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Development of an Adaptive Hibernation Mode (AHM) Operation Technique for Optimizing Energy Efficiency In A Telecommunication Base Transmitting Station

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Abstract
Availability of constant and reliable energy supply at base transmitting stations is one of the major problems hindering the provision of efficient telecommunication service in Nigeria. Again, the cost of maintaining this scare commodity impacts negatively on the budgetary allocation of the base transmitting stations. This is because most redundant modules of the equipment are usually energized despite the fact that they are not in operation. Also the operating modules are always run on maximum power even when the traffic impinging on them is not on peak level. This research work is thus aimed at developing a hibernation-sleep mode technique for optimizing energy consumption in a base transmitting station. To achieve this goal, the first work done was to critically review the related work carried out by other researchers. After this, a typical base station was characterized to determine the energy consumption pattern. This enabled us to know the maximum energy requirement at peak traffic and the minimal energy at low traffic. It also helps us to know the time lag it takes for a redundant or hibernated module to be in operation when needed. Next, an intelligent algorithm was developed for the switching on and off power to redundant units as the need arises. The overall system was then integrated and simulated to determine the percentage improvement. The results show that the deployed adaptive hibernation mode operation technique for optimizing energy efficiency has produced 40% improvement in energy output.

Key words: *Transmitting, hibernation, consumption, characterization, redundancy, efficiency, algorithm,*

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I. Introduction:

Over the years, effective telecommunications was one of the vital tools used to measure the progress of a country in the technological advancement. In our country Nigeria, it is a well-known fact that efficient and robust mobile communication has not been fully achieved since the advent of wireless communication in August 2001 (Communicator 2019, NCC). This is due to several factors militating against the set goal of efficient wireless mobile network in the country like high energy consumption by numerous cellular networks and base stations deployed around the country resulting in high energy cost to operators in telecommunication industry which is worsen by poor supply situation in Nigeria. There is the need to save cost through efficient energy management scheme. Another factor against the set goal is the issue of quality of services (QoS) in voice, video and data rendered to users from these mobile operators which is usually characterized by its poor outputs, as one finds it difficult to enjoy any of these services without frequent interruptions and disappointments, thus requiring a means through which the quality of services can be improved. The issue of a clean environment and health of people around these communication companies` facilities is another factor. People are affected by CO_2 emissions from power generating sets used in almost all the base and mobile stations in the country due to lack of steady public power supply. This means that CO_2 emission need to be minimized to safeguard human lives. Hibernation is widely regarded as an adaptation to seasonal energy shortage, but the actual influence of energy availability on hibernation patterns is rarely considered. Here we rewrite literature on the costs and benefits of torpor expression to examine the influences that energy may have on hibernation patterns. Torpor expression provides substantial energy savings, which increase the chance of surviving a period of food shortage and emerging with residual energy for early spring reproduction. However, all hibernating mammals periodically arouse to normal body temperatures during hibernation. The function of these arousals has long been speculated to involve recovery from physiological costs accumulated during metabolic depression, and recent physiological studies indicate these costs may include oxidative stress, reduced immune or competence, and perhaps neuronal tissue damage. Using and optimality approach, we suggest that trade- offs between the benefits of energy conservation and the physiological costs of metabolic depression can explain both why hibernators periodically arouse from torpor and why they should available use energy to minimize the depth and duration of their toper bouts. On the basis of these trade-offs we derive a series of testable predictions concerning the relationship between energy availability and torpor expression. We conclude by reviewing the empirical support for these predictions and suggesting new avenues for research on the role of energy availability in mammalian hibernation. The much consumption of power in the cell site has drastically reduced the financial status of the cell site. That is the reason the researcher source the means of minimizing power consumption in the cell site to enhance the financial status of site.

II. Literature Review

The static power consumption (when the stations is on idle mode), and dynamic power consumptions (when the base stations is in operation) are the two modes of powers consumption in a bases stations. Generally, power supply modeling for BS can be classified into two broad categories. The first category is an on-grid hybrid power supply system based on the combination of an electrical grid power supply and renewable energy sources such as the energy of sun or wind (Gao et al, 2011). Zhisheng, 2019 employed the SVC technique which reduced power consumed in the base station at a small measure. Only small measure of power consumption could be reduced. Amanna, 2019 using the green mode techniques tried to minimize the power consumption at the site base station but because of did not incorporate intelligence to enhance its reduction. Another researcher utilized the ultra capacitor method in power reduction. Although the method improved energy efficiency in micro sites in cellular mobile radio network, it sparingly improved energy efficiency at the cell site because it lacked incorporate of intelligence (Fehske, 2019). The static var compensator technique was employed by Mukherjee in 2019. The techniques geared towards minimizing power in femtocell based green power to enhance the network performance at a minimal power consumption however it took a longer duration to do so because it did not imbibe intelligence in its technique. Abubakar, 2018 utilized the ATM technique. This technique could only reduce energy consumption at a smaller percentage. Andy 2021 and Fehske 2019 both used optimization techniques for the reduction of power consumption at base station. The technique sparingly reduced the energy consumed due to absence of intelligent agent. In 2018 Bazzi in the water marking technique reduced power consumed at the base station but sparingly. Abhishek, 2019, and Zhisheng, 2020 both used genetic algorithm technique, in the reduction of energy at the base station, however only a minimal energy was reduced. The Geo location technique was employed by Ana, 2017. Power reduction was achieved but in small scale. Belady, 2018 adapted the adaptive equalizer technique only mild reduction was obtained. Yong, 2017, also employed the genetic algorithm techniques to reduce power consumed at the cell site but only small measure of power could be reduced. Gilbert, 2019 used the optimization technique while C. Peng 2018 used static VAR compensator techniques they could only achieved minimal reduction.

III. Methodology

The first work done was to carry out a thorough and critical review of related works done by other researchers and establish a research gap. After this, an existing base transmitting stations (BTS) was characterized to find out the power consumptions of the system. Later a model was developed for the energy consumption. Next, a sleep mode or hibernation techniques of energy conservation was designed. An intelligent algorithm was developed for the designed parameters. This was then simulated to find the performance of the system. The adaptive sleep mode technique was integrated into the model of the BTS. Finally the overall model was evaluated and simulated using Simu-link.

1. Power consumption model

The power consumption model for transmitting base station was developed. The important parameter considered was the energy efficiency of the base station. The energy efficiency is defined as the power consumption needed to cover a certain area (in W/m2). The power consumption P(t) at the base station is given as

$$P(t) = I.V(t) \quad (1)$$

A base station is defined as the equipment needed to communicate with the mobile stations and with the backhaul network. The area covered by a base station is called as cell that is further divided into a number of sectors. Each sector is covered by a sector antenna, which is a directional antenna with a sector-shaped radiation pattern (Son, Kim, Hi & Krishanmachari, 2011). To determine the load, measurements were carried out at the base station in the urban area of Enugu State, Nigeria. The power consumption of the three base stations for three days including weekend days were measured. The average measured power was obtained. The group of load-independent components i.e., the rectifier, the air conditioning and the microwave link were not included in these measurements.. The effort to save power for telecommunication base stations is the main reason of adaptive hibernation mode. The developed adaptive hibernation mode system will be enabled on the base station to be able to save power during an off grid and when there is power from the grid to stay active longer. To save power when there is no power from the grid, the adaptive hibernation mode is enabled to turn off the module that is not in use and in doing so the efficiency of power in the base station is enhanced. The modified power consumption model is shown in Figure 1.

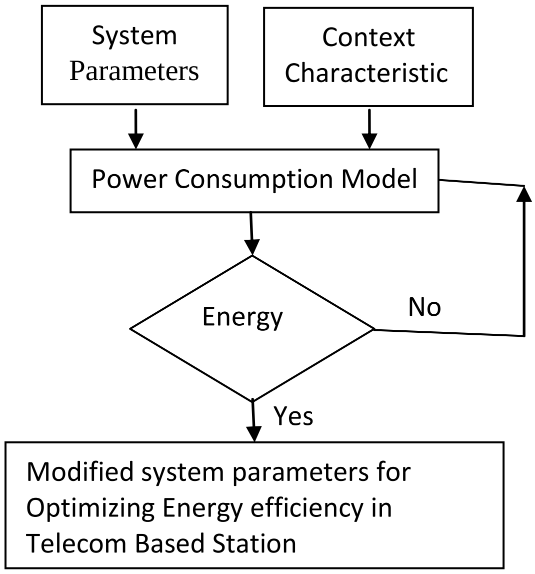

Figure 1: modified power consumption model.

2. Developed Adaptive hibernation mode Algorithm

The adaptive control algorithm is based on the control of switching ON and Off power to redundant units as the need arises and it involves four main sub-modules. The first is the predictor sub module that is based on black box model which implements a machine learning algorithm, which captures the transmitting energy consumption and determines the next action. Such a black box modeling approach requires data sensor readings but allows the scalability of the model to different transmitting base stations and so replicate the methodology and the algorithms Zhisheng Nlu. (2019).

The adaptive hibernation algorithm is shown in Table 1. Firstly, the controller evaluates a violation of energy usage in a typical transmitting base station: if the energy usage is lower than the comfort set point, the controller will enable the optimized system, while skipping a prediction step. If the set point energy is met, the controller builds a tree of possible solutions performing a status evaluation and a prediction by means of a machine learning model based on a decision tree. If a tree path state violates the comfort energy set point by higher energy, then the algorithm hibernates and save energy.

Table 1: Developed adaptive hibernation algorithm for energy optimization.

```
Adaptive hibernation Algorithm.
Procedure RULE  BASED ( Sensor, energy, control)
System initialization
Read information from sensors
Read ( Low energy, Normal, High energy)
If  Sensors  = Normal, then  check if power at base station is
satisfied
 If ( Energy level < 4.02KWh) then, Optimize
If ( Energy level >= 4.58KWh) then, Check the normal operation
of the transmitting base station
If (Energy level > > 4.58KWh) then , Hibernate and save energy
SET the control energy ON
else if( Energy Level  < = 4.58KWh < = 4.63KWh)  then
SET  the control energy to OFF
End if
else
```

SET the control energy ON
End if
End Procedure

3. Energy Consumption from some Selected Base Station:

In this work, three MTN base stations in Enugu state, Nigeria were considered and used for this study. The stations are identified as EN0364, EN0011 and EN0024. The stations were selected because they have many links and services many geographical areas and consume enough power. They are operating on 3G network. Effort was made to measure both AC current and voltage and DC current and voltage. According to Ohm`s law, power was calculated by multiplying current and voltage. Table 1, 2 and 3 shows the average values of current and voltage obtained from AC measurements.

Table1: Values obtained from AC measurement at EN0364

s/n	Voltage(V)	Current (A)	Power(W)
1	230	17.40	4002.00
2	230	18.30	4209.00
3	230	18.06	4153.80
4	230	19.09	4390.70
5	230	19.32	4443.60
6	230	18.05	4151.50

Table 2: Values obtained from AC measurement at EN0011

s/n	Voltage(V)	Current (A)	Power(W)
1	230	18.32	4213,60
2	230	18.30	4209.00
3	230	18.38	4227.40
4	230	19.11	4395.30
5	230	19.92	4581.60
6	230	19.89	4574.70

Table 3: Values obtained from AC measurement at EN0024

s/n	Voltage(V)	Current (A)	Power(W)
1	230	18.42	4236.60
2	230	18.17	4179.10
3	230	19.41	4464.30
4	230	19.22	4420.60
5	230	18.80	4324.00
6	230	18.10	4163.00

The instantaneous DC power consumption on the three base stations was measured. Changes in the instantaneous power consumption were observes. This power consumption of the individual Base stations was obtained by multiplying the measured values of the instantaneous Base station electric current consumption with constant DC voltage (56.4V). Table 4,5 and 6 shows the average values of current obtained from DC measurement.

Table 4: Values obtained from DC measurement at EN0364

s/n	Voltage(V)	Current (A)	Power(W)
1	56.40	11.20	631.68
2	56.40	11.60	654.24
3	56.40	12.80	721.92
4	56.40	11.70	659.88
5	56.40	11.40	642.96
6	56.40	12.60	710.64

Table 5: Values obtained from DC measurement at EN0011

s/n	Voltage(V)	Current (A)	Power(W)
1	56.40	10.00	564.00
2	56.40	8.42	474.89
3	56.40	10.60	587.84
4	56.40	9.40	530.16
5	56.40	8.70	490.68
6	56.40	10.40	586.56

Table 6: Values obtained from DC measurement at EN0024

s/n	Voltage(V)	Current (A)	Power(W)
1	56.40	12.20	688.08
2	56.40	11.60	654.24
3	56.40	12.10	682.44
4	56.40	11.80	665.52
5	56.40	11.60	654.24
6	56.40	12.60	710.64

IV. Discussion of Results

From the results on AC measurement, Table1 shows that the average range of power consumption at base station EN0364 is from 4002W to 4444W. It implies that the equipments at the base station are active whether they are useful at the moment or not. The cost of power consumed by EN0364 every month was high. After deploying the adaptive hibernation mode to the system, it was observed that the cost of electricity was highly reduced. Table 2 shows the base station identified as EN0011. The power consumption was between 4582W to 4209W. It was observed that many of the equipments at the base station May not necessary be ON at the same time for the system to function. The introduction of adaptive hibernation mode to the system of EN0011 saves a lot of energy and it optimized the system performance. Table 3 is identified as EN0024.The power range is 4464W to 4163W. It was observed that the only difference between the three base stations is power consumption variations due to differences in equipments. The good news is that adaptive hibernation mode when applied to the network saves energy and optimized the system`s performance. Tables 4,5 and 6 shows the average values of results obtained from DC measurement based on three base stations. It was observed that different base stations have different variations in current which affect the power output according to Ohm`s Law. The batteries used as power storage in the base stations last for few hours due to equipments power consumption. Introducing adaptive hibernation mode was recommended as it bust the performance of the system and save energy consumptions by the equipment.

V. Conclusion

The study was successful completed the outcome will help telecommunication service providers to minimize the cost of running a base transmitting stations. This will greatly impact on the services being provided by them and will make them to consider providing their services to rural areas because of their reduced cost

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