Integrated Cellular and Ad Hoc Relaying Systems: Analysis of Call Blocking Probability & Performance

Nazmul Hossain, Md. Alam Hossain

Abstract— iCAR is a modern wireless technology. It is based on dividing the network area into some cells (areas) and integrating the cells. In iCAR, Ad-hoc networks are dynamically distributed and self-organized cellular systems. It allows internetwork communication between the topologies without infrastructure. The main purpose of iCAR is to present new architectures to address congestion in cellular systems due to unbalanced traffic. It can effectively increase system’s capacity and also can add interoperability between different networks. Here, we try to analyze whether the increasing traffic loads between the internetworking cells and limited capacity of the systems can be effectively balanced by the new architectures or not. We also interrogate how limited number of ARS stations is used for balancing congestion. We also evaluate the performance of iCAR in terms of ARS coverage.

Index Terms— Wireless Networks, Ad hoc Network, cellular systems, call blocking probability, load balancing, and performance.

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1 INTRODUCTION

Previously cellular concepts was used to identify the problem of having truncate frequency appliances. It divides the networking geographical area into a number of smaller networked cells. Every cell's system capacity increases by frequency reuse. Meanwhile, the cell boundaries do not allow the users to fully use the channel resources. In order to avoid potential channel interference, all users are limited from frequency reuse. An MH has the ability to use only the channels of the currently available BTS. These channels are a subset of the available data channels in the cellular system. If an MH has no access to DCHs of other cell's, the channel's efficiency and capacity are become limited. In a ward, when a call request has no free DCHs, this call become congested. As a result, it will be blocked or dropped. Moreover, the problem we face for having limited capacity will be provoked by the presence of bursty traffic. It also causes limited data channel's access in existing cellular systems[2]. As a result, heavy amount of calls will be blocked. Although the existing traffic load is far from reaching the maximum capacity of the system. The positions of congested cells may also vary in time (e.g., Saturday morning, or Sunday afternoon). It is truly difficult to provide enough resources in each cell by being cost-effective. Literally, by increasing resources of a cellular system only can increase the system capacity. But it cannot increase the efficiency. So, it is hard to control the time-altering unbalanced traffic.

In this paper, we address and analyze the importance of how to expand modern wireless systems from the existing heavily congested cellular infrastructure. The systems will scale greatly with the maximum number of mobile hosts. And notably will overcome the congestion. The main concern is to balancing the load dynamically among different cells. The basic idea is to establish a certain number of ARSs at critical locations. Where the ARSs can be used to transmit the signals between different cell's MHs and BTSs [1], [2]. By using relay stations, it is possible to deflect data traffic from a cell to another cell. This helps to prevent congestion and maintain calls engaging in MHs which are shifting into a cell(congested). It also helps new call requests to be accepted by the MHs acting in a congested cell. Besides load balancing, there are many benefits of using the iCAR system. The ARSs can extend system’s network coverage in an efficient manner. They also can improve the interoperability between incongruous networks.

Here, we try to analyze the call blocking probability of iCAR through analysis and simulation. The previsions of our analysis are justified by simulation results. The call blocking probability, signaling overheads and throughput are the main functions used for measuring the performance of the iCAR system. These results reveal that by using limited ARSs, an iCAR system can successfully balance the loads among different cells. This also shows how an iCAR system reduces call blocking probabilities significantly in synonymous cellular systems.

We analyze the performance of a wireless relaying system with a modern technology named iCAR. In iCAR, analysis of performance depends on the reduced call blocking probability. We can acquire good performance if a call is transferred from cell A to more congested cell named cell B, resulting a DCH released by MH is free. In this paper, we rack up an analytical result for the performance in iCAR. In addition, we justify the analytical results through simulations and compare the blessings of the iCAR system with the traditional cellular systems. This results show that we can increase the performance of an advanced hetero-geneous system named iCAR by reducing call blocking probability and increasing signaling overhead. This analytical and simulation results will guide the researchers to develop the ad-hoc technologies.

2 OVERVIEW OF iCAR SYSTEM

In this section, we briefly describe the principle operation and the major benefits of iCAR system. We also take a look on the primary objective and aim of the system.

2.1 Principle Operation

In order to discuss the principle operation of iCAR system, we will have to focus on traditional cellular ad-hoc systems. In these systems, a BTS is generally controlled by a MSC. There are some principle differences between them. The BTS is a fixed installed network system. The MSC is connected to it through a wired interface and a interface to the backbone wireless network. On the contrary, an ARS station is a wireless transmission device which is handled by operator. The complexities and functionalities of an ARS is much lower and fewer than the BTS. But it has limited mobility. It is controlled by an MSC and communicated directly with either ARS or a BTS or an MH. The communication happens through relevant air interfaces.

Each ARS includes two different categories of air interfaces. In ARS, the C interface is used for communications with a BTS and the R interface is for communications either with another ARS or an MH. The MHs also include two different categories of air interfaces. As like in ARS, the C communicates with a BTS and the R communicates with an ARS. We know that each ARS is controlled by an MSC. It also has limited mobility. It helps to launch a relaying route quickly. It also helps to maintain a higher level of stability. Routing in the iCAR system is identical to have a hybrid structure for efficient hand-offs performance in mobile ATM networks. The Path extension between two BTSs is connected with direct wired connections.

As we know multiple ARSs can be used for efficient relaying with the help of R interface. Each ARS can short its transmission range than that of a BTS. It intends that an ARS can be smaller conjointly less costly than a BTS. In the meanwhile by reason of having limited mobility and specialized hardware, it hold the possibility for ARSs to communicate with one another and also with BTSs at a data rate higher than MHs. In the iCAR system, dynamic relaying also occurs without the occurrence of call congestion in the entire network. Such that in any occasion when there are differences in traffic patterns between neighboring cells, the system relays are mobilized to mitigate the differences. Interference in cellular band by channel borrowing is fend off in this scheme. Moreover, one still needs to govern the critical interference concerns in the ISM band.

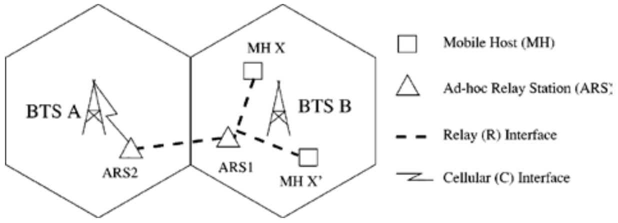

Fig. 1. A example of relaying where a mobile host MH X establish a communication with BTS via two ARSs.

An example of ad hoc system is illustrated in the figure.1. In this system, an MH X in congested B cell communicates with BTS A in cell A through two ARSs [1,2,5,9]. We see that cell A is non-congested. There are partially one ARS through which a relaying route will be set up. In previous discussion we know that, each ARS includes two different categories of air interfaces. Interface C is used for communications with a BTS and interface R is for communications with either another ARS or an MH. MHs also include two different categories of air interfaces. As like in ARS, the C communicates with a BTS and the R communicates with an ARS.

2.2 Objectives

In a cellular system, an Mobile Host have the data channels of the BTS. They are established in the same cell subset of the accessible data channels in the entire system. Limited ability to access the data channels by the MH limits the efficiency of the channel and therefore the system capacity. In words, a perceptible amount of calls may be blocked due to localized congestion. These also affect call dropping.

In this paper, We try to analyze and evaluate the traffic load and the call blocking probability with a minimum number of network cells. We also analyze the probability if the system can provide higher security and better management of mobile networks through wireless communication.

2.3 Aim of iCAR

By using ARSs, we can transfer traffic from a cell to another cell. This assists us to bypass congestion. This also helps to maintain calls which are acting into a congested cell. The other advantages of ARSs are to obtain new call requests engaging MHs in a congested cell.

The relaying through ARSs is suitable in any cellular network system in which congestion may occur. Although calls may not be regulated into dedicated DCHs during the total call duration. Here our objective is to analyze performance of the available iCAR system. We determine the performance of the iCAR system covered by idealize wireless channel situations where the ISM band has no restriction in usage and the fading effects are considered as non-existent. We know that, in the three-tier iCAR system network, it increases the channel capacity of any congested cell comparatively by 70%.

In order to provide the benefits for the system, one need to make small modifications to the existing cellular networking techniques. In addition, he/she have to design novel approaches in order to deal with the characteristics and solitary problems of the system. In this paper, we analyze these approaches and evaluate their workability and adjustments considering their cost and effectiveness.

There are three basic relaying strategies -

- Primary Relaying
- Secondary Relaying
- Cascaded Relaying

Primary Relaying: In an existing iCAR system, if any mobile host i.e. MH X is engaged in a new call in cell B and whenever it is congested, the call will be blocked. In the analyzing system, structured with integrated cellular technologies we analyze that this call may not be blocked. In brief explanation, using the R interface, MH X engaged in cell B can switch over to communicate with an ARS in cell A. This communication is also possible with other ARSs situated in cell B. This strategy is known as primary relaying.

Using the primary relaying strategy, MH X can also communicate indirectly with BTS A through relaying. The process of switching over from C to R interface is referred as switching-over. It is similar to frequency-hopping. A relaying route can also be built between MH X and it's corresponding MH X'. But in order to happen this, both of them need to switch over from C interfaces to R interfaces. But the probability of this is typically very low.

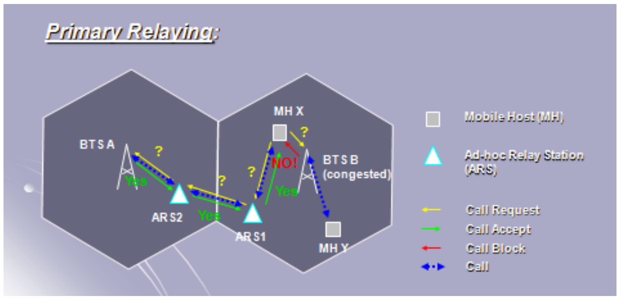

Fig. 2. Primary Relaying System

Secondary Relaying: Suppose ARS 1 is far enough to MH X or there is no other nearby ARSs. In this situation, primary relaying is not possible. Then one can transfer to secondary relaying in order to release a Data Channel from BTS B for being used by the MH X. In this process MH Y will denote any number of MHs in cell B that is directly engaged in a call. Now two basic conditions can be happened[1, 3].

1. A relaying route may be set up through MH Y, BTS A in same cell or in a different cell. In this process, when MH Y transfers the DCH over , it is available for being used by MH X[3].

2. A relaying route may be created through MH Y and it's complementary MH Y´ in B or in other cell. It depends on if MH Y is engaged in inter cell or intra cell call[3].

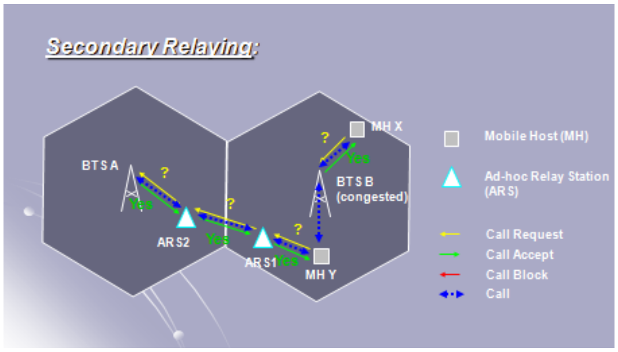

Fig. 3. Secondary Relaying between two cells

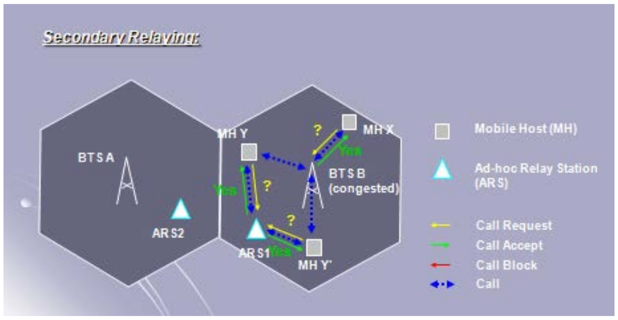

Fig. 4. Secondary Relaying within a cell

- *Nazmul Hossain is currently pursuing masters degree program in Computer Science and engineering in Jessore University of Science & Technology, Bangladesh, PH-042172058. E-mail: nazmul.justcse@gmail.com*
- *Md. Alam Hossain is currently serving as Chairman in Computer Science and engineering Department in Jessore University of Science & Technology, Bangladesh, E-mail: alamcse_iu@yahoo.com*

Congestion in the cell B means that MH Y is involved in a lot of on-going calls. In this case, the performance of secondary relaying will be better that the primary relaying. The conception of having MH-MH calls through ARSs is similar to the concept of ad-hoc networking. It does not use any of the BTSs. One major benefit of this system is that, an MSC can handle the call management activities. The functions consists of billing, authentication, locating two MHs and/or establishing a relaying route.

Cascaded Relaying: If primary and secondary relaying does not work, the new call still be supported. Assume that there is a relaying route. It can be relayed either primary or secondary between ARS and MH X. The route may be established within nearby C cell which is unluckily congested. One can use any of the two secondary relaying techniques described before in the congested cell C. It helps to create a relaying route among an MH of cell C and MH Z´ or a BTS in any non-congested cell. In this way, ARS 2 can allocate the DCH which was formerly used by MH Z in C. And consecutively, MH X can allocate the DCH which was formerly used by MH Y in B. Note that, the communication route between ARS 2 and MH X is set up through secondary relaying.

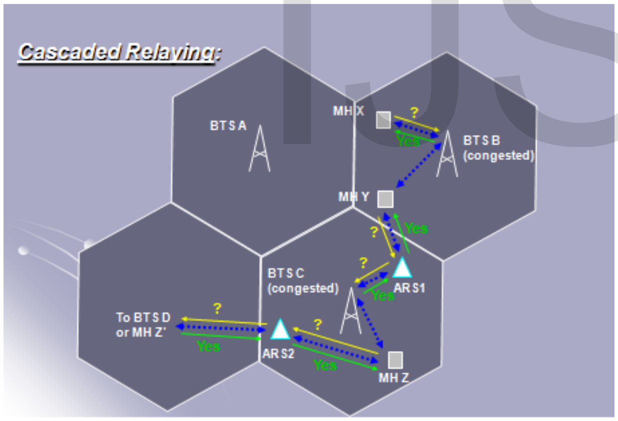

Fig. 5. Cascaded Relaying

2.4 Applications

The decentralized behavior of ad-hoc networks make them applicable for a wide range of applications. Hereabouts central nodes have lack ability to be relied on. It may raise the scalable functionality of different networks as compared to networks managed by wireless technologies. Howbeit theoretical and practical limitations of such networks' overall capacity have been identified, but they have been used in wide areas. Some of them are:

- Used in wireless communication.
- Used for all mobile applications.
- Used in packet-switched (PS) and circuit-switched (CS) data transmission.
- Mobile Ad hoc Networks (MANET).
- IP-based applications.

3 PERFORMANCE EVALUATION

3.1 Principles

The principle for performance evaluation of the iCAR system will be discussed first. We consider this system inspite of a conventional cellular system. Here we assume that the entire iCAR system can be covered by some ARSs. So that an mobile host in a cell can reach any of the BTS in any cell in the whole system through relaying. We analyze the following theorem to understand that iCAR system will perform better compared to the conventional cellular system.

Theorem: Assume that if the total traffic in an n-cell system is T Erlangs, then the call blocking probability is minimized when the traffic in each cell is T/n Erlangs [1], [2]. So that, in general if the amount of traffic loads of a congested cell can be distributed, then the call blocking probability is proportionally minimized.

3.2 Analysis of iCAR Call Blocking Probability

The performance of iCAR using limited number of relying stations is conceptually measured by an Erlangen model. Here, we analyze how the limited ARS coverage affects the load balancing capacity of the system. For this purpose, we separate the iCAR system into subsystems. Here each subsystem is assumed to be location-dependent. There is no interaction between different cells in each subsystem. To analyze this, we consider a 3-tier cellular structure. There lies the most congested cell (A) with traffic intensity $\mathbf{T}a$ is surrounded by less congested tier B cells with $\mathbf{T}b$ traffic intensity and third tier C cells surround B cells with $\mathbf{T}c$ traffic intensity.

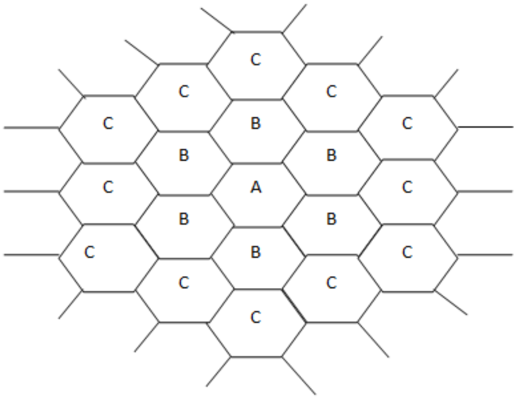

Fig. 6. A three tier subsystem

In figure-6, we show that the cell A is surrounded by B cells and C cells. The structural distribution of calls in a cell is uniform. So that a call is covered by an ARS with probability ρ. As the traffic in cell A is growing, so this causes a growing impact on the surrounding cells. Traffic is not spreading to an equally loaded surrounding cell. The cells A, B, C have call blocking probabilitys B_a, B_b and B_c respectively. Now when perfect load balancing is obtained, then the steady state traffic intensity per cell will be-

$$T_f = (T_a + 6T_b + 12T_c)/19$$

$$\text{Or, } T_f = \sum T_n / 19 \quad \text{(i.e. n =a, b, c)} \quad \text{-------} \ (1)$$

Where T_n = Total traffic intensity in a three tier subsystem. $T_a > T_b > T_c$, and $T_a > T_f$, $T_c < T_f$ and T_b could be smaller, equal or larger than T_f. Now if the actual traffic intensity in a cell be T_i, then the difference between traffic intensity in each cell and traffic intensity in the subsystem will be $(T_i - T_f)$ (where i= a, b, c), will provide us our desired amount of load balancing.

Now we consider primary relaying strategies to illustrate the probability of a cell that relayed to one of its neighboring cell. We first assume that the traffic is uniformly distributed among given number of cells. Each cell has the probability parallel to the fractional ARS coverage ρ.

Primary Relaying: The traffic or call in a cell is uniformly distributed. As primary relaying strategy describe the transfer of the amount of blocked calls or traffic overload, the amount of blocked calls or traffic overload transferred from cell A to tier cell B is **Rs** (where **Rs** = $(T_a - T_f)$ (1- B_b)) and the amount of average traffic load in A will be-

$$Ta^{p} = T_a - \rho \{T_a - (\sum T_n / 19)\} (1 - B_b),$$

$$Ta^{p} = T_a - \rho (T_a - T_f) (1 - B_b),$$

$$Ta^{p} = T_a - \rho Rs \qquad \text{------------------------} \ (2)$$

Now the new call blocking probability in A is-

$$Ba^{p} = \{(Ta^{p})^{M}/M!\} / \{\sum_{i=0}^{m} (Ta^{p})^{i} / i!\} \approx f\,(Ta^{p}, M)$$

Where, M refers to the number of cellular band channels. As a consequence of primary relaying, the amount of traffic load in the ARS coverage area in A may have been decreased. But the total traffic load in A has not and the total load in cell A is remain higher than T_f. More specifically, the average amount of traffic overload in cell A is still nonnegative and can only be reduced only by secondary relaying.

The amount of average traffic overload relayed from cell A is distributed between each of the B cells. So, the amount of traffic load in each B cell is- $[\rho \{T_a - (\sum T_n / 19)\} (1 - B_b)] / 6$.

The amount of average traffic load in cell B will be-

$$Tb^{p} = T_b - [\rho \{T_a - (\sum T_n / 19)\} (1 - B_b)] / 6,$$

$$Tb^{p} = T_b - \{\rho (T_a - T_f) (1 - B_b)\} / 6,$$

$$Tb^{p} = T_b - \rho Rs / 6$$

$$6Tb^{p} = 6\,T_b - \rho Rs \qquad \text{--------------------------} \ (3)$$

Now the new call blocking probability in cell B is-

$$Bb^{p} = \{(Tb^{p})^{M}/M!\} / \{\sum_{i=0}^{m} (Tb^{p})^{i} / i!\} \approx f\,(Tb^{p}, M)$$

But some amount of traffic overload relayed from cell A is distributed between each of the C cells. So, the amount of traffic load in each C cell is- $[\rho \{T_a - (\sum T_n / 19)\} (1 - B_b)] / 12$

The amount of average traffic load in cell C will be-

$$Tc^{p} = T_c - [\rho \{T_a - (\sum T_n / 19)\} (1 - B_b)] / 12,$$

$$Tc^{p} = T_c - \{\rho (T_a - Tf) (1 - B_c)\} / 12,$$

$$12Tc^{p} = 12\,T_c - \rho Rs \qquad \text{---------------------------} \ (4)$$

Now the new call blocking probability in cell C is-

$$Bc^{p} = \{(Tc^{p})^{M} / M!\} / \{\sum_{i=0}^{m} (Tc^{p})^{i} / i!\} \approx f\,(Tc^{p}, M)$$

So, the total amount of traffic load in the subsystem will be-

$$\begin{aligned} T_p &= Ta^{p} + 6Tb^{p} + 12Tc^{p} \\ &= T_a - \rho Rs + 6\,T_b - \rho Rs + 12\,T_c - \rho Rs \\ &= T_a + 6\,T_b + 12\,T_c - 3\,\rho Rs \\ &= \sum T_n - 3\,\rho Rs \qquad \text{----------------------------} \ (5) \end{aligned}$$

And the total amount of new call blocking probability in the primary relaying system is-

$$B_p = Ba^{p} + Bb^{p} + Bc^{p}$$

3.3 Evaluation Algorithm

Traffic Load: The computation algorithm for measuring the overall traffic load is described below:

1. Read T_a, B_a, B_b and B_c,
2. Initialize T_b, T_c,
3. Compute $T_f = (T_a + 6\,T_b + 12\,T_c) / 19$,
4. Compute $Ta^{p} = T_a - \rho (T_a - T_f) (1 - B_b)$,
5. Compute $Tb^{p} = T_b - \{\rho (T_a - T_f) (1 - B_b)\} / 6$,
6. Compute $Tc^{p} = T_c - \{\rho (T_a - T_f) (1 - B_b)\} / 12$, and
7. Compute $T_p = Ta^{p} + 6Tb^{p} + 12Tc^{p}$.

Call Blocking Probability: The computation algorithm for measuring the overall call blocking probability is described below:

1. Read T_a, B_a, B_b and B_c,
2. Initialize T_b, T_c,
3. Compute $T_f = (T_a + 6\,T_b + 12\,T_c) / 19$,

4. Compute $\mathbf{T}a^{\mathbf{p}} = T_a - \rho\ (T_a - T_f)\ (1\text{-}\ B_b)$,
5. Compute $\mathbf{T}b^{\mathbf{p}} = T_b - \{\rho\ (T_a - T_f)\ (1\text{-}\ B_b)\}/6$,
6. Compute $\mathbf{T}c^{\mathbf{p}} = T_c - \{\rho\ (T_a - T_f)\ (1\text{-}\ B_b)\}/12$, **and**
7. Compute $T_p = \mathbf{T}a^{\mathbf{p}} + 6\mathbf{T}b^{\mathbf{p}} + 12\mathbf{T}c^{\mathbf{p}}$.
8. Read the number of cellular band channels **M**,
9. For factorial **M!**, compute $\{(\mathbf{T}b^{\mathbf{p}})^{\mathbf{M}}/\ \mathbf{M!}\}$,
10. For i=0 to **M**, compute $\{\sum_{i=0}^{m}(\mathbf{T}a^{\mathrm{p}})^{\mathbf{i}}/\ \mathbf{i!}\}$,
11. Calculate $\mathbf{B}a^{\mathbf{p}} = \{(\mathbf{T}a^{\mathbf{p}})^{\mathbf{M}}/\ \mathbf{M!}\}/\{\sum_{i=0}^{m}(\mathbf{T}a^{\mathrm{p}})^{\mathbf{i}}/\ \mathbf{i!}\}$,
12. Similarly calculate $\mathbf{B}b^{\mathbf{p}} = \{(\mathbf{T}b^{\mathbf{p}})^{\mathbf{M}}/\ \mathbf{M!}\}/\{\sum_{i=0}^{m}(\mathbf{T}b^{\mathrm{p}})^{\mathbf{i}}/\mathbf{i!}\}$,
13. Similarly calculate $\mathbf{B}c^{\mathbf{p}} = \{(\mathbf{T}c^{\mathbf{p}})^{\mathbf{M}}/\mathbf{M!}\}/\{\sum_{i=0}^{m}(\mathbf{T}c^{\mathrm{p}})^{\mathbf{i}}/\mathbf{i!}\}$,
14. Finally calculate $B_p = \mathbf{B}a^{\mathbf{p}} + \mathbf{B}b^{\mathbf{p}} + \mathbf{B}c^{\mathbf{p}}$.

4 RESULTS

4.1 Analytical Result

Without loss of observation, we consider that each BTS has M= 50 DCHs and Ta is 50 Erlangs which resembles to 5% call blocking probability(approximate) in cell A. We also consider that the traffic intensity of the system decreases to 0.8 fragment from one tier to another which means that $T_b = 0.8T_a$ and $T_c = 0.8T_b$, and consequently results in 1.87% blocking probability in B cells and 0.75% in C cells respectively.

Traffic Load: Traffic load is measured for the fractional ARS coverage ρ between the ranges 0.0 – 1.0 as follows:

Call Blocking Probability: Call Blocking Probability is measured for the fractional ARS coverage ρ between the ranges 0.0 – 1.0 and for M=5 DCHs as follows:

TABLE 1
TRAFFIC LOAD FOR VARYING ARS COVERAGE

T_a	Intensity Fraction	T_b	T_c	B_a	B_b	B_c	ρ	$T_a{}^p$	$T_b{}^p$	$T_c{}^p$
50	0.8	40	32	5	3	2	0.0	50	40	32
50	0.8	40	32	5	3	2	0.1	48.59	39.765	31.881
50	0.8	40	32	5	3	2	0.2	47.182	39.53	31.763
50	0.8	40	32	5	3	2	0.3	45.773	39.295	31.644
50	0.8	40	32	5	3	2	0.4	44.363	39.061	31.525
50	0.8	40	32	5	3	2	0.5	42.955	38.825	31.407
50	0.8	40	32	5	3	2	0.6	41.545	38.591	31.288
50	0.8	40	32	5	3	2	0.7	40.136	38.356	31.169
50	0.8	40	32	5	3	2	0.8	38.727	38.121	31.051
50	0.8	40	32	5	3	2	0.9	37.318	37.886	30.932
50	0.8	40	32	5	3	2	1.0	35.909	37.651	30.813

TABLE 2
CALL BLOCKING PROBABILITY FOR VARYING ARS COVERAGE

T_a	Intensity Fraction	T_b	T_c	B_a	B_b	B_c	ρ	$B_a{}^p$	$B_b{}^p$	$B_c{}^p$
50	0.8	40	32	10	7	5	0.0	9.880	6.850	4.812
50	0.8	40	32	10	7	5	0.1	9.876	6.849	4.811
50	0.8	40	32	10	7	5	0.2	8.873	5.848	4.701
50	0.8	40	32	10	7	5	0.3	7.869	4.847	3.810
50	0.8	40	32	10	7	5	0.4	6.865	3.846	3.456
50	0.8	40	32	10	7	5	0.5	5.861	2.845	2.808
50	0.8	40	32	10	7	5	0.6	4.856	1.844	2.377
50	0.8	40	32	10	7	5	0.7	3.852	0.843	1.721
50	0.8	40	32	10	7	5	0.8	2.847	0.842	1.321
50	0.8	40	32	10	7	5	0.9	1.842	0.841	0.804
50	0.8	40	32	10	7	5	1.0	0.836	0.840	0.603

4.2 Simulation Result

According to analytical result, we observe the simulation process and develop a simulation model. According to the model, the average call arrival time and holding time are considered as the two main factors for regulating the load in a cell which is measured in Erlangs. To simplify our simulation results of different traffic intensities, we tried to keep the average call propagation rate fixed and vary the call holding time.

We observe from the simulation model that there is a similarity between analytical and simulation results with primary relaying. Inconsequential differences may be aspected to the fact that in this analysis we tried to carefully balance the load by regulating the traffic even when there is no spontaneous blocking in that cell, whereas in simulation relaying is pursued on a call-by-call approach whenever there is a blocking.

Traffic Load: The figures for traffic load in primary relaying system for different cell are given below:

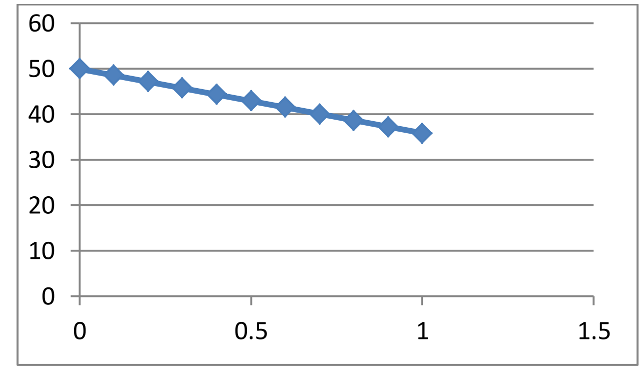

Fig. 7. Traffic Load in cell A

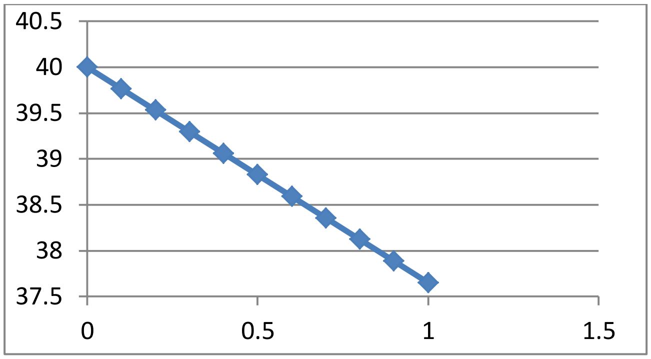

Fig. 8. Traffic Load in cell B

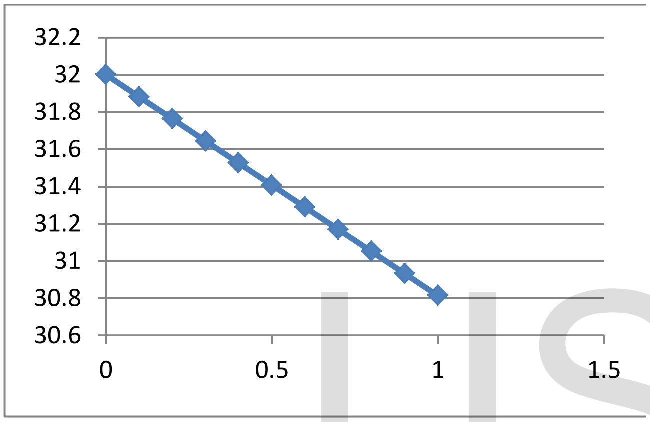

Fig. 9. Traffic Load in cell C

Call Blocking Probability: Call blocking probability is obtained by domineering exuberant control bandwidth, for example if there is a abundant number of signaling channels are available. We know that new calls will be blocked if there is no available DCH when it is generated. Following figures show the results for call blocking probability in A, B and C with stable MHs. Here we see that without any relaying techniques, the call blocking probability increases with traffic intensity.

With the help of primary relaying techniques, the blocking probability in particular cells may be reduced but not so much as needed. When traffic load is limited, primary relaying is helpful to decrease the blocking probability to an admissible level. After primary relaying, most of the ARSs in tier A and tier B are by the time been adopted to relay the calls from A to Bi and from Bi to Cj respectively, The operating MHs that uses DCH in cell A and Bi are most likely not wrapped by an ARS.

The figures for Call Blocking Probability in primary relaying system for different cell are given below:

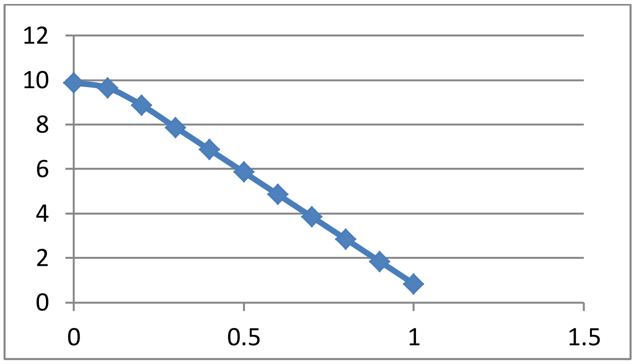

Fig. 10. Call Blocking probability in cell A

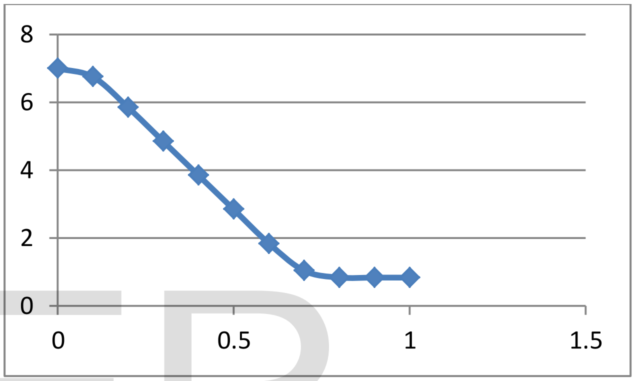

Fig. 11. Call Blocking probability in cell B

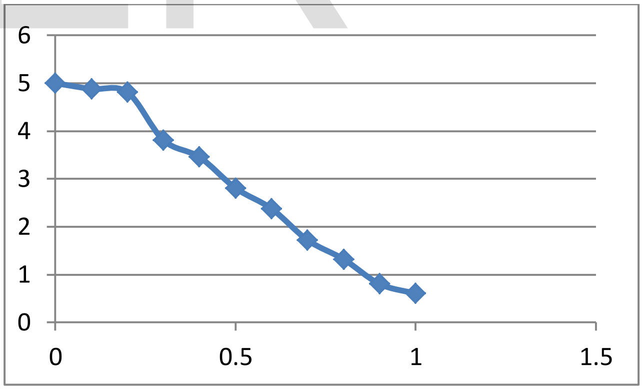

Fig. 12. Call Blocking probability in cell C

5 PERFORMANCE ANALYSIS

5.1 Analysis

In this section, we analyze the relaying performance of the existing iCAR system over a traditional cellular system via analysis. We analyze the relaying performance in terms of reduced current call blocking probability and increased number of calls that can be continuously supported as a function of the number of ARS's deployed within a cell. Here, we consider a ARS cell that is established at every border of two adjacent cells and can connect with two BTS's in the cells on other interface.

Two main factors affecting the performance of the iCAR system are the probability of establishing a route from a congested cell and the availability of the DCH's in other cells. Suppose that if the ARS's are haphazardly distributed in every cell, then the performance of primary relaying can be measured as-

$$\mathbf{P= 3*(r^2/R^2)}$$

Where,

P = performance.
r = the coverage of ARS in the cell.
R = the coverage of the cell..

5.2 Evaluation Algorithm

Performance of the iCAR system: The computation algorithm for measuring the overall performance of the iCAR system is described below:

1. Read the coverage of ARS in the cell **r,**
2. Read the coverage of the cell **R,**
3. Compute performance **P= 3*(r^2/R^2).**

5.3 Analytical Result

Performance is measured for varying coverage of ARS in the cell with the fixed coverage of the cell as follows:

TABLE 3
MEASURING PERFORMANCE

the coverage of ARS in the cell **r km**	The coverage of the cell **R km**	performance **P (%)**
=500	2000	18.75%
600	2000	27.0%
700	2000	36.75%
800	2000	48%
900	2000	60.75%
1000	2000	75%

6 RELATED WORK

In order to meet the demand of increasing number of subscribers, the system [1] needs to be redesigned. One obvious solution would be to allocate more frequency for the cellular system [3]. While this is being done, it is important to realize that there is only a limited amount of frequency bandwidth that can be used. As we push frequency transmission above the giga-hertz range, device cost begins to increase rapidly [5]. The bottom line is that frequency bandwidth is a very limited and scarce resource and some alternative approaches of increasing the system capacity should be sought. This section presents the basic concepts of these approaches as well as their advantages and disadvantages [6].

We know each ARS is controlled by a MSC and it also has limited flexibility. This feature is very important to ensure the establishment of a relaying route fast and the maintenance of it with a immense degree of stability. Routing strategies in iCAR system is similar to have a hybrid strategies (both flat and hierarchical) for efficient routing as well as handoffs in ATM networks [9].

The difference between the two strategies is path extension between two rigid BTSs via direct wired networks. In the multi-hop systems approach [19] and the Mobile-Assisted Connection Admission (MACA) system [20], relaying is executed by MHs and hence that approach also have many detriments in terms of security billing and mobility management along ad-hoc networks. The main goal of the multi-hop cellular systems is to reduce the transmission capability of each BTS or the number of BTSs , but it cannot fully assure a full coverage of the area. Literally, Alike in the optimal case where in an area, every MH disclosed by any BTS can discover a relaying route along other MHs, The multi-hop technique will not increase the system capacity. It also will not limit the call blocking probability, except the percentage of the intra-cell calls are large which is not generally the case in practice.

7 CONCLUSION

The objective of this work is to address the congestion problem in response to the limited bandwidth in a Integrated-cellular system, balance traffic among cells, increase system's ability to minimize the call blocking probability efficiently. The major contributions of this dissertation are as follows.

1. We have analyze the existing ad-hoc system architecture based on the integration of cellular with ad hoc relaying systems that called iCAR. We learn that, the system is able to efficiently balance the traffic loads and minimize the call blocking probability by using ARSs to dynamically transfer traffic within different cells.

2. We have analyzed the system performance in terms of handling the traffic load and the call blocking probability and verified the analytical results with simulations. Our results have shown that by using a limited number of ARSs and increasing signaling overhead and decreasing hardware complexity, the ratio of call blocking probability in a congested cell as well as in the overall system can be minimized.

We have also evaluated the performance of iCAR over conventional cellular systems. It allows us to determine the number of ARS required in a cell as well as in the entire system to get better performance from the system.

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