ISSN 2278-3091
Volume 9, No.1.4, 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse1691.42020.pdf
https://doi.org/10.30534/ijatcse/2020/1691.42020

An Adaptive Handover Initiation Thresholdfor Seamless Mobility basedWireless Networksusing Particle Swarm Optimization (PSO) Algorithm

Azita Laily Yusof[1], Muhammad Aiman Zainali[2],AinnurEiza Azhar[3], Norsuzila Ya'acob[4]
[1234]Faculty of Electrical Engineering,
UniversitiTeknologi MARA, Shah Alam, Malaysia.
laily012001@yahoo.com, aimanzainali@gmail.com, ainnur.azhar@yahoo.com, norsuzilayaacob@yahoo.com,

ABSTRACT

In the near future mobility management, handover initiation procedure is important as it will become a necessity trend. The major problem related to mobility performance is the time required for the network to make the decision of handover. A poorly designed handover process tends to make more cases of data loss or radio link failure and thus there must be an optimum handover threshold value to ensure a seamless handover process from serving to the target base station.Throughout this work, a system for analytical handover with mathematical equations was developed and derived by using MATLAB software. This research has proposed An adaptive Reference Signal Received Power Threshold ($RSRP_{th}$)to initiate the handover process by using the user's speed and the handover signaling delay value.probability of handover failure (p_f) was analyze based on the derivation of the adaptive value of $RSRP_{th}$. From the obtained result, it has been found that with the developed analytical handover framework, the proposed adaptive $RSRP_{th}$ value for handover initiation has improved the number of handover failures.

Key words : Handover initiation, handover signaling delay, handover threshold, mobility management, probability of handover failure

1. INTRODUCTION

Over the past few years, the growth of wireless communications technologies resulted in the increase of handover process.The handover failure caused by unsuitable parameter is defined in [1] – [3] and divided into three cases: (a) too early handover, (b) too late handover and (c) handover to wrong cell. Another cause of failure case is due to the ping-pong handover. With unnecessary handover, the ping-pong handover will burden the base station.In case of too late handover, high value of time-to trigger (TTT) caused the radio link failure. On the other hand, for the case of handover to wrong cell, it occurs when user equipment (UE) is located at the cell edge of base stations, the signals are overlapped. The UE may be chosen a wrong target of base station which result in radio link failure. Forping-pong handover, unnecessary handover occurs in a short time caused by the UE moves at the cell edge of base station [4] – [6].
To support seamless handover in wireless networks, a number of handover schemes have been proposed. Reference[7] had proposed a handover decision algorithm which stated that by increasing the time interval between handover trigger, it can later reduce the frequent number of handover. The proposed handover decision algorithm is based on the received signal strength and the velocity of users is considered to be the criteria for decision making. Reference[8] on the other hand has presented a handover algorithm using RSRP Constraint.An optimized system performance of the technique is evaluated using simulation and compared with the three well-known handover algorithms. From the outcome, it showed that the technique outperformed the other three well-known handover algorithms by having less average number of handovers per UE per second, shorter total system delay while maintaining a higher total system throughput.The proposed handover algorithm can effectively give less number of handovers and lower system delay is maintained.

Research done in[9] studied the handover mechanism in LTE-Advanced by using joint processing technique. The parameter used is the RSRP as the threshold value for the handover by considering the two variables which are handover margin (HOM) andTTT timer. The results showed that this algorithm improves the system throughput and minimize packet loss ratio (PLR) effectively. However, this algorithm overloaded the system capacity and saturated system throughput in congested network. This issue has later been improved by the limited CoMP handover algorithm developed by the same author. One of the current issues that the author does not consider in this research is the handover algorithm by using CoMP joint processing in heterogeneous network.

In computational science, the so-called particle swarm optimization (PSO) is a computational technique that optimizes a problem by iteratively trying to improve a candidate solution with respect to a given quality measure[10].By using the technique, it solved a problem by having a population of candidate solution and moving it according to simple mathematical formula over their location and velocity in the search-space.Each candidate's movement is determined by its best known local position and is often directed to the best known search-space positions, which are later revised as other candidates have found better positions.Therefore, this technique is supposed to push the swarm towards the best solutions. Initially credited to Kennedy, Eberhart and Shi[11], the PSO was the first to concentrate on simulating social behavior as a stylized image for species movement or as a group [12] like bird flock or fish school. The algorithm was simplified, and optimization was observed and search performance improved [13].The book by Kennedy and Eberhart identified several philosophical aspects of PSO and swarm intelligence. In addition, Poli has also done a comprehensive survey of PSO applications. A comprehensive review of theoretical and experimental work on PSO was published recently by reference[14].

A lot of researches have been done on mobility management as stated above. Although many handover schemes have been introduced to provide seamless handover mode by minimizing complexity and delay, but it still results in potential loss of communications. Thus, it is necessary to find an optimum handover initiation threshold in order to avoid handover failure as much as possible. The rest of this paper is organized as follows. Section 2 explains methodology of this research. Section 3 discusses the results obtained from the simulation. Finally, conclusion is presented in Section 4.

2. RESEARCH METHODOLOGY

In this study,, handover initiation threshold, $RSRP^{th}$ will be started to evaluated when the UE moves with specific speed value. Figure 1 shows the analytical framework built for movement of the UE from point P. It is assumed that the UE can move in any direction within the range [$\theta \in (-\theta_1, \theta_1)$]. The direction, size, *a* and length, *d* for movement direction are shown in the Figure 1. Every angle and side are used to form mathematical equations.The direction of motion of the UE from point P is given by β where $\beta \in [(0, \theta_T)]$.In order to identify direction of UE motion, β is divided into two region which are$\beta 1 \in [(0, \theta_1)]$ and $\beta 2 \in [(\theta_1, \theta_2)]$. Thus, it will have two regions of which are *β1* and *β2* as given in (1) and (2)

for $\beta 1 \in (0, \theta_1)$

$$\theta_1 = arctan \frac{30d\left(1+\frac{a}{d}\right)}{(120)d\cos 30} \tag{1}$$

for $\beta 2 \in (\theta_1, \theta_2)$

$$\theta_2 = arctan \frac{a - d\cos 60}{d\cos 30} \tag{2}$$

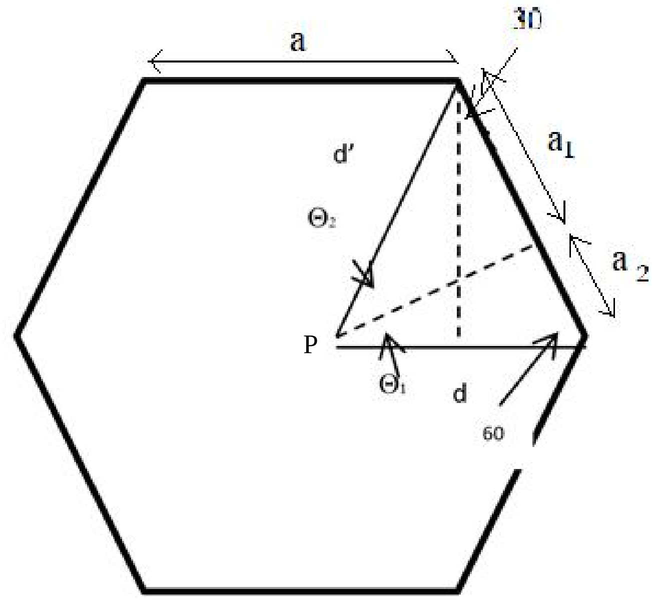

Figure 1: Region for θT = θ1 + θ2

Thus, the probability of handover failure (p_f) by considering θ_1 and θ_2 is given as in (3)

$$p_f = \begin{cases} 1 & ; \quad \tau > \frac{\sqrt{{a_2}^2 + {d'}^2}}{v} \\ \frac{1}{\theta_1} arccos\left|\frac{d}{v\tau}\right| & ; \quad \frac{d'}{v} < \tau < \frac{\sqrt{{a_1}^2 + {d'}^2}}{v} \\ \frac{1}{\theta_2} arccos\left|\frac{d}{v\tau}\right| & ; \quad \frac{d'}{v} < \tau < \frac{\sqrt{{a_1}^2 + {d'}^2}}{v} \\ 0 & ; \quad \tau \le \frac{d'}{v} \end{cases} \tag{3}$$

From the p_f, τ is the summation of Radio Link Failure (RLF) timer called as handover signaling delay. RLF handover is one of handover procedure as stated in 3GPP release 8 specifications [15] which is a UE-based mobility prepares a recovery stepto target base station if servingbase stationpartiallyfailed to transmit data. However, this RLF handover procedure causes additional delay and thus, a longer interruption in service. Therefore, in this research, this parameter will be considered in deriving the handover initiation threshold.

The derivation of equation (3) is used to determine the distance(*d*) in the equation. The *d* is varied with different speed values and$\tau$to see the variation in RSRP. The $p_f$was set 2%, which mean that only 2 from 100 users will experience the failure and it is same target as a traditional operator. By using the value, it will greatly help to reduce the $p_f$and thus increase the performance of radio coverage.

In order to find the optimum value of d with respect to certain value of p_f, PSO technique has been used. In this research, $p_f$value of 0.02 is set which means that only 2 from 100 handover attempt will fail and the other 98% attempt will succeed to be handover to the target base station.

Since the algorithm of PSO imitates from animal societies, so the movement of the algorithm will follow the behavior of the animal group or swarm. The ability of this PSO technique is that the algorithm will explore different areas of the search space to find the optimum value, this process is called the exploration. On the other hand, the ability to concentrate the research around a promising area to refine a candidate's solution is known as exploitation[16] – [18].The swarm particle flies throughhyperspace both exploration and manipulation, and has two essential reasoningcapabilities: its own best position memory-local best and knowledge of the global or best of its neighborhood-national best. Particle orientation is determined by velocity [19][20].

The particle 's position is changed by adding a velocity, vi(t) to the current position as in equation (4), where xi(t) is the particle 's position in the search space at the time step

$$xi(t+1) = xi(t) + vi(t+1) \qquad (4)$$

where$vi(t) = vi(t-1) + c1r1(localbest(t) - xi(t-1)) + c2r2(globalbest(t) - xi(t-1))$

with $xi(0) \sim U(xmin, xmax)$, acceleration coefficient,*c1*and *c*, and random vector,*r1*and *r2*.

The velocity of the particles is initially believed to be zero. For each particle j, the two important parameters are obtained and declared as Pbest(j), which is the best value of xj(i) (particle j co-ordinates at iteration Ith).Globalbest will be the smallest target of every previous iteration to give the value function, the best value for all xj(i) particles found until the Ithiteration.

Then, by using equation (4), the particle 's position or coordinates are determined at the i th iteration. The final step, PSO will test to see if the current solution is convergent. Convergence occurred if all the particleaslocations contributed to an equal value.The iteration stops if the current solution is convergent, and the optimum value is given. In this situation, the final value from the PSO technique is the value *d*. Once*d* is calculated, the corresponding RSRP value is calculated using the path loss model and the BS cell size serving as indicated in (5)

$$RSRP_{th} = RSSI - 10\log(12N) \qquad (5)$$

with $$RSSI = 15.3 + 37.6\log(100d) \qquad (6)$$

where *N* is the number of Physical Resource Blocks (PRBs) and *d* is the optimum adaptive distance. Once $RSRP_{th}$ is calculated, the handover trigger unit monitors the RSRP from the serving base station and the handover will be executed when the RSRP value from the serving base station drops below $RSRP_{th}$.

3. RESULT AND DISCUSSION

3.1 Fitness result from PSO technique

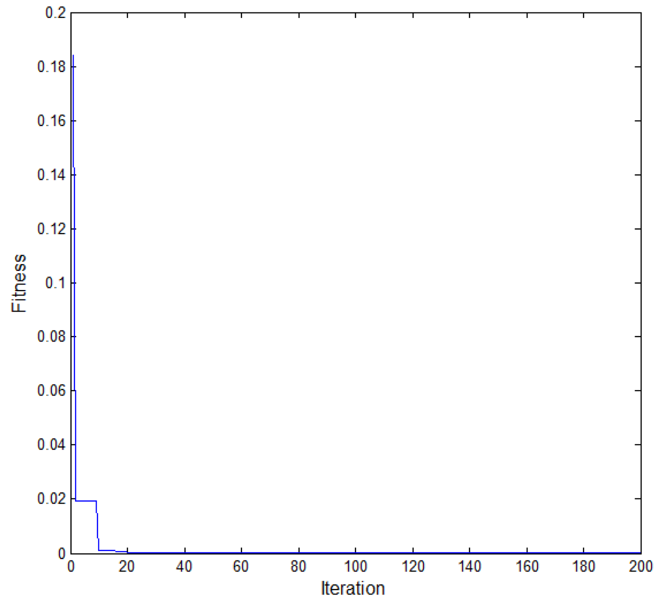

Figure 2: Fitness Result from PSO Technique with 200 Iterations

Figure 2 shows the fitness against the number of iterations for the optimization of the *d*value. The less fitness values show the more accurate the target point for the *d* value. From Figure 2, it shows that with more iteration, the chart approaching convergence value which means the value approaching the lowest value of fitness for the target parameter *d* with respect to p_f of 0.02. From the result, the best optimization point for *d*is shown in Figure 3 and Figure 4.

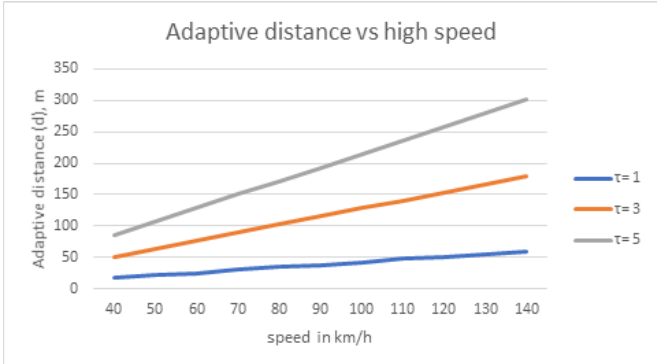

Figure 3: Adaptive distance for speed more than 30km/h with different value of τ

Figure 3 represents the adaptive distance which has been optimized for high speed user. Each line represents the different distance for the UE to initiate handover with different τ. It is shown that the higher the signaling delay and the higher the speed of UE, more distance it will take for the UE to handover from serving base station to the target base station.

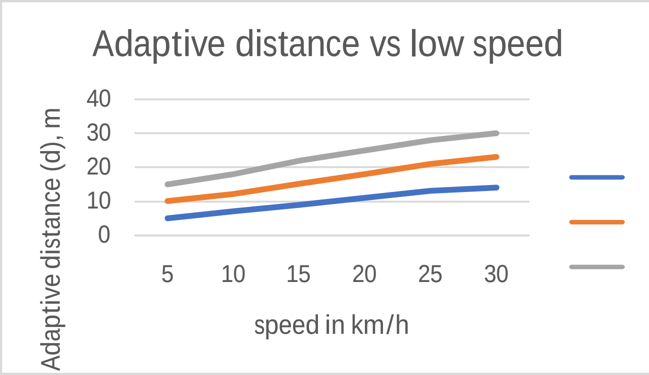

Figure 4: Adaptive Distance for Speed Less Than 30km/h with Different Value of τ

Figure 4 represents the adaptive distance that has been optimized for low speed user. Each line represents the different distance for the UE to initiate handover with different time signaling delay. It is shown that the higher the signaling delay and the higher the speed of UE, more distance it will take for the UE to handover from serving base station to the target base station. The data collected for the Figure 3 and Figure 4 are tabulated and presented in Table 1 and Table 2, respectively.

Table 1 : Best distance for handover with respect to p_f of 0.02 and speed greater than 40 km/h

Speed (km/h)	**Distance (m) ; for τ= 1s**	**Distance (m) ; for τ = 3s**	**Distance (m) ; for τ = 5s**
40	17	51	85
50	21	64	107
60	25	77	128
70	30	90	150
80	34	102	171
90	38	115	193
100	42	128	214
110	47	141	236
120	51	154	258
130	55	167	279
140	60	180	301

Table 2 : Best distance for handover with respect to *pf* of 0.02 and speed less than 40km/h

Speed (km/h)	**Distance (m) ; for τ= 1s**	**Distance (m) ; for τ = 3s**	**Distance (m) ; for τ = 5s**
10	8	12	17
20	11	18	26
30	14	23	30

Then, the best value taken from the optimization is applied into RSRP threshold equation. For our simulation, we consider a macrocell system with a cell size of a = 1km. The optimum adaptive distance that has been identified from the PSO technique is taken as the reference distance macrocell handover for low and high speed. The target handover failure probability is 0.02. The speeds of user's in a macrocell are between 0 km/h to 140 km/h.

Figure 5: RSRP Threshold for High Speed UE withDifferent τ

Figure 6: RSRP Threshold for Low Speed UE with Different τ

Figure 5and Figure 6 show the relationship between $RSRP_{th}$ and UE speed for different values of τ. Both figures showthat the higher the usage speed, the higher the value of RSRP threshold level with the proposed value of adaptive distance. For different values of speed, the required value of distance is calculated by using (3). Then, by using (6), the required value of $RSRP_{th}$ has been calculated with different value of τ and different speed of UE which is between 0 km/h to 140 km/h.

$RSRP_{th}$ increases is shown in both figures as the UE speed increases for a specific value of τ. This suggests that the handover process for a UE moving at a higher speed should be initiated earlier than a slow-moving UE in order to guarantee the optimal handover failure independent of UE speed.It is also show that $RSRP_{th}$ is increasing as τ increases. It is because the handover will be performed faster when τ is high compared with when the τ is small.Therefore, from the results it shows that by using the proposed adaptive $RSRP_{th}$value with respect to τ and v, it reduced the $p_f$as compared previously.

4. CONCLUSION

As conclusion, an analyticalframework has been developed to analyze the handover performance using PSO algorithm. The mathematical equations have been derived from the developed framework by using the value of user's speed and handover signaling delay. Under this framework, an adaptive $RSRP_{th}$ value wasproposedas the speed of user and handoff signaling delay varies. From the result, it shows that the proposed adaptive $RSRP_{th}$ value has improved the number of handover failures.

ACKNOWLEDGEMENT

This paper is part of research work that supported by Bestari Grant file no.: 600-IRMI/DANA 5/3/BESTARI (120/2018) and Faculty of Electrical Engineering, UiTM Shah Alam.

REFERENCES

1. K. Dimou*et al.***Handover within 3GPP LTE: Design Principles and Performance**, *IEEE 70th Veh. Technol. Conf. Fall*, pp. 1–5, Sep. 2009.
2. S. Abrar and R. Hussain.**A New Method for Handover Triggering Condition Estimation**, *IEICE Electron. Express*, vol. 9, no. 5, pp. 378–384, 2012. https://doi.org/10.1587/elex.9.378
3. R. Hussain, S. A. Malik, S. Abrar, R. A. Riaz and S. A. Khan. **Minimizing Unnecessary Handovers in a Heterogeneous Network Environment**, *PRZEGLĄD ELEKTROTECHNICZNY (Electrical Review)*, no. 6, pp. 300–303, 2012.
4. M. S. Demir, H. B. Eldeeb, and M. Uysal, "**CoMP-based Dynamic Handover for Vehicular VLC Networks**," *IEEE Commun. Lett.*, vol. 7798, no. c, pp. 1–1, 2020, doi: 10.1109/lcomm.2020.2994416.
5. S. S. Salihin, L. A. Nissirat, R. M. Noor, and I. Ahmedy, "**Handover Schemes for Vehicular Ad-Hoc Networks over Long Term Evolution Advanced: A Survey**," *2018 Int. Conf. Comput. Approach Smart Syst. Des. Appl. ICASSDA 2018*, 2018, doi: 10.1109/ICASSDA.2018.8477612.
6. J. Jia, G. Liu, D. Han, and J. Wang, "**Towards Studying the Two-Tier Intra-Frequency X2 Handover Based on Software-Defined Open LTE Platform**," *IEEE Access*, vol. 6, pp. 39643–39684, 2018, doi: 10.1109/ACCESS.2018.2854820.
7. M. Z. Chowdhury, Y. M. Jang and Z. J. Haas. **Network Evolution and QoS Provisioning for Integrated Femtocell/Macrocell Networks**, *International Journal of Wireless & Mobile Networks (IJWMN),*vol. 2, no. 3, 2010. https://doi.org/10.5121/ijwmn.2010.2301
8. T. Bai, Y. Wang, Y. Liu and L. Zhang. **A Policy-Based Handover Mechanism between Femtocell and Macrocellfor LTE Based Networks**, *IEEE 13th International Conference on Communication Technology*, pp. 916-920, 2011.
9. C. Lin, K. Sandrasegaran and S.Reeves. **Handover Algorithm with Joint Processing in LTE-Advanced**, *9th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology*,pp. 1–4, 2012.
10. D. P. Rini, S. M. Shamsuddin and S. Yuhaniz.**Particle Swarm Optimization: Technique, System and Challenges**, *International Journal of Computer Applications*, vol. 14, no.1, 2011.
11. O. A. Akande, O. C. Nosiri, A. C. Kemdirim, and O. C. Reginald, "**Implementation of Particle Swarm Optimization Technique for Enhanced Outdoor Network Coverage in Long Term Evolution Network in Port Harcourt, Nigeria**," *Eur. J. Eng. Res. Sci.*, vol. 2, no. 5, p. 36, 2017, doi: 10.24018/ejers.2017.2.5.346.
12. D. Sedighizadehand E. Masehian. **Particle Swarm Optimization Methods, Taxonomy and Applications**, *International Journal of Computer Theory and Engineering*, vol. 1, no. 5, pp. 486–502, 2009. https://doi.org/10.7763/IJCTE.2009.V1.80
13. Maria Zemzami, AichaKoulou, NorelislamElhami, MhamedItmi and Nabil Hmina. **Interoperability Optimization using a modified PSO algorithm**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 2, pp. 101-107, 2019. https://doi.org/10.30534/ijatcse/2019/01822019
14. Nor Azwan Mohamed Kamari, Nur Azzamudin Rahmat and Ismail Musirin. **Optimal Power Scheduling Strategy in Power Systems using Swarm Optimization Technique**, *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 8, no. 1.6, pp. 246-251, 2019. https://doi.org/10.30534/ijatcse/2019/3781.62019
15. 3GPP TS 36.133, 3rd Generation Partnership Project; technical specification group radio access networks; requirements for support of radio source management (Release 8).
16. S. Jindal and A. Sharma, "**An Analysis on Call Admission Control and Particle Swarm Optimisation**," vol. 13, no. 5, pp. 42–48, 2018, doi: 10.9790/2834-1305014248.
17. S. Goudarzi, W. H. Hassan, M. H. Anisi, S. A. Soleymani, and P. Shabanzadeh, "**A novel model on curve fitting and particle swarm optimization for vertical handover in heterogeneous wireless networks**," *Math. Probl. Eng.*, vol. 2015, 2015, doi: 10.1155/2015/620658.
18. Z. Altman, S. Sallem, R. Nasri, B. Sayrac, and M. Clerc, "**Particle swarm optimization for Mobility Load Balancing SON in LTE networks**," *2014 IEEE Wirel. Commun. Netw. Conf. Work. WCNCW 2014*, no. 1, pp. 172–177, 2014, https://doi.org/10.1109/WCNCW.2014.6934881
19. H. Kang *et al.*, "**A new particle swarm optimization algorithm based on local-world evolving network**

model," *2018 IEEE 4th Int. Conf. Comput. Commun. ICCC 2018*, pp. 598–601, 2018, https://doi.org/10.1109/CompComm.2018.8781049

20. Y. Shen *et al.*, "**Research on swarm size of multi-swarm particle swarm optimization algorithm**," *2018 IEEE 4th Int. Conf. Comput. Commun. ICCC 2018*, pp. 2243–2247, 2018, doi: 10.1109/CompComm.2018.8781013.