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An Efficient Call Management Scheme for Cellular/ Wi-Fi Mixed Cells in Next Generation Networks

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Abstract

Background/Objectives: Next generation heterogeneous network will comprise multi access systems with multiple service support. Call management scheme is necessary to provide low call dropping probability for high priority services. Call management scheme for mixed cells (i.e., a 4G cell with embedded WLANs) increase cellular system capacity and reduce dropping probability of cellular-to-WLAN vertical handoff calls. **Methods:** We propose an efficient call management scheme which considers all possible vertical handoff scenarios and provides the maximum usage of WLAN. A blocked request in WLAN is taken back by the overlaying cellular system, if channels are available. Several existing models do not reflect the effect of configuration of neighbor cells which is important for cell planning for a cellular operator. **Findings:** Call management scheme is executed by diverting every request of WLAN that was blocked, to cellular system. **Improvements/ Applications:** The proposed call management scheme shows that new call and handoff call dropping probability is decreased when compare with Complementary-WLAN scheme (C-WLAN) and also increases in system throughput.

Keywords: Blocking and Dropping Probability, C-WLAN, Call Management Scheme, WLAN

1. Introduction

Next Generation Networks (NGN) is becoming the most discussed topic nowadays. The fastest technology advancement has been generated a hope worldwide, both among the wireless operators and customers, to fulfill the demand of high-speed video, low cost and other forms of high-speed data over the next generation platform[1]. Evolution of future network will be driven by better service quality, heterogeneity of networks, reliability, fast response, and high session rate. The broadband wireless services may be dominated by the use of WiMAX and its variants. The complementary services of both cellular with Wi-Fi and WiMAX within a unified IP-based platform may realize the NGN dreams within a short period. A mobile station (MS) can select best available Radio Access Technology (RAT) for better service. An ongoing call can automatically be handed over from one RAT to another for better Quality of Service (QoS) [2]. Joint spectrum of multiple RAT will provide better throughput and lower call dropping probability for the users. Users will generate multiple classes of calls related to multiple services such as data, voice, video and multimedia calls. Joint spectrum techniques for a mixed cell, which provides low call dropping probability. As one of the prime component of the Radio Resource Management (RRM), the usefulness of the call management scheme has the immediate impact on the service quality and offered by the network. There will be three types of call related to each service class; new calls, Horizontal Handoff (HH) calls and Vertical Handoff (VH) calls. An efficient joint call admission control scheme[3] under multiple RATs, multiple services with multi rate traffic is essential for better bandwidth usage, low call dropping probability and better mobility support[4]. Call management scheme is needed to utilize the system resources in a more efficient way[5,6]. Analytical model has been proposed to determine the call management parameters such as blocking/ dropping probability for new and handoff request. The performance of the cellular network is shown to be significantly improved with CWLANs in the area of hotspot coverage. An efficient scheme for cellular/WLAN

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Integrated mixed cell has been proposed. Simulation results show that call dropping rate of proposed scheme is 21% better than C-WLAN.

The proposed model removes the restriction of horizontal and vertical movements of calls. It allows user to access WLAN to priority as long as the maximum number of users do not exceed. The users' restriction provides guaranteed QoS in WLAN. It also provides low dropping probability of real time calls compared to that of non-real time calls. Finally results are useful to plan the deployment of WLAN hotspot(s) under multi service with multi rate arrival of calls. Further there is an improvement in maximize the network throughput and achieves the 80% efficiency compare with the existing model.

In the literature, there has been extensive study on call management scheme for hierarchical cellular networks with a two-tier overlay topology. Many of the recent research address the importance of call management scheme in Radio Resource Management (RRM). There are a variety of call management schemes being proposed to meet the user service demands. To meet the objectives on performance that are predefined, injected traffic into the network are controlled by the schemes of call management. On condition that availability of the free channel is there in a network integrated type (mixed cell), a new user can be accommodated in network of heterogeneity based call management scheme. Admitting a new call always increases the dropping/blocking rate in the mixed cell. Since call management scheme monitors and restricts the users directly in the scheme by taking a decision on admitting/rejecting in the event of arrival of a call in NGN schemes.

In tunnel based WLAN-first access scheme shows that[7-10] users are always reside in the coverage of WLAN. Bandwidth utilization in the WLAN system is maximized as long as user stays in the WLAN coverage. Handoff call dropping rate in WLAN is decreases only if the rate of blocking requests is less than the cellular. As a result, performance of the network becomes poor when there is increase in WLAN traffic. In existing models, free movement of the handoff request from UMTS to WLAN and WLAN to UMTS is not to be considered. The models show the effect of identical hotspot[11].

C-WLANs reduce the dropping probability of data-requests in the cellular system. But the vertical handover of ongoing data sessions from WLANs to cellular is not supported. This is required because some users may wish to continue some data services even when they come out of the WLAN. So, these users will initiate Vertical Handoff Requests (VHRs) in cellular. Some of these users may be moving fast and may enter hotspots again, and initiate VHRs in WLANs. These VHRs need to be considered to capture the net data traffic in a mixed cell. The model needs to perform indirect vertical handoff (IVH) to avert the dropping of a blocked data-request of the cellular coverage. Proposed model consider the vertical movements of calls without any restriction. As long as maximum number of users does not exceed, users are allowed to access WLAN on priority based call management scheme. The significant decrease in call dropping probabilities of handoff calls and new calls. Further, the throughput of the network increases 80% of the system capacity compare with C-WLAN.

2. System Model

Cellular/WLAN integration is thought to be a feasible solution for next generation heterogeneous access networks. The performance of a cellular/WLAN mixed cell can be computed by the estimation of traffic in cellular and WLAN. Integration of cellular (UMTS) and WLAN increases the user's density and provides better bit rate on WLAN Hotspot. The mobility patter in a mixed cell has been developed in Figure1 shows the effect of cellular with WLAN hotspots. In a mixed cell, the cellular traffic is shared by the WLAN based on the coverage area. In UMTS cell, 26% of the call capacity increases three times with 25% WLAN coverage. The user's capacity also further increases at hotspots[11]. User's density in WLAN hotspot is higher than the UMTS Coverage. Railway station, shopping malls, cafeteria and airports are densely populated areas in a mixed cell. Non-hotspot coverage area represents coverage of the area outside the hotspots. WLAN service is inside in the hotspot area is called WLAN-hotspot. Otherwise it is called as WLAN-less-hotspot in Figure1.

Each WLAN is directly connected to the core network using tightly coupling architecture[12]. Upward vertical handoff and downward vertical handoff is performed using proper signaling conditions[13]. In a mixed cell, if users are located in hotspot or Non-hotspot (only WLAN, WLAN-less, only UMTS). If any user access only WLAN service is called only WLAN user. In only UMTS, without integrating WLAN there are two types of calls: Handoff

(Horizontal) and new call. If UMTS is integrated with WLAN, there are three types of calls occur: HH, VH and new call. In a mixed cell, if user is move from WLAN to UMTS and UMTS to WLAN, vertical handoff traffic is generated is shown in Figure1. Similarly if a user is move from UMTS to UMTS, horizontal handoff traffic is generated. Session mobility support is required to initiate if a user is move from WLAN to UMTS. Similarly VH, HH and new call are generated in WLAN coverage. Call Intercepting (CI) probability is useful to estimate the number of user in a mixed cell. Call intercepting probability is calculated using linear analytical model[14]. Which helps the proper planning of hotspots in a UMTS cell, and then hotspots are deployed in WLAN. In nonlinear model, there is no accuracy in the call intercepting probability under the fixed user density. Linear model provides 7.6% improvement in call intercepting probability compare with non-linear model. The net traffic of each class of calls and dropping probability of real time and non-real times services are estimated. But proposed method offers a WLAN as the system of first access in superimposing coverage area of cellular; in turn there is a decrease on the probability of dropping rate/ blocking rate of request.

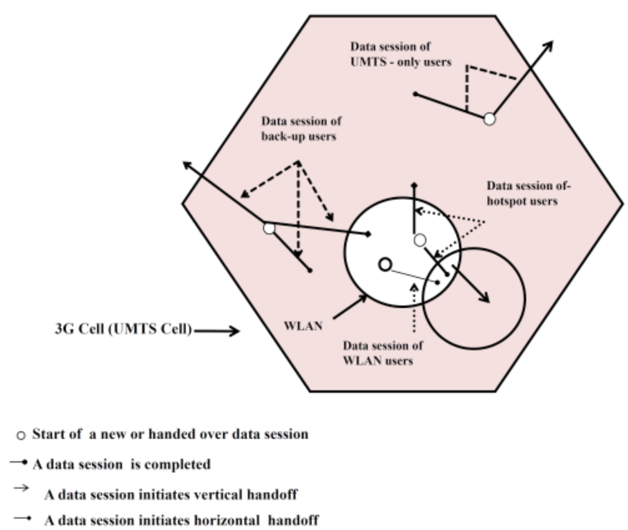

Figure 1. Mobility pattern in a mixed cell.

3. Proposed Call Management Scheme

The motivation of call management scheme is to check the admission of request at network of integrated type (Cellular and WLAN). Existing call management scheme need to be modified to fit in NGN networks. Figure 2 shows the flowchart of call management scheme for the proposed scheme of the logical coverage in a heterogeneous cell. The availability of ambience of wireless access of heterogeneity where the MNs have the facility to get connected to networks of various kinds leads to lot of complexities in the resources reservation as well as call management scheme for NGN. In this scenario, the network initiates a VHR (from cellular to WLAN) of a data session of any user residing in a WLAN hotspot. As a result, a cellular channel is released and that can be assigned to the user whose data request is being blocked at the area of coverage of cellular-only. So, a blocked data-request of cellular is not necessarily dropped. In the case of a mixed cell, it provides data-request's low probability of dropping rate. But, the Indirect Vertical Handoff (IVH) requires new handoff signaling for the WLAN standards. Further, this model takes care of the data-requests of UMTS that are blocked, necessitates some allocated WLAN bandwidth. An exclusive air interface of type for reserved WLAN bandwidth is compulsory for a UE. So, to put into service cellular-WLAN integration employing traditional WLANs, a model with C-WLANs brings difficult to implement the integration. In Tunnel-WLAN, users are permitted to access WLAN once move into the hotspot region. Such users are not visible to cellular coverage.

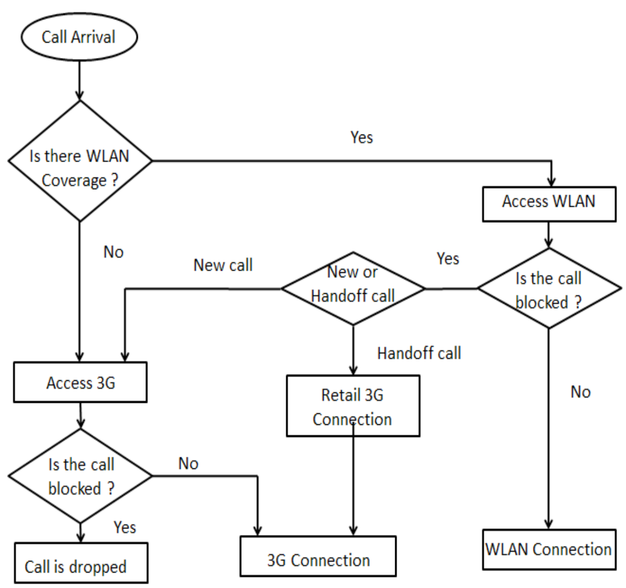

Figure 2. Flowchart of Call management scheme for the proposed scheme.

Vertical and horizontal are two types of handoff. In Horizontal Handoff (HHO) or intra-system handoff, MN can move from WLAN to WLAN or cellular to cellular system. In the case of its counterpart, Vertical Hand Off (VHO) or inter-scheme handoff happens between a WLAN to cellular or cellular to WLAN system e.g., WLAN AP and cellular BS. To make available QoS facility and optimal utilization of resource, a new call management scheme is essential for the integrated networks of cellular and WLAN. An efficient call management scheme improves the call blocking performance of a mixed cell. An accurate estimate of net traffic in WLAN and cellular is required to compute the performance of a mixed cell. Most of the existing analytical models assume identical cellular/WLAN mixed cells and balance of call flow (i.e., number of incoming calls equals number of outgoing calls) between two neighbor cells which is contrary to the real scenario. Hence, the proposed research work aims at improved call managing schemes for cellular/WLAN mixed cells.

4. Estimation of Handoff Call Dropping/Blocking Probability

A demand cannot be approved to any channel if no channel is free, that is, a call is blocked if all channels are busy. Therefore, blocking probability is same as the steady state probability, when no channel is free. Cells can be exhibited as M/G/m queuing structure, where data channels are allotted a Node B in UMTS (that is, a base station). The M/G/m queue scheme defines a model, such that, if a request senses no channels (servers) as free, it will not arrive in the queue, hence it will get vanished in the system. Three events can take place in UMTS, viz. new request arrival, HHR-arrival, VHR-arrival. By Erlang 3-D loss formula for steady state Markov chains, probability for j HHR-successful, i New call successful, k VHR-successful states inside UMTS cell is denoted by:

$$P^u(i,j,k) = \frac{P^u(0,0,0)(\lambda^u_{nc}T^u_{ns})^i(\lambda^u_{hhr}T^u_{hhs})^j(\lambda^u_{vhr}T^u_{vhs})^k}{i!\,j!\,k!} \tag{1}$$

$P^u(0,0,0)$ denotes the probability of no call being handled in the UMTS cell. $T^u_{vhs}, T^u_{hhs}, T^u_{ns}$ denote mean Channel Holding Times (CHTs) of vertical handoff call, horizontally handoff call and new call in a UMTS cell.

$$P^u(0,0,0) = \left(\sum_{i=0}^{m}\frac{[(\lambda]^u_{nc}T^u_{ns})^i}{i!}\left\{\sum_{j=0}^{M-i}\frac{[(\lambda]^u_{hhr}T^u_{hhs})^j}{j!}\left\{\sum_{k=0}^{M-i-j}\frac{[(\lambda]^u_{vhr}T^u_{hhs})^k}{k!}\right\}\right\}\right)^{-1} \tag{2}$$

The total coverage of all WLAN located in the hotspot area is considered as a single hotspot with equal coverage. In addition to that, at each WLAN hotspot, consider fixed users density. Here the capacity in the cellular only system gets its coverage decreased; with the increase in WLAN APs. Therefore, users capacity in cellular only coverage network differs with respect to the number of WLAN hotspots increases.

Probability of blocked requests is represented as the number of users new request is blocked in cellular system with respect to the total user's requests at a particular moment.

$$b_1^m = \sum_{\alpha=0}^{M-m}\sum_{\beta=0}^{M-m-\alpha}\pi^u(m,\alpha,\beta) \tag{3}$$

Let b_1^M stand for the probability that entire $\mathbf{M}$ channels that occupy a cellular is given by,

$$b_1^M = \sum_{\alpha=0}^{m-1}\sum_{\beta=0}^{M-\alpha}\pi^u(\alpha,\beta,M-\alpha-\beta) \tag{4}$$

Total probability of new blocking request in a cellular system is given by

$$bp_1 = (b_1^m + b_1^M) \tag{5}$$

5. Implementation of the Simulation Platform

Two simulation scenarios are designed, UMTS network and heterogeneous network. In this article, OPNET Modeler™ 14.5 is used as the simulation platform top-down design approach is implied.

5.1 Network Architecture

The upper level of the design platform is explicitly portrayed in Figure 3. The system comprises of the Gateway GPRS (General Packet Radio Service) Support Node (GGSN), Application server, the Radio Network Controller (RNC), the hub, the Node Base Station (Node-B), Serving GPRS Support Node (SGSN), and UE Nodes. By the proposed CAC, the target network will decide the allotment of channels on the basis of user's bandwidth, speed and service type. Hence, the proposed scheme can exploit the network's resources in a better manner, diminish call dropping probability and time-delay, and increasing the throughput of the system. System capacity of cellular and WLAN as 2 Mbps and 11 Mbps with coverage radius of 2 Km for cellular system and 100m for WLAN.

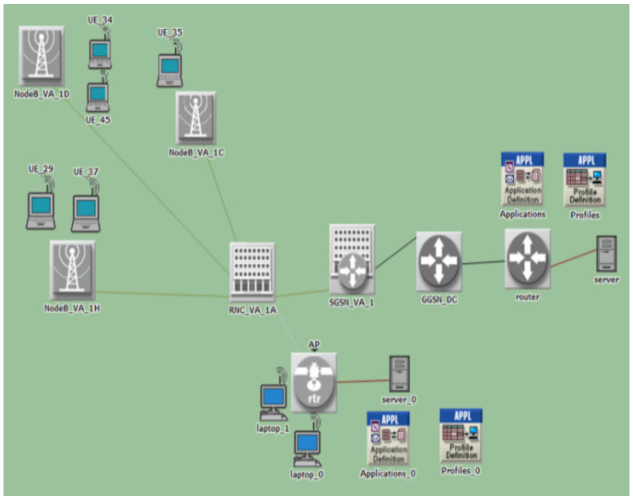

Figure 3. Network model in the simulation platform.

6. Results and Discussion

Figure 4 (a), (b) show the change in Dropping Probability of New calls and Handoff calls respectively, as the call arrival rate increases. Call Dropping Probability is maximum when only UMTS network is employed, while it is lesser in the case of Complementary WLAN scenario, and it is least in the case of proposed Call management scheme for Heterogeneous networks. The simulation results show that proposed scheme is best suited for implementation than the previously implied conventional schemes. Figures show the final analytical result, which compares the General analysis (without dividing the calls on the basis of service type) for UMTS only Network scheme and proposed scheme (on dividing the calls on the basis of service type) for Heterogeneous Network scheme. The improvement percentage is always above 100%. This shows significant improvement in the call dropping probability. Hence this result clearly proclaims the superiority of the Proposed Call management scheme over the General analysis scheme.

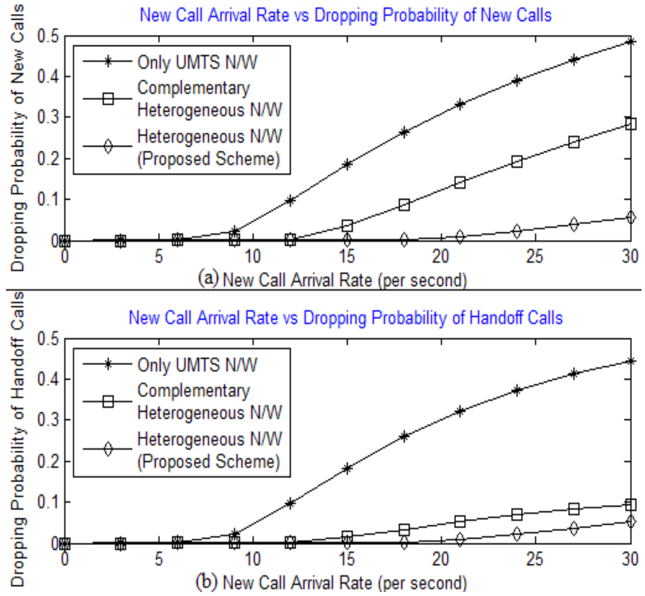

Figure 4. Effect of Increasing Call arrival rate: (a) Dropping probability of new calls (b) Dropping probability of handoff calls.

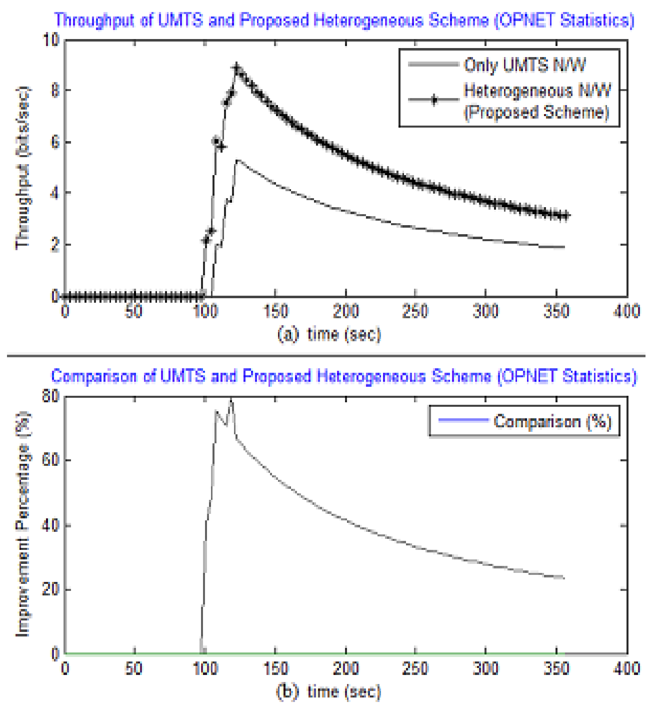

Figure 5. Effect of Increasing Call arrival rate: **(a)** Dropping probability of new calls **(b)** Dropping probability of handoff calls.

Figure 5 (a) shows the OPNET statistical result simulated in MATLAB to compare UMTS only network and proposed heterogeneous network scheme. This gives similar results as to the OPNET platform design simulation result. Figure 5 (b) shows the final simulation result, which compares UMTS only network and proposed scheme for heterogeneous network. The improvement percentage is always more for the proposed scheme. This shows substantial enhancement in throughput. Hence this result clearly states the pre-eminence of the proposed heterogeneous network scenario over the UMTS Network scenario.

7. Conclusion

Call management scheme is very essential to make the resource utilization of integrated networks effectively, which provides the better QoS. To do allocation of resources in the wireless networks of heterogeneity the method needed are vertical handoff and also the call management scheme with velocity and user service. In C-WLAN scheme, the users are allowed to access WLANs only if the requests are blocked in cellular system. Therefore, a high speed data service of WLAN is not fully utilized because the users are not allowed to access the WLAN. Analytical model has been proposed to determine the call management parameters such as blocking/dropping probability for new and handoff request. The performance of the cellular network is shown to be significantly improved with complementary WLANs. The future expectations are that wireless schemes need to offer throughput that is uniform with a minimum of 1 Gbps, with a peaking approximately near 10 Gbps with about 2 milliseconds of the latency, providing a very high as well as a better service reliability.

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