithm uses function values of RSS value, throughput value, cell load, SINR received by the user. The physical tuning approach is made by changing the tilting value of the antenna used. Physical tuning can increase the strength in the optimized site area. This happens because changes in the direction of transmission or changes in the direction of the tilt angle of the antenna will affect the strength, especially in bad point areas. Based on the results of the optimization simulation performed using the timer decision algorithm, it was found that the physical tuning method was able to improve the quality of repairs that were more optimal than the new macrocell site. In terms of time efficiency and affordable operational costs, optimizing physical tuning can increase the quality value in the observation area and increase the HOSR parameter value up to 100%, which results in excellent communication links without handover failure.

The present research only investigates the mobility of individual UEs in high-speed moving conditions depending on the handover control parameters scheme based on the location and speed of the UE. This research has not investigated how a timer decision algorithm affects the user's direction of movement at different cell boundaries based on the direction of movement and variations in the user's speed.

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