

Green Radio Technology for Energy Saving in Mobile Towers

Srudhi Lakshmi V., Roshni R., Paulthi B. Victor, and Roshini D.

Abstract—The number of users and the use of telecommunication systems are increasing rapidly and this result in greater demands on energy usage. Based on the extensive Life-cycle assessment (LCA) conducted by various network operators, it is learned that energy consumption in the usage phase of its radio access networks is the most imminent factor relating to impact on the environment. The amount of CO₂ emission is increasing in communication system, in parallel with increase in mobile consumers. And it is also observed that current wireless networks are not energy-efficient, mainly the base stations (BS). This alarming growth in mobile users forces us to use higher data rate mobile broadband. The need for restructuring of existing network architecture, we need to control the systems in every base station. This paper discusses the current energy consumption scenario in base station devices. It also describes innovative and promising method for enhancing the energy-efficiency of the wireless networks and developing solutions that reduce operating costs and effects on the environment.

Index Terms—CO₂ emission reduction, Energy efficient wireless network, Green Radio Technology, Power saving in base stations.

I. INTRODUCTION

Recent analysis by manufacturers and network operators has shown that current wireless networks are not very energy efficient, particularly the base stations by which terminals access services from the network. Green radio technology describes one of the most promising research directions in reducing the energy consumption as well as the carbon emissions of future base stations.

Given the worldwide growth in the number of mobile subscribers, the move to higher-data-rate mobile broadband, and the increasing contribution of information technology to the overall energy consumption of the world, there is a need on environmental grounds to reduce the energy requirements of radio access networks [3]. The Green Radio program sets the aspiration of achieving a hundredfold reduction in power consumption over current designs for wireless communication networks. This challenge is rendered nontrivial by the requirement to achieve this reduction without significantly compromising the quality of service (QoS) experienced by the network's users.

The power consumption of various elements has been shown in Fig. 1.1. It clearly states that reducing the power usage of the base station will reduce the power consumption as it consumes the maximum power.

Fig. 1.2 shows the CO₂ emissions per subscriber per year for base station and mobile handsets. It is seen that the

operational energy for mobile handsets is much less than that of base station. It also shows that the manufacturing or embodied energy is greater in mobile handsets when compared to base station. This is just for one single tower. The impact due to several million towers installed in a country is unimaginable. Thus our objective is to reduce the energy consumption in base stations and reduce the amount of CO₂ emission. We have to keep controlling system in every base station for switching purpose. To have complete control over base station we prefer to use PC. This enables us to implement SCADA concept to monitor all the base stations and provides full control over them. Apart from this, the architectural operation of present scenario is not energy-efficient. It does not account for user frequency (i.e. number of mobile users) in an area. All the towers in that area is turned on irrespective of the user frequency. This leads to enormous amount of fuel wastage.

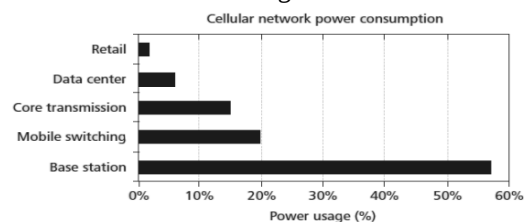


Fig. 1.1. Power consumption of a typical wireless cellular network.

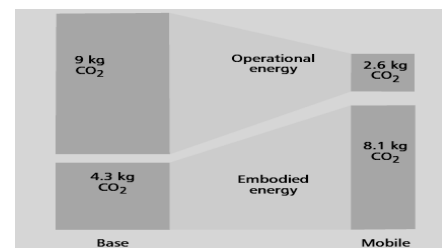


Fig. 1.2. CO₂ emissions per subscriber per year for base stations and mobile handsets

Now considering one single tower, power is not only used for the signal transmission process (which consumes major portion of power), but also for running the cooling unit of generator and light indicator present along with lightning arrestor. Cooling unit consists of an Air-Conditioner and a Fan. Both Air-Conditioner and cooling fan operate throughout the day, irrespective of the climate change and temperature around the generator. Also the light indicator (Red Light) present along with lightning arrestor glows day & night continuously without any rest. But, during day time, we are unable to notice this light, which is still operating. Thus, it can be seen that all these instruments consume more power (or energy) than that is actually required. From an operator's perspective, reducing energy consumption will also translate to lower Operating Expenditure (OPEX) costs. Reducing carbon emissions and OPEX for wireless cellular

networks are two key reasons behind the development of the Mobile Green Radio program. This technology helps in minimizing the power consumption, reduces CO₂ emission and prevents depletion of fossil fuel. The Green Radio project is pursuing energy reduction from two different perspectives. The first is to examine alternatives to the existing cellular network structures to reduce energy consumption. The second approach is to study novel techniques that can be used in base stations or handsets to reduce energy consumption in the network.

II. CURRENT SCENARIO

- 1) The architectural operation of present scenario is not energy-efficient. It does not account for user frequency (i.e. number of mobile users) in an area.
- 2) In India more than 4 lakhs towers are present. By 2014 it is estimated to go beyond 5 lakhs.
- 3) Every tower consumes 28 litres of diesel per day.
- 4) All the towers in an area are turned ON irrespective of the user frequency. One tower delivers 85 kg of carbon per day.
- 5) During night time only 10% of the total users communicate still all the towers remain in the working state
- 6) The source for towers is based on the power requirement. A critical mobile network consumes 40-50MW approximately, even excluding the power consumed by users' handsets.
- 7) A typical diesel generator, used for supplying power for communication purpose, consumes seven million litres of diesel per day.

III. GREEN RADIO TECHNOLOGY

Green radio technology aims at two major reductions.

- 1) To provide a novel method for establishing Energy-Efficient wireless network by reducing the total power consumption in the base stations.
- 2) To achieve Eco-Balance in nature by reducing carbon-di-oxide emission.

The objective of this chapter is to explain the different concepts and techniques involved in this green radio technology and also scope & merits of this technology.

A. Technique Involved

The technique used in this project is that power used in the base stations is reduced by controlling different parameters within the station and also the network topology. Change of network topology means that for a given control area only required amount of mobile towers is switched ON, instead of all the towers present in that region[1]. Here, all the towers are in IDLE state except those which are under operation. This technique helps in reduction of huge amount of power consumption, which in turn reduces fuel consumption and hence prevents the environment from the harmful effects of green-house gases. Secondly, the parameters which are to be controlled in base stations are the power supplied to cooling unit and lighting process. We can see that it reduces the power consumption by at least 30% (considering one single base transceiver station or BTS). So, on the whole, it contributes to a major portion of

power consumed all over the world. Thus, it reduces that major portion of power instead of being wasted.

B. Basic Operation

Our objective is to reduce the energy consumption in base stations and reduce the amount of CO₂ emission. We have to keep controlling system in every base station for switching purpose. To have complete control over base station we prefer to use PC. In this technology, the mobile-communication tower in an area is turned ON, based on the frequency of users present in that area. In general, within a pre-defined control area, there will be multiple towers operating (of same network type). And each tower has pre-defined user-strength capacity, up to which it can operate. Thus, based on the user strength in a region, the number of towers in that particular region is turned ON and remaining towers are kept in IDLE state.

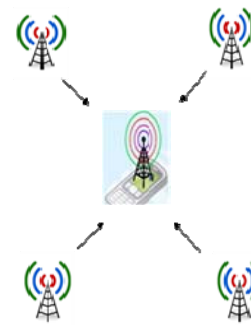


Fig. 3.2.1. Current configuration

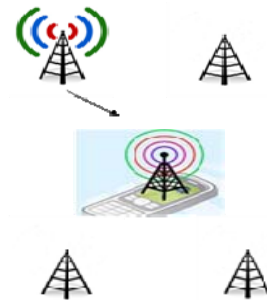


Fig. 3.2.2. Proposed configuration

Apart from implementing this configuration, we monitor certain parameters, which can help in reducing energy consumption. Those parameters are Responder Frequency, Cooling-Fan, Air Conditioner, and Light Indicator. Every tower has a lightning conductor, along with Light Indicator. This light glows throughout the day, which is not necessary. Similarly, we have Cooling-Fan and Air Conditioner running round the clock. Thus a tower consumes power to run all these accessories, apart from power used for transmitting signal. So, this technology proposes a novel method to implement a corrective measure, which will ensure optimum utilization of energy resources.

In order to control these parameters automatically, we use micro-controller based embedded system. The PIC micro-controller is used to do the control job and send the signal to a computer. Here, PIC micro-controller is interfaced with all the above mentioned Integrated chips (ICs). Each of those ICs perform different task whose output is given to PC through PIC micro controller. We use LDR to monitor the light intensity around the tower to determine day-break and

night. We use two thermistors to determine temperature and moisture content. There is standard value fixed for all these parameters. When it deviates from that switching action takes place through relay circuits.

In our model, we use four relays to monitor each of temperature, humidity, light intensity and frequency. For example light intensity above 1000 lumens is considered to be day-break, if not, its night. Hence light indicator will be turned ON automatically during night time. Similarly, based on Temperature and Humidity of the generator room, Air-Conditioner and Cooling-Fan will operate respectively. This is the basic operation of our model.

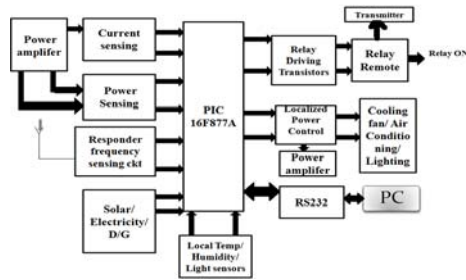


Fig. 3.2.3. Hardware configuration

C. Hardware Snap Shots

The hardware consists of a transmitter and a receiver. Transmitter is considered as a tower and receiver is considered as another tower. When the number of users exceeds a particular limit, the receiver tower is switched on and the signals are transmitted from the transmitter tower to the receiver tower. The hardware with various components is shown.

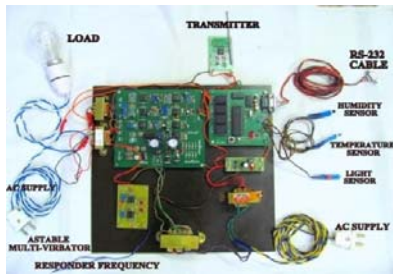


Fig. 3.3.1. Transmitter model.



Fig. 3.3.2. Receiver model.

D. Software Snap Shots

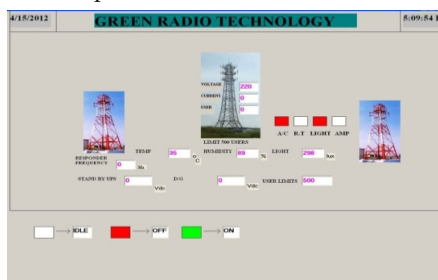


Fig. 3.4.1. Output without responder frequency.

This picture shows the state of present hardware configuration when the circuit is turned ON. It is designed in such a way that, out of the three towers, middle tower is our base station and other two are neighboring station towers. We can notice that, our tower is in IDLE state. At present tower-1 is operating, whose user frequency is within the predefined limit.



Fig. 3.4.2. Output with responder frequency

Now, when the user frequency of remote tower-1 crosses the predefined limit, responder frequency is sent from its station to next base station tower. Thus, our BS tower starts operating. We can see that amplifier of our tower is turned ON, which is indicated by change in color from red to green.

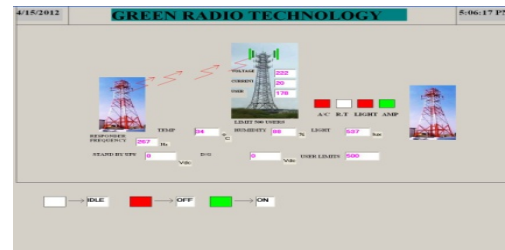


Fig. 3.4.3. Tower is ON and in operation

When our tower's amplifier is turned ON, our tower responds to the tower-1 frequency and starts operating. We can see the user limit displayed in the screen for current tower. Since it is within the user limit range, the next remote tower R.T is not turned ON. This turn- ON process is carried out using wireless network, which sends signal from our station to next station. Every station has transmitter and receiver units, which enables to carry out this automatic turn- ON & OFF operation.



Fig. 3.4.4. Increase in user limit

We can see that user limit has increased than previous state. The lines on the tower indicate the signal strength based on user frequency, i.e. number of users.

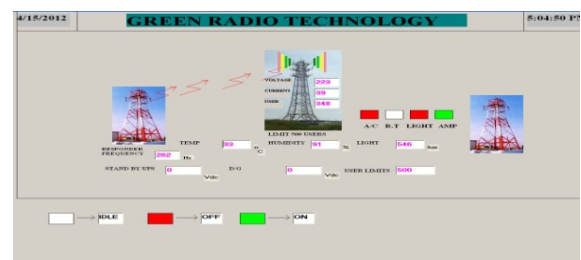


Fig. 3.4.5. Further increase in user limit

User strength is further **more** increased.

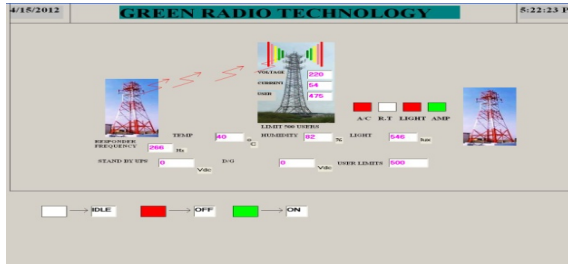


Fig. 3.4.6. Tower about to exceed user limit

This image shows the state of tower which is about to cross its user limit. Signal strength is too high and is shown by dark red lines.

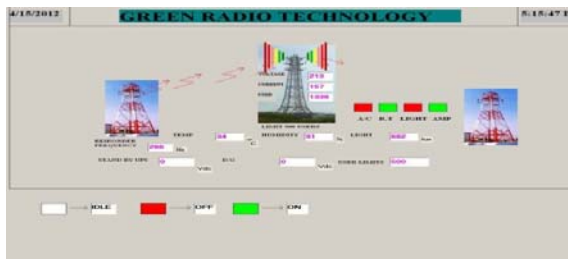


Fig. 3.4.7. Remote tower is ON

We can see that, our tower has crossed the user limit and try to turn on the remote tower. We can also notice that, this change is indicated by change of color of R.T block from RED to GREEN.

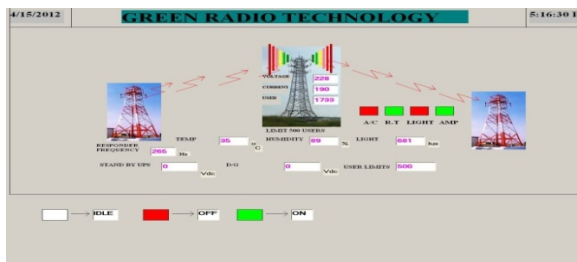


Fig. 3.4.8. Remote tower in operation

Thus remote tower starts operating.

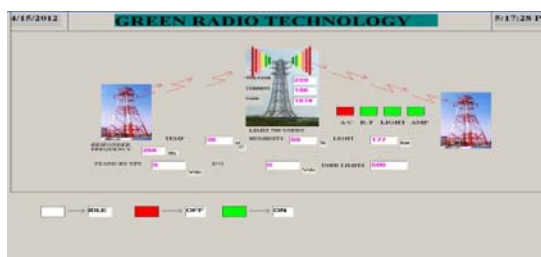


Fig. 3.4.9. Light is turned on

This image shows the change of state of light block. The LDR **used** to monitor the luminous intensity around the tower to determine night-fall or day-break. Thus, light is turned ON during night time alone instead of entire day.

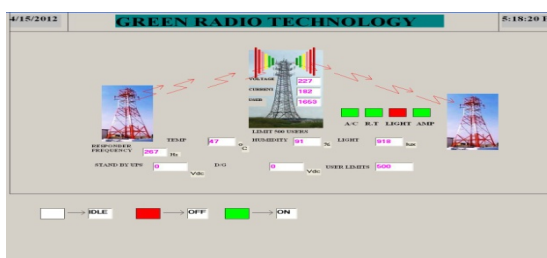


Fig. 3.4.10. AC is turned ON

This image shows that based on temperature & humidity around the **tower**, Air-Conditioner is turned –ON & OFF.

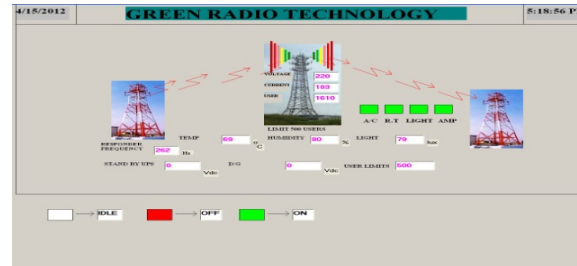


Fig. 3.4.11. All parameters turned ON

Shows the entire working aspect of this project. All the parameters like Air-conditioner, Lighting, Humidity, Temperature and Responder Frequency- corresponding relay is turned ON & OFF to save power consumption and reduce CO2 emission.

IV. MERITS OF THIS TECHNOLOGY

- 1) The main advantage of this technology is the reduction of total power consumed by the base transceiver station of Wireless mobile networks.
- 2) This technology helps in maintaining and improving the ecological balance of the nature by reducing the CO2 emission.
- 3) This technology helps in reduction of the size of generator set, which leads to low - capital investment.
- 4) This technology helps in preventing depletion of fossil fuels.

V. FUTURE SCOPE

This technology has huge scope of improvement in future, which will lead to fully implemented GREEN technology. Various other techniques of green radio technology like network topology restructuring, antenna design, switching technique used, transmitter and receivers used, communication techniques can all be combined together to achieve complete energy-efficient communication system[2]. To start with, the leading way is with solar energy. It is powering mobile towers with solar photo voltaic cells in remote rural India. The Solar Photo Voltaic uses sunlight to generate electricity thus eliminating dependency on grid power and diesel. This is a standalone system which can be installed on site. The installation process is easy and once installed the equipment needs almost zero maintenance, keeping operating costs at a minimum. Its lifespan of 25 years provides the site with a stable and permanent source of power, minus noise pollution or toxic emissions. On an average, installation of solar photo voltaic cells can lead to reduction of 2.5 tons of CO2 emission per tower every year.

VI. CONCLUSION

It can be seen that increase in mobile users leads to increase in power consumption, which in turn leads to emission of more and more CO2. This leads to global warming as CO2 is considered to be one of the green house gases. In order to control this effect, the major area to be controlled is to reduce power consumption. This can be

reduced by taking various parameters into account such as the operation of Air Conditioner, cooling fan, light indicator and power amplifier. This project has aimed at reducing the power consumption by taking these parameters into account and the outcome has been positive. As per the objective, energy consumption will be reduced as much as possible and hence the emission of harmful green house gases will be reduced. This leads to an environmental friendly approach towards wireless communication.

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