PERFORMANCE EVALUATION OF RELAYS ON RURAL MACRO CELL ENVIRONMENTS FOR LTE-ADVANCED

[1]ABDULJALIL SAIF, [2]MAHAMOD ISMAIL, [3]ROSDIADEE NORDIN, [4]NOR FADZILAH ABDULLAH, [5]MOHAMMED FADHIL

[1,2,3,4,5]Dept. of Electrical, Electronic and System Engineering, UniversitiKebangsaan Malaysia, 43600 UKM Bangi, Selangor Darul Ehsan, MALAYSIA

Abstract - Relay stations (RS) has an essential role in throughput. It makes the rate of data high and improve the coverage of LTE-Advanced. Among the most useful solution to throughput by increasing the rate and coverage is the use of fixed relays (FR)to transfer data among eNB and UE via multi hop communication. The purpose of this paper is to propose a solution of an optimal deployment using various locations and height of antenna relays. This is conducted by implementing and analyzing several scenario including up to 10 relays deploying two cooperative relaying strategies namely: AAF and DAF. Using this method, the data is transmitted between eNBand UE via multi-hop communication over WINNER channel model in Rural microcells of LTE-Advanced networks Environment. To determine the optimal deployment, the number of relays, location, and height of antenna is evaluated at targeted SER or SNR. Findings of simulation indicated that relay substantially increases the link performance compared with direct connection. In addition, the AAF was proven to be better than DAF. Furthermore, the optimal deployment occurred in several stage. First using the 4-8 relays with having relay close to eNB. Second, with 6~8 relays as relays is placed around the celledge. Lastly, with 2~6 relays when relays is placed near the cell edge to extend coverage. The analysis results show that Relay antenna height has improved the performance when increasing the antenna height Relay.

Keywords - Relay Deployment, Height Antenna, WINNER, macro Cell, LTE-Advanced.

I. INTRODUCTION

During the last years, effect Relays were examined generally as a piece of the Long Term Evolution-Advanced (LTE-A) [1]. For the purpose of increasing the coverage, enhance the efficiency of spectrum, speeding the data traffic demand, and increase the efficiency of emergency service model, the use of relay station is vital and can help in improving the user data experience and rate as well as the coverage [2].Network and coverage problems might occur where there is high attenuation between the channel that users use to receive the signal and the sender of the signal (macro-cell). Consequently, increasing the density of the existing rural macro cellcommunity with low-powered RS is anticipated to enhance the performance of customers with reasonable expenditure compared to the major investments needed for deploying new macro site or acquiring lower frequency spectrum. Moreover, one of the limiting elements for small cell deployment is backhaul in view that wired Fiber access is in most instances cost-prohibitive or now not feasible [3].

Based on this fact, the use of relay wireless that deploy LTE spectrum provides a competitive edge against wired backhaul despite the fact that this option has some disadvantage such as the less capacity and shared usage of radio resource [4] [39] [40-46]. Using the RS, distance between eNB and UE is divided into two hos. Figure 1 shows the distribution. This method reduce the path loss existed between eNB and UE. When considering the path loss associated with three different types of radio links: direct link (eNB-UE), relay link (eNB-RS) and access link (RS-UE)[47-49] [5].

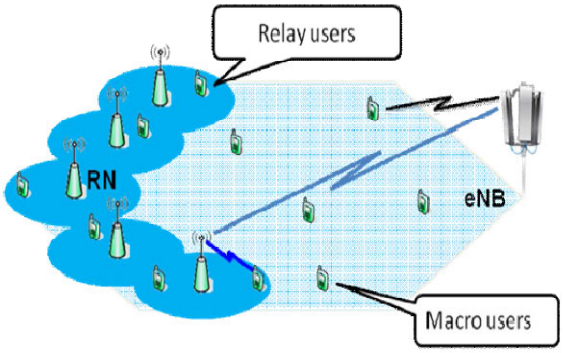

Figure 1:Transmission Links for Relays at Cell Edge on Rural Macro Cell Network

RS Deployment at the edge cell. Relay users are served by RSs, whereas macro users are directly served by the eNB. Such deployments for coverage extension where the cell users are connected to the RSs suffer fromless path loss and benefiting higher resources. The main focus of this paper is the performance of the relay link-based derived from empirical testing of a rural macro scenario. To achieve the objective of this study, an active 4G network was deployed and the main aim is to demonstrate how sensitive relay deployment is when it comes to receiving antenna height, receive relay style and the performance with serval relay locations. This study is different from the study conducted by [7], which used only received signal. This study added the experienced Signal-to-noise-Ratio(SNR),

which describes the effect of interfering neighbouringsites on the performance of the relay link. The measured SNR values are then utilized to estimate the achievabledata-rates over the multi-hop transmission when different relaylocations are considered[8]. This study has deployed 10 RS in different locations from the eNB and different environment of relays.Also,to analyse the effect of the height antenna relay in different heights,we used two protocol relaysto amplify and forward(AAF) and decode and forward (DAF) and analysis for all the scenariosabove under rural micro cell of long-term evolution advanced (LTE-A) .The contribution of this paper is toRadio range extension,Combat shadowing at high radio frequencies, reduce infrastructure deployment costs and admit rapid deployment,enhance capacity in cellular networks, Higher bandwidth due to shorter hops and The Relay-UE links can use unlicensed spectrum than the BS-UE links that should be licensed spectrum. So, we are employing AAF & DAF with different places, different antenna heights and different numbers of relay using WINNER channel model which consider as realty reference for channel model in rural macro cell environment. Also increase signal to noise ratio by deploying relay nodes through 7 scenarios, one scenario without relay and others with one or more relays, apply error correction technique, the convolutional code with Viterbi algorithm to eliminate noise effect or reduce Symbol Error Rate. Optimal deployment Relay by evaluating the number of relays and their locations by analysing the Symbol Error Rate (SER) for a certain range of Signal to Noise Ratio (SNR). For the simplicity of the simulation environment, a number of maximum ten Relays Nodes have been considered in this model.

II. RELAY DEPLOYMENT IN LTE-ADVANCED

Based on the fact that the technology of wireless currently is advanced and users always request high speed connection and coverage, the technology of high data rate and throughput relaying has found its way into the pre standardization things to do as two IEEE 802.16j standard, IST-WINNER project which specifies relaying for the mobile WiMAX (802.16e) structures and LTE-Advanced as a technology. The relay investigation potential enhances coverage and permits greater flexible deployment options at low cost. Recently, the relay work object used to be standard to specify in-band relays (type 1 relays) at least for the coverage-improvement scenario. Therefore, the RSs are deployed at the mobile facet to grant coverage. Two-hop RS deployment is depicted in discern (2). Note that, in view that in-band eNB to RSs are considered relay hyperlink operates in the identical provider frequency as the RS to UE is an get right of entry to link. Cover and El Gamal formulated capacity theorems for an easy relay channel. Multiple-input multiple-output (MIMO) for relay networks are regarded and ability for relay MIMO channels are studied. The relay can be realized both in a cooperative or multi-hop of relay. The cooperative use of relays creates digital transmit range and exploits the spatial separation ensuing in extensive enlarge in the accessible potential [9].

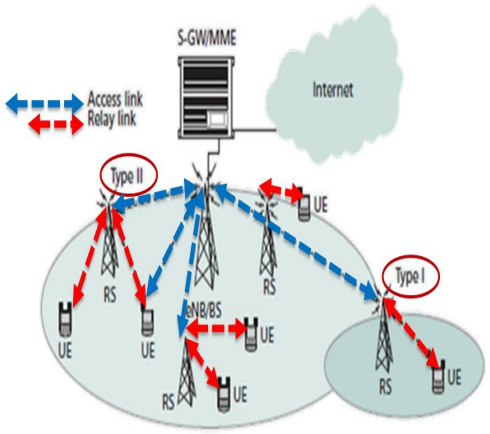

Figure 2: Relay Deployment Type

Figure (3) shows a scenario in which a message is send from the source node to the receiver node using a cooperative relay and directly. The receiving node then combines the signals received from the relay and the source node and can exploit the diversity gain. In addition, multi-hop relaying the source node communicates with the destination node either directly or via a relayas it can'treceive both at the same time. In Figure (3), the most typical benefits of the multi-hop relay is shown in[10].

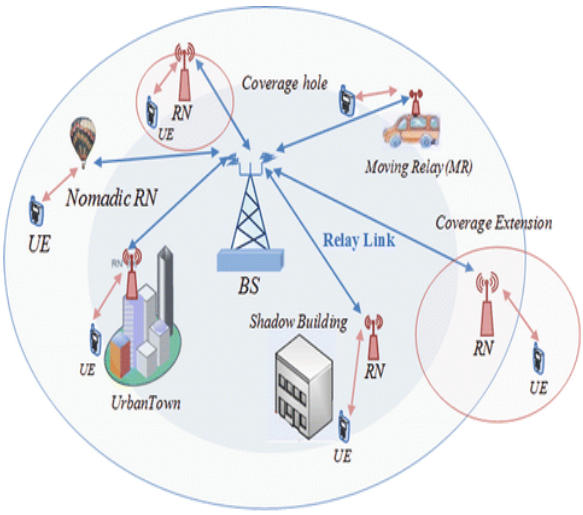

Figure 3: LTE-Advanced relay networks benefits

WINNER Channel Models OF LTE-AdvancedIMT-Advanced channel model is geometry based stochastic channel model. It was proposed for the evaluations for radio interface technologies. The framework of the primary module is based on WINNER II channel model. It ischaracterized by the

bandwidth of 100 MHz with center frequency between 2 and 6 GHz. WINNER channel model is a geometry based stochastic model[11]. Geometry based modeling of the radio channel enables separation of propagation parameters and antennas. The channel parameters for individual snapshots are determined stochastically, based on statistical distributions extracted from channel measurement. Antenna geometries and field patterns can be defined properly by the user of the model. Channel realizations are generated with geometrical principle by summing contributions of rays (plane waves) with specific small scale parameters like delay, power, AoA and AoD. Superposition results to correlation between antenna elements and temporal fading with geometry dependent Doppler spectrum.

Transfer matrix of the channel is [12]:

$$H(t,\tau) = \sum_{m=1}^{m} H_m(t,\tau) \quad (1)$$

It is composed of antenna array response matrices $f_{tx}$for the transmitter, $f_{rx}$for the receiver and the propagation channel response matrix $h_m$for cluster m as follows :

$$H_{u,s,m}(t,\tau) = \iint F_{rx}(\varphi) h_m(t,\tau,\emptyset,\varphi) F_{tx}^{T}(\emptyset) d_{\emptyset} d_{\varphi} \quad (2)$$

The channel from $T_x$antenna element s to $R_x$element u for cluster n is as follows [13]:

$$H_{u,s,m}(t,\tau)(t,\tau) = \sum_{n=1}^{N} \begin{bmatrix} F_{rx,u,V}(\varphi_{m.n}) \\ F_{rx,u,H}(\varphi_{m.n}) \end{bmatrix}^{T} \begin{bmatrix} \alpha_{m,n,VV} & \alpha_{m,n,VH} \\ \alpha_{m,n,HV} & \alpha_{m,n,HH} \end{bmatrix} \begin{bmatrix} F_{tx,s,V}(\emptyset_{m.n}) \\ F_{tx,s,H}(\emptyset_{m.n}) \end{bmatrix} \times e^{\left(j2\pi\lambda_0^{-1}(\overline{\emptyset_{m,n}} \cdot \overline{r_{rx,u}})\right)} e^{\left(j2\pi\lambda_0^{-1}(\overline{\varphi_{m,n}} \cdot \overline{r_{rx,s}})\right)} \times e^{j2\pi v_{m,n} t} \delta(\tau - \tau_{m,n}) \quad (3)$$

Where, $F_{rx,u,V}$ and $F_{rx,u,H}$ are the antenna element u field patterns for vertical and horizontal polarizations respectively. $\alpha_{m,n,VV}$ and $\alpha_{m,n,VH}$, are the complex gains of vertical-to-vertical and horizontal-to-vertical polarizations of ray m,nrespectively ,λ_0 is the wave length of carrier frequency, $\overline{\emptyset_{m,n}}$ is AoD unit vector, $\overline{\varphi_{m,n}}$ is AoA unit vector , $\overline{r_{rx,u}}$ and $\overline{r_{rx,s}}$ are the location vectors of element u and s respectively, $v_{m,n}$is the Doppler frequency component of ray m,n. If the radio channel is modelled as dynamic, all the above mentioned small scale parameters are time variant t.

In OFDM system design, a number of parameters are used such as subcarrier, guard time, symbol duration, subcarrier spacing, modulation type and error correcting code. The choice of parameters depends on bit rate, bandwidth, and delay. FFT/ IFFT which modulates a block of input values onto a number of subcarriers. In the receiver, subcarriers are demodulated by FFT, which perform reverse operation of IFFT. The introduction of a cyclic prefix (CP)and a cyclic prefix remove(CPR)can also insert zero padding as a Guard Interval to reduce interference between the symbols. Also,the coding and interleaving and some successive subcarriers in the OFDM system may suffer from deep fading in which the received SNR is below the required SNR level. There are two types of interleaving: block interleaving and convolution interleaving. Bit-wise, data symbol-wise, or OFDM symbol-wise interleaving can be used for block interleaving. Interleaving type and size must be determined by the type of FEC code, degree of frequency, time fading and delay due to interleaving. Analog to digital converter (ADC), digital to analog converter (DAC) and radio frequency (RF) are shown in [13].

The signal received by Relay Station is given by

$$y_{R,m} = \sum_{n=1}^{N} h_{RM,n} x_{BS,n} + n_{R,m} = h_{RM} x_{BS} + n_{R,m}$$

$$h_{RM} = [h_{RM,1m}\, h_{RM,2m} h_{RM,3m} \dots\dots\dots h_{RM,Nm}]$$

Where

is the 1 ×NRM channel vector (where$h_{RM,Nm}$corresponds to the complex-valued, channel gain between the ntheNB and the RS,which takes into account path loss)

$$x_{BS} = [x_{BS,1}\, x_{BS,1}\, x_{BS,1} \dots\dots\dots x_{BS,N}]^{T}$$

I is the N × 1 vector of thetransmitted signal ($x_{BS,n}$is the signal transmitted by the ntheNB), and nRM,Iis theadditive white Gaussian noise observed at RS. The power of this noise term is $\varepsilon\{ |n_{RM,n}|^2\} = \sigma^2_{RM,n}$ The signal received at the kth UE is a superposition of all the signalstransmitted by eNBs and the RS, which is given by

$$y_{UE,k} = \sum_{n=1}^{N} h_{DL,nk}\, x_{BS,n} + h_{AL,mk}\, G\, y_{RN,m} + n_{UE,k}$$

$$y_{UE,k} = \sum_{n=1}^{N}(h_{DL,nk} + G\, h_{AL,mk} h_{RL,nm})x_n + (G\ \ h_{AL,mk} n_{RN,m} + n_{UE,k})\ k = 1,2,3,\ldots\ldots,K$$

Where $h_{AL,mk}$ corresponds to the complex-valued, channel gain (which includes path loss, shadowing and Rayleigh fading) between the RS and the kth UE, $n_{UE,k}$ is the additive white Gaussian noise with power equals to $\varepsilon\{\ \ |n_{UE,k}|^2\} = \sigma^2_{UE,k}$

AndGis the amplification gain of RS, which is defined as

$$G\ \ = \sqrt{\frac{P_{RN,m}}{\sum_{n=1}^{N} p_{BS,n}|h_{RL,nm}|^2 + \sigma^2_{RN}}} > 1$$

$$P_{RN,m} = \square\{\ \ |G\, y_{RN,m}|^2\} \text{and} P_{BS,n} = \varepsilon\{\ \ |x_{BS,n}|^2\}$$

in Equation (3) are the transmit power of the RS and the ntheNB, respectively. Equation (2) can be expressed as

$$y_{UE,k} = \left(h_{DL,k} + G\, h_{AL,mk} h_{RM}\right)x_{BS} + \tilde{n}$$

Where x_{BS} is similar to the transmitted signal vector of Equation (1), h_{RM} is the RM channel vector as in Equation (1)

$$h_{DL,k} = [\, h_{DL,1k} h_{DL,2k} h_{DL,3k} \ldots\ldots\ldots h_{DL,Nk}]$$

is the 1 ×N DL channel vector($h_{DL,Nk}$corresponds to the complex-valued, channel gain which includes path loss, shadowing and Rayleigh fading) between the ntheNB and the kth UE, and

$$\tilde{n} = G\ \ h_{AL,mk} n_{RN,m} + n_{UE,k}$$

is effective noise term. The power of the effective noise term is

$$\varepsilon\{\ \ |\tilde{n}|^2\} = |G|^2\, |\sigma^2_{RN,m}|^2 + \sigma^2_{UE,k}$$

For K UEs, we can represent the network MIMO channels in the downlink by a system of linear equations as

$$\overbrace{\begin{bmatrix} y_{UE,1} \\ y_{UE,2} \\ \cdot \\ \cdot \\ y_{UE,k} \end{bmatrix}}^{UE} = \overbrace{\begin{bmatrix} h_{DL,1} + G\, h_{AL,m1}\, h_{RM} \\ h_{DL,2} + G\, h_{AL,m2}\, h_{RM} \\ \cdot \\ \cdot \\ h_{DL,k} + G\, h_{AL,mk}\, h_{RM} \end{bmatrix}}^{H} \overbrace{\begin{bmatrix} x_{BS,1} \\ x_{BS,2} \\ \cdot \\ \cdot \\ x_{BS,k} \end{bmatrix}}^{BS} + \overbrace{\begin{bmatrix} G\, h_{AL,m1}\, n_{RN,m} + n_{UE,1} \\ G\, h_{AL,m2}\, n_{RN,m} + n_{UE,2} \\ \cdot \\ \cdot \\ G\, h_{AL,mk}\, n_{RN,m} + n_{UE,k} \end{bmatrix}}^{\tilde{n}}$$

For multiuser transmission and reception, the transmitted signal vector x_{BS} in Equation (5) is generated by a weighted linear combination of data symbols contained in a K × 1Vector

$$d = [d_1\, d_2 \ldots\ldots\ldots d_k]^T$$

where$d_k$is the specific data symbol intended for the kth UE.Thus, the kth UE receives its own symbols as well as the other users symbols[14, 15].

III. PATH LOSS MODELS

The path loss between transmitter and receiver is characterized by path loss exponent, which depends on environment. For free space or rural area its value is 2, for subdural from 2 to 3, for rural its value is about 4. The higher the path loss exponent is, the faster the signal strength drops with increasing the distance. In some more composite environments such as irregular terrain, the path loss exponent is not deterministic. So, some empirical model is used to model the path loss [7]. Path loss models for the various WINNER scenarios have been developed based on the results of measurements carried out within WINNER, as well as results from the open literature. These path loss models are typically of the following form [16].

$$PL = A \log_{10} d + B + C \log_{10} \frac{f_c}{5} + K \qquad (4)$$

Whered in [m] is the distance between the transmitter and the receiver,$f_c$in[GHz] is the system frequency, A the fitting parameter which includes the path-loss exponent. B is the intercept, it is a fixed quantity based on empirical observations. It is determined by the free space path loss to the reference distance and an environment dependent constant. C describes the path loss frequency dependence; K is an optional environment-specific term depends on the scenario.

The models can be applied in the frequency range from 2 – 6 GHz and for different antenna heights. The processing of measuring the values from empirical observation of the variables A,B,C and K of Equation are described in [17].The free-space path loss (PL)_free can be written as follows

$$PL_{free} = 20\log_{10} d + 46.4 + 20\log_{10}\frac{f_c}{5} \quad (5)$$

The path loss models used in different scenarios of WINNER channel model are based on measured data obtained mainly at 2 and 6 GHz. These models have been extended to arbitrary frequencies in the range from 2 – 6 GHz with the aid of the path loss frequency dependencies and the path loss intercept.We will focus on subrural macro cell scenario take in WINNER are briefly discussed below. Propagation scenario D1 represents radio propagation in large areas (radii up to 10 km) with low building density. The height of the AP antenna is typically in the range from 20 to 70 m, which is much higher han the average building height. Consequently, LOS conditions can be expected to exist in most of the coverage area. In case the UE is located inside a building or vehicle, an additional penetration loss is experienced which can possibly be modelled as a (frequency-dependent) constant value. The AP antenna location is fixed in this propagation scenario, and the UE antenna velocity is in the range from 0 to 200 km/h.

In WINNER Phase I, measurements were conducted in a flat rural environment near Oulu in Finland, at both 2.45 and 5.25 GHz, and with an AP antenna height of 18 - 25 m. A channel model derived from these measurements is available and has been reported in [WIND54]. The channel model from Phase I for propagation scenario D1 is generalised for the frequency range 2 – 6 GHz and different BS and MS antenna heights.The path loss equation for the rural macro cell (D1) scenario is in Equation (6, 7 and 8).

$$PL_{BS-RS\,(rural)} = 40.0\log_{10}(d_{BS-RS}[m]) + 10.5 - 18.5\log_{10}(h_{BS}[m]) - 18.5\log_{10}(h_{MS}[m]) + 1.5\log_{10}(f_c\,[GHz]/5.0) \quad (6)$$

$$PL_{RS-MS\,(rural)} = 40.0\log_{10}(d_{RS-MS}[m]) + 10.5 - 18.5\log_{10}(h_{RS}[m]) - 18.5\log_{10}(h_{MS}[m]) + 1.5\log_{10}(f_c\,[GHz]/5.0) \quad (7)$$

h_{BS} = 32 m ;h_{RS} = 20 m; h_{MS} = 1.5 m, σ_{urban} = 6 dB; 50 m <d <10 km .

$d_{BP} = 4\,h_{BS} \times h_{RS} \times h_{MS} \times (f/c)$, where $h_{BS}$$h_{RS}$and h_{MS} are the actual antenna heights.

In the formula, it has been assumed that the effective antenna height is the real height because in rural areas there is macro cell scenario.

It is assumed that the vehicle density is relatively small.Shadow fading standard is 8dB[12, 18] [19] [20] [21] [22] [23] [24].

Where,
h_{BS} is the height of the eNB
$h_{RS}$is the height of the relay station
$h_{MS}$is the height of the mobile station
dis the distance between transmitter and the receiver
c = the velocity of light in vacuum
fc is the carrier frequency
σ= Shadow fading standard deviation

IV. SIMULATION SCENARIOS

The simulation in a network is by a regular hexagonal cellular layout with eNB, RS and UE. Simulation follows the assumption of WINNER II and the down link is simulated andEqualization Minimum Mean Square Error (MMSE),multiplexing techniques Orthogonal Frequency Division multiplexing (OFDM) are used. The parameters of system are summarized below [25] [26] [27]:

Parameter	Value
Carrier frequency	2.5 GHz
Bandwidth	10 MHz
Data modulation	QPSK
PRB bandwidth	180 kHz
Sub carrier(tone) spacing	4.88 kHz
Channel Model used	WINNER II
Transmitter IFFT size	2048
Cyclic prefix	64
eNB Transmit power	46 dBm
eNB Elevation gain	14 dBi
eNB Noise figure	5 dB
eNB Antenna pattern (horizontal)	A(θ) = −min[10(θ/θ3 dB)2, Am] θ3 dB = 70◦ and Am = 23 dB
eNB height	32m
Relay site planning	Considered via higher probability of LOS and 5 dB bonus on NLOS
RS Transmit power	30 dBm
RS numbers	10
RS-UE elevation gain	9 dBi
Relay link antenna pattern (horizontal)	A(θ) = −min[12(θ/θ3 dB)2, Am] θ3 dB = 75◦ and Am = 22 dB
RS Access link antenna pattern	Omni-directional
RS height	15-25m
RS Noise figure	7 dB
UE Maximum transmit power	23 dBm
UE Maximum antenna gain	0 dBi
UE Noise figure	7 dB

UE height	1.5m
Shadow fading	Log-normal
Standard deviation (σ)	6 dB on the direct link 6 dB on the access link 4 dB on the relay link
Detection	Hard Decision
De-correlation distance	50 m
Correlation factor	0.5 between sites 1.0 between sectors
Number of iterations	10^5
Equalization	MMSE

Table 1: Parameters of the System

The locations of the eNB and the UE can be anywhere within rural macro cell,and the distance between eNB and UE will follow WINNER II. We insert a Relay Stations in different locations between eNB and UE, put the relay stations at different heights for relay antenna (5,10,15,20, 25 m), and have different roads between eNB and UE with different environments. Otherwise there may be some situation where the distance between eNB and UE is less than the distance between eNB and RS. If we put the Relay stations in between the eNB and UE, it will be set up randomly.

V. SIMULATION RESULT

Simulations were designed usingMatlab program and WINNERMatlab coded source to insert different propagation environments. we will show and discuss simulation results of both direct signal anddeployment of relays to cooperative diversity networks. We take the symbol error rate (SER) Vs. single Noise Ratio(SNR) to show optimalperformance analysis of both AAF & DAF protocol for LTE-advanced technology inrural macro cell environment by usedifferent number of Relays on different locations and different height antenna of Relays.

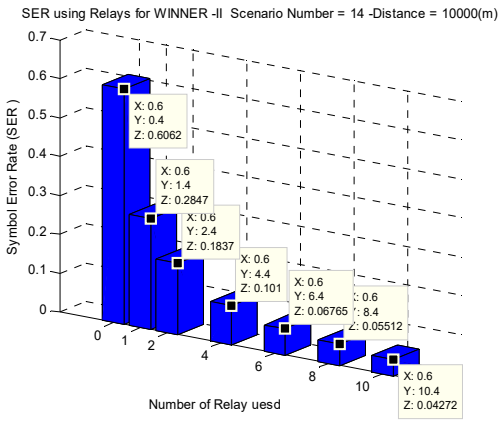

Figure 4 : illustrate the effect employing relay on SER

The figure shows the effect of deploy relays between eNB and UE on enhancing the result of the signal in the destination. It shows the effect of deploy relays Cooperates to give the best performance than that of the single relay cooperation & direct signal. In this case there is a round 35,41,50,58,59 and62%SER improvement is achieved with 1,2,4,6,8,10 relay on sequent and the deploying of ten relays show the best performance.

A. Performance evaluation of number of relays at different locations

The first simulation contains the seven scenarios,one without relay and six with different number of relays (1,2,4,6,8 and 10 relays), it studies the performance evaluation of cooperative relay number in the network performance using AAF and DAF protocol. The effect deployment of number of relays between eNB and UE on enhancing the results of the signal in the destination clearly.Obviously, increasing the number of relays scattered between the eNB and UE operating on the further improvement in performance. But note that the benefit rate improvement at least a certain number of relays which would lead to the futility of increasing the number of relays scattered and this depends on the relay site, and the scenarios used. Environment of rural macro cell of Figure 5 showed deploying relaysused AAF techniquearound the eNBthat the less Bit Error Rate (BER) appears with higher Signal to Noise Ratio (SNR) in all relay scenarios. Also it's noticeable that, without relay scenario exhibits the worst BER, next come with onecooperation relay scenario, then, two, four, six, eight and ten cooperative relays are deployed the results becomes even betterwhen increase number deployment of relays, the average reduction in BER of sixprevious scenario over without relay scenarios is59%, 64%, 70.3%,75.6%, 69.7% and 68.5% respectively. Clearly can used 4~6 relays to enhance the performance to keep the best performance and the cost with reduced infrastructure deployment less than 6 relays. Also figure 6 showed deploying relaysused DAF technique around eNB with the average reduction in BER of six previous scenarios over without relay scenarios is35%, 44%,52.5%,56.7%, 61% and 59% respectively. Clearly in this section can used 6~8 relays to enhance the performance also to keep the cost with reduced infrastructure deployment less than 8 relays .

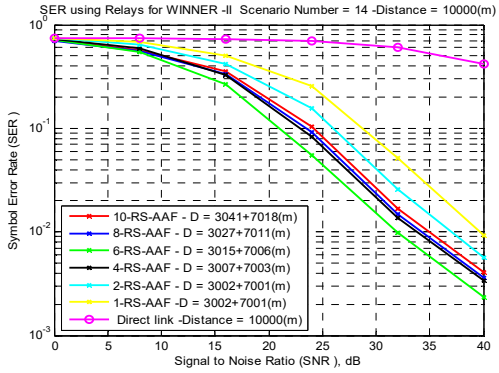

Figure 5:distributing Relays aroundeNB with using AAF

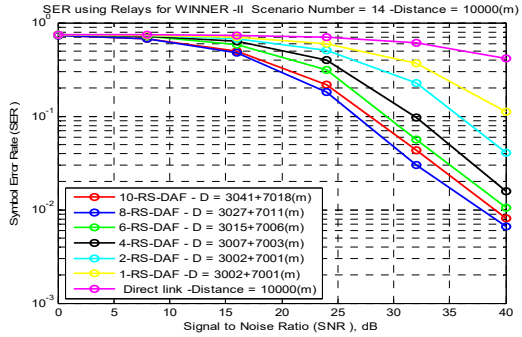

Figure 6: Relays around eNB with using DAF

Figure 7 showeddeploying relays used AAF technique around the cell edge, scenario of without relay has highest BER through varying values of SNR, then cooperative with one scenario, then cooperative with two relay scenarios and so on with four, six, eight and lastly cooperative with ten relayscenarios.The average reduction in BER of cooperative relays scenarios over without relay scenarios as follow: with one relay scenario is more than 57%, with two relay scenarios is 63%, with four relay is 68.5%, with six relay is 72%, with eight relay is 73% and with ten relay is 74.5%. also, in the figure 8 when used DAF technique the average reduction in BER of six previous cooperative relay scenarios is 49%, 54%, 60%, 63.6%,65% and 66.5% respectively.It's clear that by comparing AAF with DAF, the BER in the former achieved with less SNR than that of the later in the sex scenarios. In this section we can used 4~6 relays to get best gain of reduced in SER and solve the problem of signals in the cell edge with Reduce infrastructure deployment costs and admit rapid deployment [28] [29] [30] [31] [32] [33] [34].

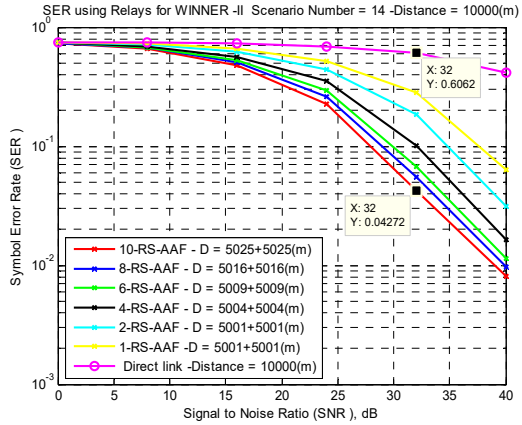

Figure 7: distributingRelays around cell edge with using AAF

When the deployment relays in the cell edge the average reduction in BER of six cooperative relays scenarios over without relay scenario showed in figure 9are 40.5%, 48%, 54%, 58%, 46% and 44.7% respectively with used AAF technique.Also,average reduction in BER of pervious scenario when used DAF technique are 35%, 40.3%, 44.8%, 51%, 44.2% and 35.5% respectively. it's clear that all the relay scenarios perform much better than the without relay scenario and increasing the number of cooperative relays enhance SNR vs. BER but not more than 6 relays .Clearly the best performance at 6 relay used to get on the reduced in BER with 4~6 relays deployed in cell edge to extension coverage and enhanced throughput of the signals .

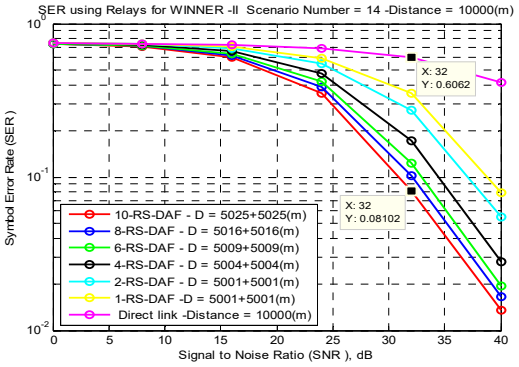

Figure 8: distributing Relays around cell edge with using DAF

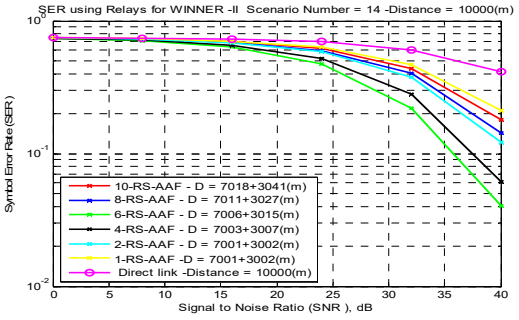

Figure 9:distribute Relays Far from eNBat cell edge with AAF is used

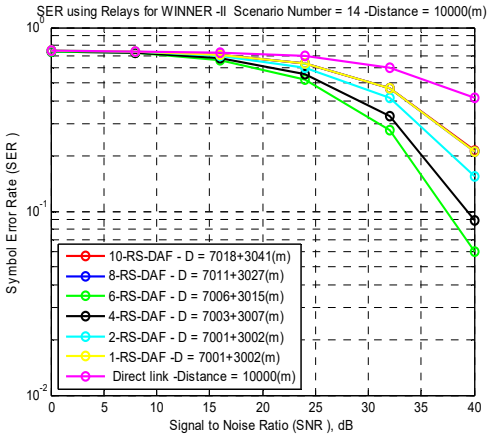

Figure 10: distributing Relays Far from eNB at cell edge with using DAF

In this case, ten relays DAF are used although significant gain is not achieved as compared to AAF but fixed DAF relaying has the advantage over AAF relaying in reducing the effects of additive noise at the relay. It involves the possibility of forwarding erroneously detected signals to the destination if

decoded wrongly causing error propagation that can reduce the performance of the system.

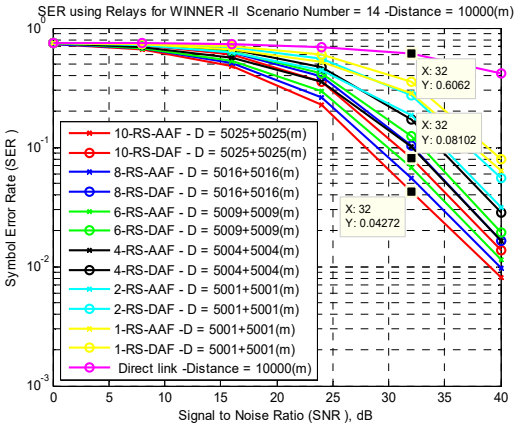

Figure 11: comparing AAF vs. DAF around the cell edge

The figures above(11) show comparison between AAF and DAF scheme when the Relays put in middle locations betweeneNB and UE. The best performance of all environments of distributedRelays Scheme is shown clearly with AAF than DAF.Clearly,find gain is achieved of other deployed Relays scheme of AAF compared to deployed Relays scheme of DAF when Relaysare distributed around cell edge from the eNB.

B. Relay comparison with different antenna height

In this section, the results of analyzing the impact of transceiver Height Antenna for Relays(HAR) in an LTE-Advanced relaying in rural macro cell scenario will be shown. A multi-antenna height of the Relays (5,10,15,20,25 m) measurement campaign was performed in arural macro-cellular environment. The analysis results show that Relay antenna height has improvedthe performance when increasing the antenna height Relay. In order to evaluate this dependence on the antenna heightmore thoroughly, additional measurements and analysis have to be performed when the WINNER models for relaying scenarios were used [35] [36] [37] [38].

Figure 12,13 showed deploying relays used DAF and AAF technique around the cell edge, scenario of Height Antenna for Relays (HAR) 5m has highest BER through varying values of SNR, then HAR10m scenario, then HAR15m scenarios, then HAR 20m scenarios and lastly cooperative with HAR 25m scenarios has lowest BER at all values of SNR. The average reduction in BER of AAF technique in figure 12of HAR 20m scenarios over HAR 25m scenarios is more than 16 %, HAR 15m scenarios over HAR 25m scenarios is 28%, HAR 10m scenarios over HAR 25m is 41%and HAR 5m scenarios over HAR 25m scenarios is 54.5%. Also, in the figure 13 when used DAF technique the average reduction in BER of four previous HAR scenarios is 18%, 26%, 40%, and 51% respectively. clearly the increase HAR produced the reduction in BER and the optimal HAR with 20m and 25m .To comparing AAF with DAF, the BER of AAF in the former achieved with less SNR than that of DAF in the four scenarios.

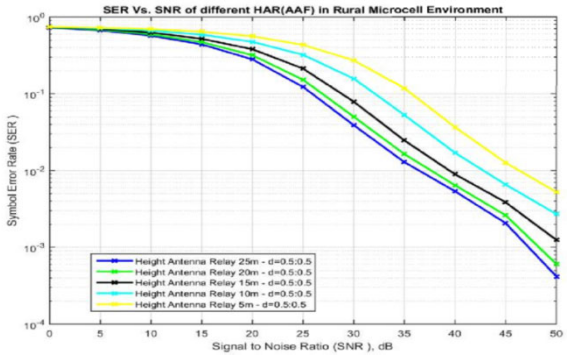

Figure 12: Performance evaluation of different antenna height relays for AAF technique

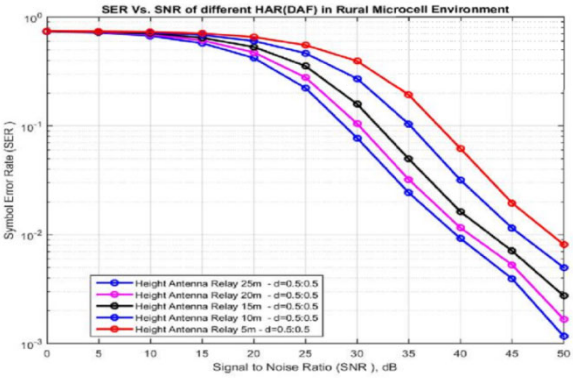

Figure 13: Performance evaluation of different antenna height relays for DAF technique.

VI. CONCLUSION

The main purpose of using LTE-Advanced with Relay is to reduce the operational cost of multi-antenna support and to increase the flexibility of the bandwidth operation. The technology also contributes to increasing the high peak rates and provide higher throughput, coverage, and less latencies which ultimately contribute to improved experiences of users. This study centered around the idea that of testing the optimal relay utilization by conducting various scenario that include up to 10. Mainly, the study used two strategies that are namely: AAF and DAF along with WINNER II channel in rural macro cell scenario in support for the LTE-Advanced. The simulation results showed the optimal performance when deployed less than six relays if relays near toeNB, less than eight relays if relays near to the cell edge, and less than six relays if deployment relays in the cell edge. It is also clearly noted that AAF is better than DAF at all different location of Relay. The analysis shows optimal performance when increasing the antenna height Relay. The more gain is achieved of different antenna height Relay (5, 10, 15, 20, 25 m) sequentially of different locations Relays actually results in the SNR vs BER curve.

REFERENCES

[1] Kong, Q., et al., Achieve Secure Handover Session Key Management via Mobile Relay in LTE-Advanced Networks. IEEE Internet of Things Journal, 2016.

[2] Abdalwahid, M.B., Performance Evaluation of Relayed Enhanced Long Term Evolution Advanced Network Using Decode and Forward Protocol. 2015, Sudan University of Science and Technology.

[3] Rodriguez, I., C. Coletti, and T.B. Sorensen. Evaluation of potential relay locations in a rural macro-cell scenario with applicability to LTE-A. in Vehicular Technology Conference (VTC Spring), 2012 IEEE 75th. 2012. IEEE.

[4] Yuan, Y., LTE-A relay scenarios and evaluation methodology, in LTE-Advanced Relay Technology and Standardization. 2013, Springer. p. 9-38.

[5] Bulakci, Ö., et al., Impact of power control optimization on the system performance of relay based LTE-Advanced heterogeneous networks. Journal of Communications and Networks, 2011. 13(4): p. 345-359.

[6] Bultitude, Y.d.J. and T. Rautiainen, IST-4-027756 WINNER II D1. 1.2 V1. 2 WINNER II Channel Models. 2007, Sept.

[7] Chu, Q.H., J.-M. Conrat, and J.-C. Cousin. Propagation path loss models for LTE-advanced rural relaying systems. in Antennas and Propagation (APSURSI), 2011 IEEE International Symposium on. 2011. IEEE.

[8] Van Nguyen, B. and K. Kim, Performance Analysis of Amplify-and-Forward Systems with Single Relay Selection in Correlated Environments. Sensors, 2016. 16(9): p. 1472.

[9] Abdallah, A., D. Serhal, and K. Fakih. Relaying techniques for LTE-advanced. in European Wireless 2015; 21th European Wireless Conference; Proceedings of. 2015. VDE.

[10] Teyeb, O., et al., Dynamic relaying in 3GPP LTE-Advanced networks. EURASIP Journal on Wireless Communications and Networking, 2009. 2009(1): p. 1.

[11] WINNER, I., Final CG" metropolitan area" description for integration into overall System Concept and assessment of key technologies,". IST-4-027756 WINNER II, www. ist-winner. org/WINNER2-Deliverables.

[12] Kyösti, P., IST-4-027756 WINNER II D1. 1.1 v. 1.0, WINNER II Interim Channel Models. IST-WINNER II, Tech. Rep, 2006.

[13] Gawande, P.D. and S.A. Ladhake, BER PERFORMANCE OF OFDM SYSTEM WITH CYCLIC PREFIX & ZERO PADDING. 1963.

[14] Zetterberg, M.B., et al., IST-2003-507581 WINNER D5. 4 v. 1.4 Final Report on Link Level and System Level Channel Models. 2005, Nov.

[15] Di Renzo, M. and W. Lu, End-to-end error probability and diversity analysis of AF-based dual-hop cooperative relaying in a Poisson field of interferers at the destination. IEEE Transactions on Wireless Communications, 2015. 14(1): p. 15-32.

[16] R1-092820, G., 3GPP R1-092820 Proposal for macro-relay pathloss model based on measurement results. RAN1 #57bis, CMCC, june 2009.

[17] Conrat, J.-M., et al. Path loss model comparison for LTE-Advanced relay backhaul link in rural environment. in The 8th European Conference on Antennas and Propagation (EuCAP 2014). 2014. IEEE.

[18] Yuan, Y., LTE-Advanced relay technology and standardization. 2012: Springer Science & Business Media.

[19] A. Andrawes, R. Nordin, and M. Ismail, "Wireless Energy Harvesting with Cooperative Relaying under the Best Relay Selection Scheme," Energies, vol. 12, no. 5, p. 892, 2019.

[20] I. Shayea et al., "New Weight Function for Adapting Handover Margin Level over Contiguous Carrier Aggregation Deployment Scenarios in LTE-Advanced System," Wirel. Pers. Commun., pp. 1–21.

[21] M. H. Mazlan, E. Ali, A. M. Ramly, R. Nordin, M. Ismail, and A. Sali, "Pilot Decontamination Using Coordinated Wiener Predictor in Massive-MIMO System," IEEE Access, vol. 6, pp. 73180–73190, 2018.

[22] S. Bohanudin, M. Ismail, M. Abdullah, and F. Adlan, "Minimizing Mobile Location Error Based on Hybrid ToA-CTA for Heterogeneous Network," J. Telecommun. Electron. Comput. Eng., vol. 10, no. 3, pp. 97–102, 2018.

[23] N. L. Ismail, M. Kassim, M. Ismail, and R. Mohamad, "A review of low power wide area technology in licensed and unlicensed spectrum for IoT use cases," Bull. Electr. Eng. Informatics, vol. 7, no. 2, pp. 183–190, 2018.

[24] C. Arunachalaperumal, S. Dhilipkumar, and G. Abija, "Enhanced 3D MIMO Channel for Urban Macro Environment," Int. J. Pure Appl. Math., vol. 118, no. 10, pp. 259–269, 2018.

[25] A. Rajesh, "NOMA based Co-operative Relaying under Winner II Channel (B5f) for LTE-A Network," in 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN), 2019, pp. 1–5.

[26] A. H. Kelechi, N. F. Abdullah, R. Nordin, and M. Ismail, "SMART: Coordinated Double-Sided Seal Bid Multiunit First Price Auction Mechanism for Cloud-Based TVWS Secondary Spectrum Market," IEEE Access, vol. 5, pp. 25958–25971, 2017.

[27] W. A. Jabbar, W. K. Saad, and M. Ismail, "MEQSA-OLSRv2: A Multicriteria-Based Hybrid Multipath Protocol for Energy-Efficient and QoS-Aware Data Routing in MANET-WSN Convergence Scenarios of IoT," IEEE Access, vol. 6, pp. 76546–76572, 2018.

[28] N. Yoza-Mitsuishi and R. Sun, "Path Loss Characterization of 7-GHz Terrestrial Propagation Channel in Urban Environment," in 2019 IEEE 90th Vehicular Technology Conference (VTC2019-Fall), 2019, pp. 1–5.

[29] D. Wang, R. R. Sattiraju, and H. D. Schotten, "Performances of C-V2X Communication on Highway under Varying Channel Propagation Models," in 2018 10th International Conference on Communications, Circuits and Systems (ICCCAS), 2018, pp. 305–309.

[30] E. Ali, M. Ismail, R. Nordin, and N. F. Abdulah, "Beamforming with 2D-AOA estimation for pilot contamination reduction in massive MIMO," Telecommun. Syst., vol. 71, no. 4, pp. 541–552, 2019.

[31] S. Alaaraj, Z. A. Mohamed, and U. S. Ahmad Bustamam, "External Growth Strategies and Organizational Performance in Emerging Markets: The Mediating Role of Inter-Organizational Trust," Rev. Int. Bus. Strateg., vol. 28, no. 2, pp. 206–222, 2018.

[32] M. Fadhil, N. F. Abdullah, M. Ismail, R. Nordin, C. Ciftlikli, and M. Al-Obaidi, "Maximizing signal to leakage ratios in MIMO BCH cooperative beamforming scheme.," Int. J. Electr. Comput. Eng., vol. 9, 2019.

[33] A. Saif, M. Ismail, R. Nordin, M. Fadhil, and N. F. Abdullah, "Optimal deployment of locations and Height Antenna for relays on macro cell environments for LTE-Advanced," J. Eng. Appl. Sci., vol. 13, no. 16, pp. 6883–6893, 2018.

[34] M. Fadhil, N. F. Abdullah, M. Ismail, R. Nordin, A. Saif, and M. Al-Obaidi, "Power Allocation in Cooperative NOMA MU-MIMO Beamforming Based on Maximal SLR Precoding for 5G," J. Commun., vol. 14, no. 8, pp. 676–683, 2019.

[35] N. Ferdous, G. C. Hock, S. H. A. Hamid, M. N. A. Raman, T. S. Kiong, and M. Ismail, "Design of a Small Patch Antenna at 3.5 GHZ for 5g Application," in IOP Conference Series: Earth and Environmental Science, 2019, vol. 268, no. 1, p. 12152.

[36] T. Yuwono, M. Ismail, and I. Hajar, "Design of Massive MIMO for 5G 28 GHZ," in 2019 2nd International Conference on Computer Applications & Information Security (ICCAIS), 2019, pp. 1–4.

[37] S. Alaarj, Z. Abidin-Mohamed, and U. S. B. A. Bustamam, "Mediating Role of Trust on the Effects of Knowledge Management Capabilities on Organizational Performance," Procedia - Soc. Behav. Sci., 2016.

[38] S. Alaarj, Z. Abidin-Mohamed, and U. S. A. Bustamam, "The Mediating Role of Inter-Organizational Trust between External Growth Strategies and Organizational Performance of Malaysian Companies," Adv. Glob. Bus. Res., vol. 13, no. 1, p. 26, 2016.

[39] E. Ali, N. F. Abdullah, M. Ismail, R. Nordin, M. H. Mahzan, and M. Balfaqih, "2D-AOA Estimation and Tilt Angle

Adaptation for 3D Beamforming Interference Reduction in Massive MIMO," in 2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring), 2019, pp. 1–5.

[40] S. Alaaraj, "Knowledge Management Capability , Trust , and Performance of Manufacturing Companies in Emerging Economies," Int. J. Manag. Appl. Sci., vol. 4, no. 8, pp. 45–53, 2018.

[41] M. Behjati, M. H. Mazlan, A. M. Ramly, R. Nordin, and M. Ismail, "What is the Value of Limited Feedback for Next Generation of Cellular Systems?," Wirel. Pers. Commun., pp. 1–16.

[42] A. Andrawes, R. Nordin, and N. F. Abdullah, "Energy-Efficient Downlink for Non-Orthogonal Multiple Access with SWIPT under Constrained Throughput," Energies, vol. 13, no. 1, p. 107, 2020.

[43] M. Behjati, J. S. Mandeep, M. Ismail, and R. Nordin, "Investigation of accuracy of rain-rate and rain-attenuation prediction models in satellite communications based on meteorological skills."

[44] S. Alaarj, Z. A. Mohamed, and U. S. A. Bustamam, "The Effect of Knowledge Management Capabilities on Performance of Companies : A Study of Service Sector," Int. J. Econ. Res., vol. 14, no. 15, pp. 457–470, 2017.

[45] M. I. Abduljalil Saif, R. Nordin, M. Fadhil, and N. F. Abdullah, "Optimal Deployment of Locations and Height Antenna for Relays on," J. Eng. Appl. Sci., vol. 13, no. 16, pp. 6883–6893, 2018.

[46] Z. Farid, R. Nordin, and M. Ismail, "Recent advances in wireless indoor localization techniques and system," J. Comput. Networks Commun., vol. 2013, 2013.

[47] A. H. Kelechi, R. Nordin, and M. Ismail, "Spectrum Sharing Etiquette Considering Primary User Activity Pattern in Dynamic TVWS via Cournot Game Theory," Wirel. Pers. Commun., vol. 91, no. 1, pp. 463–485, 2016.

[48] S. Alaaraj, "Knowledge Management Capability , Trust , and Performance of Manufacturing Companies in Emerging Economies," Int. J. Manag. Appl. Sci., vol. 4, no. 8, pp. 45–53, 2018.

[49] S. Alaarj, Z. Abidin-Mohamed, and U. S. A. Bustamam, "The Mediating Role of Inter-Organizational Trust between External Growth Strategies and Organizational Performance of Malaysian Companies," Adv. Glob. Bus. Res., vol. 13, no. 1, p. 26, 2016.

[50] S. Alaaraj, "Knowledge Management Capability , Trust , and Performance of Manufacturing Companies in Emerging Economies,"Proceedings of 177 th The IIER International Conference, Istanbul, Turkey, pp. 1-9, 2018.

[51] A. Saif, M. Ismail, R. Nordin, M. Fadhil, and N. F. Abdullah, "Performance Optimal for Deploying Relays in Urban Micro Cells on LTE-Advanced Technology," Int. J. Innov. Technol. Explor. Eng., vol. 9, no. 3, pp. 2145–2155, 2020.

★★★