Energy Consumption Analysis and Minimization Techniques in Heterogeneous Wireless Network-A Survey

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ABSTRACT: Energy minimization is the imperative task in wireless networks to improve the network performance. Performing the same task on the heterogeneous networks (HetNets) and small cells is an additional burden and it complicates the work more. Although much research has been done and addressed the energy consumption task in different wireless networks, there some limitations, which concentrated only on the homogeneous networks. To achieve the profit on energy minimization task in HetNets, numerous techniques were used. This survey discusses the techniques and tools used for energy analysis and minimization in HetNets and finally provide an outline to overcome the problems of those techniques.

KEYWORDS: Heterogeneous networks, energy saving, cellular networks, cell-association, on-off schemes

I. INTRODUCTION

Wireless Networks (WNs) are the large group of communication devices which are not connected via cables. These WNs allow users to communicate, broadcast and access resources with various types of devices [1]. Among all the above networks, the survey handles the energy consumption analysis and minimization techniques in heterogeneous wireless networks. A (HWN) **Heterogeneous wireless network** is a special case of a Heterogeneous network (HetNet), in HetNets many more base stations (BSs) are installed in any given geographical area [2]. And HetNet may consist of a network of computers or devices with different capabilities in terms of operating systems, protocols, hardware etc.; a HWN is a wireless network which consists of devices using different underlying radio access technology (RAT).

There are several problems still to be solved in heterogeneous wireless networks such as; determining the capacity of heterogeneous wireless networks, the handover problem, high mobility and the overall quality of service is limited. These are the unsolved issues in the heterogeneous wireless networks. But still, there are several benefits of using HWN while comparing with the traditional homogenous networks. This has the following benefits such as reliability; it increases the coverage, improved spectrum efficiency. In HWN, when one particular radio access technology within the HWN is unsuccessful, it may still be potential to maintain a connection by falling back to another RAT, this shows the reliability achieved in the HWN. With the use of RATs, HWN increases the coverage and spectrum efficiency [3].

Due to several aspects, the energy consumption may increase on the network, if it is in the HetNets, the analysis of energy consumption is a dreamy task. Finding the best technique and minimizing the energy consumption din the HetNets is an active research area. And there are huge research problems belong to this area have been highly concentrated in the literature.
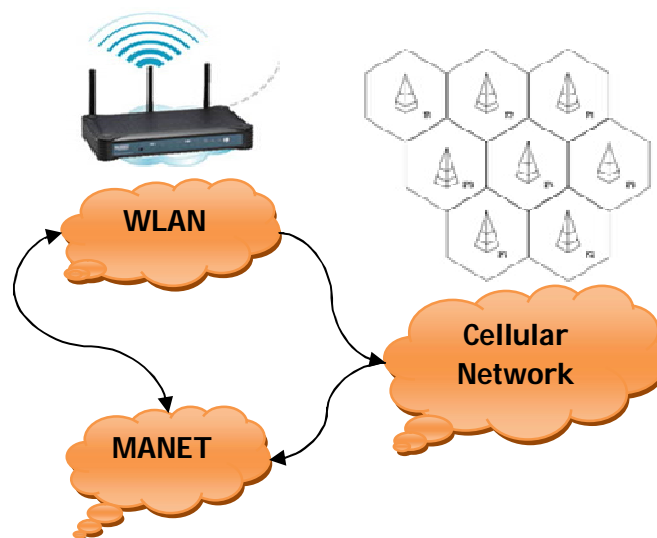
Fig 1.0 Heterogeneous wireless network

From the above fig 1.0, the heterogeneous wireless network consists of WLAN (Wireless Local Area Network), Cellular network and MANET (Mobile Adhoc Network). In this survey, we reviewed different techniques and methods used to analyze the energy consumption in heterogeneous wireless network.

II. TYPES OF NETWORKS IN WIRELESS NETWORK

HetNet consist 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 chapter shows the sub types of heterogeneous networks.

a. Cellular Network (CN):

A cellular network consists of multiple low-power transmitters, which has 100 W or less. The cellular network areas divided into cells and each served by its own antenna and base station consisting of transmitter, receiver, and control unit. The cellular network has different Mobile switching center (MSC), which connects calls between mobile units. The CN has two types of channels available between mobile unit and BS, the Control channels are used to exchange information having to do with setting up and maintaining calls and Traffic channels are used to carry voice or data connection between users [4].

Energy consumption minimization in CN:

This section reviews the energy consumption tools for CN from stochastic geometry to analyze the energy efficiency of cellular networks through the deployment of two strategies named as sleeping strategy and small cells. By assuming that the network operators have some information of the traffic usage patterns, they can employ a coordinated sleeping mode, where certain BSs will be shut off while others increase their coverage areas to avoid coverage hole. In particular, we model the sleeping mode at each MBS as a Bernoulli random variable, where q denotes the probability that a BS remains in operation and the underlying spatial distribution of BSs is modeled as a PPP.

Energy efficiency in cellular networks is impressive area in both industry and academia, which addresses the aforementioned issues. While, the major energy inefficiencies and wastage occur at the CN, it has received the most concentration. Beyond improving the hardware components of the BS [5], [6], one of the more effective ways to reduce the energy consumption at the CN is by turning BSs off. In HetNets, such action is possible since more than one BS

may provide coverage in a particular area. To address the energy consumption at the RAN in HetNets, appropriate models are required for the (i) network deployment strategies, (ii) energy consumption at the BSs, and (iii) traffic demands (TDs).

III. LITERATURE REVIEW

There are huge researchers were in the development of energy minimization techniques and proposed Remote different strategies to overcome the energy related issues in HetNets. Those strategies much relies on sleep strategy, inactive mechanisms and BS selection.

The following chapter describes the various approaches and techniques are developed from the above methods.

Jeffrey G. Andrews [7] developed a new framework, which supports downlink cellular network analysis. This framework is better than the traditional grid based models, but prior works only relies on any one BS deployment. This paper also developed and utilizes the technique of SINR (signal-to-interference-plus-noise ratio) CCDF (equivalent to the coverage probability) to optimize the multi client settings. Random spatial placement options are not considered in this paper. The main advantages of this approach are increases the performance and accuracy by providing modeling neighboring base stations.

Kyuho Son and Bhaskar Krishnamachari [8] had developed a theoretic framework for BS, which saves the energy and overcomes the BS operation related problems. In specific the author formulate total cost minimization and this achieved flow level performance improvement and energy consumption minimization. In order to achieve this, the authors proposed an optimal energy efficient user association policy. Additionally heuristic algorithms based on the distances between BSs or the utilizations of BSs that do not impose any additional signaling overhead and thus are easy to implement in practice. Numerical results based on the acquired real BS topologies under practical configurations

F. Akyildiz, D. Gutierrez-Estevez, and E. Chavarria Reyes,[9] considered an approach to quantify the energy efficiency of large geographical areas by using the existing small scale deployment models along with long term traffic models. And additionally, the framework is applied to quantify the energy efficiency of the downlink of a radio access network. In order to identify the key levers for energy savings the power consumption of mobile communication systems needs to be quantified. This includes sophisticated power models that map the radiated power to the supply power of a BS site, as well as traffic and deployment models that extend short term small scale evaluations to the country wide power consumption of a network over a whole day or week. Authors show the numerical results that reveal that for current network design and operation, the power consumption is mostly independent of the traffic load. This highlights the vast potential for energy savings by improving the energy efficiency of BSs at low load.

K. Chen and D. Peroulis [10] presented novel adaptive power amplifier (PA) architecture for performing dynamic load-modulation and energy analysis. When comparing with the previous research, a dynamically load modulated PA design that achieves high power, bandwidth, and high efficiency simultaneously is experimentally established. A novel methodology for designing and implementing adaptive power amplifier with continuous tenability for broadband dynamic load modulation has been proposed in this paper. The tunable output matching network is composed of a combination of a tunable series resonator in cascade with a sixth order low-pass filter.

F. Han, Z. Safar, and K. Liu,[11] proposed an energy efficient BS switching strategy in which some BSs are turned off and BS cooperation is used to effectively extend coverage with guaranteed QoS. Based on the standard hexagonal cell network model, four switch off patterns are introduced to progressively turn more BSs off to save energy according to the offered traffic load. Authors consider QoS from both the network-layer and the physical layer perspectives, and analyze the call-blocking probability and the channel outage probability. This guaranteed the QoS of the UEs under the energy-efficient patterns by focusing on the worst-case transmission/reception locations instead of just looking at the spatially averaged performance. With guaranteed QoS, the energy-saving performance of the proposed scheme is evaluated. Both the analytical and numerical results exhibit significant energy-saving potential of the proposed idea of BS switching and cooperative coverage extension several implications based on this work can be useful to practical cellular networks. First, switching off some BSs during low-traffic hours according to several pre determined pattern s is effective in energy-saving with feasible complexity. Although the regular hexagonal cells hardly exist in reality, the well-planned macro cell BS deployment and the consistent periodicity of traffic profiles afford the off-line computation

of several progressive switching patterns for a certain area. Second, BS co-operation can be used to effectively extend coverage, especially when some BSs are off. Cooperation among BSs has been made available in recent standards such as LTE-advanced, referred to as Coordinated Multi Point CoMP, facilitating a basis for the proposed cooperative coverage extension scheme. Lastly, given the significant energy saving potential predicted by the theoretical model, it can be worthwhile to investigate the potential signaling cost of pattern switching, UE handover, and BS Cooperation, which will be interesting future research.

Yong Sheng Soh, Tony Q. S. Quek, Marios Kountouris [12] investigated the design of energy efficient cellular networks through the employment of base station sleep mode strategies as well as small cells. The authors also investigated the tradeoff issues associated with the sleep mode and small cell strategies. Using a stochastic geometry based model derived the success probability and energy efficiency under sleeping strategies in homogeneous macro cell and heterogeneous *K*-tier networks. In addition, in this research formulated optimization problems in the form of power consumption minimization and energy efficiency maximization and determined the optimal operating frequency of the macro cell base station. In particular, we investigated the impact of random sleeping and strategic sleeping on the power consumption and energy efficiency. Numerical results confirmed the effectiveness of sleeping strategy in homogeneous macro cell networks but the gain in energy efficiency depends on the type of sleeping strategy. Besides the deployment of small cells generally leads to higher energy efficiency but this gain saturates as the density of small cells. Future work may include the extension of the above model to the case where base stations have multiple antennas and may perform opportunistic user selection. It would also be of interest to explore how random spatial placements of base stations that model repulsion or inhibition affect the results in terms of throughput and energy efficiency. Finally, the energy efficiency metric investigated here is only dependent on the power consumption and the coverage within the network, and does not take into account the infrastructure cost and backhaul over head associated with implementing small cell networks.

Oh, Eunsung, and Bhaskar Krishnamachari, [13] the operation of cellular network infrastructure incurs significant electrical energy consumption. From the perspective of cellular network operators, reducing this consumption is not only a matter of showing environmental responsibility, but also of substantially reducing their operational expenditure. Additionally discussed about the dynamic operation of cellular base stations, in which redundant base stations are switched off during periods of low traffic such as at night, can provide significant energy savings. In addition, the author leaves some process for future work such as coverage extension, other technical issues, and considers the location estimation problem that arises in some cellular deployments.

Tao Han, and Nirwan Ansari, [14] developed the energy utilization in cellular networks whose BSs are powered with both regular energy from the grid and the renewable energy. The authors developed framework to minimize the on-grid energy consumption of BSs by adapting their cell sizes. The cell size optimization problem is NP-hard, which is the decision making problem. The authors divided the problem into two sub problems: the multi-stage energy allocation problem and energy consumption minimization problem. And finally proposed an energy allocation policy and an approximation algorithm to solve these sub problems, respectively, and subsequently solve the cell size optimization problem. The framework reduces the energy consumption of cellular networks with hybrid energy supplies by optimizing the cell size and network size.

The results and discussion of the existing approaches 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. 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.

IV. CONCLUSION

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.

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