International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Analytical Model of Heterogeneous Cell under Traffic Environment

Sweta Kumari Barnwal

Department of Electronics & Communication Engineering, Arka Jain University, Jamshedpur, Jharkhand, India

Abstract: ***This paper explains how the heterogeneous networks with small cells have been widely used to increase the capacity of mobile systems. On increasing demand for broadband service, at least in hot-spot areas, in today's wireless communication is causing cellular network providers to consider the integration of 3G cellular systems and wireless LAN. This has the particular advantages of high data rates and unlicensed spectrum. With the establishment of heterogeneous network structure, the statistical characteristics of both strongest interference and overall interference are analyzed, we get the statistical characteristics of the strong interference and the total interference, so as to determine the total interference is determined by the strong interference and the relationship between them is established, and the related model is established. Finally, the analytical conditions on the interference system model parameters are derived and the distributions are determined, on which the statistical properties of total interference power can be accurately modelled by several strong interference. Here an analytical model is developed for the evaluation of Heterogeneous cell (integrated 3G/WLAN) networks with multi-rate traffic. For analysis of handover traffic rates a network topology is used. Blocking probabilities, dropping probabilities as well as some interesting performance measures are derived and calculated. Both analysis and numerical results show that the performance of the 3G networks is significantly increased when the integrated 3G/WLAN network is deployed and that the performance of integrated 3G/WLAN network is improved greatly when the WLANs are in the hot-spot areas.***

Keywords: 3G; heterogeneous small-cell networks; QoS; WLAN; handoffs; UMTS; Hotspot

1. Introduction

The rapid increase in mobile data traffic is an emerging issue, and small cells are expected to be an effective solution for improving the spatial density of cellular mobile systems Future wireless networks will generally be characterized by heterogeneity in radio access technologies. The developed 3G technologies such as UMTS, cdma2000 and TD-SCDMA provided to mobile users wide coverage area. However, the costs of acquiring the necessary radio spectrum and the network equipment upgrades are very high. In the same time, wireless local area networks (WLANs) continue to proliferate in corporate and residential environments due to their low-cost, high-speed wireless Internet access for the localized hot spots. It is not a big step to imagine, that WLAN access will not be limited to hot spots but provided by a sufficiently dense network of scattered cells providing a non-contiguous radio coverage in the area that are controlled in a way to provide virtually a continuous connectivity of mobile terminals to a wireless broadband network for access to multimedia contents. cellular is characterized as a narrowband service with high quality of service (QoS) and high cost of usage whilst WLANs provide broadband access to the Internet with an Internet typical QoS and low cost of usage. A 3G cell containing underlying isolated WLAN hotspots is called a heterogeneous cell. In a heterogeneous cell there are mainly four type of traffic generate first new call traffic, second horizontal handoff traffic, third vertical handoff traffic and fourth is overflow traffic. Now, call admission control (CAC) is the process of admitting new calls (originating in the serving cell) or handoff calls into the system in an optimum way while ensuring uninterrupted service provisioning of existing connections. The integration of cellular networks and Wireless Local Area Networks (WLANs) aims to take advantage of the coverage-complementary characteristics of both wireless networks. For applications which require quality of service (QoS) guarantee (e.g., voice, real-time video), admission control is necessary so as to limit the number of connections in a network. A connection request will be blocked if the minimum bandwidth requirement cannot be satisfied.

2. Heterogeneous System

In this explains about the basics of system structure, user classification, traffic and mobility pattern. Before presenting the model and the problem statement, it's essential to define some of the technologies used. Those explanations will be about basics in WLAN, WCDMA, and Vertical Handover (Interworking UMTS-WLAN). Important factors influencing directly the user's behavior are the cost or the accessibility and the simplicity of use. One data oriented technology which fulfill those criteria is the WLAN (also known under several appellations: Wi-Fi, 802.11 (b/g)...). Then a question can rise about having a seamless connection between the UMTS and WLAN. Indeed, the interworking between those two technologies is motivated by the ubiquitous coverage of cellular with the high data rate of the WLAN -hotspots are appearing almost every day (either user deployed or operator deployed) and in different places (train station, airport , bus station, coffee shop, hotels, ...).

Economic Importance of WLAN-Cellular Technology

Table 2.1: Importance of cellular and WLAN

Cellular	WLAN
• Licensed, therefore expensive because spectrum is auctioned by the government. • Regulated. • Equipment is expensive but offer great degree of mobility. • Low Bandwidth (max. of 2Mbps) . • Covers large geographical area. • Need large capital investment. • Revenue flow is slow & long term.	• Unlicensed-Anyone can install the systems & offer services. Also cheaper. • Not much regulation. • Cheaper equipment. • High Bandwidth (max. of 11Mbps for 802.11b, 54Mbps for 802.11a). • Coverage is limited to smaller areas. • Initial cost is low comparatively • Good chances of getting return on investment in short term due to low initial cost.

2.1 3G

The main characteristic for 3G is the capability to provide various mobile multimedia services. It can support a maximum date rate of 144kbps in highly mobility environment, 3 84kbps in low or medium mobility environment and 2Mbps in static status. There are three mainstream 3G standards worldwide: WCDMA, CDMA2000 and TD-SCDMA.

2.2 WCDMA

"WCDMA, for Wide Band Code Division Multiple Access, is using a 5MHz carrier and allowing data transfer rates as high as 2Mbps. Currently it is 64 Kb/s in the Uplink but the system considered here is an evolved version allowing 384 Kb/s.

The technology used is UMTS. There are two specifications in the UMTS family:

UMTS-FDD: using W-CDMA in public micro and macro cells environment with data rates up to 384Kb/s.
UMTS-TDD: using TD-CDMA in public micro and Pico cells with up to 2Mbps.

2.3 Heterogeneous Cell Structure

Figure.1 shows that a hexagonal UMTS cell contains some isolated WLAN hotspots completely within itself. Each hotspot is under the dual coverage of UMTS and a WLAN cell. Depending upon the accessing capability and subscription profiles, the users in heterogeneous cell are classified as follows:

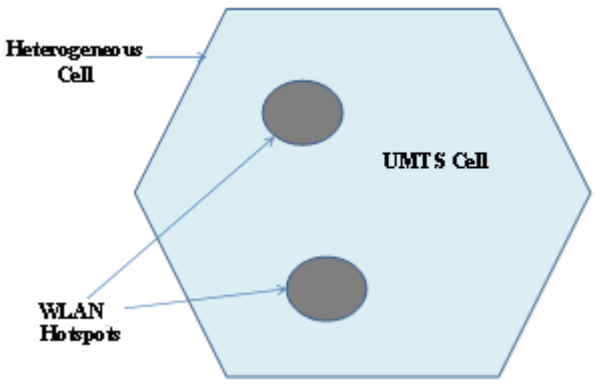


Figure 1: Heterogeneous cell structure

- UMTS User: A UMTS user has subscriptions for only UMTS services. He/she cannot access WLAN system even if he/she is within a WLAN hotspot
- WLAN User: The users having subscription for only WLAN services are called WLAN users. They cannot use the UMTS system.
- Mixed User: A mixed user is a UMTS user having additional subscriptions for WLAN services. Thus, a mixed user can access both the UMTS and WLAN systems.
- Hotspot User: The mixed users who are currently residing in WLAN hotspots are called hotspot users. Some hotspot users (with or without ongoing data sessions) may move out of WLAN coverage, and they become back-up users as defined below.
- Back-up User: The mixed users who are residing in UMTS-only coverage are called backup users. Some of the back-up users (with or without data sessions) may move to WLAN hotspots and they become hotspot users.
- Background User: The UMTS-only users and back-up users are together called background users. Currently all background users are under UMTS system.
- Total User: The sum of background users and hotspots users is called total users i.e., the sum of UMTS only users and mixed users is equal to total users

This can represent users as follows in figure.2

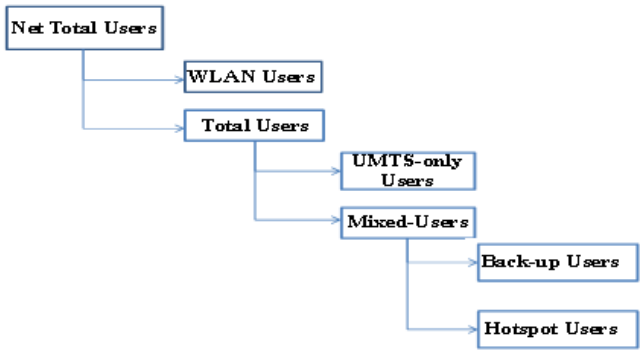


Figure 2: Users class in Heterogeneous cell

2.4 Traffic and its Model

There are broadly two classes of traffic in a mixed cell, real traffic such as voice traffic and non-real traffic such as elastic data session. We consider same mobility pattern for both the classes of traffic. Each class of traffic is generated by various types of requests as shown in below Chart . There are two basic types of requests in a mixed cell, UMTS request and WLAN request, and they are generated for UMTS and WLAN systems, respectively.

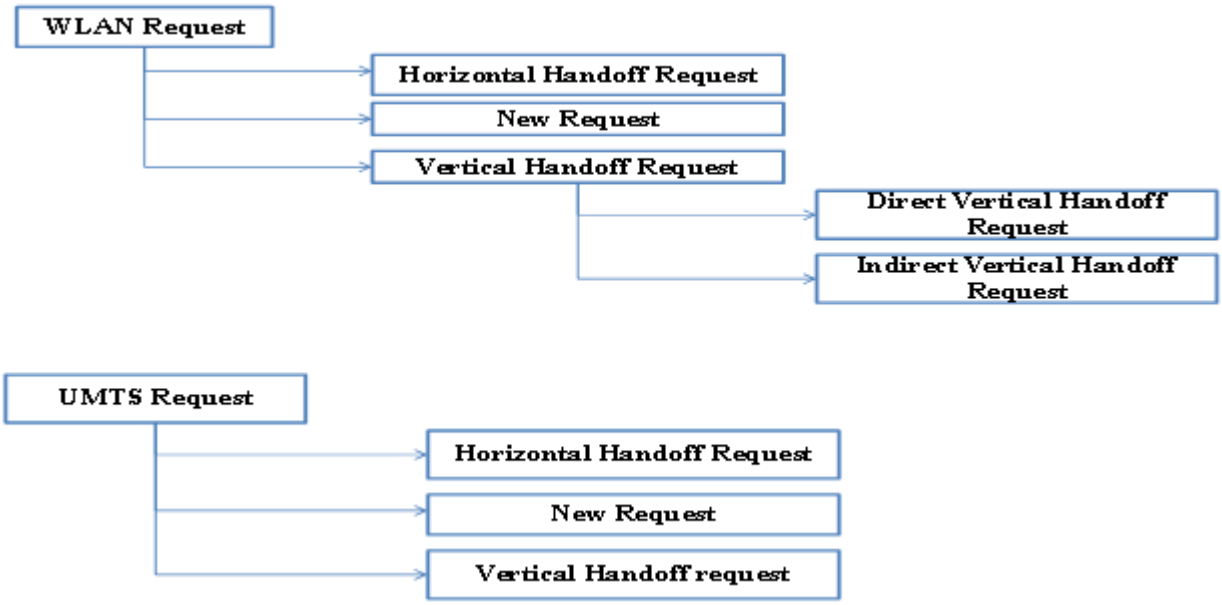


Figure 3: Request (i.e., call) types in a Heterogeneous system

2.5 Node Traffic

Based on the conservation of traffic flow, traffic flows into a node and out of the same node should be equal. The overall incoming traffic to each node consists of new traffic, horizontal handover traffic, vertical handover traffic, and overflow traffic shown in figure. When a new call request is there then it is called new traffic in a system, when an ongoing call is moved from one network to other but similar network then it is called horizontal handover, when an ongoing call moves from one to other kind of network then it is called vertical handover and when an ongoing call moves from UMTS to WLAN and all channel is busy then the call will be back in UMTS and it is called as overflow traffic from WLAN.

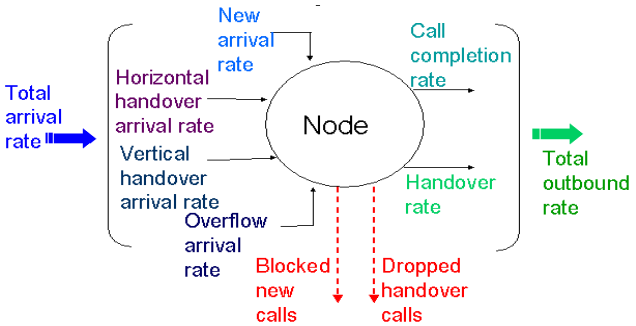


Figure 4: Node Traffic

2.6 Handoff Scenarios- Mobility Pattern and its Model

Session-Mobility Scenarios: We specify following mobility scenarios of sessions in a mixed cell (Fig.5).

- A new session (NS) (i.e., a session established by a new request), or a horizontally handed over session (HHS) of a UMTS-only user may be completed within the same cell or it may initiate HHR in a neighbor UMTS cell.
- An NS, or an HHS or a VHS (i.e., vertically handed over session) of a back-up user may be completed in the UMTS-only coverage of the same cell or it may initiate HHR in neighbor cell or it may initiate VHR in WLAN.
- An NS, or a VHS of hotspot user may be completed in WLAN itself or it may initiate VHR in the UMTS-only coverage.
- An NS of a WLAN user is always completed in the WLAN itself.

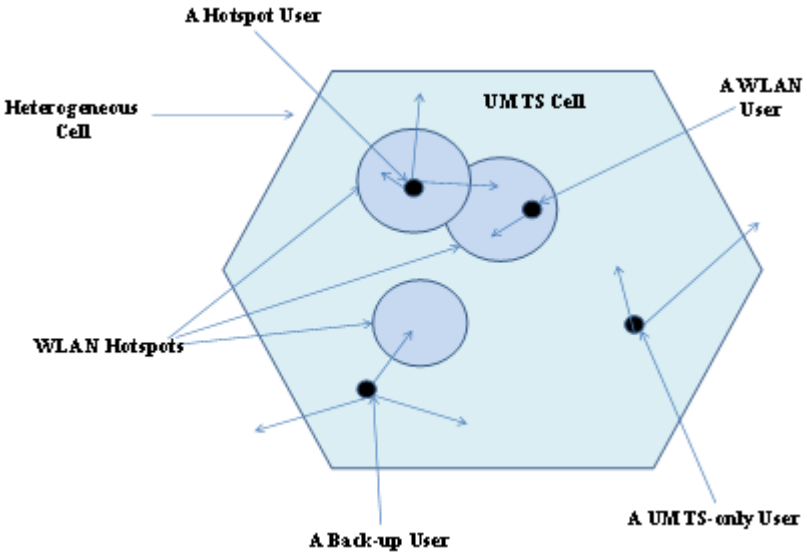


Figure 5: Mobility scenario

2.7 Handoff Probability from 3G to WLAN

We define the following parameters in respect of a heterogeneous cell:

A: Ratio of total WLAN coverage in mixed cell to the coverage of a pure UMTS cell.
D: Ratio of users' density in WLAN to that in UMTS-only coverage. It is called density ratio.
Pc: This the ratio of hotspot user to mixed users. It represents the probability that a mixed user is a hotspot user i.e., the probability that a mixed user will reside in WLAN hotspot. We assume that a mixed user moves from UMTS-only coverage to a WLAN hotspot with the probability of Pc
W: Number of WLAN hotspots.
H: Total number of hotspots.

$$P_c = \frac{W}{W + \frac{1}{d}\left(\frac{1}{A} - H\right)} \quad \text{.....(i)}$$

Where

$$d = d^h / d^{nh} \quad \text{.....(ii)}$$

$$A = A^w / A^u \quad \text{.....(iii)}$$

3. Cellular/WLAN System Model

This chapter provides a broad overview of heterogeneous system model network deployment and its topology. Here we analyze and derive the equations for node traffic and link traffic in a system. We explain the fundamental admission control and resource sharing in an integrated cellular/WLAN system.

3.1 Network Deployment and Topology

Consider an integrated cellular/WLAN system where one or more WLANs may be deployed inside each cell of the cellular system. The cellular network and WLANs have an agreement to share resources (i.e., unused capacity) to guarantee the connection-level QoS, and to reduce the handoff dropping probability. In this system, there are two specific coverage areas to consider, namely: the cellular-only area, and the dual-coverage area. Here coverage means service availability. The area with only cellular access is referred to as cellular-only area, while the area covered by both a cell and a WLAN is referred as double-coverage area. Horizontal and vertical handoffs can occur in different coverage areas. These are shown in figure.6. Here we considered two cellular cells. Under each cellular cell two wireless LAN (hotspots) are deployed. A mobile user is shown here when he moves from cell j to cell i it performs horizontal handoff. Mobile user when moves from wireless LAN to cell i or cell j then it performs vertical handoff in the system. As WLANs are usually deployed in hot-spot areas, on average, the traffic density in the double-coverage area is higher than that in the cellular-only area. Here we consider real-time voice traffic, video call, chat and interactive data services (such as web browsing). Hence more than one type of traffic class is considered here.

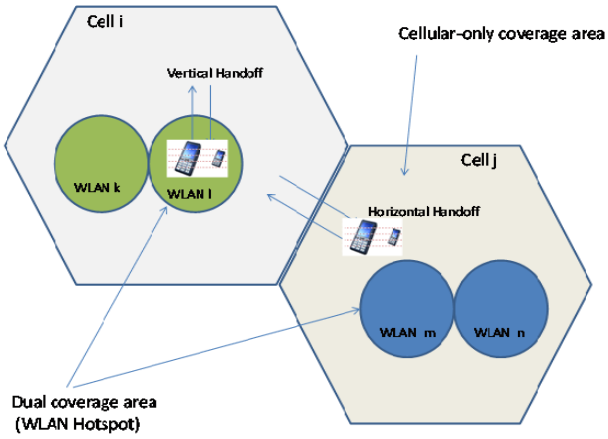


Figure 6: An Integrated 3G/WLAN System

Assume in our system,
M^c = The number of cells in the system
A_i^c = The set of cells adjacent to cell i
W_i^c = The set of WLANs inside the coverage of cell i
A_k^w = The set of WLANs adjacent to WLAN k
D_k^w = The set containing the overlaying cell of WLAN k (i.e. a dual-coverage)

The new connection arrival processes to cell i and WLAN k are Poisson with rates λ_i^c and λ_k^k, respectively, which are independent of other arrival processes.

The channel holding time of a connection in cell i (i.e., the time that a user is using resources in cell i) is an exponentially distributed random variable with mean $\frac{1}{\mu_i^c}$. The channel holding time in WLAN k is exponentially distributed with mean $\frac{1}{\mu_k^w}$. Both are independent of earlier arrival times and connection duration times.

At the end of a holding time, the probability that a mixed user is a hotspot user i.e., the probability that a mixed user will reside in WLAN hotspot. We assume that a mixed user moves from UMTS-only coverage to a WLAN hotspot with the probability of (Pc or g) and is given by the formulae as shown in equation (i), (ii) & (iii).

3.2 Admission Control And Resource Sharing

Let us assume,
C_i^c = Capacity of the each cellular cell i in units of bandwidth.
C_k^w = Capacity of the each WLAN k in units of bandwidth.
$R_{i_t}^c$ = The reservation parameter of cell i for handoff connection.
$R_{k_t}^w$ = The reservation parameter of WLAN k for handoff connection.

These parameters act as the admission policy to provide handoffs priority over new connections. Two admission control schemes from cellular networks are considered:
a) The cutoff priority and
b) The fractional guard channel.
- Handoff requests are accepted.
- Each new connection request is accepted with the probabilityw_i^c.
- Cutoff priority is a particular case of the fractional guard channel with$w_i^c = 0$.

Let n_{i_t} be the number of connection in cell i of traffic type t. . When cell i is in any of the state:
$n_i \leq C_i^c - R_i^c$, it accepts new call and handoff connection under both admission policies.
$n_i \leq C_i^c - R_i^c$, it accepts only handoff requests for the cutoff priority scheme.

The resource sharing capability provided by the agreement among different access networks operates as follows: if a handoff request is not accepted in one network, then the request is transferred to the other network.

3.3 Call Admission Control Scheme

A call admission control (CAC) algorithm must try to admit as many calls as possible provided their quality of service (QoS) requirements can be met without violating those of previously admitted calls. Here, we propose a simple and effective call admission control algorithm and its associated resource allocation mechanism together will be referred to as the flexible call admission control, for recently proposed multi-service wireless local area networks (WLANs). The proposed flexible call admission control effectively takes the advantages of flexible pattern assignment in WLANs and the rate-adaptive feature of multimedia services to support multiple classes of traffic with diverse QoS requirements and priority levels. Here in new call admission control scheme there is no use of queuing concept for blocked requests it means if a request is coming and all the channel is busy then call will be blocked and lost in system. When a new request is blocked in WLAN, promptly it can try for UMTS without requiring queue in WLAN. When a session moves to WLAN , its wireless network interface card for WLAN works independently .

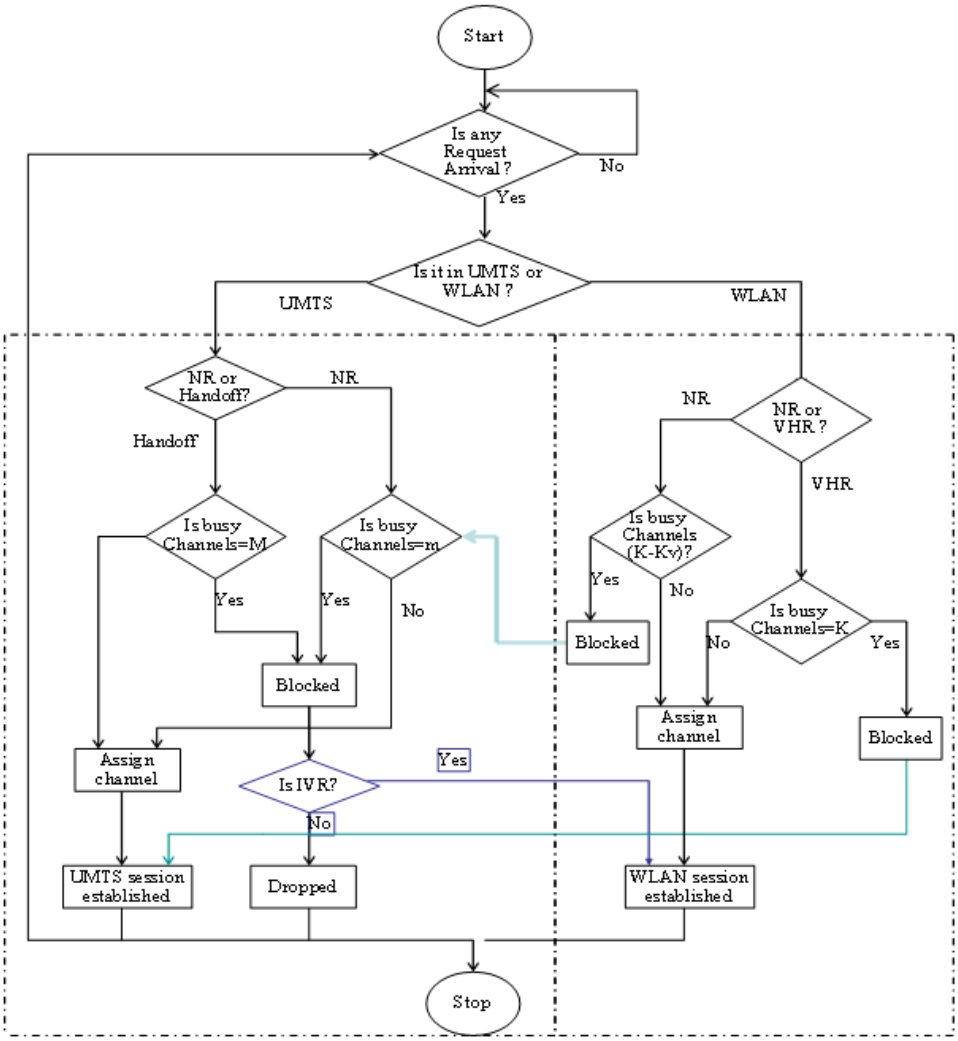


Figure 7: Flow chart for CAC scheme.

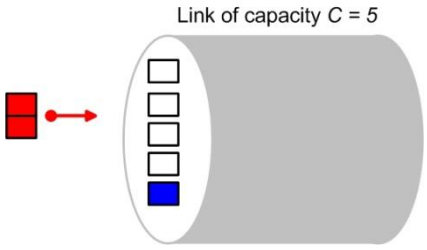
3.4 System States

Link bandwidth capacity and calls bandwidth requirements are expressed in bandwidth units(b.u.).

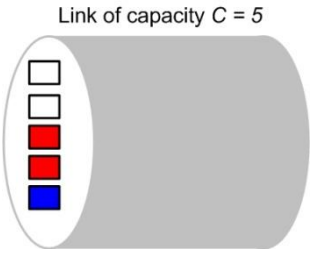
For example 1b.u. = 64 Kbps.

Example:
Two services b1=1 and b2=2

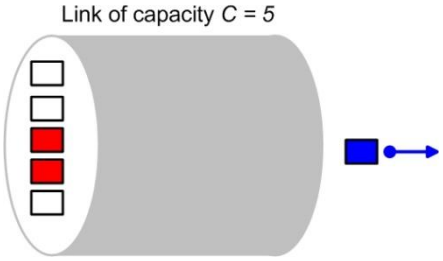
Capacity:5
System state: j
System states can be shown as below diagram:



j=1



j=1 to 3



j=**3 to 2**

Figure 8: System States

4. Performance Measures in Heterogeneous Cell

What are the performances measures which we are interested in for heterogeneous network? There are numbers of factors, all of which have some importance from different

perspectives. First, the probability of blocking of a new call request, I call it as new call blocking, is a significant measures. The new call blocking probability is defined as the probability that a new call will be unable to access the network due to channel unavailability due to no free channel being available. In other words, according to resource utilization of cell system, new calls may be rejected or accepted. In a certain time span, there are rejected new calls and accepted new calls. The ratio of total rejected new calls to total new calls in a certain time span is defined as Call-Blocking Probability. A distinctive feature of cellular networks is handoff, where mobile subscribers cross cell boundaries during a call, and therefore need to be allocated a new channel in the new cell. The probability that this reallocation cannot be achieved is an important performance measure, which we refer to as handoff blocking. In other words, according to resource utilization of cell system, the call handoff from neighbor cells may be rejected or accepted. In a certain time span, there are rejected handoffs calls and accepted handoff calls. The ratio of total rejected handoff calls to total handoff calls in a certain time scale is defined as Handoff-call Blocking Probability. Call Admission Control (CAC) schemes are the most critical part for wireless networks. On one hand, CAC schemes provide users with access to a wireless network for services.

5. Conclusion

This thesis proposes an analytical model of Heterogeneous cell with admission control and resource sharing capabilities that is able to effectively use the additional capacity provided by the WLANs. Results show that the performance improves significantly when resource sharing is allowed between different wireless access networks. Our numerical results in an example scenario show the model can be used in a realistic situation.

References

[1] S. S. Rappaport, and L. Hu, “Microcellular communication systems with hierarchical macrocell overlays: traffic performance models and analysis,” Proceedings of IEEE, vol. 82, No.9, September, 1994.
[2] D. E. Everitt, “Traffic Engineering of the radio Interface for cellular mobile networks” Proceedings of IEEE, vol. 82, No.9, September,1994
[3] A. K. Salkintzis,."Interworking Techniques and Architectures for WLAN/3G Integration toward 4G Mobile Data Networks" IEEE Wireless Communications, Vol. 11, Issue: 3, pp. 50- 61, Jun. 2004.
[4] E. Stevens-Navarro, and V. W. S. Wong, “Resource sharing in an integrated wireless cellular/WLAN system,” Proc. of CCECE’07, Vancouver, Canada, April, 2007
[5] W. Song, H. Jiang, and W. Zhuang, “Performance analysis of the WLAN-first scheme in cellular/WLAN interworking,” IEEE Tran. On Wireless Communications, vol. 6, no. 5, pp. 1932-1943, May 2007.