An Adaptive Load Balance Allocation Strategy for Small Antenna Based Wireless Networks

JONG-SHIN CHEN[1] NENG-CHUNG WANG[2] ZENG-WEN HONG[3] YOUNG-WEI CHANG[4]
[14]Department of Information and Communication Engineering
Chaoyang University of Technology
168, Jifong E. Rd., Wufong Township Taichung County, Taiwan, R.O.C.
[2]Department of Computer Science and Information Engineering
National United University, Miao-Li 360, Taiwan, R.O.C.
[3]Department pf Computer Science and Information Engineering
Asia University, No. 500, Lioufeng Rd., Wufeng , Taichung County 41354, Taiwan
{[1]jschen26, [4]s9530621}@cyut.edu.tw [2]ncwang@nuu.edu.tw [3]stewart@asia.edu.tw

Abstract: - Technological advances and rapid development in handheld wireless terminals have facilitated the rapid growth of wireless communications. Since this tremendous growth of wireless communication requirements is expected under the constraint of limited bandwidth. The small antenna frameworks that can provide more flexible to handle the limited bandwidth will be the mainstream for wireless networks. The antenna divided a cell into several sections. Each section contains a part of the system codes used to provide wireless communications. Therefore, the system codes allocated to each section will effect the system capacity and a reasonable allocation should provide more codes to a section with heavy traffic than a section with light traffic. However, the large number of sections increases the difficult to allocate system codes to sections. Especially, when there are variations in the traffic loads among sections will lessen the traffic-carrying capacity. This study proposes an adaptive load balance allocation strategy for small antenna based wireless networks. This strategy is implemented to solve traffic-adaptation problem that can enhance the traffic-carrying capacity for variations in traffic. Furthermore, the simulation results are presented to confirm the efficiency of the proposed strategy.

Key-Words: Small antenna, wireless network, load balance, and traffic-adaptation.

1 Introduction

Technological advances and rapid development in handheld wireless terminals have facilitated the rapid growth of wireless communications. Since this tremendous growth of wireless communication requirements is expected under the constraint of limited bandwidth [1, 5-8, 10, 14-20, 23-24]. The small antenna frameworks that can provide more flexible to handle the limited bandwidth will be the mainstream for wireless networks [3, 9, 13, 18, 21, 24].

The geographical (service) area of a system is covered by cells. For a small antenna based cellular system, each cell is split into small sectors. The cell splitting to sectors is achieved using higher directional antennas, which provides higher antennas gains for the served users in the sector and ensures reduced interference to the adjacent cells. Different channelization techniques can partition the system bandwidth to channels (or codes) to suit the small antenna systems, such as in [3], small antennas have already been used in GSM and time-division multiple-access systems. Moreover, in [21], small antennas were applied to WCDMA systems.

Each sector has a number of the system codes used to establish communications sessions. Accordingly, the number of codes allocated to a sector will affect the communication quality in this service area and the allocations of system codes among sensors will affect the traffic-carrying capacity of a system [5, 7, 14-15, 18, 20]. A reasonable allocation should provide more codes to a sector with heavy traffic than a sensor with light traffic. Otherwise, it will experience that the heavy traffic sectors do not have sufficient codes to carry their traffic loads but the light traffic sensors have many available codes. Thus, the traffic-carrying capacity of a system is reduced and the call blocking probability arises.

The conventional method, termed as the fixed allocation, prefers that each section has a fixed system codes. The fixed allocation is difficult to handle the changeable traffic loads among sections or cells. Therefore, in [7], an adaptive (dynamic) method is presented. In dynamic method, sections are partitioned in to several groups. This method considers the average traffic load of sensors in each group. A high-traffic group can acquire more codes than a low-traffic group. The sections in the same group have the same codes. Since there are high probability that traffic loads of sensors in the same group are different, the problem that code allocations can not be adaptive to the traffic loads still exist.

In light of above discussions, this study presents an adaptive load balance strategy for small antenna based wireless networks. This strategy can dynamically allocate codes among sensors according to variations in traffic to solve the traffic-adaptive problem and, accordingly, enhance the traffic-carrying capacity of cellular systems. The rest of this paper is organized as follows. Section 2 introduces the system model and the correlation research. In section 3, we describe the proposed strategy. The numerical results are given in Section 4. Conclusions are finally offered in Section 5.

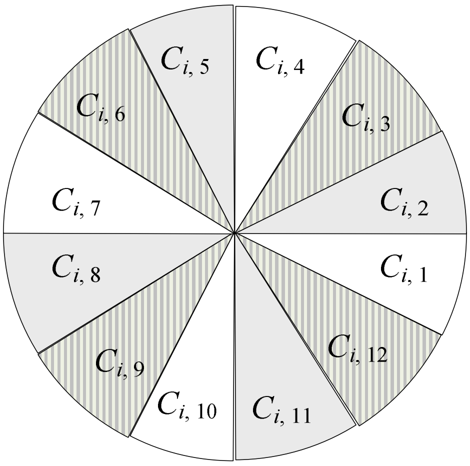

Fig. 1: Service areas of sensors

2 System Model & Correlation Research

Herein, first we introduce the system model. Then, use the definition of system model to describe the previous research contents.

2.1 System Model

The geographical area of a system is covered by cells. In each cell C_i, a base station using a small antenna in the center supports the wireless communications. Each antenna has m sensors and each sensor can charge a region in C_i to provide communication service. For convenience, $C_{i,1}$, $C_{i,2}$,…, $C_{i,m}$ respectively represents the service areas of the m sensors in C_i.

The management of the system bandwidth is based on code division multiple access (CDMA) technique [6, 18-19, 22,], where each cell can acquire all the system bandwidth B. Each sensor $S_{i,j}$ has a part $B(S_{i,j})$ of system bandwidth B used to provide service of $C_{i,j}$. A communication session (or a call) can be established if available codes can be allocated for supporting the communication between the mobile host and the sensor $S_{i,j}$. Two sensors cannot concurrently assign the same code to calls if their geographical distance is less than the minimum reuse distance D_{min}; otherwise, their communication sessions will interfere with each other. This situation is referred to code interference [5, 18].

Definition 1: Given a sensor $S_{i,j}$ in cell C_i, the set of interfering neighbors of $S_{i,j}$, denoted by $IN(S_{i,j})$, is: $IN(S_{i,j}) = \{S_{i,k} \mid S_{i,k} \in C_i \text{ and } D(S_{i,j}, S_{i,k})<D_{min}\}$, where $D(S_{i,j}, S_{i,k})$ is the geographical distance between $C_{i,j}$ and $C_{i,k}$.

Definition 2: denotes the interfering neighbors $IN(S_{i,j})$ of a sensor $S_{i,j}$. When $S_{i,j}$ assigns a code to an incoming call, it must ensure that this code is not concurrently assigned to other calls in $IN(S_{i,j})$. Code allocation to sensors must ensure if a code c is allocated to $S_{i,j}$, no other sensors in $IN(S_{i,j})$ can keep c as their code. Therefore, Definition 3 is the condition of code allocation.

Definition 3: (The condition of code allocation): Given two distinct sensors $S_{i,j}$ and $S_{i,k}$ in cell C_i, where $S_{i,k} \in IN(S_{i,j})$, the condition of code allocation between $S_{i,j}$ and $S_{i,k}$ is $B(S_{i,j}) \cap B(S_{i,k}) = \varnothing$.

For instance in Fig. 1, the area of cell C_i was divided to 12 subareas: $C_{i,1}$, $C_{i,2}$, …, and $C_{i,12}$ according to 12 sensors: $S_{i,1}$, $S_{i,2}$, …, and $S_{i,12}$. If D_{min} is 2 subareas away, $IN(S_{i,3})=\{S_{i,1}, S_{i,2}, S_{i,4}, S_{i,5}\}$. When $S_{i,3}$ was allocated to a $B(S_{i,3})$, $S_{i,1}$, $S_{i,2}$, $S_{i,4}$, and $S_{i,5}$, their allocated codes that respectively are $B(S_{i,1})$, $B(S_{i,2})$, $B(S_{i,4})$, and $B(C_{i,5})$, can not have the same code with $B(S_{i,3})$, i.e., any $S_{i,j} \in IN(S_{i,3})$, $B(S_{i,3}) \cap B(S_{i,j}) = \varnothing$.

The traffic load $\lambda(a)$ of an area a will determine its code allocation. The traffic load is defined as Definition 4.

Definition 4: The traffic load $\lambda(a)$ of an area a is: $\lambda(a)=t_a \cdot n_a$, where t_a is the average call holding time in a and n_a is the average call arrival rate in a.

In a cellular system, the Erlang B formula, as shown in (1), can be used to evaluate the call blocking probability of an area $C_{i,j}$ with the number n of available resources (codes) and the traffic load $\lambda(C_{i,j})$ (in erlangs).

$$EB(n,\lambda(C_{i,j})) = \frac{\lambda(C_{i,j})^n}{n!}\left[\sum_{k=0}^{n}\frac{\lambda(C_{i,j})^{-1}}{k!}\right]^{-1} \tag{1}$$

When a call arrives at an area, the targeted sensor $S_{i,j}$ will choose available codes from $B(S_{i,j})$. The available code c is defined as Definition 5.

Definition 5: $A(S_{i,j})=\{c \mid c\in B(S_{i,j})$ and c don't assign to any mobile host at $C_{i,j}\}$.

Table 1: Traffic distribution

Areas	Traffic load	Areas	Traffic load
$C_{i,1}$	6.0	$C_{i,7}$	5.0
$C_{i,2}$	2.0	$C_{i,8}$	0.5
$C_{i,3}$	5.0	$C_{i,9}$	4.0
$C_{i,4}$	2.5	$C_{i,10}$	1.0
$C_{i,5}$	4.5	$C_{i,11}$	6.0
$C_{i,6}$	2.0	$C_{i,12}$	2.0

2.2 Correlation Research

The Correlation Research divides into two parts: sensor-based code allocation and call-based code assignment. The sensor-based code allocation means the method to allocate each sensor $S_{i,j}$ a part $B(S_{i,j})$ of system resource B. Accordingly, when a call arrives at $C_{i,j}$, the $S_{i,j}$ assigns its allocated codes, using a call-based code assignment method, to assign codes of $A(S_{i,j})$ for this call.

Given a cell C_i with m sensors $\{S_{i,1}, S_{i,2},\ldots, S_{i,m}\}$ and the system bandwidth B. Two previous studies can be used to allocate B to m sensors.

In fixed allocation, each sensor $S_{i,j}$ permanently keeps the same number of codes. This code allocation to sensors can be formally described as follows [7, 18].

Step 1. Partition the sensors $\{S_{i,1}, S_{i,2},\ldots, S_{i,m}\}$ in cell C_i into G_1, G_2, …,and G_{cs} disjoint subsets, such that any two sensors in the same subset are apart by at least a distance of D_{min}. Accordingly, partition the available bandwidth B into B_1, B_2, …, and B_{cs} disjoint subsets, where the cs disjoint subsets are as fair as possible. (cs is also termed as the *cluster size*).

Step 2. The subset B_k is the allocated codes of sensors in G_k, where $k = 1, 2, \ldots, cs$.

For instance in Fig. 1, if the D_{min} is 2 subareas away, i.e., cs=3, sensors $\{S_{i,1}, S_{i,2}, \ldots, S_{i,12}\}$ can be divided into $G_1=\{S_{i,1}, S_{i,4}, S_{i,7}, S_{i,10}\}$, $G_2=\{S_{i,2}, S_{i,5}, S_{i,8}, S_{i,11}\}$, and $G_3=\{S_{i,3}, S_{i,6}, S_{i,9}, S_{i,12}\}$. Accordingly, if the bandwidth B has 12 codes, B can be divided into B_1, B_2, and B_3 and each contains 4 codes. Sensors in G_k can acquire the codes G_k, where k =1, 2, 3.

The fixed allocation applied each subset G_k a same number of codes. In fact, the traffic load of each subset is changeable according to the mobility of the mobile subscribers. However, the allocation is fixed and does not be adaptive to the traffic loads of the subsets.

In [7], a dynamic strategy, that applied each subset a different number of codes according to the traffic load of this subset, is studied. Similar to the fixed allocation, the strategy first divide sensors in C_i into cs subsets. Next, the traffic load of each subset G_k is valuated as (2).

$$\lambda(G_k) = \sum_{C_{i,j}\in G_k}\lambda(C_{i,j}). \tag{2}$$

According to (2), the capacity of G_k using B_k is valuated as (3).

$$PB(G_k) = \frac{\sum\limits_{C_{i,j}\in G_k}\left(EB(|B_k|,\lambda(C_{i,j}))\cdot\lambda(C_{i,j})\right)}{\lambda(G_k)}. \tag{3}$$

The capacity of cell C_i using B can be evaluated as (4).

$$PB(C_i) = \frac{\sum\limits_{k=1}^{cs}\left(PB(G_k)\cdot\lambda(G_k)\right)}{\sum\limits_{k=1}^{cs}\lambda(G_k)}. \tag{4}$$

According to the evaluations of (2)-(4), different allocation of partitioning B into $\{B_1, B_2, \ldots, B_{cs}\}$ will have a different $PB(C_i)$. This strategy evaluates all of the combinations and evaluates the $PB(C_i)$ of each combination. Then, this combination having minimal $PB(C_i)$ will be adopted. For instance in Fig. 1 under D_{min} is the one subarea away and 10 system codes, $\{S_{i,1}, S_{i,2},\ldots, S_{i,12}\}$ can be divided into $G_1=\{S_{i,1}, S_{i,3}, S_{i,5}, S_{i,7}, S_{i,9}, S_{i,11}\}$ and $G_2=\{S_{i,2}, S_{i,4}, S_{i,6}, S_{i,8}, S_{i,10}, S_{i,12}\}$, i.e., cs = 2. Accordingly, 10 codes need to divide into 2 subsets B_1 and B_2. Under the traffic distribution of Table 1, all allocation combinations with the corresponding capacity of B_1 and B_2 are shown as Table 2. Since the allocation that $|B_1|$=7 and $|B_2|$=3 presents best performance. Therefore, sensors $S_{i,1}$, $S_{i,3}$, $S_{i,5}$, $S_{i,7}$, $S_{i,9}$, $S_{i,11}$ can respectively acquire 7 codes and sensors $S_{i,2}$, $S_{i,4}$, $S_{i,6}$, $S_{i,8}$, $S_{i,10}$, $S_{i,12}$ can respectively acquire 3 codes.

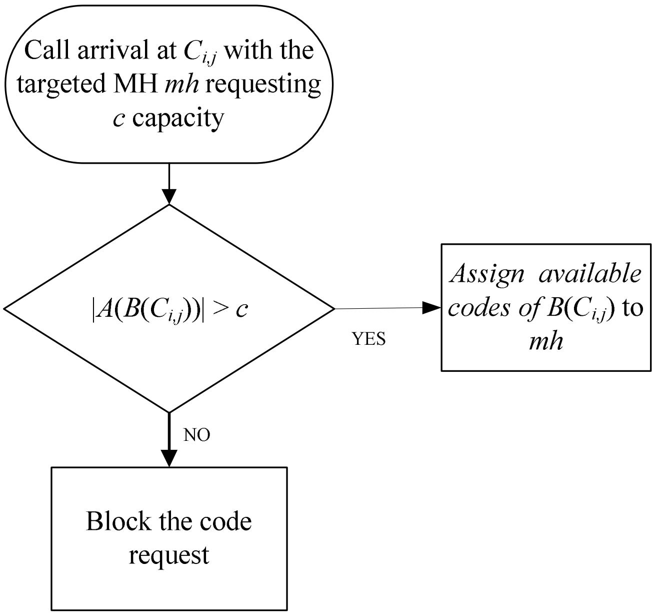

Fig. 2: Call assignment

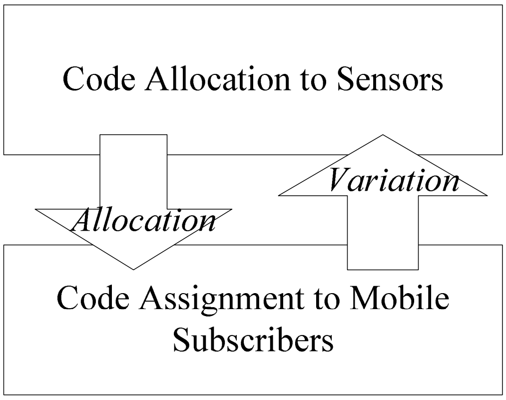

Fig. 3: Outline of the subject strategy

Table 2: Allocation combinations

$\|B_1\|$	$\|B_2\|$	$PB(G_1)$	$PB(G_2)$	$PB(C_i)$
10	0	-	-	-
9	1	0.047	0.645	0.195
8	2	0.082	0.382	0.156
7	**3**	**0.134**	**0.204**	**0.151**
6	4	0.205	0.096	0.178
5	5	0.297	0.040	0.234
4	6	0.409	0.014	0.311
3	7	0.538	0.005	0.406
2	8	0.681	0.001	0.513
1	9	0.836	0.000	0.630
0	10	-	-	-

As shown in Fig. 2, after the area $C_{i,j}$ acquired the resource $B(C_{i,j})$, when a MH mh requests r capacity to establish communication session, the sensor $S_{i,j}$ will find codes c from $B(C_{i,j})$ and the assignment procedure is presented as follows, where $|A(B(C_{i,j}))|$ is the number of available codes in $B(C_{i,j})$.

3 Subject Strategy

The bandwidth management strategy can be divided into a sensor-layer code allocation strategy and a call-layer assignment strategy. The former strategy is responsible for allocating system codes of each cell to its sensors. Accordingly, when calls arrive at this service area of a sensor, the latter strategy is activated to assign the allocated codes to calls to establish communication sessions. For the latter strategy, the strategy as shown in Fig. 2 is applied by this study. The relation of the two strategies is shown as Fig. 3. When there are variations such as traffic, the cell-layer strategy will be activated, accordingly to the variations, to allocated system codes to the sensors. The new allocation is submitted to the call-layer strategy. Then, the call-layer strategy uses the new allocation to carry the traffic.

Our strategy is divided into two aspects to describe. The first aspect is allocation condition. The allocation condition is used to valuate the capacity when a cell incurs variations of traffic load. According to the allocation condition, an allocation strategy is activated to allocate the system codes to sensors. A cell C_i has the system code B and m sensors, $S_{i,1}$, $S_{i,2}$,…, and $S_{i,m}$, that partitions C_i into m subareas $C_{i,1}$, $C_{i,2}$,…, and $C_{i,m}$. In the initialization, we assume each sensor $S_{i,j}$ has be allocated codes $B(S_{i,j})$ and the allocation need to satisfy the condition of code allocation.

This strategy uses an allocation condition function R to valuate the capacity effects of a sensor acquires a new channel. The valuation is described as follows. Based on (1), the evaluation that sensor $S_{i,j}$ use $B(S_{i,j})$ to carrying the traffic $\lambda(C_{i,j})$ is $EB(\lambda(C_{i,j}), |B(C_{i,j})|)$, in which $|B(C_{i,j})|$ is the number of codes in $B(C_{i,j})$. Then, the valuation of $S_{i,j}$ increasing and decreasing a code c can be represented as (5) and (6), respectively.

In order to satisfy the condition of code allocation, when $S_{i,j}$ acquires a new code c, the original owners $IP(S_{i,j}, c)$ need to give up c. the capacity effect can be represented as (7). In order to enhance the system capacity, the necessary condition to reallocate a code c to $S_{i,j}$ is $R(S_{i,j}, c) > 0$.
The proposed strategy is performed by each sensor $S_{i,j}$, which accords to the current traffic loads and the code allocations of it itself and the each interfering neighbor $S_{i,k}$ to determine the new code allocations. The formal description of the strategy is shown as Fig. 4. Sensor $S_{i,j}$ first sets $B'(S_{i,j})$ as $(B- B(S_{i,j}))$. $B'(S_{i,j})$ is the candidates that $S_{i,j}$ has the opportunities to acquire them as its new codes. Then, $S_{i,j}$ collects the traffic loads and code allocations of itself and its interfering neighbors $S_{i,k}$. For each code c in $B'(S_{i,j})$, $S_{i,j}$ evaluates the $R(S_{i,j}, c)$ value. A positive value of $R(S_{i,j}, c)$ means the utilization of code c in $S_{i,j}$ will be larger than in original owner(s) $IP(S_{i,j}, c)$. Therefore, $S_{i,j}$ selects a code c_{max} having maximal positive value as its new code, i.e., $B(S_{i,j}) \leftarrow B(S_{i,j})$ □$\{c_{max}\}$. Accordingly, the original owner(s) need to give up c_{max}, i.e., $B(S_{i,k}) \leftarrow B(S_{i,k}) - \{c_{max}\}$ and c_{max} also needs to remove from $B'(S_{i,j})$, i.e., $B'(S_{i,j}) \leftarrow B'(S_{i,j}) - \{c_{max}\}$. Then, $S_{i,j}$ uses the new $B(S_{i,j})$ and $B(S_{i,j})$ to evaluate the R(-) values of $B'(S_{i,j})$ and selects its new codes until $B'(S_{i,j})$ is empty.

$$incr(S_{i,j},c) = \left(EB\left(\lambda(S_{i,j}), \left|B(S_{i,j})\right|\right) - EB\left(\lambda(S_{i,j}), \left|B(S_{i,j})\right| \cup \{c\}\right)\right) \cdot \lambda(S_{i,j}) \tag{5}$$

$$decr(S_{i,j},c) = \left(EB\left(\lambda(S_{i,j}), \left|B(S_{i,j}) - \{c\}\right|\right) - EB\left(\lambda(S_{i,j}), \left|B(S_{i,j})\right|\right)\right) \cdot \lambda(S_{i,j}) \tag{6}$$

$$R\left(S_{i,j},c\right) = incr\left(S_{i,j},c\right) - \sum_{S \in IP(S_{i,j},c)} decr\left(S,c\right). \tag{7}$$

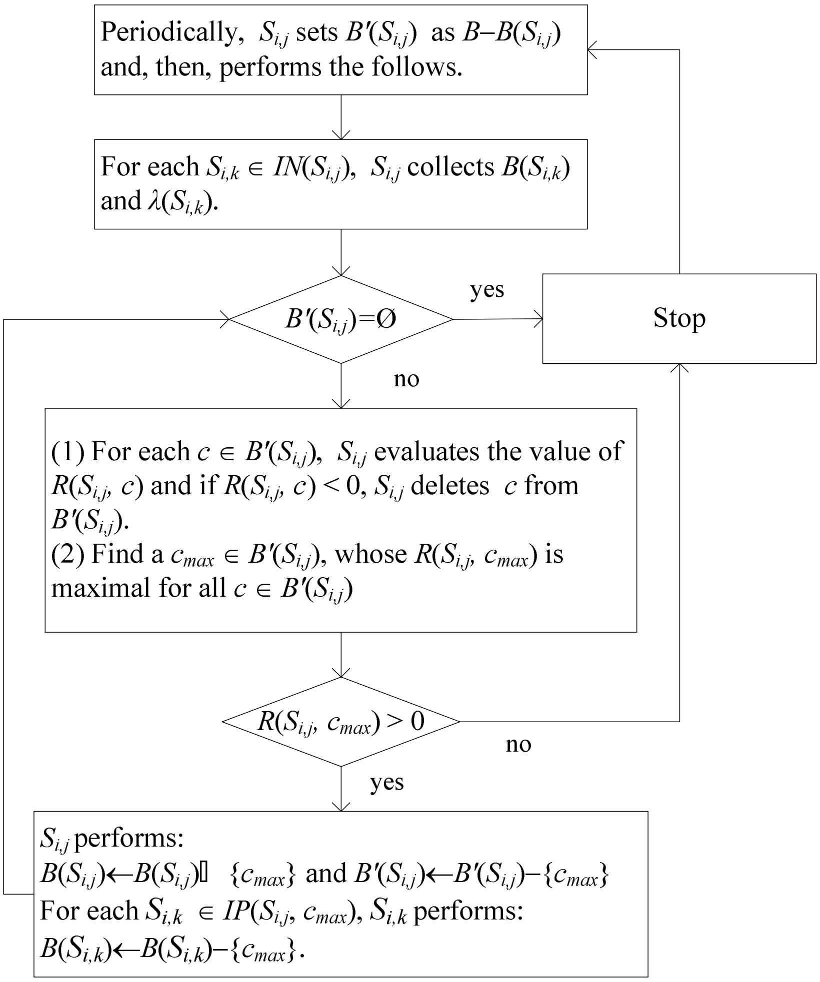

Fig. 4: Subject strategy

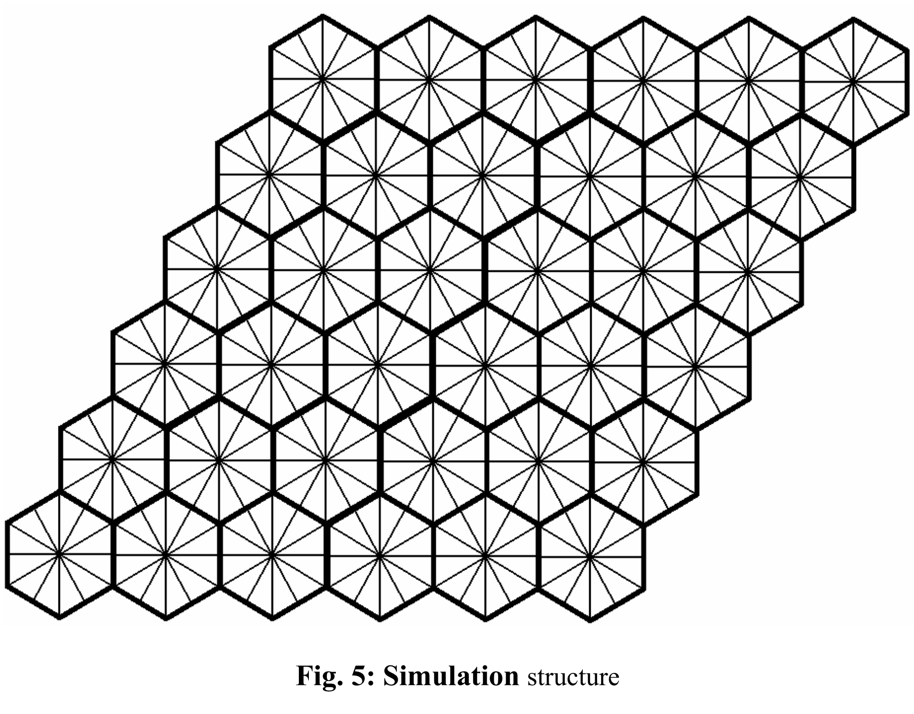

Fig. 5: Simulation structure

For instance in Fig. 5, we assume the system has 30 codes and marked as $B=\{c_1, c_2, \ldots, c_{30}\}$ and sensor $S_{i,2}$ currently has 10 codes, $c_1, c_2, \ldots$,and c_{10}, i.e., $B(S_{i,2}) = \{c_1, c_2, \ldots, c_{10}\}$. Continually, we assume sensors $S_{i,3}$, $S_{i,8}$, and $S_{i,11}$ have a code c_{15}. If a large number of mobile subscribers move to the service area $C_{i,2}$ of $S_{i,2}$. $S_{i,2}$ performs our strategy will first set $B'(S_{i,2})$ as $B- B(S_{i,2}) = \{c_{11}, c_2, \ldots, c_{30}\}$. $S_{i,2}$ will select some codes from $B'(S_{i,2})$ as its new codes. Then, $S_{i,2}$ collects the code allocations and traffic loads of $IN(S_{i,2}) = \{S_{i,4}, S_{i,3}, S_{i,1}, S_{i,12}\}$. Then, $S_{i,2}$ will evaluate the value $R(S_{i,2}, c)$ of each code c in $B'(S_{i,2})$. For code c_{15}, since $IP(S_{i,2}, c_{15})=\{S_{i,3}\}$. The value $R(S_{i,2}, c_{15})$ will be $incr(S_{i,2}, c_{15})–decr(S_{i,3}, c_{15})$. The $incr(S_{i,2}, c_{15})$ represents the increase of capacity if $S_{i,2}$ acquires new c_{15} and $decr(S_{i,3}, c_{15})$ represents the decrease of capacity if $S_{i,3}$ gives up c_{15}. If $R(S_{i,2}, c_{15})$ is large than 0, it means the code utilization of c_{15} in $S_{i,2}$ is larger than in the original owner $S_{i,3}$. When $S_{i,2}$ performs the strategy, in each round, $S_{i,2}$ will select a code c_{max} that the R(-) value is larger than 0 and is maximal for other code in $B'(S_{i,2})$. Next, $S_{i,2}$ will take c_{max} as its new code and the original owners in $IN(S_{i,2})$ will give up this code. In this round, c_{max} and some codes having negative R(-) values will be deleted from $B'(S_{i,2})$. In next round, $S_{i,2}$ will use the new allocation and re-evaluate the R(-) value and acquire a new code. The strategy is performed round by round until $B'(S_{i,2})$ is empty.

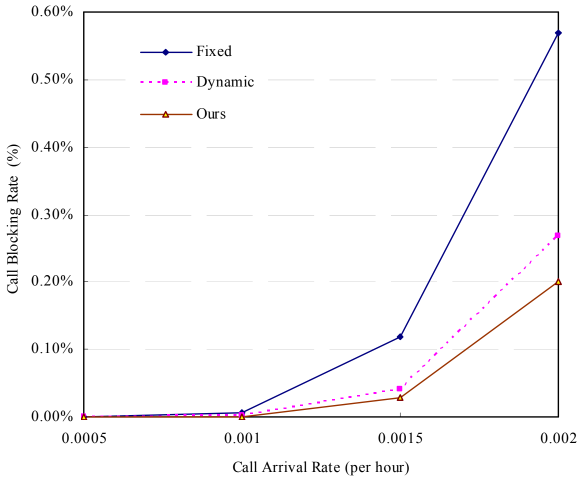

Fig. 6: Call blocking rate with p_{mh} =100 and p_{hot} =0.

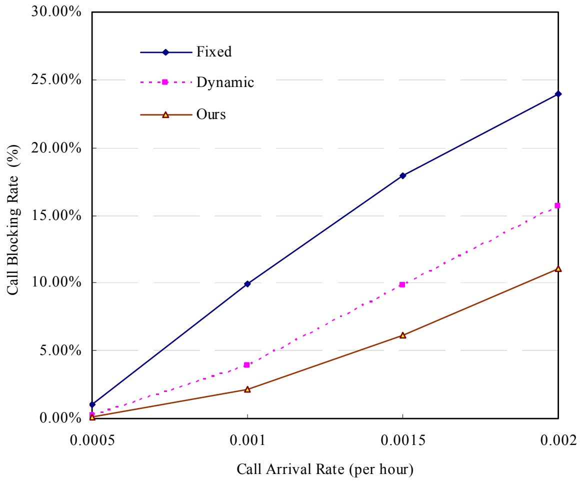

Fig. 7: Call blocking rate with p_{mh} =30 and p_{hot} =10.

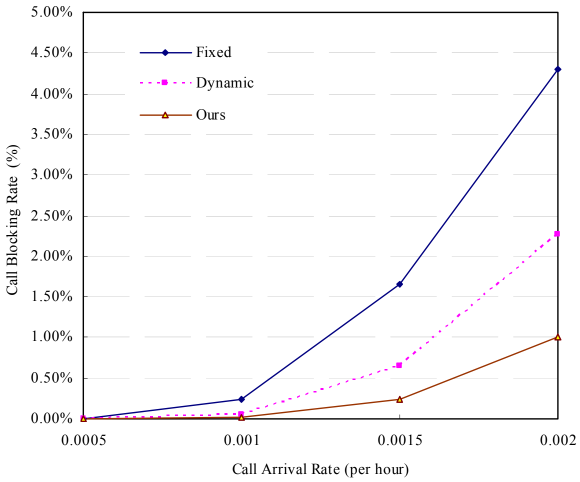

Fig. 8: Call blocking rate with p_{mh} =30 and p_{hot} =20.

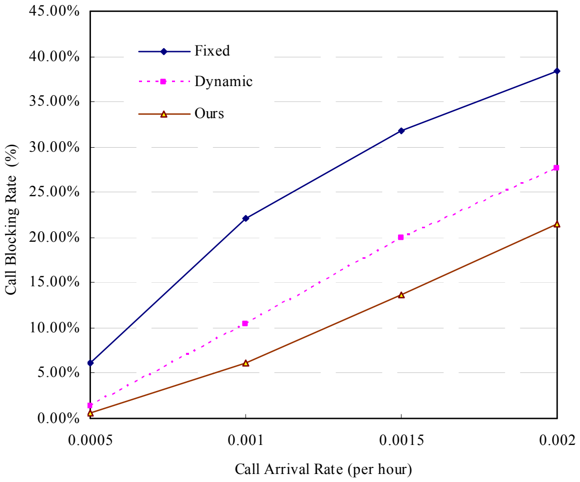

Fig. 9: Call blocking rate with p_{mh} =40 and p_{hot} =10.

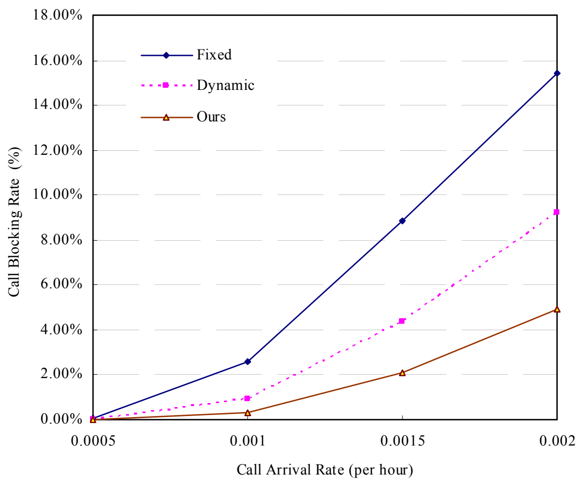

Fig. 10: Call blocking rate with p_{mh} =40 and n_{hot} =20.

4. Simulation Results

The simulation environment has 36 cells with 432 sections, arranged as 6-parallelogram structure, where the antenna divided each cell into 12 sections. There are p_{hot}% sections, termed as hot sections and $432 \cdot (1 - p_{hot}\%)$ general sections. The reuse distance is 2 subareas apart, where *cs* is 3, respectively. The system has 64 codes, where each call requests a code. The total MHs are 10,000. The distribution of MHs is that there are p_{mh}% MHs located at p_{hot} hot sections and there are $(100- p_{mh})$% MHs located at $432 \cdot (1 - p_{hot}\%)$ general sections, where p_{mh} = 100, 30, and 40, and p_{hot} = 0, 10, and 20. The distributions of MHs and hot sections are generated according to the random process. The call arrival rate of each non-calling MH is generated according to the Poisson process from 0.05% to 0.2% calls/second and the average call holding time is 3 minutes.

Fig. 6-Fig. 10 describes the simulation results of fixed and dynamic and our strategy. Fig. 6 presents the result of no hot sections, i.e., p_{mh}=100 and n_{hot}=0. For the fixed strategy, the call blocking rates from 0.0005-0.002 call arrival rates are 0%-0.57%. For the dynamic strategy, the call arrival rates are 0%-0.27%. For our strategy, the call arrival rates are 0%-0.20%. Fig. 7-Fig. 10 present the results that some mobile subscribers are located at hot sections. Fig. 7 presents the result of 30% mobile subscribers at 10% hot sections, i.e., p_{mh}=30 and n_{hot}=10. For the fixed strategy, the call blocking rates from 0.0005-0.002 call arrival rates are 0.99%-23.97%. For the dynamic strategy, the call arrival rates are 0.20%-15.66%. For our strategy, the call arrival rates are 0.08%-11.10%. Then, Fig. 9 and Fig. 10 present the results of 40% mobile subscribers at 10% hot sections and 20% hot sections. As shown in Fig. 9, the results demonstrate that our strategy can decrease the call blocking rates 90.92%-43.83 for the fixed strategy and 58.05%-21.83% for the dynamic strategy based on 0.0005-0.002 call arrival rates. As shown in Fig. 10, our strategy can decrease the call blocking rates 97.23%-68.07 for the fixed strategy and 80.98%-46.45% for the dynamic strategy.

The results reveal that our strategy can provide higher capacity than fixed and dynamic strategies. The reason can be described as follows. In fixed strategy, the code allocation cannot conform to the traffic distributions. Heavy sensors cannot acquire sufficient codes to serve the incoming calls when other light traffic sensors still have some available channels. In dynamic strategy, sensors are partitioned in to *cs* groups. The dynamic strategy considers the average traffic load of sensors in each group. A high-traffic group can acquire more codes than a low-traffic group. The sensors in the same group have the same codes. Since there are high probability that traffic loads of sensors in the same group are different, the problem that code allocations can not be adaptive to the traffic loads still exist. Our strategy considers the traffic loads of a sensor and its interfering neighbors. A high-traffic sensor can acquire more codes than its low-traffic neighbors. Therefore, our strategy presents better performance than the dynamic strategy.

5. Conclusion

The investigation proposed an effective load balance strategy. This strategy is implemented to solve traffic-adaptation problem that can enhance the traffic-carrying capacity for variations in traffic. Our strategy considers the traffic loads of a sensor and its interfering neighbors. A high-traffic sensor can acquire more codes than its low-traffic neighbors. Therefore, our strategy presents better performance than the dynamic strategy.

Wireless networks that employ small antenna have been proposed to increase the traffic-carrying capacity and circuit quality. Variations in the traffic loads among cells will lessen the traffic-carrying capacity. The antenna divided a cell into several sections. Moreover, the handoff procedure usually takes place when the call crosses the section boundary. A larger number of sections will increase the system overhead for handling the handoff procedure. An ineffective management will increase the system overheads, such as code switch, data switch, and even network switch [1, 11, 14, 17]. The investigation will propose an effective load balance and handoff management strategy. This strategy is implemented to solve traffic-adaptation problem that can enhance the traffic-carrying capacity for variations in traffic. For the management of handoff procedure, currently, we considers the mobility of mobile hosts and the bandwidth utilization to decrease the number of handoff procedures and, accordingly, lessen the system overhead. Moreover, considering ergonomic and economic factors [2] to allocate codes among sensors that can satisfy new trends in the telecommunication industry is one of our future works.

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