IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

An Improved M-Layer Architecture to Minimize Energy in Heterogeneous Wireless Networks

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Abstract: The increasing consumer demand for access to communication services anywhere and anytime is accelerating the technological development towards the integration of various wireless technologies, such as, Radio networks, Wi-Fi, WiMAX and cellular systems, which is called as heterogeneous networks. The wireless systems provide higher data rates, high speed, and allow global roaming among a diverse range of wireless access networks. In such a heterogeneous wireless environment, energy minimization is a promising process. In this thesis, some important problems within the heterogeneous networks are addressed, with an emphasis on the efficient use of the system parameters, to achieve certain application specific objectives. In this thesis, a novel approach for the design and implementation of a multi-layered energy minimization technique for heterogeneous wireless networks is presented. In general, energy management is performed in different phases, in the routing phase, channel selection phase, Network selection, and signal processing. An efficient, routing algorithm with ON/OFF/IDLE state selection algorithm is proposed, which focuses on the first three steps is developed. In literature, Energy consumption analysis and minimization in heterogeneous wireless network has several problems, such as on/off scheduling, network selection etc., Energy minimization is the toughest task and this is mandatory in wireless networks to improve the network performance. This thesis handles the energy consumption analysis and minimization in heterogeneous networks using new dynamic programming and m-layer architecture. However several researches have been done and addressed the energy consumption task in different wireless networks. But the proposed system is concentrating a hybrid approach for the energy reduction technique in HetNets. The experiments and results show the proposed system increases the energy consumption rates than the existing systems effectively.

Keywords: Energy minimization, heterogeneous wireless network, Ad-hoc networks, Wireless LAN, cellular networks, cell-association, on-off schemes.

I. INTRODUCTION

Wireless technology is a fanatic standard, which enables communication between devices from any location without connected cables and wires, with the use of radio waves to maintain communication channels. Due to these expressive technology enhancements and innovations in the past few decades, the size and energy requirements of the wireless devices are reduced dramatically. Heterogeneous Network (HetNet) consists of several types of networks such as Cellular network, WLAN and MANET. To deal with the energy related issues associated with the HetNet, there are several traditional systems deployed numerous techniques. This section gives the sub types of heterogeneous networks [1]. it gives the introduction of the wireless systems and its types, features etc., Wireless networks can be divided into two types

- Infrastructure Network
- Ad-hoc Network

Wireless mobile networks and cellular concept s are depends on infrastructure support of base stations. This acts as access points to the mobile devices to route messages to and from mobile nodes in specified transmission region. WLAN, Global System for Mobile Communications (GSM), Wireless local loop (WLL) [2] are wireless networks based on this concept. Whereas MANET does not require any pre existing fixed network infrastructure and the centralized message passing device is not required for communicating between mobile nodes.

Wireless environment need better performance in several critical applications such as anomaly detection; data transmission etc. while performing those processes, energy consumption of every node should be monitored and controlled. Energy minimization is the toughest task and this is mandatory in wireless networks to improve the network performance. This study handles the energy consumption analysis and minimization in heterogeneous networks using new dynamic programming and m-layer architecture. However several researches have been done and addressed the energy consumption task in different wireless networks. But the proposed system is concentrating the energy reduction technique in HetNets.

In order to achieve the profit on energy minimization task in HetNets, a new resource analysis and allocation scheme is used. And this scheme reduces the knapsack problem and spatio temporal based resource allocation issues

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II. PROBLEM DEFINITION

The results and discussion of the existing approaches [3][4]shows the overall drawback of the existing system. several techniques provides a good insights, but it is not readily usable to characterize the expected amount of energy that would be consumed according to the specific set of users with their traffic demands that the BS is expected to serve.

This is a serious problem of the existing system. One more limitation of existing approaches is that they generally focus on satisfying simple performance thresholds in QOS, such as service peak traffic, outage probability, and minimum SINR among others [5]. Still, such metrics are not adequate for the analysis of the energy efficiency of a network when spatially and temporally varying traffic demands are considered in different types of networks.

III. PROPOSED SYSTEM

Energy consumption analysis and minimization in heterogeneous wireless network has several problems, which are described in the previous chapters. Energy minimization is the toughest task and this is mandatory in wireless networks to improve the network performance. This study handles the energy consumption analysis and minimization in heterogeneous networks using new dynamic programming and m-layer architecture. However several researches have been done and addressed the energy consumption task in different wireless networks.

But the proposed system is concentrating a hybrid approach for the energy reduction technique in HetNets. To achieve the profit on energy minimization task in HetNets, new resource analysis and allocation scheme is proposed. And this scheme reduces the knapsack problem and spatio temporal based resource allocation issues. The followings are the contributions of the proposed system.

a. Contributions:

- The proposed system helps to improve QOS parameters in HetNets by applying different set of energy consumption reduction techniques.
- The proposed system performs Dynamic allocation with low-power wireless access points.
- The proposed system reduces the resource consumption in m-layer and as well as in routing in Hetnets.
- This has the ability to predict the energy consumption in a particular traffic distribution.
- The proposed system utilizes on-off scheme with optimal base station detection for energy reduction.
- To perform the above there are two main approaches are introduced. The first one is minimizing energy in layered architecture, which is named as M-Layer. And the energy minimization in routing process is performed using MAODV (Modified/Mlayered Adhoc On demand Distance Vector Protocol).
- Design an efficient protocol (MAODV) to improve Delay and Throughput of MANETs.
- Design a routing protocol (MAODV) with effective path selection that provides multiple, node disjoint and loop free paths to destinations.
- Design a routing protocol (MAODV) that facilitates the functionalities of energy efficiency along with link life time and delay.

The proposed system utilizes 3 layered architectures, which are segmented into Micro Layer, Macro Layer and Femtocell Layer. The work used optimal state definition and demand analysis for improved energy minimization over wireless network.

b. Network Setup:

The proposed system involved in the heterogeneous wireless system, which combines cellular and adhoc networks. This proposal includes an Infrastructure-based heterogeneous wireless system (IbHWS). The IbHWS is the collection of multiple layers of Base Stations. Each layer operates in a different frequency band. In this type of network, each layer consists of base station, the base stations are not overlapped among others.

The coverage are of each femtocell of a BS that belongs to the microcell layer. Similarly, the coverage area of each microcell is a subset of the coverage area of a BS that belongs to the macrocell layer. The coverage area of the femtocell BS on the right is not a subset of any single BS. The proposed system handles different type of layers for energy minimization strategy. The first part of the work handles the layer enhancements and the second part handles the protocol based approaches.

Layer Concepts:

This has the m-layer setup; every layer has 3 base stations. The following sections represent the overall process of the proposed network setup process. In heterogeneous networks the cells of different sizes are referred to as macro cell, micro cell, pico cell and femto-cells; listed in order of decreasing base station power. The actual cell size depends not only on the lower power stations but also on antenna position, as well as the location environment; this network architecture helps to handle different types of networks in the wireless environment.

Macro Layer: A macro layer is a layer in a mobile phone network that provides radio coverage served by a high power cellular base station (tower). Generally, macrocells provide coverage larger than microcell. A macro layer provides the largest area of coverage within a mobile network. The antennas for macro layer can be mounted on ground based pole, rooftops or other existing structures. These must be positioned at a height that is not obstructed by terrain or buildings. Macrocells provide radio coverage more than varying distances depending on the frequency exploited in the number of calls made and the physical terrain.

ISSN (Online) 2278-1021
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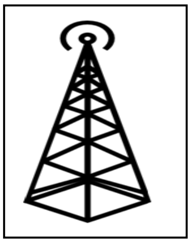
Vol. 5, Issue 11, November 2016



MacroCell:

- It covers less more than 20 miles.
- It has high power cellular base stations

Fig 1.0 Macro cell layer capacity

Micro Layer: these are difficult to precisely distinguish from other layers in specific the Pico layer, but their coverage area is the prime delineator. Micro Layer can cover areas less than a mile in diameter and uses power control to limit this radius. Micro Layer can be deployed temporarily in anticipation of high traffic within a limited area, such as a sporting event, but are also installed as a permanent feature of mobile cellular networks.

MicroCell:

- It covers less than a mile.
- It is used when needs additional

Fig 2.0 Micro cell layer capacity

Picocells Layer: offer greater capacities and coverage areas, supporting up to 100 users over a range of less than 250 yards. Picocells are frequently deployed indoors to improve poor wireless and cellular coverage within a building, such as an office floor or retail space.

PicoCell:

- It can support up to 100 users at a time.
- It is used in indoor applications (office or building)

Fig 3.0 Pico cell layer capacity

Femtocells Layer: are typically user-installed to improve coverage area within small vicinity, such as home office or a dead zone within a building. Femtocells can be obtained through your mobile operator or purchased from a reseller. Unlike picocells and microcells, femtocells are designed to support only a handful of users and are only capable of handling a few simultaneous calls.

FemtoCell:

Femtocells are the smallest of small cells.
It is capable of handling only few users at a time

Fig 4.0 Femto cell layer capacity

The above fig Fig 1.0, Fig 2.0, Fig 3.0 and 4.0 shows the range capacity and basic process of different layers in the wireless network. The proposed model finds appropriate network layer according to the demand. This facilitates the energy efficiency in the M-layer architecture.

c. State Management in M-Layer:

The proposed system provides different state management for energy efficiency at the layer level. The initial implementation of state management will be an off state. This has three types of states; one is On, Off, Idle state. The selection of state is performed after the several factors. This chapter discusses about the state, changes in that and the factor analysis in the M-layer architecture.

Energy verification when the BS is ON: the calculation of energy of every base station b, with demand analysis is performed in this step. This is calculated by setting the initial energy I for every based station B and calculating the remaining energy after changing every state.

Eon, min (Dtj)→ for "on" state, the minimum energy consumed by Bs1 is calculated. Here Dtj is the time interval and finally the energy is represented in joules. The energy utilization at every stage and with every demand will be calculated and analyzed.

Eon, max (Dtj)→ for "on" state, the maximum energy consumed by Bs1 is calculated.

Eon, Avg(Dtj)→ for "on" state, the average energy consumed by Bs1 is calculated.

The above aggregated results on energy consumption provide the summarized results for every base station in different layer in the network. As like the above, this will be calculated for the remaining other states such as Off and Idle.

Eoff, min (Dtj),…Eoff, max (Dtj)…, Eoff, avg (Dtj)

Eidle, min (Dtj),… Eidle, max (Dtj)…, Eidle, avg (Dtj)

After calculating the above aggregated results, the system finds the demand for every base station; this will find using the following process.

d. Demand analysis:

The traffic demand is typically characterized by the session arrival rate and the average file size. With these two values, the overall load of a BS is then estimated in terms of (a) the total number of bits served by the BS, or (b) the average bitrate, i.e., total number of bits divided by the total time. Then, based on the value of overall load, the energy consumption of the BS is predicted. However, this

 DOI 10.17148/IJARCCE.2016.51124

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

approach is highly inaccurate, mainly because it assumes a linear relationship between a particular bitrate and the corresponding power needed to provide it.
If the transaction is transmits the same number of bits r at two different bitrates R1 and R0, where R1 = mR0 and m > 1, then the amounts of time t1 and t0 that would be required at each rate, respectively, would be related by
t0 = mt1
Therefore, for the energy consumption at both rates to be equal it would be needed that
$\mathbf{P_{RX1} = mP_{RX0}}$
Where P_{RX1} and P_{RX0} represent the received power required to achieve each bitrate, respectively. However, utilizing Shannon's Channel Capacity theorem, it can be shown that the relationship between P_{RX1} and P_{RX0} is exponential rather than linear:

The demand analysis is the process of identifying extra requests than the channel capacity. In the proposed system the channel capacity is calculated using Shannon's Channel Capacity theorem. This helps to find the maximum rate at which information can be transmitted over a communications channel of a given bandwidth.
1) For every active location L that can only be served by a single BS, its serving BS must be in the on state. For any such BS, its energy contribution to the overall RAN (Radio Access Network) energy consumption is at least Eon, min (Dtj).
2) Every BS b for which no location under its coverage requests any traffic can be switched to the off state. For any such BS, its energy contribution to the overall RAN energy consumption is determined by Eq. (1).
E_B=Eoff(Dtj)→ find the total energy consumed by base station B when it is off (1)
E_B=Eon(Dtj)→ find the total energy consumed by base station B when it is on (2)
From an analytical perspective, this condition should always be enforced. However, in a real IbHWS, turning off a cell should only be done when it is highly probable that no user will appear in that area (e.g., an office femtocell during the night) or when another active cell is serving the area of the cell being turned off.

Algorithm: M-layer Energy based state selection
Notations: Dtj→time interval, B-Base station, E-Energy
Steps:
1. For each base station $B_1, B_2 \ldots B_N$ in M-Layer
a. Initiate Energy E for Bi
i. $E1_{Bi} = E_{BiON}$(Dtj) { when the Bi is ON}
ii. $E2_{Bi} = E_{BiOFF}$(Dtj) { when the Bi is OFF}
iii. $E3_{Bi} = E_{BiIdle}$(Dtj) { when the Bi is Idle}
2. Calculate the traffic demand T_D for every B
a. Channel capacity for Macro Cell
b. Mc=avg(coverageMc(total_nodes))
c. Channel capacity for Micro Cell
d. Nc=avg(Mc∩coverageNc(total_nodes))
e. Channel capacity for Pico Cell Pc=avg(Mc∩Nc
f. ∩coveragePc(total_nodes))
g. Channel capacity for Femto Cell Fc=avg(Mc∩Nc ∩Pc
h. ∩coverageFc(total_nodes))
3. For every state S in B, match the T_D..
a. For j as Energy of Bi at every state S
i. EjBi=MinE(Dtj→ T_D)
b. End for
4. Find state which has MinE for max T_D
a. Optimal(state) Os= MinE→ maxT_D
5. Activate Os for Bi.

Algorithm1: M-layer Energy analysis
The algorithm 1 M_layer based energy analysis and state selection algorithm performs three type of process in the layered hardware oriented design. This initially calculates the energy consumption at every base station for three different states.

This may differ from layer to layer. If the micro and macro cells are deployed, the energy size huge, because it shares the energy with other components in the configurations. But femto and Pico cell layers only need small amount of energy, the ON, OFF and idle states will be selected according to the minimum energy for maximum demand. Using this, the base station state will be activated.

Simulation Parameters:
As mentioned earlier, the proposed system performed a comparison study with AODV and the modified AODV. The AODV protocol in NS-2.35 maintains a send buffer of 64 packets used in route discovery. The maximum waiting time in the send buffer during route discovery is 30 seconds. If the packet is in the send buffer for more than 30 seconds, the packet is dropped.

The size of the interface buffer of each node for simulation is taken as 50 packets. The simulation environment is constructed with 50 mobile nodes and the data transmission will happen between 3 pair of nodes at different periods of time. The data transmissions between all the three pair of nodes are traced and all the required parameters are logged in the trace file. These trace files are later analyzed to evaluate the performance of the protocol.

This has used a constant bit rate (CBR) source as the data source for each node. The proposed system is considered 7 base stations, 3 source nodes and 3 destination nodes for simulation, each node transmitting packets at the rate of 3 packets per second, with a packet size of 1024 bytes. A movement scenario arranges the movement and the position of the nodes according to the random waypoint model.

Table 1.0 simulation parameter list

Parameters	
Number of Nodes	50
Total Base stations	7
Total Layers	3
Topography	1500 * 1500
Simulation time	200

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 5, Issue 11, November 2016

Our proposed work is successfully implemented using Ns2. The performance of this proposed work M-Layer and MAODV scheme is discussed in this chapter. The table 4.3 and 4.4 above shows the configuration of the simulation.

Parameter name	Parameter value
Stimulation tool	NS2
Antenna	Omni antenna
Network Interface Type	Wireless Physical
Channel	Wireless Channel
Number of Mobile nodes	40
LL	Link layer type

Table 2.0 TCL parameter list

Packet Loss :
The comparison of packet loss between AODV and MAODV is represented by the following Figure

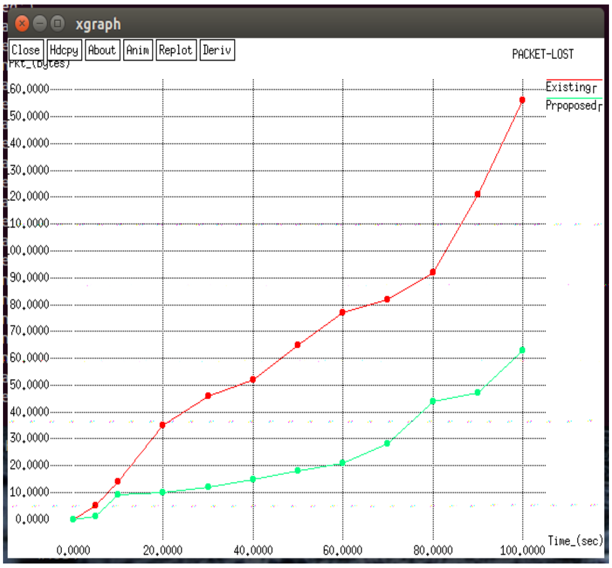


Fig 5.0 comparison chart

X- axis - Time
Y –axis – Packet Loss
The above graph shows that the packet loss during the data transfer between source 2 and sink 2 pair is high. This high loss may be due to high traffic in the network. Since packet loss is high, it will lead to a throughput reduction in the network.

CONCLUSION

In this manuscript the system introduced an efficient method for energy efficient data collection along with Mlayer concepts. This paper provides a survey of the various techniques involved with energy analysis and minimization techniques in HetNets. In this paper various methods for energy minimization for wireless network on heterogeneous model are discussed. It is observed that various methods and techniques for energy minimization are presented. Additionally other QOS related issues also refereed. The selection of the methods may depend on the type of network deployment details. Finally the survey summarizes the overall drawbacks of all the methods with various considerations.

In performance analysis of architectural and protocol design techniques in heterogeneous networks for energy minimization applications, Cross-Layer design was implemented in multi layer basis. However, to further improve the overall QoS parameter, Cross-Layer design across all layers can be considered. A novel adaptable Cross-Layer interface can be embedded in the mobile device itself to make the future devices to be more user centric. Finally, at the network side, novel network elements fusing user functionalities with network status shall lit up nascent technological path way to near future.

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