# Improve the Handover Decision Based on a Kalman Filter and Fuzzy

**Rula Sami Khudhair**
*College of Material's Eng., University of Babylon*
rula.sami@yahoo.com.
**Fatin N. Abdullah**
*Electromechanical Eng. Dept., Univ. Of Technology*
Fatin7@yahoo.com.
**Dhamyaa H. Mohammed**
*Dept. of Computer Eng., Al-Mansour Univ. College*
dhamyaa.husam@yahoo.com.

## Abstract:

The major aim of a Mobile network system is to provide premium Quality of Service (QoS) to the user by an establishment of guaranteed seamless connection between the users. The radio signal strength has been regularly measured from mobile station and BTS in a cellular network. If the BTS detects a decrease in the radio signal, it initiates a handoff request. Many parameters have been effected by the handoff decision. In this paper, a proposed algorithm has been presented to track the mobile location, distance, and velocity by using Kalman filter, while, monitoring the mobile direction, and measure RSS. Then applying the Fuzzy Membership Function of RSS and distance to decide the handoff decision. From the results, it is cleared the advancement in the handoff performance.

**Key-Words**: Handoff, Wireless Network, handover management. Kalman filter, Fuzzy.

**الخلاصة :-**

الهدف الرئيسي لنظام شبكة الجوال هو توفير الخدمة الجيدة (QoS) للمستخدم عن طريق إنشاء اتصال سلس مضمون بين المستخدمين. وقد تم قياس قوة الإشارة اللاسلكية بشكل منتظم من المحطة المتنقلة BTS في الشبكة الخلوية. إذا كشف BTS انخفاض في إشارات الراديو، فإنه يبدأ طلب التسليم. العديد من العوامل تؤثر بقرار التسليم. في هذه الورقة، تم اقتراح خوارزمية لتتبع موقع الهاتف النقال، وبعد المسافة، والسرعة باستخدام مرشح كالمان، في حين رصد اتجاه المحمول، وقياس RSS. ثم تطبيق علاقات Fuzzy من RSS والمسافة للبت في قرار التسليم. من نتائج، تقدم في أداء التسليم بشكل واضح.

**الكلمات المفتاحية:-** عملية التحويل، شبكات لا سلكية، أدارة التسليم، مرشح كالمان، الضبابية.

## 1.Introduction:

The major aim of a Mobile network system is to provide premium Quality of Service (QoS) to the user by an establishment of guaranteed seamless connection between the users ( Patil, 2011; Thamir, 2013). The connection needed when the user is in roaming which represents the hallmark of the mobile phone. Therefore, When the user travels from one cluster to another during a call, the seamless switching processing is much more important for QoS(Thamir, 2013; Yoo, 2010; Zahran, 2011). Where an adjacent cluster use same radio channels, also the call must be switched from busy radio channel to another free one, and the process of handoff(handover) takes place this switching while a call is in progress ( Khan, 2011). In this context, the handoff has been classified into two categories: hard and soft. Hard handoff is described by “break before make” i.e. current calls are released before new one are used. While the Soft handoff is described by “make before break” i.e. both existing and new calls are released before new calls are used during the handoff process[S. A. Mawjoud, 2007]. According to the RSS, the handoff is decided to trigger. Then, for optimum handoff, the distance criterion is also considered (Kim, 2008). If a handoff has been done at the wrong time, the QoS may be dropped below an adequate level, and the connection will be dropped ( Khan, 2011).

In this paper, a proposed algorithm has been presented to track the mobile location, distance, and velocity by using Kalman filter, while, monitoring the mobile

direction, and measure RSS. Then applying the Fuzzy Membership Function of RSS and distance to decide the handoff decision.

## 1.1 Related Work:

In resent year there are many studies about handover decisions, where;( Patil, 2011; Mawjoud, 2007; Sadiq, 2011; Ayyappan, 2010; Halgamuge, 2006) are presented a simple fuzzy control theory concept used for design a vertical handover decision algorithm based on RSS measured with related matrices and the parameters which derived by the FLS. While (Selvan, 2010), is based his criteria on the Mobile Node (MN) which reduces handoff latency in Mobile Networks. In this context, S. G. Yoo, 2010; is focused his work on a predictive handover framework that uses the neighbor network information to generate timely the link triggers so that the required handover procedures can appropriately finish before the current link goes down. The current( Kim, 2008); focuses on a handoff triggering criterion, which uses both the RSS and distance information. While the network selection method is based on the context information such as the dropping probability, blocking probability, GoS (grade of service), and some handoff attempts. ( Yan, 2008); is based his work of a handover decision on the prediction of traveling distance within an IEEE 802.11 wireless local area network (WLAN) cell. Then, this prediction distance is compared with a certain thresholds to minimize the probability of failures or unnecessary handovers from a cellular network to a WLAN. While, Lin, (Selvan , 2010); was proposed a handover algorithm, based on the estimates of the trajectory of the mobile station, to suppress the ping-pong effect in cellular systems.

## 1.2 Call Transformation

The radio signal strength has been regularly measured from mobile station and BTS in a cellular network. The mobile station transmits its measurement's reports continuously to the BTS, and to ensure a good continuity of these reports, must ensure the quality of mobility management ( Zahran, 2011; Selvan, 2010). If the BTS detects a decrease in the RSS, it starts a handover request. The BTS was reported the BSC about the request, then, it is verifies; and transfers the call into a new adjacent cell. Where, the verfication process is included the BSC checks, whether a free radio channel is available or not. If there is, then handoff decision can be satisfied, and the mobile station transfer to a new cell. If there is not, then, it increases the handoff dropping probability of the call. The drawback of this handoff procedure is the fact that the handoff request for a channel is the same as used for new calls since the user can much prefer to block a fresh call rather than to be dropped a call in the middle of transmission ( Khan, 2011)

## 1.3 Handoff Algorithms:

When a mobile station in roaming, a shadow fading and path loss are contributed to a large-scale variation in the (RSS)(Lin, 2005). Then, related to the RSS there are many Handoff algorithms, these are:

- Handoff based on RSS in which the strongest base station (BS) is selected at all time( Kim, 2008).
- Handoff based on RSS with a threshold (T) in which a user handover is executed only if the current signal is sufficiently weak (less than a threshold) and the other is the stronger of the two.

There are two approaches for applied the threshold: level-crossing (static threshold) methods and dynamic threshold methods. The level crossing can reduce the unnecessary handoff processing by calculating the number of level-crossing rates and compare to a certain threshold to decide whether a handoff process needs to be executed .While ,the dynamic threshold methods based on actual quality

measurements, and adopted by 3G cellular systems and future cellular systems ( Huang, 2008).

- Handoff based on RSS with hysteresis (H) in which a user handoff is done if the new BS is sufficiently stronger by hysteresis margin (n) than the current one. This method prevents repeated handoff (Ping-Pong effect).
- Handoff is based on RSS with H and T of serving base station in which the user handover to a new BS occurs only if the current radio signal level drops below a certain threshold and the target BS is stronger than it by a given hysteresis margin.
- Handoff is based on prediction techniques: in which the handoff decision is made on the expected future value of the RSS (Zahran, 2011; Mawjoud, 2007; Selvan, 2010; Stojmenovic, 2002; Ekiz, 2005). Therefore, there are many parameters have been used to support handoff decisions, including; received signal strength (RSS), mobile velocity and direction and the distance between the mobile and BS ( Lin, 2005).

## 1.4 Handoff Decisions Parameters

Many parameters have been effected by the handoff decision, these are;

**a-Received Signal Strength (RSS).**

To express the *RSS* in dBm, a log-linear path loss channel propagation model with shadow fading within WLAN given by(Iwan Kustiawan, 2015):

$$RSS(d) = P_T - L - 10log_{10}(d) + \epsilon \quad (1)$$

where

$P_T$- transmitted power,

$L$ - a constant power loss,

$d$- distance between the mobile terminal (MT) and the Access Point (AP).

$\epsilon$ - Gaussian random variable (zero-mean) with σ (standard deviation; a typical value of 6 to 12 dB) that represents the statistical variation in *RSS*(*d*) caused by shadowing.

**b-Mobile Velocity and Direction.**

To formulate the trajectory of mobile station movement, the Gauss-Markov model is used. Then, the speed and direction are as in equations(Xiaorong, 2016);

$$V_n = \alpha V_{n-1} + (1-\alpha)\overline{V} + \sqrt{(1-\alpha^2)}\,\delta_{n-1} \quad (2)$$

$$\theta_n = \alpha\theta_{n-1} + (1-\alpha)\overline{\theta} + \sqrt{(1-\alpha^2)}\,\gamma_{n-1} \quad (3)$$

Where;

$0 \leq \alpha \leq 1$ - a tuning parameter(for linear motion $\alpha = 1$ ).

$\overline{V}$ and $\overline{\theta}$ - mean speed and direction ($n \to \infty$) , respectively.

$\delta_{n-1}$ and $\gamma_{n-1}$ - uncorrelated Gaussian process with zero means and unit variances.

In this context, the X, Y location of mobile station at time n is;

$$X_n = X_{n-1} + V_{n-1} \times T\cos\theta_{n-1} \quad (4)$$

$$Y_n = Y_{n-1} + V_{n-1} \times T\sin\theta_{n-1} \quad (5)$$

## 2. Proposed Work:

The aim of the proposed algorithm is to improve the QoS by reduced the false or miss handoff. Where the handoff is represented the hallmark parameter in mobile network requirement. Therefore, the proposed algorithm has been designed to satisfy this requirement as shown in figure (1). However, this algorithm is based on four steps, they are;

Step 1: track the mobile location, distance, and velocity by using Kalman filter.

Step 2: monitoring the mobile direction.

Step 3: measure RSS.

Step 4: applying the Fuzzy Membership Function of RSS and distance to decide the HO.

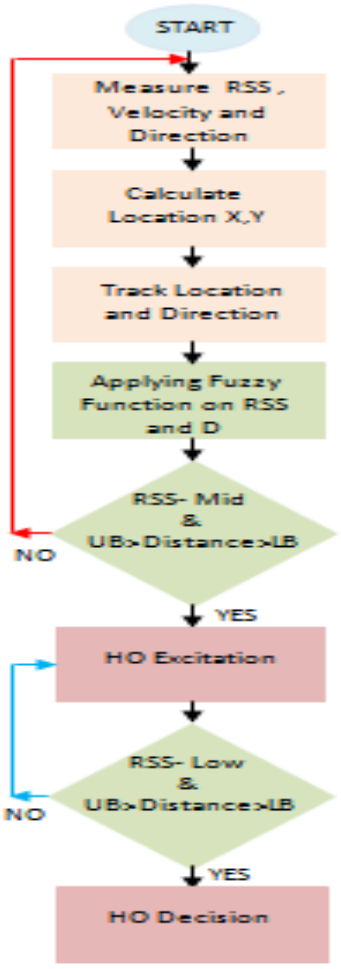



**Figure (1) Proposed algorithm flowchart (UB, LB- upper, lower band, respectively)**

## 2.1 Operation of the Proposed Algorithm*:*

The operation of the proposed algorithm is based on the above four steps. Where, the RSS, velocity and direction of the mobile have been measured, the process began when the mobile reach of the handoff boundary as shown in figure (2). For tracking the mobile the coordinate (X, Y) is calculated and tracked. The distance between the mobile and the station has been calculated also. Then the fuzzy function is applied on the measured RSS and distance as;

*If mid <RSS<high and D> UB then re-measured*
*If low <RSS<mid and LB<D<UB then HO Excitation*
*If RSS≤ low and LB≤D<UB then HO Decision*

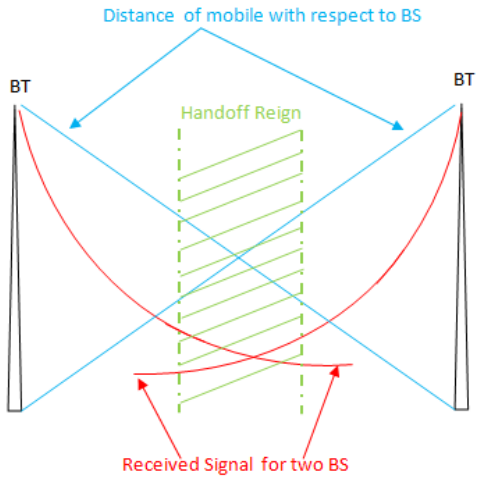



**Figure (2) Handoff reign with RSS and Distance**

## 3. Results and Discussion

At the beginning of the work, there are some assumptions for simulation parameters must be taken into account. These parameters were adopted from(Selvan, 2010; Iwan, 2015), as in table(1).

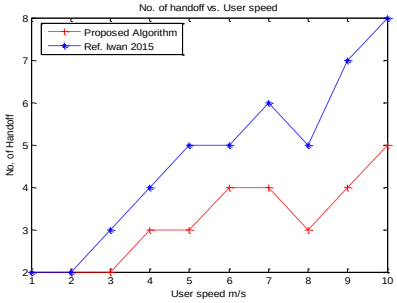
**Table(1 ) Simulation Parameters**

| Parameter | Value |
|---|---|
| $P_T$ | 100mW |
| $L$ | 40 dB |
| $d$ | 20 |
| RSS Threshold | -76 dbm |
| Rx sensitivity | -90 dBm |
| RSS | -95 to -27 dBm |
| Data rate | 0-54 Mbps |
| velocity | 0-3 m/s |
| Traffic load | 0-20 user |

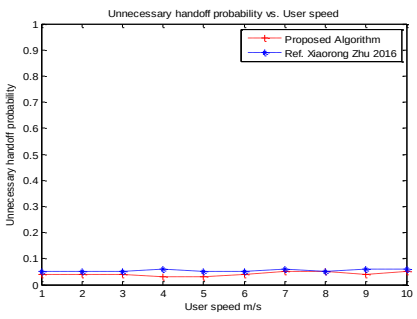
The previous work was used Kalman filter (KF) as channel equalizer to track *RSS*. While, the proposed algorithm has been used KF to track the location of the mobile.

The simulation results, as shown in figures (3), show that the proposed method significantly enhances the handover performance in heterogeneous wireless networks.

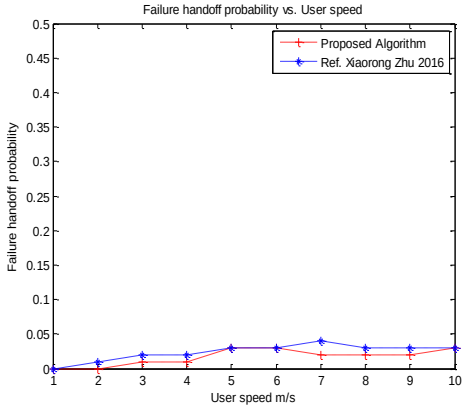
From the results in figure (3), the proposed algorithm has been over-performed the previous work caused by the usage of KF. Where the KF is used previously for tracking the RSS, but RSS is effected by many factors like fading and different path loses factors. While, in the proposed algorithm, it has been used KF to track the location of the user and measure the RSS.




**a)No. of HO vs. User speed**




**b) Unnecessary HO vs. User speed**




**b)Failure HO vs. User speed**

**Figure (3) Handoff vs. User speed**

Therefore, it has been cleared the advancement in the handoff performance as shown in figure (3-a), where the number of required handoff is reduced by 31.9% according to the requirement. In this context, the unnecessary handoff has also been reduced by 3.4% as shown in figure (3-b). This advancement has been tending to reduced the failure of handoff also by 41.6% as in figure (3-c).

## 4.Conclusions:

From the above results, we can conclude, many factors have been effected on the mobile network function. The handoff is represented the major one because it is related to the roaming feature. Therefore, many types of research are working to improve the QoS by improving the handoff. In this work, the advancement has been cleared to other work by tracking the location and measures the direction and RSS of the users. The effect of RSS on the Handoff is related to the selected threshold. Where their effect will be concentrated on the false and miss detection will be studied in feature work. Also, the neural network will be used in feature work to improve the performance of the proposed algorithm.

## 5.References:

Ayyappan K. and Dananjayan P. , 2010 "RSS Measurement For Vertical Handover in Heterogeneous Network", Journal of Theoretical and Application Technology.

Ekiz N., Salih T., Kucukoner S. and Fidanboylu K. , 2005"An Overview of Handoff Techniques in Cellular Networks", World Academy of Science, Eng. And Technology 6.

Halgamuge M. N., Ramamohanatao K., Vu H. L. and Zukerman M. , 2006 "Evaluation of Handoff Algorithms Using a Call Quality Measure with Signal Based Penalties", IEEE Communication Society, WCNC.

Huang C. Y., Ho C. H. and Lin H. L. , 2008"Handoff Management in Cellular System", Bentham Science Pub., Patents in Electrical Eng., 1,225-230.

Iwan Kustiawan; Kuang-Hui Chi, 2015 "Handoff Decision Using a Kalman Filter and Fuzzy Logic in Heterogeneous Wireless Networks", IEEE Communications Letters, Pages: 2258 - 2261, Volume: 14, Issue: 8.

Khan J., Abbas A. and Khan K., 2011 " Cellular Handover Approaches in 2.5G to 5G Technology", International J. of Computer Application (0975-8887), Vol. 21, No. 2, May.

Kim J. S., Serpedin E., Shin D. R., and Qaraqe K., 2008. "Handoff Triggering and Network Selection Algorithms for Load-Balancing Handoff in CDMA-WLAN Integrated Networks", EURASIP Journal on Wireless Communication and Network, ID 136939,

Lin H. P., Juang R. T. and Lin D. B., 2005 "Validation of an Improved Location-Based Handover Algorithm Using GSM Measurement Data", IEEE, Trans. On Mobile Computing, Vol. 4, No. 5, Sep.

Mawjoud S. A. , 2007" Simulation of Handoff Techniques in Mobile Cellular Networks", Al-Rafidain Eng. Journal, Vol.15, No. 4.

Patil C. G. and Kolte M. T., 2011 "An Approach for Optimization of Handoff Algorithm using Fuzzy Logic System", IJCSC, Vol.2, No.1, PP. 113-118 Jan-June.

Sadiq A. S., Bakar K. A., Ghafoor K. Z. and Gonzalez A. J., 2011 "Mobility and Signal Strength-Aware Handover Decision in Mobile IPV6 based Wireless LAN", Procc. Of the international multi-conference of eng. And computer scientists, Vol.1.

Selvan C. and Shanmugalakshmi R., 2010"Performance Analysis of Modern Handoff Technology Provide QoS inMobile Network", IJCSNS, Vol. 10, No. 8, August.

Stojmenovic I., 2002."Handbook of Wireless Networks and Mobile omputing", John Wiley.

Thamir R. Saeed, 2013 "Seamless Handover by Optimal Route to Materialize ABC With Heterogeneous B3GWN", Eng. &Tech. Journal, Vol.31, No.2.

Xiaorong Zhu; Mengrong Li; Wenchao Xia; Hongbo Zhu,2016 "A novel handoff algorithm for hierarchical cellular networks", IEEE Journals & Magazines, China Communications, Pages: 136 – 147, Volume: 13, Issue: 8.

Yan X., Mani N. and Ahmet Y., . 2008 "A Traveling Distance Prediction Based Method to Minimize Unnecessary Handover from Cellular Networks to WLAN", IEEE Communication Letters, Vol. 12, Issue 1, PP 14-16, Jan.

Yoo S. G., Cypher D. and Golmie N. , 2010 "Timely Effective Handover Mechanism in Heterogeneous Wireless Networks", Wireless pers Commun, 449-475.

Zahran A. H., Liang B. and Saleh A., 2006"Signal Threshold Adaptation for Vertical Handoff in Heterogeneous Wireless Networks", Mobile Network and Applications Journal, Vol. 11, Issue 4, Aug.