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Performance analysis of handover parameter for natural disaster in LTE-a network

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ABSTRACT

Natural disaster is an unpredictable event which can cause service communication disruption. The disruption of service communication can be divided into three cases which are power outage, broken backhaul and physical destruction by disaster. This paper focuses on power outage case. Although each base stations equipped with backup batteries, it only last for several hours. After natural disaster hit certain areas, traffic is highly congested due to panic and rescue operation of lifesaving. This scenario will drain the backup batteries quickly. In order to limit the UEs' connection to the affected base station, this research proposed to adjust Received Signal Strength (RSS) based on parameter called as a distance fraction coefficient, α so that the affected coverage area is reduced when in disaster area situation. The parameter is added in the path loss equation and later in the RSS equation. The numerical results show the RSS improved whereby α=0.2 gives the optimal value and therefore limit the incoming traffic to the affected base station.

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1. INTRODUCTION

Natural disasters (flood, landslide, hurricane, earthquake, tsunami and other) will affect telecommunication sector such as critical hardware equipments were knocked down and service disruption of base stations. Hence, many users in the area will be affected. Due to the natural disaster, there is also power outage which can using only several hours on the backup batteries [1]. It will cause the traffic heavily congested and have critical remaining power to operate.

Previous researchers had studied several issues regarding natural disaster in mobile communication. One of the issues is rescue operations of affected areas. Author in [2] and [3] proposed a navigation system using Device-to-Device (D2D) communications and Global Positioning System (GPS) to rescue a person trapped during disaster. Researchers in [4] developed a method for event detection using mass GPS data provided from mobile phone carriers. By using GPS, it can accurately detect the location however it makes the mobile phone's battery drain faster due to the GPS requires more energy. Another study in [3] proposed in utilizing low cost Raspberry Pi devices with software defined radio network to centralized devices management in areas where no communications especially for natural disaster. Next, in [5], the author presented a novel emergency communication system involving unmanned vehicles that can support humans in the affected area hence significantly reduce their radius of operation. The advantage of this research is using sensor however it does not has priority task. Meanwhile, authors in [6] and [7] proposed using Geographical Information System (GIS) to identify the disasters areas accurately by developing a tool. By using the method, it provides quick response and can be useful for post-earthquake management. It is use as alternative to the GPS. In [8], the author proposed combination of the GIS and Mobile IT-based Android in the form of Geospatial information to encounter disaster. The benefit of the proposed method is an early warning system for large-scale incidents which use social media. The author in [9] proposed a hybrid network architecture that integrates LTE and satellite technologies for public protection and disaster relief (PPDR). It has easy connectivity, extended coverage and high performance guarantees. Authors in [10] and [11] also proposed prediction awareness for minimizing the vulnerability and subsequent losses for ocean and flood disasters. The proposed techniques help to respond quickly, reduce time rate, increase efficiency and effectively post disaster. However, by using above techniques, the data is depends from the nearest base stations to the server, and because of disasters, the methods have limited power supply to operate due to power outage.

The authors in [12] used the social media to collects disaster data. They proposed a big data driven approach for disaster response through sentiment analysis that collects disaster data from social networks and categorize them according to the needs of the affected people using machine learning algorithm. The advantages are it provides help to the victims, can locate exact location for help, for monitoring and maintaining the required inventory to manage the needs of the people in disaster affected area and can be used by the government organizations and rescue personnel in the preparation phase for the upcoming disasters. However, the proposed method has challenges which are difficulty in collecting the disaster related data to build a better sentiment model for disaster analysis and lack of standard crisis data set for accurate evaluation of the needs of the people. On the other hand, author in [13] presented self-organization in disaster-resilient heterogeneous small cell networks which proposed resilient heterogeneous small cell network architecture, self-configuring (power, physical cell ID, and neighbor cell list self-configuration) and self-optimizing (coverage and capacity optimization and mobility robustness optimization). The simulation results show that self-configuration and self-optimization can effectively improve the performance of the deployment and operation of small cell networks in disaster scenarios. It has advantage due to small cell only require low power to operate. However, the method only focuses on small cell.

From the above studies, power supply is a critical issue in rescue operation in disaster areas. Several researchers had proposed various techniques to improve capacity can relieve the over congested Evolved Node Bs (eNBs) (in the affected areas) which are already running low on battery backup power from getting more congested. In [14], the proposed scheme can help to limit the number of new clients connecting to available eNBs, consequently reducing per-eNB load and allowing eNBs to remain alive for longer. The pro of the method is it using Wi-Fi tethering depends on low battery but the con is it using data network if not disturbed. In [15], the author proposed bandwidth allocation of contingency cellular network. It is a smart bandwidth allocation to facilitate prioritized bandwidth sharing will maximize the contribution of contingency cellular network to the disaster response operation. Although its response is quick and efficient, however it has high complexity due to heuristic algorithm. In [16], the authors adopted relay to harvest energy through base station using radio frequency combining with clustering method for energy saving in emergency environment. In addition, in [17], the authors also employed relays using device-to-device communication for disaster recovery in routing protocol. It is proved that this technique has high efficiency in order to extend user coverage when there is network damage failure. The advantage of this method are robust, energy saving and time saving for communication, however it has higher complexity.

Authors in [1] and [18] proposed a technique namely as contingency cellular network. The objective of contingency cellular network is designing a multi-hop network for failure base stations in a break up communication. By doing this, the contingency cellular network can accommodate users capacity. However, this technique requires extensive time to solve. Besides, the other technique proposed to use Wi-Fi connectivity as the backup for the loss connectivity of cellular signal [14]. However, the battery lifetime is still unresolved. In continuity to solve on battery backup, paper [19] and [20] proposed a handover scheme where UE selecting the appropriate base station according to the weighted averaging of scores for each base station based on leftover power of base stations at the emergency area and the users distance of motion relative to a base station parameters. The proposed scheme has benefit whereby the user selects individual scores to the different base stations according to the two parameters, counts the overall weighted averaging of scores for each and lastly chooses the target base station for the handover activity. However, user has to choose among five different direction which is a little complicated. Meanwhile, in [21], the authors proposed a technique to save energy by using software defined network for heterogeneous network in emergency environment. It is use to support victims in disaster situations by adding two new criteria counting energy efficiency and robust heterogeneous communication an software defined network for providing an energy saving in heterogeneous network for victims in emergency environment. The results have confirmed the flexibility and provided small delay of the proposed system. However, the disadvantage of the technique is it using Bluetooth and Wi-Fi which require change of physical interface.

This paper investigates the continuity of the paper [19] and [20] which identify the parameter of distance of motion that can limit the new traffic to the affected base stations and hence, it can prolong the battery backup. The rest of this paper is structured into five sections. Section II explains the distance of motion parameter used. Section III deals with results and discussion and finally conclusion is drawn in Section IV.

2. DISTANCE OF MOTION

To limit the incoming traffic in disaster affected area, the RSS should be adjusted by reducing the distance between users with its serving base station. A distance of motion parameter namely as radius fraction coefficient, α is introduce to the RSS expression for controlling the distance. By multiplying α to the distance, d it can decrease the area covered by the network and hence, reducing the path loss value. The area covered is acceptable because it is able to represent the scenario in natural disaster environment. When area covered reduces, the path loss also reduces. Therefore, the RSS at UE can be improved significantly to accommodate current user at the affected base station. According to [14], [22] and [12], the two-ray path loss (PL) equation [23] is

$$PL = 20 \log (d^2 / ht \times hr) \quad (1)$$

Where d is the distance between user and base station, ht and hr are the transmitter and receiver antenna heights, respectively. In decibel, the RSS is expressed as:

$$RSS\ (dBm) = Pt + Gt + Gr - PL \quad (2)$$

Where Pt is the transmitted power of a base station, Gt and Gr are the transmitter and receiver antenna gains, respectively. From (1), the modified path loss equation is expressed as:

$$PL_{modified} = 20 \log ((\alpha \times d^2) / ht \times hr) \quad (3)$$

In decibel, the modified RSS or called as received power, Pr is expressed as:

$$Pr_{modified}\ (dBm) = Pt + Gt + Gr - PL_{modified} \quad (4)$$

The distance fraction coefficient is set between 0 and 1 ($0 < \alpha < 1$). When $\alpha = 1$, it means the original distance. When α is near to 0, it means area covered by the network is reduced. Thus, the expression of $PL_{modified}$ becomes lower. In order to improve RSS at UE, the value of distance fraction coefficient need to be in a minimum value. Table 1 shows the simulation parameter used.

Table 1. Simulation parameter for α

Parameter	Value
Pt (dbm) in natural disasters	46 dBm [24]
Gt (dbi)	15 (dbi) for downlink [25]
Gr (dbi)	0 (dbi) for downlink
ht	30 m
hr	1.5 m
d	minimum distance 35 m
α	$0 < \alpha < 1$

3. RESULTS AND ANALYSIS

Figure 1 shows graph of RSS versus distance for UE. The result demonstrated that RSS value at UE decreases as the distance increases. The reason behind this result is due to the values of RSS drop when the UE moves away from its serving base station.

Figure 2 shows graph of RSS versus distance of UE from base station with α value {0.2, 0.4, 0.6 and 0.8}. In terms of value α on RSS, the result shows that the SINR for UE using variable distance fraction coefficient have higher values in comparison to without using α. The reason is due to the distance fraction coefficient affects the area covered, hence giving it much lower path loss value to the system. Therefore, it was safely assumed that the distance fraction coefficient increases the value of RSS. Among the distance fraction coefficient values, α=0.2 gives highest value of RSS when compared to others. The reason is due to the α gives the lowest value of area covered compares to others. Table 2 shows RSS values at d=30 for without and with α= {0.2, 0.4, 0.6 and 0.8} for UE. By adding α to original path loss equation, the value of RSS improved as much as 29~212% for UE.

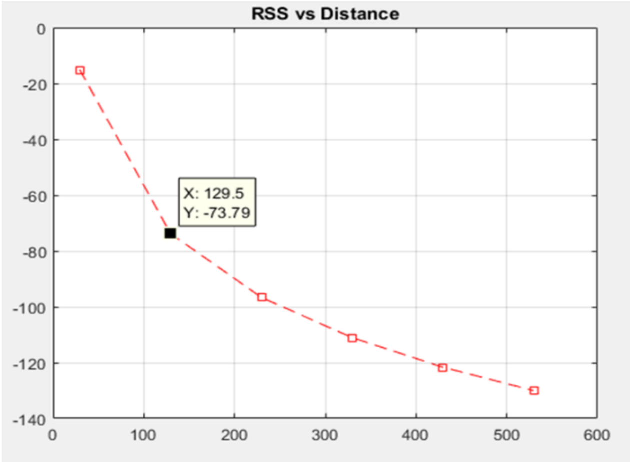

Figure 1. RSS vs distance for UE

Table 2. RSS value with and without α-coefficient

α	Without α	α=0.2	α=0.4	α=0.6	α=0.8
RSS in dBm	-15.13	17.05	3.19	-4.91	-10.67
% Improvement		212.69	121.08	67.54	29.48

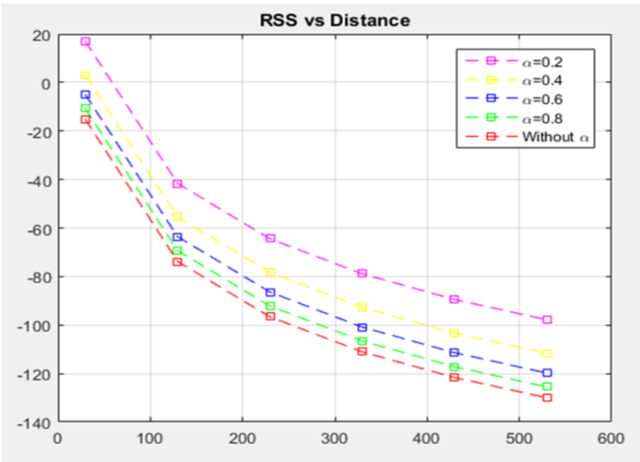

Figure 2. RSS vs distance for UE using α

4. CONCLUSION

In this paper, a distance of motion parameter called as a distance fraction coefficient is proposed in RSS expression in order to limit the UEs' connection to the base station at natural disaster area and hence, prolong the battery backup. By multiplying distance fraction coefficient to the distance, it can decrease the area covered by the network and hence, reducing the path loss value. The modified formulation of path loss equation by adding distance fraction coefficient had improved RSS performance of UEs with distance fraction coefficient of 0.2 gives the optimal value. For future work, the weighted average power will be investigate to self-select suitable target base station.

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