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Performance evaluation of UE-controlled intelligent handover algorithm for natural disaster

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ABSTRACT

This paper proposes a UE-controlled intelligent handover algorithm for natural disaster. In this handover algorithm, two variables known as modified received signal strength (RSSm) and left over power (LoP) are identified. The RSSm is an improved formulation from RSS where distance fraction coefficient has been introduced. The fraction coefficient of 0.2 is used where the affected areas is reduced so that the users can receive good signal quality due to its location near to the base station. Meanwhile, the LoP also has been investigated to control power consumption of base station. In this research, 80% RSSm and 20% LoP has been chosen for the proposed handover algorithm as it can maintain good quality of service (QoS) for all users and also can prolong battery life. From the simulation results obtained, the average number of handovers for the proposed handover algorithm outperformed the conventional natural disaster handover algorithm.

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1. INTRODUCTION

Natural disaster is an unpredicted event that will disturb the operation of mobile communications. One of critical damage is the dis-function of base stations due to hardware failure [1] and power outage. Although, each base station is equipped with battery backup, it can only last several hours depend on its power consumption [2]. During natural disaster, the affected areas will heavily congested with more users [3] as they need to connect to the base station due to search and rescue operation [4]. When more users connected to the affected base station, more power is needed to operate [5] and automatically battery power will decreases significantly.

The mobile operators need to propose a countermeasure to make sure users in the affected area receive satisfying network quality while prolong battery life of base station [6-7]. If there is no countermeasure taken, the battery life becomes critical, eventually the traffic will becomes congestion, user experience may degrades and rescue operation will becomes difficult. As example, a smartphone-based post-disaster management mechanism in natural-disaster affected areas using WiFi tethering can be use for search and rescue operation. The technique make the smartphones into temporary mobile hotspots and provide internet connectivity to other WiFi-enabled clients during disaster [8]. In addition, in [9], the author adopted device-to-device (D2D) communication to extend cellular coverage during natural disaster by enabling nearby UEs to directly communicate with each other by passing the cellular base stations. This technique can make the UE to serve as a decode-and-forward relay node to communicate with other UEs. It shows the need to have a good quality of mobile communication network although the affected areas has power outage [10].

2. RESEARCH WORKS

Several researchers had proposed various handover algorithms to maintain users' experience. According to [11], handover is defined as a mechanism that transfers an ongoing call from one cell to another as a user moves through the coverage area of a cellular system. If handover does not occur quickly, the QoS may degenerate below an acceptable level [12]. Authors in [13, 14] investigated handover algorithms in LTE high-speed railway networks. The papers focused on optimization of A3 event-based HO algorithms especially for high-speed velocity which the link quality may worsen and the wireless channel environment may become unstable with the increase of velocity. The advantage of the technique is it considers several variables which are reference signal received power (RSRP), reference signal received quality (RSRQ) and the rate of cell resources.

Researchers in [15, 16] proposed handover algorithm with received signal strength that can reduce the number of average handovers per UE per second, shorter total system delay whilst maintaining a higher total system throughput. However, both techniques limit the number of handovers although its improve quality of wireless communication; but for natural disaster scenario, more users are need to connect to base station for the rescue operation purpose. On the other hand, there are several articles focus on load balancing in 3GPP LTE network. Papers in [17, 18] investigated auto-tuning of LTE mobility and self-optimizing networks (SON) algorithms, respectively. In [19], the author proposed Heaviest-First Load Balancing algorithm. The results shown that the technique balance the load in the entire network, however, during natural disaster, unbalance load may occur due to traffic congestion. Meanwhile, author in [20] introduced an energy-centric handover algorithm as handover decision to minimize the power consumption of LTE UE and cell in LTE-femtocell network. However, this technique increased the LTE network signaling.

Author in [21] proposed Limited CoMP Handover Algorithm with joint processing (JP) in CoMP technique to overcome capacity problem for high congested network. Although the system throughput improved, the system delay also increased due to all the packets need to be buffered longer in the queue to get transmitted to all the UEs. Other than that, the author in [22] proposed a radio problem detection based rescue handover for 3G long term evolution (LTE) by adopting radio link failure (RLF) detection mechanism. This technique can decrease the amount of RLFs, hence improving the handover and system performance. However, this technique applies the non-regular simulation scenario instead of the regular macro defined by the 3GPP. Another article in [23] introduced two variables which are UE's distance of motion (DoM) relative to a NeNB and left over power (LoP) of NeNBs as handover decision to maintain the user's QoS during disaster and provided power control for battery backup. However, the technique is complicated as it used angle of divergence (AOD) for determining DoM value.

This paper investigates the continuity of the paper [23] and propose a handover algorithm that use receive signal strength and left over power. Both parameters will be use to compute weighted-average score (WAS) that is use as handover decision to improve signal quality and prolong the battery life by reduces the power consumption. The rest of the paper is organized into six different sections. Section 2 discusses previous related works. Section 3 presents the proposed handover algorithm and Section 4 describes on simulation description. Simulation results and discussion are explained in Section 5 and finally conclusion is drawn in Section 6.

3. PROPOSED HANDOVER ALGORITHM

This section explains detail on the proposed handover algorithm. When an UE is moving away from the serving cell, there are two conditions that will occur which are natural disaster and no natural disaster conditions. The no natural disaster represents scenario which used received signal strength only to handover. On the other hand, the natural disaster condition takes left over power of a base station into account as during the incident, the base station uses battery backup as the area power outage may occur. Hence, the affected base stations need to control its battery power so that users can have satisfied user's experience although in natural disaster condition.

For natural disaster, the WAS value which is the summation of number of users that connected to a base station, the distance value of an UE to the serving base stations and the weight of RSS and LoP is calculated to satisfy $WAS>WAS_{TH}$. When the WAS is greater than the WAS_{TH}, the UE is allowed to progress toward the next step. The value of WAS_{TH} is chosen from the value of WAS with Wrss=0.8 and wlop=0.2 for 100 users because it maintain the QoS of UE and only provides 20% of battery backup, hence more users can connected to the affected base station. In this work, the WAS is based on distance of UE from the serving base station and left over power of base station during natural disasters. The modified WAS for each NeNB can be expressed as:

$$WAS(modified) = S_{LoP}(NeNB_i) \times W_{Lop} + S_{RSS\_modified}(NeNB_i) \times W_{RSS} \quad (1)$$

where $S_{LoP}$is the left over power score of a battery, $S_{RSS_modified}$is RSSmodified score of UE with value of 0.8 (1<d<50), W_{LoP} and W_{RSS} are the weight of LOP and RSS, respectively with value of 80% wRSS and 20% wLOP that means location of UE is near to BS with only small percentage of battery backup in natural disaster incidents. The S_{LoP} can be defined as [23] with N is total of subscribers and n is number of connection to the base station:

$$S_{Lop} = \left[\left(N - \frac{n}{N}\right)\right] \times Ratedpower\ of\ the\ battery \quad (2)$$

In continuity, the handover algorithm decided to check the RSS of the UEs before initiating the handover call to another BS. It must satisfied condition for $RSSm < RSS_{TH}$. If the condition of the handover threshold serving value was not satisfied, the process will return to calculate the new distance of UE and base stations and then calculate the RSS again. Channels will be released once the call is finished and the simulation will be terminated at the end of the simulation times. The RSSm is the modified expression of RSS that can improve the signal strength of an UE. The modified received signal strength ($RSS_{modified}$) in decibel is given by:

$$RSS_{modified} = P_t + G_t + G_r - PL_{modified} \quad (3)$$

where P_t is the transmitted power, G_t is the transmitted antenna gain, G_r is the received antenna gain and $PL_{modified}$ is the modified path loss between the transmitter and the UE. The modified path loss for this work is adopted two-ray path loss and can be defined as:

$$PL_{modified} = 20 \times \log(\alpha \times \frac{d^2}{h_t} \times h_r) \quad (4)$$

where d is the distance between the eNodeB and UE. The h_t and h_r are height of transmitter and UE, respectively. The α is the proposed coefficient namely as distance fraction coefficient. The α of 0.2 is used as the optimal value as it reduces the user's area serving hence giving it much lower path loss value to the system. Hence, it gave the highest RSS value of UE compare to others. Then, the handover will check the availability of channels and bandwidth at the target base station. If $Load < Load_{TH}$, the UE will be connected automatically to the target base station. If the above conditions are not satisfied, the UE will return to the step of checking WAS and RSS measurement again. Under this condition, if the channel at the target traffic load is at maximum, the UE is prepared to initiate the handover to another base station.

For no natural disaster, the handover algorithm decided to check the RSS of the UEs only. If the RSSm<RSSTH, the UE is acceptable for next condition. If the above condition is not satisfied, the UE will then check the traffic load at base station. If the traffic loads condition at the target base station has available channels or bandwidths, the UE will automatically handover to macrocell. If the traffic loads condition at the target base station does not have available channels or bandwidths, the UE then return to the step of checking speed and RSS measurement again. The channels will be released once the call finished and terminated at the end of the simulation times. Table 1 shows the procedure of the proposed handover algorithm.

Table 1. Procedure of the proposed handover algorithm

Steps	Description
Step 1	RSS measurement of UE.
Step 2	Natural disaster incident? If yes, trigger the new handover algorithm for natural disaster. Otherwise, the no natural handover algorithm is used.
Step 3	UE position near target base station? If yes, go to step 4 for natural disaster. For no natural disaster, go to step 5. Otherwise go to step 1.
Step 4	Calculate the value of the criterion function for natural disaster $WAS > WAS_{TH}$. When the triggering condition as shown above is fulfilled for the entire TTT time duration, go to step 5. Otherwise go to step 1.
Step 5	Calculate the value of the criterion function $RSSm < RSS_{TH}$. When the triggering condition as shown above is fulfilled for the entire TTT time duration, go to step 6. Otherwise go to step 1.
Step 6	Available bandwidth? If yes, go to step 7. Otherwise go to step 1.
Step 7	Calculate the value of the criterion function for natural disaster $Load < Load_{TH}$. When the triggering condition as shown above is fulfilled for the entire TTT time duration, handover to target base station.

The system performance of the proposed handover algorithm in natural disaster and no natural disaster are evaluated on the basis of average handover per number of UE based on UE speed [15] and UE movement [24]. According to [25], the transmitter's location is an important factor for the users receive satisfying signal quality. The average handover represents the number of handover occurs during a simulation is expressed as [15]:

$$HO_{avg} = \frac{HO_{Total}}{J \times T} \quad (5)$$

where HO_{avg} is the average handover per UE per second, HO_{Total} is the total number of successful handover from source to target cell while maintaining the on-going data transmission, J is the total number of users and T is total simulation time.

4. SIMULATION DESCRIPTION

For this work, the area was simulated as a homogeneous network with the UE is moving in certain movement throughout the network. As shown in Figure 1, the simulation model was developed using 29 hexagon cells with 29 of macro base station (MBS) and represented by black triangle. The framework was modelled as illustrated in order to see the movement of UE within the network. The radius of MBS deployed was estimated to be in range of 1 km following as the 3GPP specifications in [26] for urban macro network and 20 to 100UEs were generated in this simulation model. In this work, handover decision is based on RSSm and WAS for an UE. The RSSm is the modified expression of RSS that can improve the signal strength of an UE. Meanwhile, the WAS is based on distance of UE from the serving base station and left over power of base station during natural disasters. System parameters used in the simulation are given in Table 2.

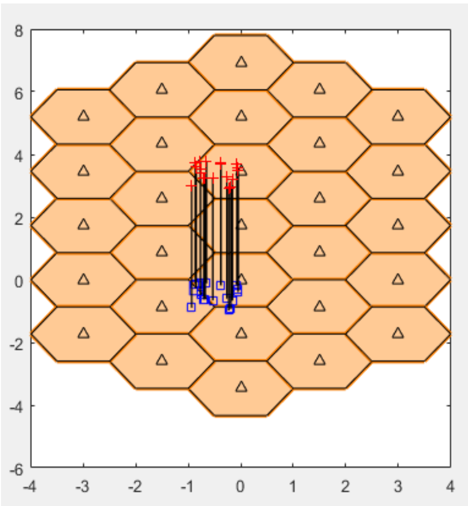

Figure 1. Proposed simulation of handover algorithm

Table 2. Simulation parameters and its value

Parameter	Value
Transmitted power of a BS, P_t	46dBm [27]
Transmitter antenna gain, G_t	15 (dbi) for downlink
Receiver antenna gain, G_r	0 (dbi) for downlink
Distance fraction coefficient, α	0.2
Distance from UE to BS, d	minimum distance 35 m [26]
Transmitter's antenna height, h_t	30m [26]
Receiver's antenna heights, h_r	1.5m [26]
UE speed [km/h]	3, 30, 120 [15]
UE movement	North, South, West, East, South-East, South-West, North-East and North-West
Number of connection, n	20,40,60,80 and 100
Maximum of N connections at any time without any degradation in the QoS, N	100
Modified RSS score for neighboring eNB, $S_{RSS\_modified}(NeNB_i)$	0.8
Weight of lop, W_{LoP}	0.2
Weight of RSS, W_{RSS}	0.8
Threshold Modified RSS, $RSSm_{TH}$	-68dB
Threshold WAS, WAS_{TH}	0.6
Load MBS Threshold, $Load_{TH,MBS}$	90% [28]

5. SIMULATION RESULTS

This section explains the simulation results and its analysis for the proposed handover algorithm between natural disaster and no natural disaster. For no natural disaster, the RSS prediction method will give full weight (i.e., 100%) while LoP not considered at all (i.e., 0% weight). Meanwhile, for natural disaster, the RSS prediction method will give 80% full weight and LoP is 20% weight.

Figure 2 shows an average number of handovers versus number of UEs for proposed handover algorithm in natural disaster and no natural disaster. The number of UE is increases from 20 to 100 with step-size 20. The result demonstrated that the average number of handovers grow larger with the number of UEs for both algorithms. It is because of more handovers take place when there are more users. However, the proposed handover algorithm for natural disaster has higher average number of handovers as compare to no natural disaster because of improvement in received signal strength value. On the other hand, Figure 3 shows an average number of handovers versus UE speed for the proposed handover algorithm in natural disaster and no natural disaster. The number of UE is fixed to 100 UEs with different UE speed which are 3km/h, 30km/h and 120km/h. The result demonstrated that the average number of handovers grow larger with the UE speed for both algorithms. It is because of UE at high speed has faster initiation time take place than low speed. In addition, the proposed algorithm has reduces the ping-pong handovers at high speed due to the improvement of received signal strength value.

Figure 4 shows an average number of handovers versus UE movement for the proposed handover algorithm in natural disaster and no natural disaster. The number of UE is fixed to 100 UEs with different UE movement which are East, West, North, South, South-East, South-West, North-West and North-East. The result demonstrated that the average number of handovers in natural disaster have similar value. It is due to improvement of received signal strength. By comparing average number of handovers with no natural disaster, it has lower value due to poor received signal strength.

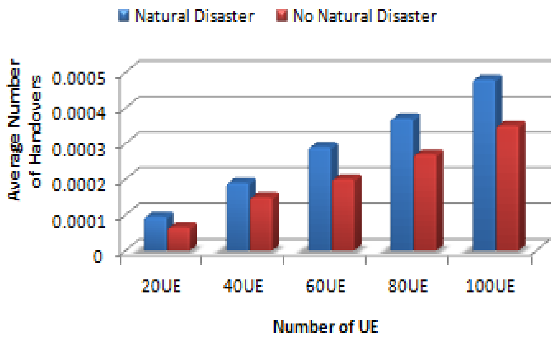

Figure 2. Average number of handovers according to number of UE

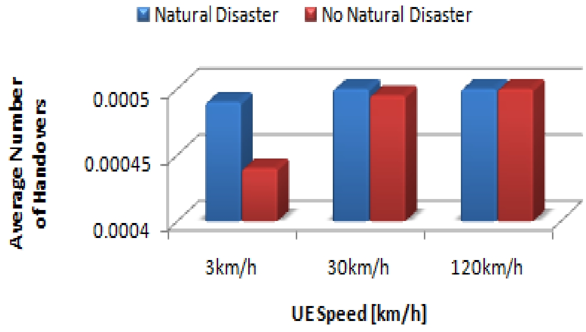

Figure 3.Average number of handovers according to UE speed

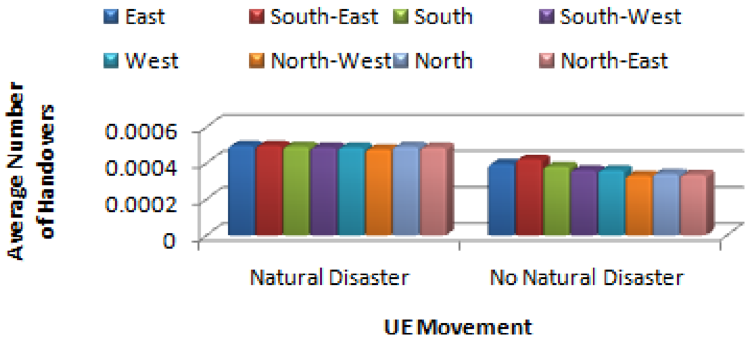

Figure 4. Average number of handovers according to UE movement

6. CONCLUSION

During natural disaster, mobile communications may facing problems such as traffic congestion, power outage and critical hardware failure. This paper proposed a UE-controlled intelligent handover algorithm for natural disaster which incorporated two variables known as RSS and LoP. The 80% RSS and 20% LoP have been chosen for this algorithm as it can provides good quality of signal, together with 20% of battery power usage. From the simulation results of average number of handovers versus number of UE, the proposed handover algorithm outperformed the no natural disaster handover algorithm.

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