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Power consumption based on the Homogeneous Cellular architecture

Sivachandran.V[1], Dr.M.Malleswaran[2]
[1]Full Time Research Scholar, Anna University Chennai
[2]Associate Professor and Head of the Department, University College of Engineering Kancheepuram.
Corresponding Auther: Sivachandran.V

ABSTRACT
Telecommunication industry has burgeoning day by day, as the same time power required to run the base station also increases. As many countries had decided to shut down all the nuclear power reactors. Now energy efficiency has become a critical issue. Base stations (BS) account for a significant portion of energy budget in a cellular network. Traditional saving techniques switch some BS off completely during light loads in order to save energy. This creates a problem for backhaul network and also has a high probability of quickly returning to full capacity when demand increases. In this paper we propose a novel technique can cell zooming to reduce energy consumption at base station using adaptive greedy algorithm. With cell zooming, BS will dynamically adjust their coverage radius and hence the transmit power based on the user location. The transmit power is set to the minimum required level depending on the user location and Signal to Interference plus Noise Ratio (SINR) required. With the help of Reference Signal Received Power (RSRP) and Reference Signal Received Quality (RSRQ) can able to determine the conditions to achieve efficient usage of traffic in terms of link failure and delay. Our aim is to ameliorate the value of SINR and minimize the power consumption.

KEYWORDS: Energy consumption, Low traffic, Link Failure, Homogeneous Cellular

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I. INTRODUCTION

In communication system especially while considering the physical layer are mainly concerned with the signal to noise ratio. However, when we look at a system with multipath users or multiple transmissions going on simultaneously then usually we need to reuse the radio resource. This reused radio resources causes' co-channel interference to the undesired user. Cellular system offers the carrier frequency is reused in order to increase the capacity. So, while one transmitter uses a frequency the other transmitter physically away from the first. The transmitter is assigned to the same frequency for transmitting the information to the target. In cellular communication the carrier frequency is reused to support high number of users. Reuse of frequency means that the same frequency may be used simultaneously in two different cells for supporting two different active users at the same time. As a result of simultaneous transmission on the same carrier frequency interference occurs. The Base station division mechanism significantly reduces the power consumption of a base station to a considerable extent. By implementing greedy algorithm, the link failure can be minimized comparatively [1]. The performance of any mobile communication system depends upon the quality of the received signal at User Equipment (UE). The various components like microscopic path loss, shadowing, multipath fading, different types of interfering signals and receiver sensitivity in order to determine the strength of the received signal at UE and hence overall throughput of the network [2]. The mobility affects the signal strength at the UE. The SINR of a system depends on the quality of signal at the UE. The value of SINR used to calculate the Channel Quality Indicator value (CQI) which is feedback by the UE. Depending on the CQI value appropriate MCs is selected by node and system performance can be improved [3]. The typical cell planning mechanism currently in practice is to set cell size according to the estimated traffic load measured at peak time. However, while the static cell planning is simple to operate, it may lead to poor performance when the traffic patterns do not conform to the estimation. In this regard the instability in different mobile network absorbs different pollution level in case of Long Term Evolution (LTE). The cells in radio communication network are offloaded if they persist over loading of data signals or signals in BS through the changing the size of the cells. This proper mechanism of loading and unloading the cell is called cell breathing technique. This will reduce the level of signal loss in mobile radio environment.

II. LITERATURE SURVEY

Xiangnan Weng et.al(2011)[2] modulated a framework for energy efficient enhancement under insufficient cell zooming condition by introducing a new parameter for traffic estimation, which is low traffic time ratio. Two feasible solutions were suggested to produce an outcome to increase the coverage extension technologies. Cell zooming ratio is reaching sufficient for certain switching off schemes and further proposed cell zooming technique for increasing the cell coverage in order to overcome the drawbacks in cell splitting techniques. The authors analyzed Direct Transmission (DT) techniques for overcome the limitations in outage probability. This reduced the higher cell radius using flow level dynamics.

Zhisheng Niu et.al(2010)[4] developed centralized and distributive algorithm to adjust the cell size according to the traffic load without detriment to performance. The concept of cell zooming is introduced, which adaptively adjusts the cell size according to the traffic load. Further developed cell zooming technology for reducing the size of cell based on the level of traffic load and channel dependencies. The critical issues in cell zooming techniques were analyzed by varying the size of cell in each mobile radio environments.

A case study is conducted by Margot Deruyck et.al (2010)[1] to compare the wireless access networks with other access network technologies. The power consumption for mobile WiMAX, fixed WiMAX and UMTS is modeled. The power consumption for the network is evaluated in relation to the coverage.

Dimitrios Tsilimantos et al. (2016)[6] developed the optimal radio resource allocation methodology for reducing the power consumption and utilization of bandwidth. This proposed work was used in cellular network which was the orthogonal architecture. The authors analyzed the architecture of cell for implementing various levels of traffic patterns in cell environment. Zhaoxu Wang et al. (2014) [7] proposed separation architecture methodology for radio resource channels to reduce the geographic area coverage. The authors analyzed different types if network traffic on different area coverage to validate the resource availability. The authors replaced existing base station system with light weight coverage base station. It was also incorporated with multiple traffic base stations. The energy consumption was reduced using these kind of base stations in radio resource channels.

Kemal Davaslioglu et al. (2014) [5] analyzed the sources which were used for mobile radio network environments. The authors described the impact of carbon footprint on radio networks with multiple channel environments. The authors found that there was a linear relationship between the number of base stations and Carbon footprint in mobile radio environment. The number of base stations increased the level of carbon footprint. The higher level of communication protocol layers were verified with respect to different layers. The authors analyzed the energy consumption problems in different ranges of base stations.

Son et al. (2011)[10] analyzed the higher level dynamic system for mobile radio channel environment.

Marsan et al. (2009)[8] analyzed deterministic traffic conditions with respect to various level of radio channels environment. Chiaraviglio et al. (2008) utilized the energy optimizing algorithms by proposing BS switching methodologies. L. Chiaraviglio, D. Ciullo et al. (2008)[9] a dynamic planning mechanism is adopted in which reduces the number of active base stations when the traffic is low also analyses link budget, propagation exposure constraints. Yong-Hoon Choi et al. (2015) [11] analyzed and estimated the overall CO_2 emission based on different traffic patterns and suggested a solution to implement adaptive cell zooming mechanism to achieve energy consumption.

III. PROPOSED METHODOLOGY

The minimum power consumption of the base station can be achieved under the following criteria.

The minimum power consumption could be estimated at both the transmitter as well as receiver end.

SINR is the measure of signal quality used by operator to quantify the relationship between the RF conditions and throughput. Based on the two parameters RSRQ and RSRP the performance of traffic base station is calculated.

The BS can be either turned OFF or ON based on the following algorithm.

Step1: Determine the number of voice calls on BS using the following equation,

$$V = \frac{C_1}{C} \times b$$

Whereas, C is the total channel capacity of the BS and C_1 is the number of users occupying the channel in BS.

Step 2: Find the Cell load factor (L) using the determined number of voice calls as stated below,

$$L = 0.6 \times V + 0.2$$

Step 3: Determine the minimum power consumption (P_{min}) of the BS during the data transmission and reception.

The minimum power consumption is based on the consumption of power in BS during both the data transmission and reception.

(a) Determination of Minimum Power consumption during transmission $P_{\min(t)}$

The power consumption of the transmitted signal for the particular user S_i can be expressed as,

$$P_{S_i} = \sqrt{P_t} \times S_i$$

Whereas, P_t is the transmission power and it is assumed to be unique for all the data transmission through the BS. S_i is the number of bits to be transmitted by a single user and the number of users on BS is assumed to be 100 in this paper. Hence the value of 'i' numerically varies from 1 to 100.

Figure 1: Base station switching methodology

The high traffic BS suffers the link failure due to its overloaded traffic in BS, which increases the energy consumption.

The flow of proposed BS switching methodology is shown in Figure 1, which measures traffic level and switch the BS mode based on the estimated traffic on BS.

The minimum power consumption can be choosing from this equation as $P_{\min(t)}$.

(b) Determination of Minimum Power consumption during reception $P_{\min(r)}$

The power consumption of the received signal for the particular user R_i can be expressed as,

$$P_{R_i} = \sqrt{P_r} \times R_i$$

Whereas, P_r is the received power which is to be unique for all the signals in receiving mode of BS.

The minimum power consumption can be choosing from this equation as $P_{\min(r)}$.

The overall minimum power consumption of the BS can be computed as,

$$P_{min} = \frac{P_{\min(t)} + P_{\min(r)}}{2}$$

Step 4: Find Sleeping factor (S) of the BS using the following equation as,

$$S = L \times P_{min}$$

Step 5: The sleeping mode of the BS will be activated and further handover is turned ON if and only if it satisfies the following condition as,

$S < S_t$

Else Active mode of BS is still continued till the above condition is achieved.

The flow of the BS switching procedure is described in Algorithm1.

Algorithm1: Criteria to switch-off BS

Inputs: total channel capacity of the BS (C1), number of users occupying the channel in BS C

Output: Sleeping factor (S)

Start

Find number of voice calls (V) in BS

Compute Cell load factor (L) using V.

Calculate minimum power consumption (P_{min}) on BS.

Find Sleeping factor (S) using P_{min}
Check condition $S < S_t$
Condition satisfied
Mode: **Sleeping mode**
Else
Mode: **Active mode**
End

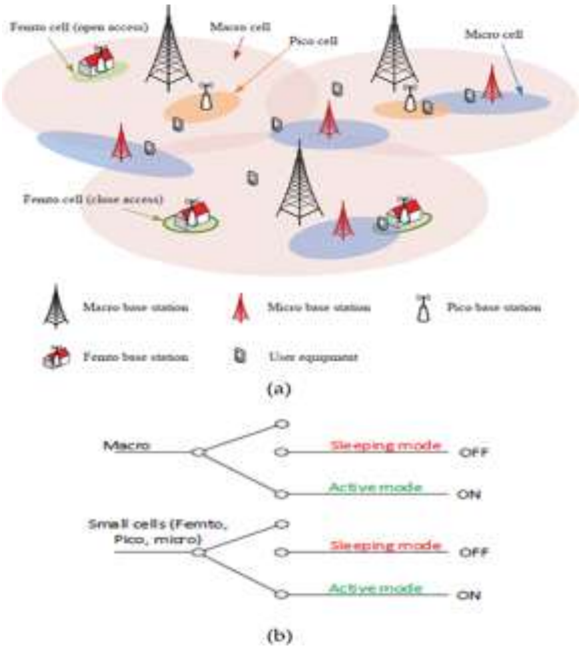


Figure 2: Illustration of homogeneous network and representation of sleeping mode and active mode of based station based on above algorithm.

The illustration framework show in Figure 2 defines how the base station switching happens according to the load. The algorithm works based on the condition $S<S_t$ once the condition satisfied it will go to sleep mode else it will be in active mode. The switching representation is shown in figure 2(b). The coverage metrics is represented on figure 2(a).

IV. SINR CALCULATIONS

Our Aim is to minimize the total power consumption and maximize the SINR at the same time. A 3gpp specification does not support SINR to network.SINR is internally measured by most UEs and recorded by drive test tools.SINR can also be calculated from RSRQ value which in turn is calculated from RSRP,RSSI(Reference Signal Strength Indicator) and N_{prb}(Number of physical resource block)

$$SINR = \frac{S}{1 + N}$$

S indicates the power measured usable signals Reference Signal (RS) and physical downlink shared channels. Indicate the average interference power, the power of measured signals or channel interference signal from the other cells in the current system. N indicates background noise, which is related to the measurement of bandwidth and receiver noise coefficients.

SINR and Power Characteristics

Our aim to ensure the high value of SINR and lower the power consumption as an output of better performance of the system. It is an arduous task to reduce the power utilization and improve the SINR value at the same time. An approach to estimate the transmission power with respect to receiver in order to meet necessity. Consider a system with no noise and estimate the output with thermal noise. Finally, an optimal solution suggested improving the performance of the system when the unauthorized usage of bandwidth that creates problem in the call connectivity.

Assume there are M transmitting nodes and L receiving nodes and at any given time node I transmits m_i packets at power q_i per packet to the receiving node c_i(the routing is assumed to be already determined). The mean channel gain experienced between each transmitter and receiver by M×L matrix Γ, which includes radio attenuation effects due to distance, shadowing and fading. Thus, the received signal power for transmitter *i* at receiving node c_i is $q_i\Gamma[i,c_i]$. The total interference power is modeled as the sum of power of all active interference. Then SIR of single user associated with link $[i,c_i]$ is

$$SIR_i = \frac{q_i\Gamma[i,c_i}{\sum_{j \neq i} m_i q_j q_i\Gamma[i,c_i] + (m_i - 1) q_i \Gamma[i,c_i]}$$

Note that we include the other m_i-1 packets on the same link as interference, while it would seem pessimistic since orthogonal codes could be used to remove the interference, in general the effects of multipath may severely reduce orthogonally. Furthermore, we have not assumed any multiuser detection capability at the receiver. Therefore, m_i-1 interfering packets is a worst-case assumption.

For successful communication there exists a threshold value that the SIR must exceed in order to support each user's required data rate R_i. For a CDMA system, the SIR is usually quite small due to processing gain and powerful coding. To make the role processing gain G more explicit we can use the relationship $SIN=E_b/I_0(\zeta W/R)^{-1}$,$E_b$ is the energy per bit.I_0 is the interference power, ζ is the constant of order quantity which depends on the cross correlation properties of the spread spectrum codes (assumed to be one hereafter), and W is the overall available bandwidth. G_i is the processing gain experienced by the user on link $[i,c_i]$ and $ɣ_i$ is the threshold. Here we assume that each user generates the same traffic and has the same requirements R (and therefore G) and ɣ, although the results can be easily extended. Then the problem of power control is to find the global allocation of powers q to solve M equations

$$\frac{E_b}{I_0} = |i \geq ɣ_i \quad i=1.....M$$

A is the M×M normalized path gain matrix

$$A_{i,j} = \frac{m_i \Gamma[j,c_i]}{\Gamma[j,c_i]}$$

From the above equation power allocations to solve the analysis of normalized path gain matrix can be analysed.

V. RESULTS AND DISCUSSION:

Table I: Simulation Parameters

Parameters	Initial Value
Number of base stations	100
Distance between base stations	100 m
Sensing region	1000 m * 1000 m
Initial node power	100 W
Packet size	512 B
Transmission power	0.02 Watts
Received power	0.01 Watts
Routing protocol	Dynamic Source Routing (DSR)
Data rate	2 Mbps
radio-propagation model	Two Ray Ground

Table II. Performance analysis in terms of Energy Consumption

No. of BS	Energy Consumption (J)
30	90
40	115
50	140
60	145
70	148
80	155
90	162
100	170

Table II shows the energy consumption of the proposed algorithm with respect to different numbers of base stations between sender and receiver base station.

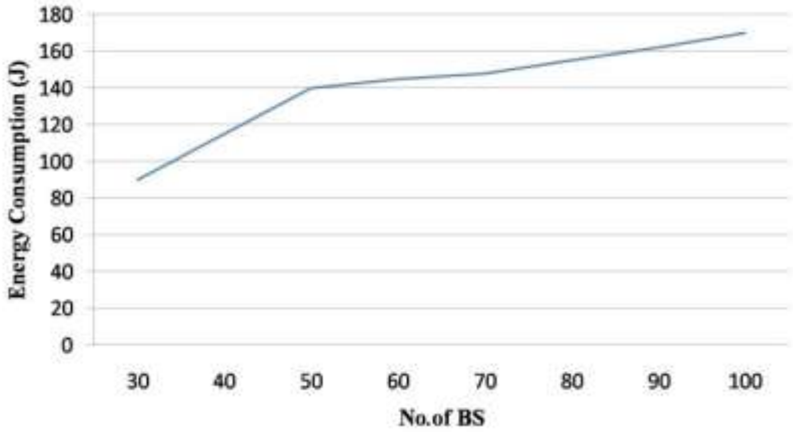
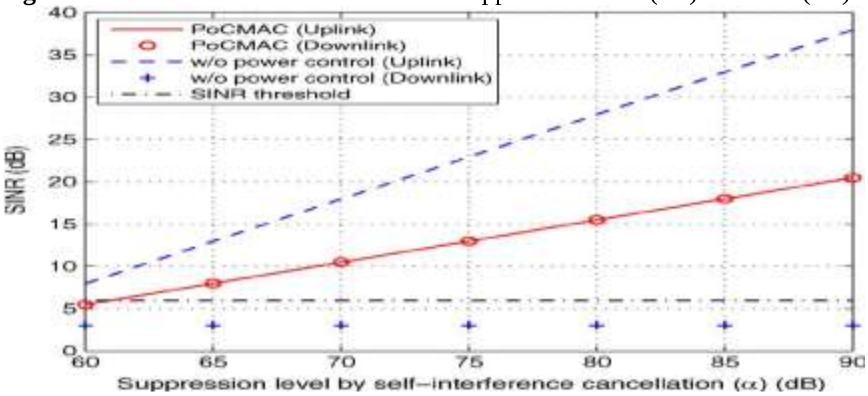


Figure 3. Graphical illustrations of Energy consumption of BSs

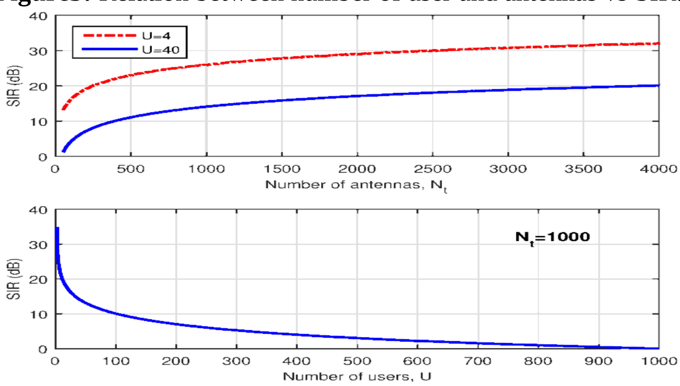
Figure 3 shows the graphical illustrations of the energy consumption with respect to different base stations. The energy consumption is increased if more number of base stations is used in environment. The energy consumption is linearly proportional to the number of base stations. The energy consumption is measured in Joules.

Figure4: Self Interference Cancellation of suppression level (dB) vs SINR (dB)



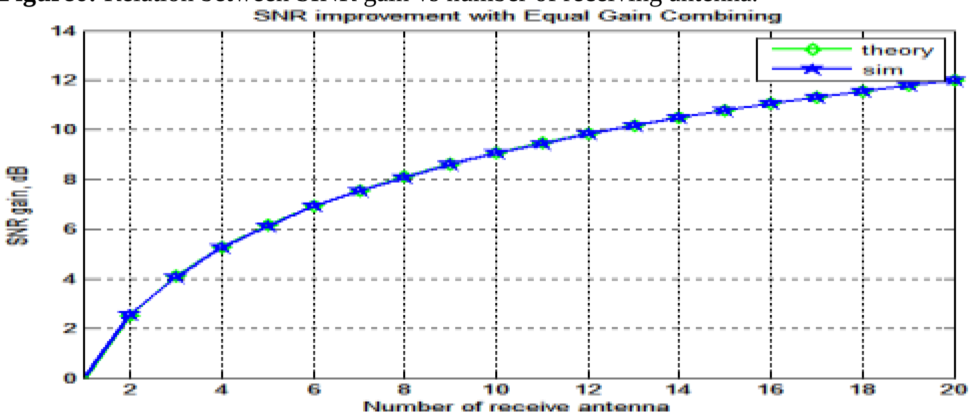
The above figure shows analysis of SINR vs Suppression level by self-interference cancellation (α) by considering uplink and downlink relation in terms of power.

Figure5: Relation between number of user and antennas vs SIR.



The figure 5 shows the relation between the number of user and SIR. The top figure shows the relation between numbers of antennas with SIR. The red curve indicates the number of users 4 for a maximum value of SIR 32 when reaching the 4000 antenna. The blue curve indicates the number of user value reaches the maximum value of SIR 24 when reaching the 4000 antenna. The second figure shows the value SIR reduces when the number of user reaches 1000 by keeping the number antennas up to 1000.

Figure6: Relation between SINR gain vs number of receiving antenna.



The figure 6 shows the relation between the SINR gain when increasing the number antenna. Our aim is to achieve maximum value of SINR in order achieve good performance of the system. The maximum value of SINR reaches to 12dB when reaching the 20 number of antenna.

SOFTWARE SPECIFICATION
OPERATING SYSTEM
UBUNTU

Ubuntu is an open source operating system for computers. It is a Linux distribution based on the Debian architecture. It is usually run on personal computers, and is also popular on network servers, usually running the Ubuntu Server variant, with enterprise-class features. Ubuntu runs on the most popular architectures, including Intel, AMD, and ARM-based machines. Ubuntu is also available for tablets and smartphones, with the Ubuntu Touch edition.

NETWORK SIMULATOR2(NS2)
INTRODUCTION ABOUT NETWORK SIMULATOR 2

NS2 is an open-source simulation tool that runs on Linux. It is a discrete event simulator targeted at networking research and provides substantial support for simulation of routing, multicast protocols and IP protocols, such as UDP, TCP, RTP and SRM over wired and wireless (local and satellite) networks. It has many advantages that make it a useful tool, such as support for multiple protocols and the capability of graphically detailing network traffic. Additionally, NS2 supports several algorithms in routing and queuing. LAN routing and broadcasts are part of routing algorithms. Queuing algorithms include fair queuing, deficit round-robin and FIFO.
NS (from network simulator) is a name for series of discrete event network simulators specifically ns-1, ns-2 and ns-3. All of them are discrete-event computer network simulators, primarily used in research and technique. NS-3 is free software, publicly available under the GNU GPLv2 license for research, development, and use. The goal of the ns-3 project is to create an open simulation environment for computer networking research that will be preferred inside the research community. It should be aligned with the simulation needs of modern networking research. It should encourage community contribution, peer review, and validation of the software.Since the process of creation of a network simulator that contains a sufficient number of high-quality validated, tested and actively maintained models requires a lot of work, ns-3 project spreads this workload over a large community of users and developer.

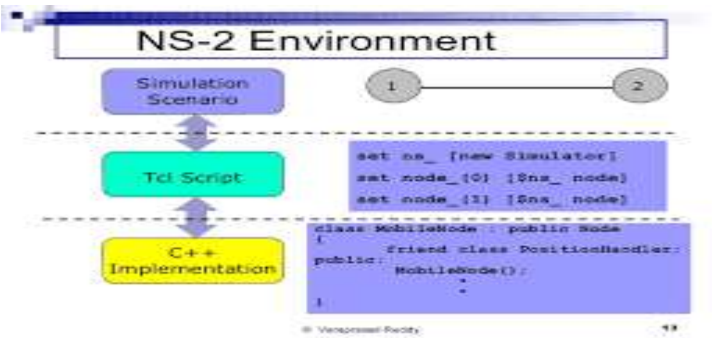


Figure 7.NS2 Environment.

ENERGY MODEL

Energy model maintain total energy at each node in wireless network. Energy model in ns2 isused to access energy of node during simulation. In ns2 energy model for any node can be assigned as following

```
[Simulator-instance] node-config  -energyModel "EnergyModel" \
                                  -idlePower 1.0 \
                                  -rxPower 1.0 \
                                  -txPower 1.0 \
                                  -sleepPower 0.001 \
                                  -transitionPower 0.2 \
                                  -transitionTime 0.005 \
                                  -initialEnergy 1000
```

Table III Energy Model's attributes

Attribute	Meaning	Value	Default Value
energyModel	Type of energy model.	EnergyModel	None
rxPower	Power for receiving one packet	power in watts (i.e. 0.4)	281.8mW
txPower	Power for transmitting one packet	power in watts (i.e 1.0)	281.8mW
initialEnergy	Energy of node in the beginning	energy in Joule	0
sleepPower	Power consumed during sleep state	power in watts	
transitionPower	Power consumed during state transition from sleep to idle	power in watts	

Table II1. Energy Model

After simulation energy stored in following format in trace file

```
[energy 998.999217 ei 1.000 es 0.000 et 0.000 er 0.001]
```

In above formate first name of attribute is given then it's value.

- energy: total remaining energy
- ei: energy consumption in IDLE state
- es: energy consumption in SLEEP state
- et: energy consumed in transmitting packets
- er: energy consumed in receiving packets

NETWORK ANIMATOR(NAM)

NAM is a TCL based animation tool for viewing network simulation traces and real world packet trace data. The design theory behind NAM was to create an animator that is able to read large animation data sets and be extensible enough so that it could be used indifferent network visualization situations.

X-GRAPH

One part of the ns-allinone package is 'xgraph', a plotting program which can be used to create graphic representations of simulation results.

Xgraph is an X-Windows application that includes:

- Interactive plotting and graphing
- animation and derivatives
- portability and bug fixes

So the characteristics of NS2 parameters like throughput, end to end delay, packets information, Energy consumption etc., can be plotted using X-graph .

SIMULATION STEPS AND RESULTS

SOURCE FILE CREATION

Source file is the basic document to run any file using ns2. Other algorithms or protocols should be added within the source file only in order to implement.

Language used in source file is Tool Command Language(TCL).

The file should be stored with the extension of ".tcl".

NODE CREATION
Nodes can be created using the following commands.
Set n0 [$ns node]
set n1 [$ns node]
And a link can be created between these two nodes as follows,
$ns duplex-link $n0 $n2 2Mb 10ms DropTail

Table IV NODE CONFIGURATION

Option	**Available Values**	**Remarks**
addressType	flat, hierarchical	
MPLS	ON,OFF	Multi protocol Label Switching
wiredRouting	ON, OFF	
llType	LL, LL/Sat	Link Layer
macType	Mac/802_11, Mac/Csma/Ca, Mac/Sat, Mac/Sat/UnslottedAloha, Mac/Tdma	Medium Access Control
ifqType	Queue/DropTail, Queue/DropTail/PriQueue	Interface Queue type
phyType	Phy/wirelessPhy, Phy/Sat	Physical Layer Type
adhocRouting	DIFFUSION/RATE, DIFFUSION/PROB, DSDV, DSR, FLOODING, OMNIMCAST,AODV,TORA,PUMA	adhoc routing protocol
propType	Propagation/TwoRayGround, Propagation/Shadowing	Propagation Type
antType	Antenna/OmniAntenna,	Antenna type
Channel	Channel/WirelessChannel, Channel/Sat	Channel to be used
mobileIP	ON,OFF	to set the IP for Mobile
energyModel	EnergyModel	energy model to be enabled or not
initialEnergy	<joule>	in terms of joules (Ex: 3.24)
txPower		Power in terms of Watts (0.32)
rxPower		Power in terms of Watts (0.1)
idlePower		Power in terms of Watts (0.02)
agentTrace	ON, OFF	Tracing to be on or off
routerTrace	ON, OFF	Tracing to be on or off
macTrace	ON, OFF	Tracing to be on or off
movementTrace	ON, OFF	Tracing to be on or off
errProc	Uniform ErrorProc	
toraDebug	ON, OFF	

Table IV. Node Configuration

EXECUTION
Ns source.tcl

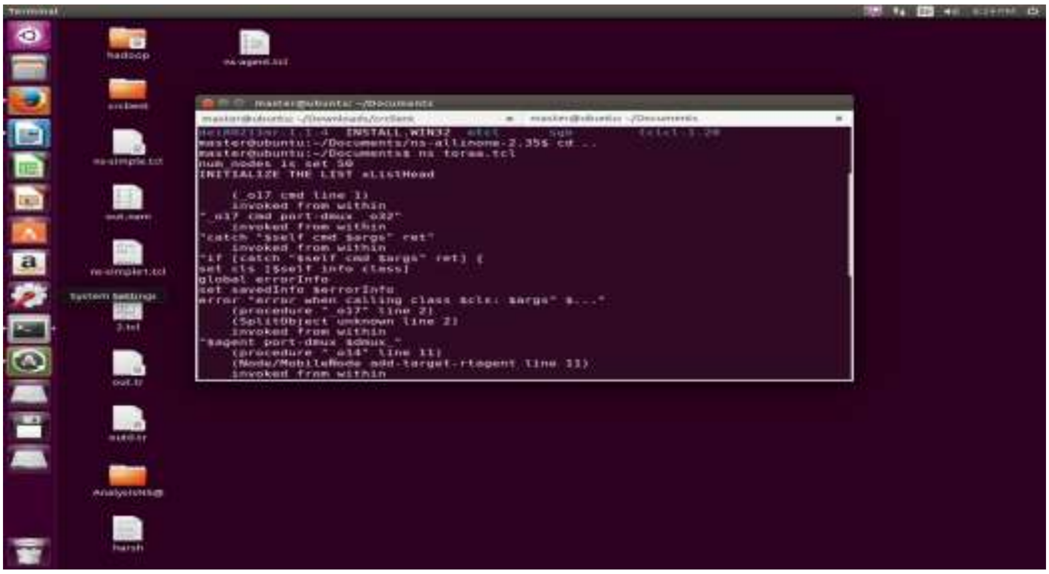
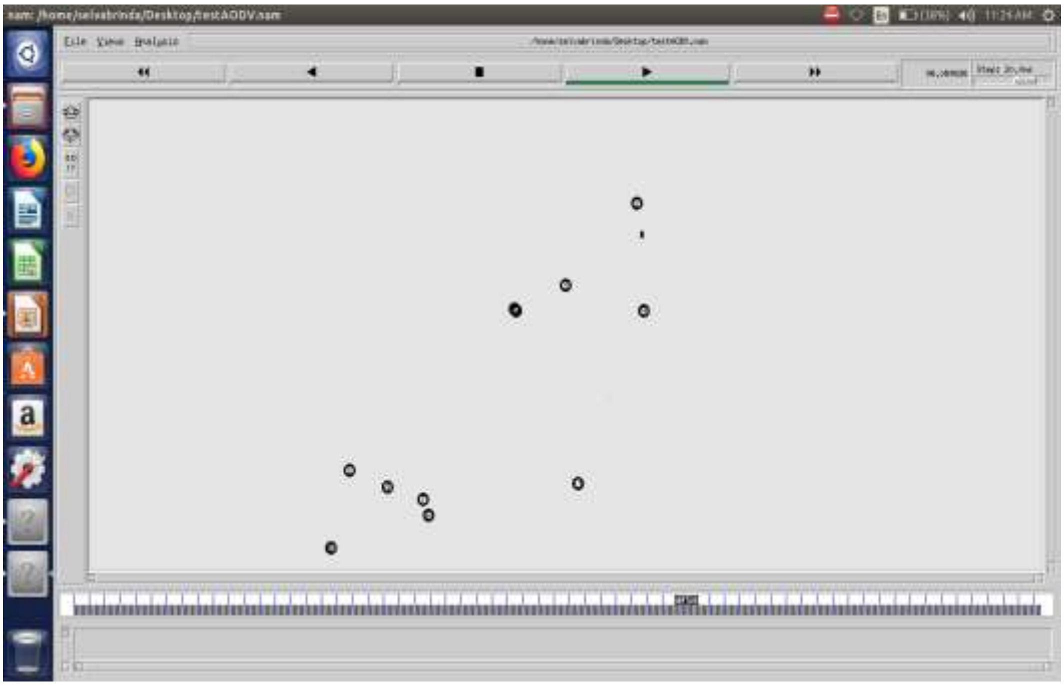


Figure 8. Command Terminal window

The figure 8 shows the screenshot of the command terminal window from that the source file can be executed by executing the command in the terminal window.

ANIMATOR OUTPUT
NODE CREATION



EXISTING METHOD

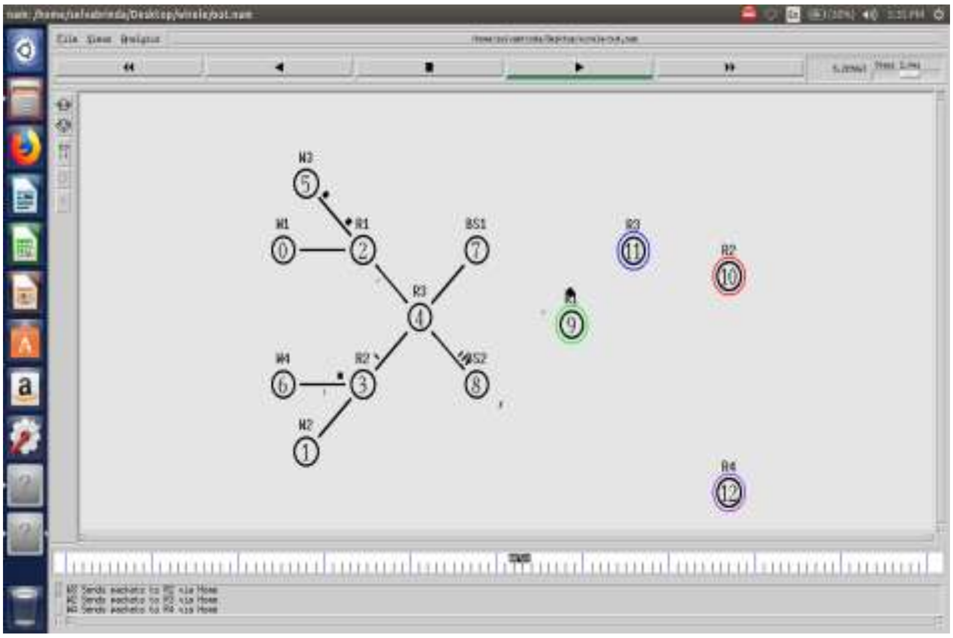


Figure 9. Existing method& Node Creation

Figure 9 shows that in simulator window how the nodesare created and the second figure shows that in existing method all the nodes are not connected as a result connectivity failure happens. These can be resolved in proposed method.

PROPOSED METHOD

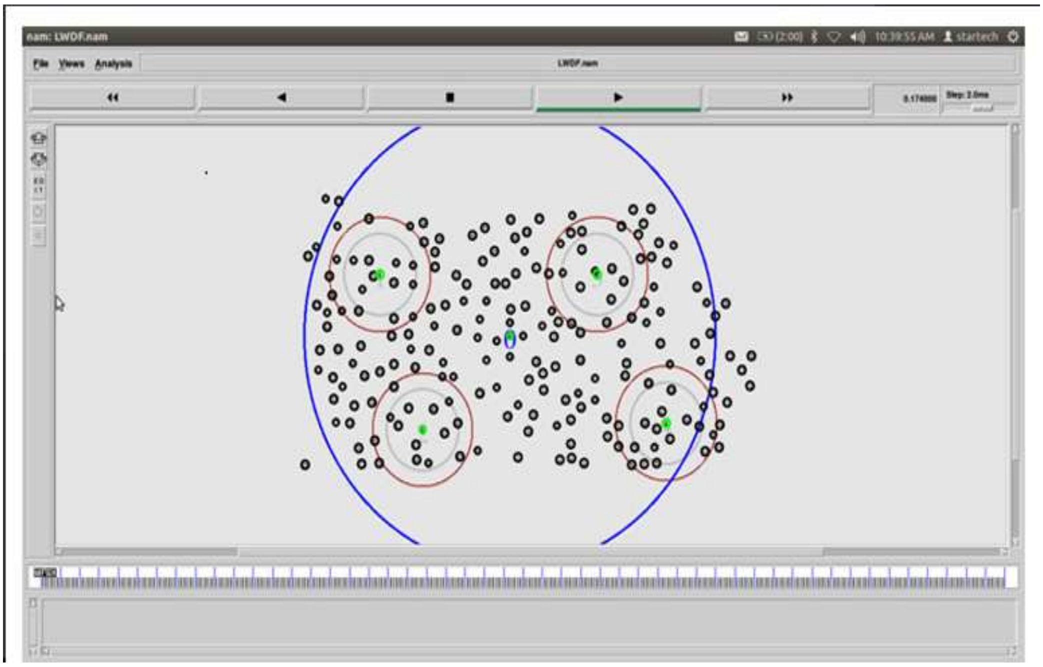


Figure 10. Proposed Method

The Figure 10 shows that in proposed method there is a centralised coverage base station which satisfies the coverage metrics and minimises the link failure. All the nodes are covered and ensured with very less connectivity failure.

ENERGY MEASUREMENT-TRACE FILE

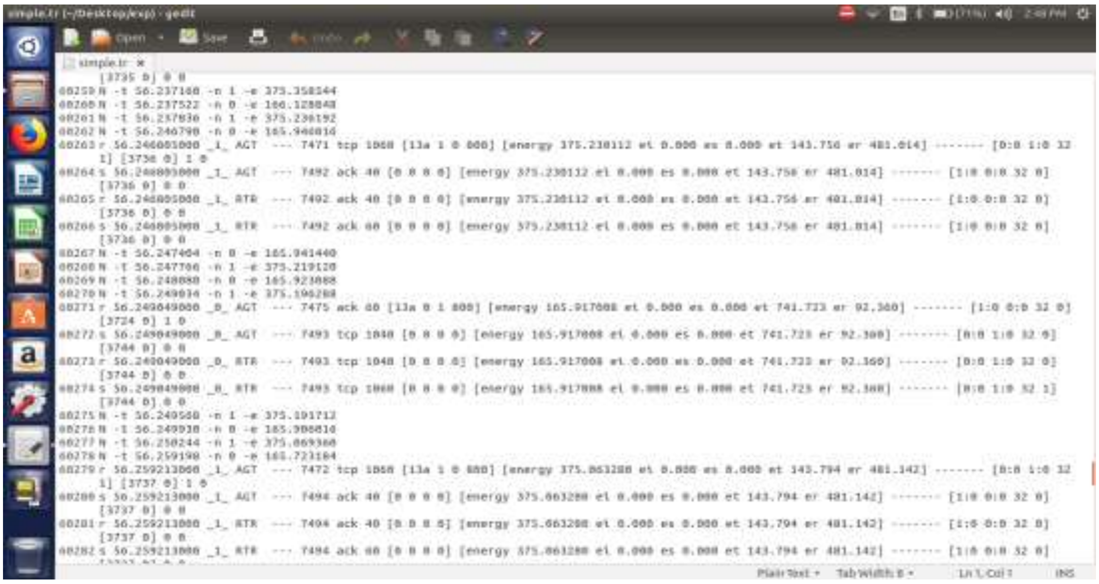


Figure 11. Energy model-Trace File

The figure 11 shows the Energy measurement trace file that shows how much energy dissipated when a data transferred from one node to another node.

GRAPH

Figure 12. Graph: Energy consumption

The Figure 12 shows the energy consumption graph when it reaches the maximum number of base stations by adopting the homogeneous networking approach it achieves an average energy consumption of 140 Joules.

VI. CONCLUSION:

In this paper, an energy efficient methodology is proposed to reduce power consumption by switching the base station to sleep from active mode and dynamically adopting homogeneous networking approach the average energy consumption of 140 Joules reaches when reaching 100 base stations. The maximum value of SINR gain is achieved to 12dB. In future this work can be extended to detect the link failure due to un authorized usage of given bandwidth.Rapid growth in number of mobile users demands the service providers to provide distortion less, continuous service. On the other hand there is a huge demand for power due to growing population. Hence, in order to compensate these customer requirements and to contribute our part in power optimization a change should be made in the current cellular architecture. That change should be a strong base to the energy-efficient network. This paper is one of the ideas to achieve the above requirements.

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