Review Paper on Call Admission Control with Bandwidth Reservation Schemes in Wireless Communication System

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Abstract - *In this paper, we bring forward the important aspect of energy savings in wireless access networks. We specifically focus on the energy saving opportunities in the recently evolving heterogeneous networks (HetNets), both Single-RAT and Multi- RAT. Issues such as sleep/wakeup cycles and interference management are discussed for co-channel Single-RAT HetNets. In addition to that, a simulation based study for LTE macro-femto HetNets is presented, indicating the need for dynamic energy efficient resource management schemes. Multi-RAT HetNets also come with challenges such as network integration, combined resource management and network selection. Along with a discussion on these challenges, we also investigate the performance of the conventional WLAN-first network selection mechanism in terms of energy efficiency (EE) and suggest that EE can be improved by the application of intelligent call admission control policies.*

Key Words: *Energy efficiency, Heterogeneous Networks, Long-Term Evolution, Multi-RAT, WLAN.*

1. INTRODUCTION

The evolution of wireless communication devices continues to explode the traffic demand in wireless communication systems. It is expected that the traffic demand will increase up to thirteen fold by 2017 as that of 2012, at a compound annual growth rate (CAGR) of 66% [1]. Therefore, wireless network providers face an enormous challenge to increase their network capacity, in order to cope with the increasing traffic demand. Since improvements in spectral efficiency (SE) at link level approaches its theoretical limits with currently existing technologies, the next generation of technology is about improving spectral efficiency per unit area [2]. Therefore, network providers and equipment vendors are looking into an evolved network topology to improve the network capacity. To this end, the heterogeneous network (HetNet) architecture is seen as a promising solution to the capacity problem of wireless communication networks.

A HetNet may consist of different size of cells with different radio access technologies (RATs). Fig. 1 depicts a typical example of a HetNet. In HetNets, small cells bring down the distance between transmitter and receiver, which results in low path loss. This leads to an increased received signal power, signal to noise ratio (SNR) and better SE. Therefore, the area efficiency (AE) (i.e SE per unit area) can be improved [3].

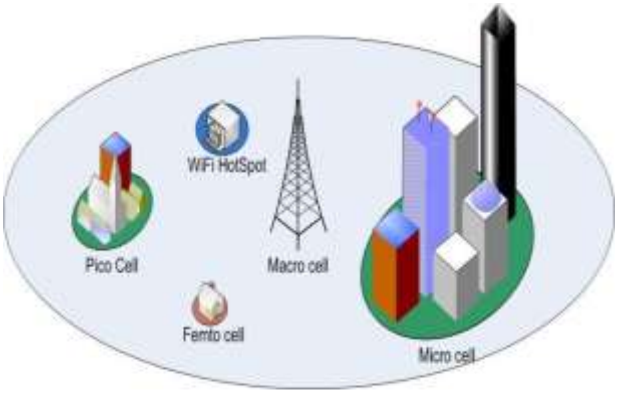

Fig -1: A typical example of HetNet

Apart from the capacity demand, energy consumption of mobile terminals becomes an increasing concern due to increased network usage of latest advanced wireless communication devices (e.g. smart phones and tablet PCs). Therefore, there is a significant threat that the 4G mobile users will be searching for power outlets rather than network access, and once again binding them to a single location. This problem is sometimes described as the *energy-trap* of 4G systems [4]. At the same time, EE of the network also considered as an important aspect of network operation, due to the increased cost of energy and environmental concerns. Hence, apart from the coverage, capacity and QoS, the energy efficiency (EE) also becomes an important performance indicator from the component design to the network operation.

2. LITERATURE SURVEY

In general, conventional antenna system architectures used in mmWave band are inadequate to combine wide-angles with high directionality. Existing reflective, parabolic dishes and lens antennas can create narrow beam, thus delivering the needed 30_40 dB antenna gain, but they lack the flexibility to cover wide angle coverage and are relatively bulky. Phased patch antenna arrays allows steering the beam to a desired direction. However, to achieve the necessary directivity, the array must consist of a large number of elements (several hundred to thousands).

Phase antenna arrays composed of a large number of antenna elements have been proposed to achieve the necessity of the wide directionality. The Phase antenna array architectures currently used for mass production employ a single module, containing a radio frequency integrated circuits (RFIC) chip that includes controlled analogue phase shifters capable of providing several discrete phase shifting levels. The antenna elements are connected to the RFIC chip via feed lines. However, due to the loss inherent in the feed lines, this approach reduces antenna gain and efficiency, and becomes a severe problem when the number of antenna elements and RF increase [7].

The call admission control strategies investigated in the literature are variedly classified into types. Generally, Deterministic Call Admission Control and Stochastic Call Admission Control are the two categories of call admission control schemes in cellular networks [5]. In deterministic CAC, QoS parameters are guaranteed with 100% confidence. These schemes typically require extensive knowledge of the system parameters such as user mobility which is not practical, or sacrifice the scarce radio resources to satisfy the deterministic QoS bounds. On the other hand, in stochastic CAC, QoS parameters are guaranteed with some probabilistic confidence. By relaxing QoS guarantees, these schemes can achieve a higher utilization than deterministic approaches. CAC schemes can also be classified as proactive (parameter-based) or reactive (measurement-based). In proactive schemes [6], the incoming call is admitted or rejected based on some predictive/analytical assessment of the QoS constraints. In reactive schemes [7], the incoming call might start transmission (by transmitting some probing packets or using reduced power) before the admission controller decides to admit or reject the call based on the QoS measurements during the transmission attempt at the beginning. In [8], CAC is classified based on the information needed in the CAC process. Some CAC schemes use the cell occupancy information [9]. This class of schemes requires a model or some assumption for the cell occupancy. Alternatively, CAC schemes might use mobility information (or estimation) in making the admission decision. The use of mobility information, however, is more complicated and requires more signaling. The information granularity used in CAC schemes can be considered at the cell level or at the user level. If a uniform traffic model is assumed, information of one cell is enough to represent the whole network condition. In a non-uniform traffic model, however, information from different cells is required to model the network status, which increases the information size. The third case, in which information of each individual user is considered, of course leads to a huge information size.

Furthermore, CAC schemes have been designed either for the uplink [10] or the downlink [11]. In the uplink, transmit power constraint is more serious than in the downlink since the MS is battery operated. On the other hand, CAC in the downlink needs information feedback from MSs to the BSs for efficient resource utilization. Applying CAC for both links jointly is crucial since some calls might be admissible in one of the links and non-admissible in the other, particularly for asymmetrical traffic. In the uplink direction of a wireless network, one CAC is based on the number of users and is referred to as number-based CAC [3] and the other is based on the interference level and is referred to as interference-based CAC [12]. The operation of the number-based CAC schemes is quite similar to the fixed-assignment FDMA/TDMA systems. That means that capacity is „hard" as the number of users that can be admitted into the system is fixed. The Signal to Noise Interference Ratio-based algorithm computes the minimum required power for the new user and accepts it if it is not below a predefined minimum link quality level.

3. SYSTEM MODEL

We consider a multimedia wireless/mobile network with a cellular infrastructure, comprising a wired backbone and a number of base stations (BSs). The geographical area controlled by a BS is called a cell. A mobile, while staying in a cell, communicates with another party, which may be a node connected to the wired network or another mobile, through the BS in the same cell. When a mobile move into an adjacent cell in the middle of communication session, a handoff will enable the mobile to maintain connectivity to its communication partner, i.e., the mobile will start to communicate through the new BS, hopefully without noticing any difference.

In this paper, we are concerned with CAC and bandwidth management in each cell. Therefore, we decompose the cellular network into individual sub-systems, each corresponding to a single cell. The correlation between these sub-systems, results from handoff connections between the corresponding cells, which is re-introduced as an input to each sub-model. Under this assumption, each cell can be modeled and analyzed individually. A same model is used for all cells in the network, but the model parameters may be different, reflecting the mobility and traffic conditions in individual cells, as well as the channel assignment policy employed by the network. Therefore, we can model the system at single-cell level.

We assume the system uses Fixed Channel Allocation (FCA), which means each cell has a fixed amount of capacity. No matter which multiple access technology (FDMA, TDMA, or CDMA) is used; we could interpret system capacity in terms of effective or equivalent bandwidth [10]. Hereafter, whenever we refer to the bandwidth of a connection, we mean the number of basic bandwidth units (BBUs) that is adequate for guaranteeing desired QoS for this connection with certain traffic characteristics.

Consider a cell that has a total capacity of C BBUs. Two types of connections share the bandwidth of the cell: new connections and handoff connections. In this work, we consider only real-time services. Typically, class-1 traffic includes voice service while class-2 traffic is comprised of video service. Thus, traffic arriving at the cell is partitioned into two separate classes based on bandwidth requirements.

Each class-i connection requires bandwidth ci BBU (i = 1, 2). The classes are indexed in an increasing order according to their bandwidth requirements, such that: $c_1 \leq c_2$. The block diagram representation of the wireless cell is shown in Fig. 2.

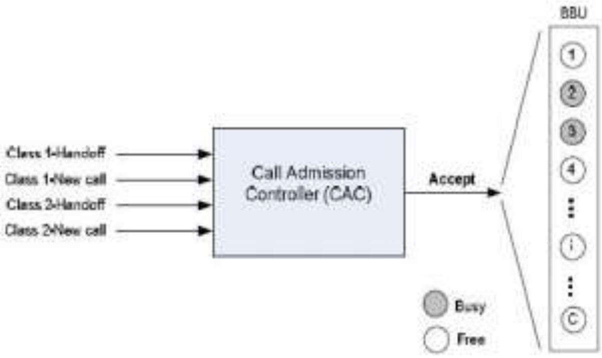

Fig -2: System Model

4. HETNET DEPLOYMENT

In terms of network deployment, a HetNet can consist of different size of cells, such as macro, micro, pico and femto cells that provide services to same coverage area in a multi-tier configuration, that utilize single RAT. This kind of HetNet is known as Single-RAT HetNet. For example, the 3rd Generation Partnership Project (3GPP) Long Term Evolution - Advanced (LTE-A) system, with outdoor macro Base Station (BS) and indoor Home BS (HBS) is a prime example for such Single-RAT HetNet. On the other hand, in a Multi-RAT Het-Net, multiple RATs such as Wideband Code Division Multiple Access (WCDMA), Worldwide Interoperability for Microwave Access (WiMAX), Wireless Local Area Network (WLAN) and LTE can jointly provide service to same coverage area in a complementary manner with different coverage ranges. A network of outdoor WCDMA/LTE macro cells with indoor and hot spot coverage of WLAN is a practical example of Multi-RAT HetNets.

The advantage of Single-RAT HetNets comes from the relatively less complex network operation compared to the Multi- RAT. For example, a Multi-RAT HetNet needs additional authentication, authorization and accounting (AAA) system, allowing users to perform authentication and authorization processes in different RATs, attending to security suites and subscription profiles for security and billing purposes. However, Single-RAT HetNet suffers from the cross-tier interference. Since the spectrum is scarce and expensive, the available licensed spectrum is limited to each operator.

Therefore, in most cases, the same spectrum will be shared between different tiers in a Single-RAT HetNet. To this end, mitigating interference while increase the network capacity, is considered as a major challenge in Single-RAT HetNet. On the other hand, in a multi-RAT HetNet, the advantage is, having different RATs that utilize different frequency spectrum including the unlicensed spectrum (e.g. WiFi). Therefore, Multi-RAT HetNet does not suffer from cross-tier interference. However, integration of different RATs becomes one of the major problems in multi-RAT HetNet, due to different techno-logical and architectural aspects of each RAT.

5. ENERGY EFFICIENCY ANALYSIS OF LTE-WIFI HETNET

Traditionally, total network EE has not been an optimization parameter in a Multi-RAT HetNet. Moreover, in current Cellular WLAN HetNets, the user terminals select the desired network based on the user preference, without specific optimization, due to the complexity involved in such optimization processes. For example, in the widely used network selection scheme, known as WLAN-first [10], the mobile terminals always connect to the available WLAN, without considering network load, quality of service (QoS) or EE. Further, there is no CAC policy in the *WLAN-first* scheme. Therefore, the WLAN network can become congested; hence the whole network performance degrades. To this end, we investigate the performance of LTE-WiFiHetNet in terms of total network EE and per user throughput for *WLAN-first* scheme with and without CAC. Here, when there is a CAC policy applied to the WiFi network, we assume that the APs only allow certain number of users (e.g. 4 users) who have best channel condition under its coverage.

For this study, we consider an LTE-WiFiHetNet comprising of a single LTE cellular macro base station (BS) and multiple WiFi access points (APs), providing service to the same coverage area. Fig. 2 depicts such typical network architecture. Since we are interested in access part of the network, we adopt tight coupled network of LTE and WiFi, where the WiFi APs are connected to the Evolved Packet Core (EPC) through a gateway router in a same manner as the LTE BS (eNodeB).We evaluate the system performance through Network Simulator 3 (NS3) based system level simulations, adopting realistic power consumption models for both networks and considering all practical aspects of full communication protocol stack according to the relevant standards. For energy consumption evaluations, we adopted power consumption profile for macro BS and WiFi AP from [11] and [12] respectively.

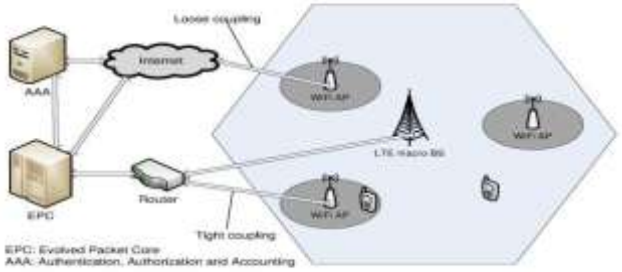

Fig -3: Typical LTE-WiFiHetNet

Fig. 3 show the simulation results in terms of per user throughput and normalized EE respectively, with respect to increased AP deployment in the considered coverage area.

6. CONCLUSION

Due to the recent evolution of mobile communication devices, demand for network capacity increases exponentially. At the same time, the energy efficiency (EE) of both wireless communication devices and network attracts increasing interests due to short battery life time of advanced mobile terminals and increasing operation cost of mobile networks. The HetNet architecture is considered as a promising solution for both aforementioned capacity and EE problems. Therefore, in this article, we summaries the challenges and opportunities to improve the EE while increasing the network capacity in both Multi-RAT and Single-RAT HetNet. Especially, in LTE-WiFi and LTE macro-femto HetNet respectively. It is evident that, through proper network operation policies and resource management strategies, the total network EE can be improved while increasing the network capacity by off-loading the traffic to WiFi hotspots or femto cells.

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