Efficient Scheme for Dynamic Channel Allocation Using Intelligent Agent in Mobile Communication

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***Abstract*— the demand for mobile communication has been growing day by day. Resource flexibility is one of the most important issues in the coming generation of mobile communication. Different techniques are required to increase the efficiency & flexibility of the network to deal with new services and to adopt the new traffic profiles and characteristics. This paper proposes a distributed dynamic channel allocation scheme using intelligent agents to provide more efficiency & flexibility to a network. This scheme of channel allocation will lead to an efficient solution under moderate and heavy load conditions. The agent architecture adopted provides greater autonomy to the base stations and a method for allowing co-operation and negotiation between them; this autonomy and co-operation allows an increase in flexibility to deal with new traffic situations and an increase of the robustness of the network as a whole.**

The performance of the Distributed FCA & DCA schemes are compaired and the we found that the average call dropping probability of FCA scheme is 96% to 98% and the average call dropping probability of DCA is 26% to 28% in different conditions, so the distributed DCA scheme is efficient than the FCA scheme.

***Keywords* – Efficiency, Intelligent Agent, Mobile communication, Resource flexibility, Traffic Profiles.**

I. INTRODUCTION

The schemes for channel allocation in mobile communication are important to handle the complexity in mobile communication. Efficiency of channel allocation is an important aspect in mobile communication. Some of the most common methods to increase the channel allocation and utilization are resource allocation schemes. Various channel allocation schemes have been proposed to provide Quality of Service (QoS) and efficient channel utilization in cellular networks [1]-[7].

The cellular structure was first proposed [2], [3] where the communication area is divided into hexagonal cells (or zones); each cell is served by a base station located at the centre of the cell. Different groups of radio channels are assigned to different cells, but the same group is reused by cells separated by a certain distance, called the reuse distance, chosen large enough to reduce co-channel interference. Only channels from the assigned group can be used to serve a call in a certain cell in the fixed channel assignment. If all the channels in this group are busy, service will not be provided to another caller in the cell even though there may be vacant channels in the other groups. In dynamic channel assignment all the channels are kept in a central pool, and any channel can be used by any cell. However a channel in use in one cell can only be reassigned simultaneously to another cell in the system if the separation distance between the two cells is greater than a specified minimum distance to avoid co-channel interference. The dynamic channel reassignment switches the channels assigned to some calls in progress to keep the separation between cells using the same channel simultaneously to a minimum. We proposes a efficient channel allocation scheme using intelligent software agents for cellular mobile networks. The main reason for using intelligent software agents is to give greater autonomy to the base stations; this autonomy allows an increase in flexibility to deal with new situations in traffic load as well as a derease in centralised informaton.

II. MOBILE NETWORKS

The first generation of mobile communication started in 1974; the Federal Communication Commission (FCC) allocated a 40 MHz band in the 800 to 900 MHz frequency range for cellular communications. The Advanced Mobile Phone Systems (AMPS) standard was introduced in 1979 and adopted by the FCC [4]. Licenses were issued in the market in 1982. An additional 10 MHz band was allocated in 1988 and called Expanded Spectrum (ES). The licenses were divided into bands: Band A and band B. Cellular communication is full-duplex and the frequency band is divided between both communication paths: 25 MHz is allocated to the forward path, which is the path from the base station transmitter towards the mobile terminal receiver. The other half is for the reverse path in the opposite direction. The paths are separated by a 45 MHz guard band in order to avoid interference between the transmission and reception channels.

Bands A and B each occupy 12.5 MHz: 10 MHz is Non-Expanded Spectrum (NES) and 2.5 MHz is ES. The 12.5 MHz bands are divided into 30 kHz channels, making a total of 416 channels per band. Twenty-one of these channels are used for specific procedures like channel assignment, paging, messaging, etc. They are called control channels. The remaining channels are used for conversation

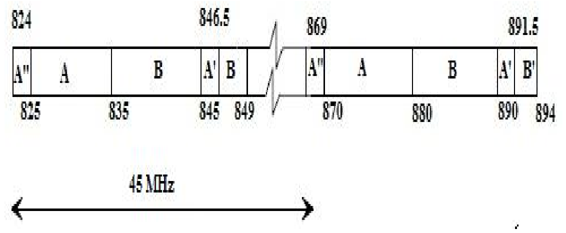


Figure II.I Cellular band allocation

and called voice channels. In AMPS, each frequency channel corresponds to a frequency carrier and only one mobile can be assigned per channel. Therefore, AMPS is solely Frequency Division Multiple Access (FDMA) and is an analogue cellular system.

The second generation of mobile communications, i.e. the digital cellular systems, emerged in the 1990's. In North America, additional standards were introduced for digital cellular systems using the same frequency spectrum as AMPS. These standards integrated other multiple access techniques in addition to FDMA.

The IS-54 standard, known as North American TDMA (NA-TDMA) or Digital AMPS (D-AMPS), has integrated the Time Division Multiple Access (TDMA) technique, where each frequency carrier is shared using time division by up to 6 mobile users (currently 3 mobile users).

In 1994, the IS-95 standard introduced the Code Division Multiple Access (CDMA) technique. It is based on the spread-spectrum modulation in which multiple users have access to the same band. Each mobile user is assigned a unique orthogonal code called a Walsh code. The 12.5 MHz of a band is divided in 10 CDMA bands of 1.25 MHz Each CDMA band supports 64 Walsh codes. CDMA can offer about eight times the capacity of analogue

The drastic growth in the use of mobile communications by public and business sectors increased the pressure to integrate fixed and mobile networks. Now, mobile networks are expected to have the same diversity of services offered by fixed networks with the same quality of service and security. Also, full mobility capability is expected. The mobile system needs to have the flexibility to integrate world-wide the different types of mobile communication systems available today, such as public and private cellular systems, data radio and satellite systems. These demands are beyond the technological capabilities of the second generation of mobile communications. These pressures and developments in component technology, network management and service engineering made inevitable the emergence of a third generation of mobile communications. The aim of third generation systems is to provide communication services from any person to any person at any place and at any time through any medium using a compact light-weight terminal with guaranteed quality of service and security.

Frequency management in mobile networks has been a hot topic for research in the past 20 years and the solutions proposed still present a lack of intelligence and flexible behaviour. The technological advances made in software and hardware in the last decade is providing the means to introduce intelligence in control and management of networks. The introduction of more intelligence and flexible behaviour in the management of channel allocation is the objective of this work.

III. THE CELLULAR CONCEPT

The cellular concept, conceived by Bell Systems under the AMPS standard in 1979, is a mobile network architecture composed ideally of hexagonal cells. The cells represent geographic areas. Inside the cells, the users, called mobile telephone switching office (MTSO) responsible for controlling the calls and acting as a gateway to other networks. When an active user (i.e. a mobile station using a frequency channel) reaches the boundary of the cell, it needs to change its current frequency channel for another belonging to the neighbouring cell. This network procedure is known as handoff or handover. Hand over can be either soft handover or hard handover.

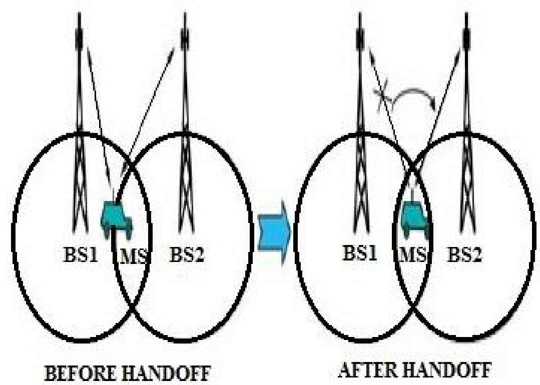


Figure III.I Handoff between MS and BS

The main objectives of AMPS for supplying a large-scale mobile-telephone service were:

- Large subscriber capacity
- Efficiency use of spectrum
- Nationwide compatibility
- Widespread availability
- Adaptability to traffic density
- Service to vehicles and portables
- Regular telephone services and special services
- Quality of service in telephony
- Affordability

An illustration of the AMPS mobile system architecture is given in Figure III.II.

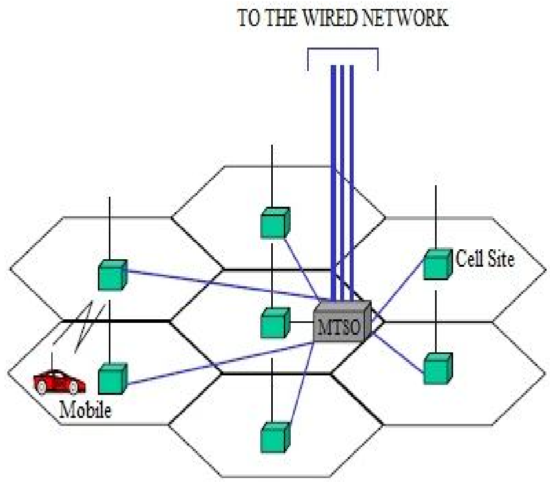


Figure III.II Cellular Band Allocation

The essential features of the cellular system were frequency reuse and cell splitting.

Frequency Reuse refers to the use of the same frequency carrier in different areas that are distant enough so that the interference caused by the use of the same carrier is not a problem. The reason for the application of frequency reuse is twofold:

- To reduce the cost of the land transmitter/receiver site by placing several moderate power land sites to cover sub-areas (cells) of the designated area for use of the network operator.

- To greatly increase the number of simultaneous calls that can be covered by the same number of allocated channel frequencies.

Cell Splitting is the reconfiguration of a cell into smaller cells. This feature makes it possible for the same network to service different densities of demand for channels. Larger cells can serve low demand areas and smaller cells high demand areas. Cell splitting is a long-term configuration planning that allows the system to adjust to a growth in traffic demand in certain areas, or in the whole network, without any increase in the spectrum allocation.

IV. CHANNEL ASSIGNMENT STRATEGIES

To satisfy the large demand of mobile telephone service, channels need to be reused in different no interfering cells. How the channels are to be assigned for simultaneous use in different cells directly affects the throughput of such systems. The frequency channel assignment in the cellular concept is static, i.e. after careful frequency planning, channels are assigned to cell sites and these sets will not change except for a new long-term reconfiguration. Cell sites will only make use of the assigned channel set or individual assigned channel sets per sector. This frequency channel assignment strategy is known as fixed channel assignment (FCA).

There are several strategies have been proposed to maximize frequency channel usage and minimise the blocking probability [5]. The strategies have been divided into three groups: those based on FCA, Dynamic Channel Assignment (DCA) and Flexible Channel Assignment (FICA)

Two FCA variant strategies have been proposed:

- Load Sharing
- Channel Borrowing (with or without channel locking)

It is assumed in the load sharing strategy that there is an overlapping coverage area between cells where mobiles can obtain a quality of transmission from the neighbouring cell almost as good as that in their own. When there is a call attempt and no more available channels, or when the channel occupancy reaches a pre-defined threshold, the MSC may advise some mobile users of the cell to check the transmission quality of channels in neighbouring cells. For each one of them that can get acceptable transmission quality from a neighbouring cell, a handoff request will be made to that cell and the mobile moved, provided the cell has enough available channels to allocate one to the requesting mobile user. In this way, the congested cell can have some of its nominal channels freed and use them in the new call requests. This load sharing strategy is also known as directed retry.

In the fixed channel assignment (FCA) strategy, a set of nominal channels is permanently assigned to each cell. Using the FCA strategy, an arriving call can only be served by the nominally assigned channels. If all nominal channels are assigned, new cells are blocked. Most of the other strategies are variations of the FCA strategy with different channel borrowing methods adopted.

Channel Borrowing Schemes

In a channel borrowing scheme, an acceptor cell that has used all its nominal channels can borrow free channels from its neighbouring cells (donors) to accommodate new calls. A channel can be borrowed by a cell if the borrowed channel does not interfere with existing calls. When a channel is borrowed, several other cells are prohibited from using it. This is called *channel locking*. The number of such cells depends on the cell layout and the type of initial allocation of channels to cells. For example, for a hexagonal planar layout with reuse distance of one cell (σ=3), a borrowed channel is locked in three additional neighbouring cells, as is shown in Fig. IV.I, while for a one-dimensional layout or a hexagonal planar grid layout with two-cell reuse distance, it is locked in two additional neighbouring cells.

In contrast to static borrowing, channel borrowing strategies deal with short-term allocation of borrowed channels to cells; once a call is completed, the borrowed channel is returned to its nominal cell. The proposed channel borrowing schemes differ in the way a free channel is selected from a donor cell to be borrowed by an acceptor cell.

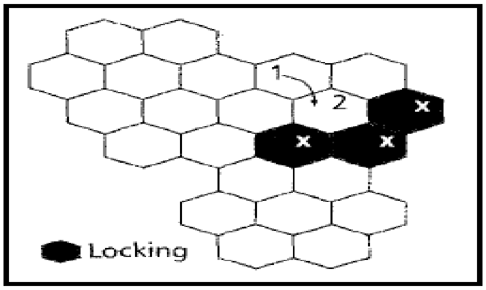


Figure IV.I Channel Blocking

The channel borrowing schemes can be divided into *simple* and *hybrid*. In simple channel borrowing schemes, any nominal channel in a cell can be borrowed by a neighbouring cell for temporary use. In hybrid channel borrowing strategies, the set of channels assigned to each cell is divided into two subsets, ***A*** (standard or local channels) and *B* (nonstandard or borrowable channels). Subset *A* is for use only in the nominally assigned cell, while subset *B* is allowed to be lent to neighbouring cells.

For macro cellular systems, where explicit communication is needed, FCA with channel borrowing offers good results and less computational complexity than DCA. However, those FCA schemes with the best results used centralised control inside the Mobile Switching Centre (MSC). Although that is less complex than DCA schemes, there is still a need to maintain an up-to-date global knowledge of the entire mobile network, leading to a slow response and a heavy signalling load. To alleviate this problem, several authors have proposed modifications to make the schemes more distributed. One example is the distributed load balancing with selective borrowing scheme is (D-LBSB) that performs better than its centralised version and also outperforms other existing schemes like direct retry and CBWL. The D-LBSB scheme is a distributed FCA algorithm with selective borrowing, channel locking and channel reassignment [6]. It takes into consideration the position of the mobile users when borrowing and reassigning channels; it triggers the execution of the algorithm when the usage of the nominal channels in a cell reaches a pre-determined threshold ***(h,*** when a previously ***cold*** cell becomes ***hot).*** It also controls the number of the channels to be borrowed from or lent to a cell according to the traffic load of the whole cellular network [7]. We selected this algorithm as the basic comparison for our work.

In the DCA strategy, there is no pre assignment of frequency channels to the cells of the cellular network. In the dynamic channel assignment due to short-term temporal and spatial variations of traffic in cellular systems, FCA schemes are not able to attain high channel efficiency. To overcome this, DCA schemes have been studied during the past 20 years. In contrast to FCA, there is no fixed relationship between channels and cell in DCA. All channels are kept in a central pool and are assigned dynamically to radio cells as new calls arrive in the system. After a call is completed, its channel is returned to the central pool.

In **DCA**, a channel is eligible for use in any cell provided that signal interference constraints are satisfied. Because, in general, more than one channel might be available in the central pool to be assigned to a cell that requires a channel, some strategy must be applied to select the assigned channel. The main idea of all DCA schemes is to evaluate the cost of using each candidate channel, and select the one with the minimum cost provided that certain interference constraints are satisfied.

DCA schemes perform better under low traffic intensity; modified FCA schemes have superior performance in high traffic loads. DCA schemes use channels more efficiently and for the same blocking rate have a lower forced call termination than FCA-based schemes. However, the near-optimum channel allocation is at the expense of high overheads through its use of centralised allocation schemes. This overhead means that such schemes are not practicable for large networks.

There is a trade-off between the implementation complexity of the channel allocation algorithms and spectrum utilisation efficiency. DCA schemes perform better under low traffic intensity; modified FCA schemes have superior performance in high traffic loads. DCA schemes use channels more efficiently and for the same blocking rate have a lower forced call termination than FCA-based schemes. However, the near-optimum channel allocation is at the expense of high overheads through its use of centralised allocation schemes. This overhead means that such schemes are not practicable for large networks. Distributed DCA schemes with limited inter-cell communication suffer less overhead, but lead to sub-optimum allocations. Such schemes are being proposed for microcellular systems as this cell structure allows inter-cell information sharing by interference measurements and passive non-intrusive monitoring at each base station (busy/idle status of the carriers).

V. PERFORMANCE OF CHANNEL ASSIGNMENT SCHEMES

Fixed channel assignment (FCA) is too limiting for mobile networks and several strategies have been proposed to maximise frequency channel allocation and minimise call blocking probability. DCA schemes perform better under low traffic intensity; modified FCA schemes have superior performance in high traffic loads. DCA schemes use channels more efficiently (better trunking efficiency) and for the same blocking rate have a lower forced call termination than FCA-based schemes. However, the near-optimum channel allocation is at the expense of high overheads through its use of centralised allocation schemes. This overhead means that such schemes are not practicable for large networks. Distributed DCA schemes with limited inter-cell communication suffer less overhead, but lead to sub-optimum allocations. Such schemes are being proposed for microcellular systems as this cell structure allows inter-cell information sharing by interference measurements and passive non-intrusive monitoring at each base station (busy/idle status of the carriers). For macro cellular systems, where explicit communication is needed, FCA with channel borrowing offers good results and less computational complexity than DCA. However, those FCA variant schemes with best results use centralised control inside the Mobile Switching Centre (MSC). Although they are less complex than DCA schemes, there is still a need to maintain an up-to-date global knowledge of the entire mobile network, leading to a slow response and a heavy signaling load. To alleviate this problem, several authors have proposed modifications to make the schemes more distributed.

VI. PERFORMANCE OF DISTRIBUTED DCA SCHEME.

The distributed DCA schemes are normally cell-based schemes or signal strength measurement based schemes.

The efficient signal strength measurement based scheme is the Channel Segregation (CS) scheme. This scheme is a self-organised DCA. Each base station scans channels when selecting an available channel with acceptable signal interference. Each base station will attribute to each channel a probability of channel selection, P (i). The channel "selectability" order is performed independently by each base station and is reviewed through learning methods. For each call request, the base station selects the channel with highest P (i). Then, the base station needs to check if the use of that channel is possible by measuring its power level. If the power level is good enough (acceptable interference) then this channel is considered idle, allocated to serve the call request and its "selectability" increased. If not, the channel is busy and P (i) is decreased. If all channels are busy the call is blocked. The CS scheme is autonomous and adaptive to changes in traffic load. Simulations results show that blocking probability is greatly reduced compared to FCA and DCA schemes and quickly reach a sub-optimum channel allocation. The presence of many local optimum allocations makes the convergence to an optimum channel allocation prohibitive. CS uses the channels efficiently and reduces the need for channel reallocation due to interference. CS is a good solution for TDMA/FDMA microcellular networks.

VII. AGENT SYSTEM.

The agent architecture adopted is able to provide greater autonomy to the base stations and allows co-operation and negotiation among them. Agents behaving under swarm intelligence can be released into a network to efficiently allocate limited resources. As such, in our case, agents distribute the limited number of cellular frequencies among the cells to accommodate network fluctuations and areas in high demand. This approach leads to agents distributing channels instead of a central system – each solving the problem at hand locally. Agents may communicate with each other in two ways, either directly or indirectly.

This thesis applies agents to the problem of mobile resource allocation in such a way that they do not work in isolation, but as a community. A community of agents is a multi-agent system, such a system being defined as a group of agents with specific roles in an organisational structure. The agents interact with the environment and with each other in a co-ordinated way, as collaborators or competitors, seeking to fulfill the local or global aims of the organisation

Multi Agent System extends the intelligent agent paradigm to improve upon the conceptual model of designing problems through agent interaction. Call admission control (CAC) is a fundamental mechanism used for quality of service (QoS) provisioning in a network by limiting the number of call connections into the networks in order guarantee connection level QoS parameters such as new call blocking probability and handoff blocking probability, packet level QoS parameters such as delay, jitter, packet loss for various classes of traffic and mobility QoS parameters such as velocity, distance and direction of the movement of mobile terminal. The Layered architecture of the above model consists of three layers. The functions of these layers are as follows:

- Reactive Layer gives fast response to the request and local allocation;
- Local Planning Layer work for distributed dynamic channel allocation using channel reassignment and channel borrowing and
- Co-operative Layer takes care of global scenario and balance the ratio of hot cell and cold cell.

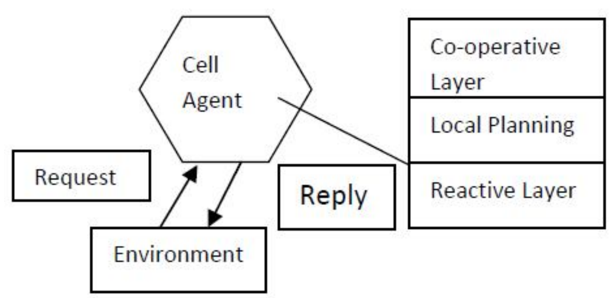


Figure VII.I Multi Agent System Model

VIII. SIMULATION MODELLING AND RESULTS.

There are two ways of measuring the performance characteristics of a channel allocation scheme: through mathematical analysis or through a simulation model. Most of the performance measurements of channel allocation schemes in the literature were made through mathematical analysis, using Markov chains, the traffic pattern in the cells being modeled using Poisson distributions. Some schemes did not distinguish between incoming calls and handoff requests. Therefore, they do not model mathematically the possible trajectories of the mobile. The reason for that is the estimation of mobility in communication networks can become too complex for mathematical analysis Moreover; the variety of signaling messages in real cellular systems is difficult to model mathematically. To be able to make measurements with different user mobility scenarios and greater range of signaling statistics, simulation models are used.

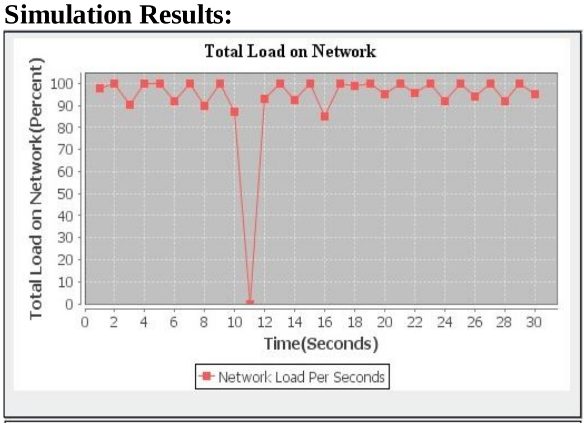
Cellular network systems can be modeled through an event driven simulator. The cellular model can be built using a simulator developed specially for this purpose or using a commercial simulator.

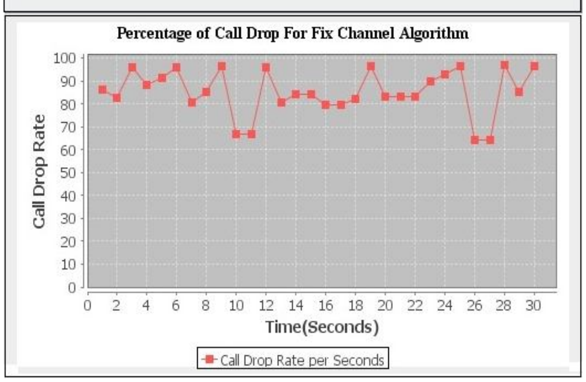
OPNET™ is a communication network commercial simulator that can be defined as a general-purpose event driven simulator.

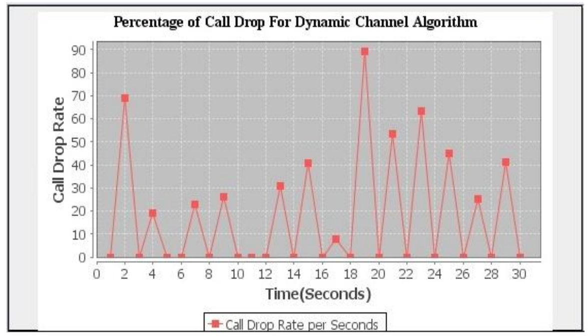
JDK with NetBeans IDE distribution of the JDK includes the NetBeans IDE, which is a powerful integrated development environment for developing applications on the Java platform. NetBeans IDE is a smarter way to code. A free open-source Integrated Development Environment for software developers. The NetBeans project consists of an open-source IDE and an application platform that enable developers to rapidly create web, enterprise, desktop, and mobile applications using the Java platform and c/c++.

The hierarchical structure of the agent architecture was implemented inside a module in the base station node. The different layers were created using JAVA with Net Beans IDE.

Simulation Results:







IX. CONCLUSION.

The cellular network implemented has nineteen cells, ten nominal frequency channels per cell in a 7-cell cluster. The network is a macrocellular structure. In each cell a source call generator process generates the call requests and randomly chooses an idle mobile station located inside the cell to place the call. The pdf for the call inter-arrival time and its mean value are changeable simulation parameters. In the scenarios simulated in this work, a negative exponential distribution was selected for call inter-arrival time with different mean values depending on the desired traffic load in the cell. The call length distribution is also a simulation parameter. Constant and exponential call length distributions were used in the simulations.

The performance of Distributed DCA scheme of a cellular network using the multi-agent system was compared with the distributed FCA scheme. The simulation results demonstrated that the use of intelligent software agents brought more flexibility than the other approaches and the distributed DCA scheme is more efficient than the other schemes of FCA.

The performance of the Distributed FCA & DCA schemes are compaired and the results are given in table

TABLE I
PERFORMANCE DISTRIBUTED FCA AND DCA

Channel Allocation Scheme	**Call Drop Rate In %**	**Status**
FCA	96% To 98%	High
DCA	26% To 28%	Low

Overall, the distributed DCA scheme using multi-agent system proved to be efficient and feasible.

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