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Assessment on Dynamic & Hybrid Channel Allocation in Mobile Network

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Abstract:-The wireless channels are the most significant resources in a mobile computing system. Each communication session that involves a mobile host requires a channel to be allocated. The possibility of reuse of wireless channels in different cells subject to fulfilling the reuse constraint is the main concern for optimizing the channel usage. The channel allocation problem deals with optimization of the channel usage in the mobile computing system.Many researchers have studied the limitation of fixed channel allocation (FCA) techniques to put up temporal and spatial traffic variations and have suggested various dynamic and hybrid channel allocation schemes in the past two decades. A range of dynamic and hybrid channel allocation techniques are studied comparatively in the context of the GSM-like system, with the aim of growing the system's carried traffic performance.The goal of this paper is to investigate and present a comprehensive survey on dynamic & hybrid channel allocation in cellular mobile system. This literature survey analyzes relevant topics of different researchers in dynamic and hybrid channel-assignment strategies.

Keywords: Dynamic channel allocation, hybrid channel allocation, channel borrowing, handoff, interference.

I. INTRODUCTION

The escalation of mobile communication users is very fast in past few years. ”It took over 100 years to connect 1 billion people to the communication network, but it will take less than 5 years to connect another 5 billion people according to McQuillan [1]. But, still the frequency spectrum allotted to this service is very inadequate. The frequency spectrum is divided into fixed number of channels with different bandwidth to carry on wireless communication sessions. Thus, the efficient management and sharing of spectrum resources is an central issue. The limitation of available frequency spectrum for the mobile communication service requires that the frequency channels have to be reused as much as possible in order to support many thousands of communication sessions that may arise in a typical mobile communication environment. In order to maximize the channel reuse the cellular architecture is proposed and the wireless/mobile communication is now known as cellular communication. The cellular communication network divides the entire geographical area over which the network exists into smaller hexagonal shaped regions known as cell [2] as in Fig. 1.

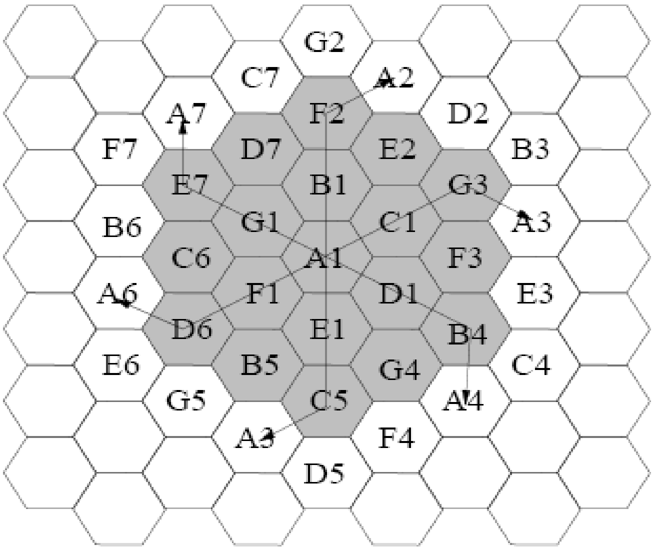

Figure 1: Cell Cluster in a Mobile Cellular Network

Each cell has a Base Station (BS) that hosts the Mobile Service Station (MSS) and a number of mobile hosts (MHs). To set up a communication session from MH, the concerned MH sends a appeal to the MSS of the cell in which it is presently located using some particular wireless channels known as control channels. The session is allowed if any wireless channel is available, otherwise the requested session is blocked until a channel is available for use in that cell. Since the frequency spectrum and thus the channels are limited, the frequency channels must be reused as much as possible to support the increasing demand for wireless communications. The frequency channels are usually separated by a bandwidth of 30 KHz in order to avoid interference while being used in the same cell. Moreover, the same channel can not be used in different cells if their geographic distance is less than a threshold known as minimum-reuse-distance (*Dmin*) [3], [4] due to the possibility of interference. The channel allocation problem deals with optimization of the channel usage in the mobile computing system.

The channel allocation schemes can be classified in three categories, Fixed Channel Allocation (FCA), Dynamic Channel Allocation (DCA) and Hybrid Channel Allocation (HCA).

In this paper, we investigate and present a survey on different dynamic and hybrid channel allocation schemes in cellular mobile network. This literature survey is meant for analyzing relevant topics of different researchers towards dynamic and hybrid channel-assignment strategies.

II. DYNAMIC CHANNEL ALLOCATION (DCA)

In dynamic channel assignment (DCA) scheme, all the channels are kept in a central pool and are assigned dynamically to the requesting cells as new communication request arrives in the system and after the session is over, the channel is returned to the central pool [5][6]. In DCA scheme, a channel can be used in any cell provided that signal interference constraints are satisfied. The DCA scheme can be implemented in a centralized or distributed manner.

In centralized DCA scheme, a central server maintains the channel pool, which is responsible for the channel allocation. This scheme seems to be near optimal under non-uniform traffic load in different cells but at the expense of a highly centralization overhead and also fault-prone [7], [8].

In distributed DCA scheme, the local information about the current available channels in the cell's vicinity is used to select a channel which is also confirmed through message passing between neighboring interfering cells [9][10][11].

Distributed DCA techniques are further divided into two classes: *cell-based and measurement-based techniques.* Cell-based techniques require each BS to maintain a table of variable channels in its vicinity and based on this table, the BS decides and assigns the channel to the users in its cell. This technique is very efficient, but the expensive incurred is additional inter-BS communication traffic, which increases with the traffic in a cell. To avoid this situation, signal-strength or measurement-based techniques are evolved. Here each BS makes the channel assignment based on received signal strength of the mobiles in its vicinity. In such schemes all channels are available to the BS, and the BS makes its decision based on the local information without any need to communicate with other BSs. These schemes are self organizing, simple, efficient and fast, but they suffer from additional co-channel interference which may result in channel interruption and network instability [12], [13], [14], [15].

III. HYBRID CHANNEL ALLOCATION (HCA)

In this scheme, a combination of FCA and DCA schemes are used to optimize the channel allocation. These types of schemes are proposed as a mixture of FCA and DCA [15] in which total number of channels available for services are divided into fixed and dynamic sets. The fixed set contains the number of primary channels that is exclusively assigned for the use of particular cell only as in FCA schemes. The primary channels are preferred to be used in the respective cells. All the cells share the second set of channels in the system to increase the flexibility. When a communication session requires a channel in a cell in which all the primary channels are busy, a channel from the dynamic set is assigned to the cells using the DCA scheme and the assigned channel is returned to the dynamic set soon after the communication session is completed.

IV. LITERATURE REVIEW ON DCA

P. Jesu Jayarin and T. Ravi in [16] proposed a DCA scheme for multi path cellular networks using MSWF in wireless network. In multi-hop cellular networks, a channel that contributes the lowest relaying delay is proposed to the current node on the path. The current node itself does not receive on the time-slot of the proposed channel that enhances the capacity and coverage problems of cellular networks. They also allow faster and cheaper deployment of cellular networks. A fundamental issue of these networks is packet delay because multi-hop relaying for signals is involved. An effective channel assignment is the key for the reducing delay. It proposes an optimal and a heuristic channel assignment scheme, called OCA and minimum slot waiting first (MSWF) respectively, for a time division duplex (TDD) wideband code division multiple access (W-CDMA) MCN. OCA provides an optimal solution in minimizing packet delay and can be used as an unbiased or benchmark tool for comparison among different network conditions or networking schemes. However, OCA is computationally expensive and thus, inefficient for large real-time channel assignment problem. In this case, MSWF is more appropriate. Simulation results show that MSWF achieves on average 95% of the delay performance of OCA and is effective in achieving high throughput and low packet delay in conditions of different cell sizes. For improving more on quality of service they have suggested to go for channel reuse by using FDMA and TDMA. They went through many previous related works. Fu et al. in [17] shown that the goal of channel assignment is to maximize channel (frequency) reuse among cells in a cellular system. Three channel allocation schemes, fixed channel allocation (FCA), dynamic channel allocation (DCA) and DCA with adaptive switching point (DCA-ASP) are discussed in [18] to allocate the channel. Both FCA and DCA consider only a single switching point in a transmission frame only. DCA-ASP supports the movement of multiple switching points to dynamically adjust the bandwidth to suit the traffic for uplink and downlink [19].

The novel feature of the proposed technique we found here is that co-coordinated, prioritized TDMA is supported for clusters of access points (AP's) using measurement based time slot assignments.

Hussein Al-Bahadili *et al.* in [20] presented a description and performance evaluation of an efficient distributed dynamic channel allocation (DDCA) scheme, which can be used for channel allocation in cellular communication networks (CCNs), such as the global system for mobile communication (GSM). The scheme utilizes a well-known distributed artificial intelligence (DAI) algorithm, namely, the asynchronous weak commitment (AWC) algorithm, in which a complete solution is established by extensive communication among a group of neighboring collaborative cells forming a pattern, where each cell in the pattern uses a unique set of channels. To minimize communication overhead among cells, a token based mechanism is introduced.

We have gone through their simulations. The scheme achieved excellent average allocation efficiencies of over 85%.

The DDCA scheme presented an excellent performance to allocate and reuse channels efficiently under different network operation environments without violating the co-channel and adjacent channel interference constraints. This is mainly because the AWC algorithm could satisfy cells needs by intelligently allocating and reusing channels. Their results obtained showed that an average allocation efficiency of 100% was achieved when the initial and the traffic loads are low and uniform as in suburban or rural areas, and the average allocation efficiency was reduced to 96% when the initial load is increased by 25% from 8 channels/cell to 10 channels/cell, and the traffic load remains unchanged at 0.2 calls/sec throughout the network.

Furthermore, the DDCA scheme presented an excellent performance even at a heavily loaded network operation environment in an urban downtown area, where the traffic load is centralized as in shopping or business districts. The minimum average allocation efficiency achieved was 86% when the initial load at the hot-spot cell reaches 10 channels/cell and the traffic load is 1.0 calls/sec. The results obtained also showed that the performance of the DDCA scheme was highly affected by the number of unused (free) channels remained after initialization, and the performance decreases as the number of free channels after initialization is decreased.

The comment we would like to give on this scheme is that it does not consider hand-off that may occur due to nodes movement between cells, therefore, it is important to modify the DDCA scheme to consider hand-offs. It is important to modify the DDCA scheme to consider total channels redistribution if there are many cells asking for more channels and they can not served, due to interference constraints, while there are many unused channels in neighboring cells. We believe the DDCA scheme could solve this situation by redistribute both the allocated and unused channels in a way that satisfies all cells needs in the system.

Megha Gupta and A.K. Sachan in [21] proposed a distributed dynamic channel allocation algorithm which is based on resource-planning model. A borrower need not to receive replies from every interfering neighbors, it can borrow a channel from that neighbor whose all group members replies with common free channels within the predefined time period.

Fig 2 shows the proposed system model of size 6*6 with cluster size 3 which means the set of cells are partitioned into 3 disjoint sets and number of channel sets is also divided into 3 channel disjoint subsets. In the proposed system model, when a channel needs to be borrowed by a cell, it has to send request message to its 6 interfering neighbors in spite of 30 interfering neighbors as proposed in [22][23]. The blocking probability and message complexity of the proposed algorithm is reduced; hence the performance of cellular system increases. The performance of the proposed DDCA algorithm is simulated taking the same metrics and parameters as in [22], for the sake of clear comparison.

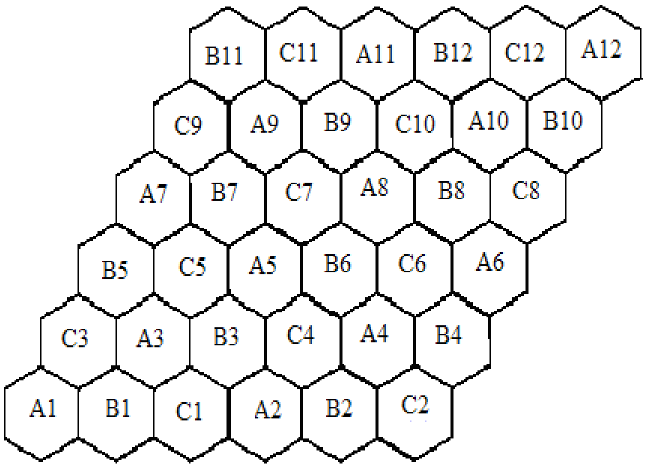

Figure 2: Cellular system model *of 6*6*

We found that the proposed algorithm makes efficient reuse of channels and evaluates the performance in terms of message complexity, blocking rate. Distributed dynamic channel algorithms have received more attention because of high reliability and scalability. Most of the algorithms did not make full use of the available channels. The proposed channel allocation algorithm makes efficient reuse of channels using resource-planning model with reducing the cluster size.

We find from the simulation result that the message complexity and blocking rate of the proposed algorithm are significantly less. It is less than algorithm in [22].

M´ark F´elegyh´azi *et al*. in [24] have proposed a non-cooperative multi-radio channel allocation in wireless networks and considered the problem of competitive channel allocation among devices that use multiple radios. Their main conclusion is that, in spite of the non cooperative behavior of such devices, their Nash equilibrium channel allocations result in load balancing. They have also studied fairness issues and coalition-proof NE. Finally, they have provided three algorithms to achieve the efficient, load balancing Nash equilibrium channel allocation and they have studied their convergence properties either theoretically or numerically.

Abeysundara in [25] proposed a DCA technique using intelligent agents. Under his implementation, agents only interact with the environment and the network cells. An aspect of self-organization is the reliance on multiple interactions, and the ability of agents to make use of the results of their own actions and the actions of others. The latter is not very apparent in his system; agents make very little use of the actions of others.

Yang *et. al*. in [26] proposed an efficient fault-tolerant channel allocation algorithm which achieves high channel utilization. In the proposed algorithm, a cell may borrow a channel even based on some partial channel usage information it receives from some of its neighbors. Moreover, a cell can lend a channel to multiple borrowers (at most three) as long as any two of them are not neighbors.

Zhang *et. al*. in [27] formalized the distributed scheduling problems in distributed wireless sensor networks, in which computation and communication resources are scarce, as DCSPs and distributed constraint optimization problems (DCOPs) and model them as distributed graph coloring. They found that to cope with limited resources and restricted real-time requirement, it is imperative to use distributed algorithms that have low overhead on resource consumption and high-quality anytime performance. In order to meet these requirements, Zhang et. al. studied two existing DCSP algorithms, distributed stochastic search algorithm (DSA) and distributed breakout algorithm (DBA), for solving DCOPs and the distributed scheduling problems.

When we compare between DSA and DBA, their results showed that DSA is superior to DBA when controlled properly, having better or competitive solution quality and significantly lower communication cost than DBA.

Bejar *et. al.* in [28] reported an experimental study of the average-case computational complexity of two early algorithms, ABT and AWC search on an application in distributed sensor networks. They also showed that random effects, both intentional such as random value selection and unintentional such as random delays, have a significant effect on the performance of the algorithms. Finally, they pointed-out that there are big performance differences between solvable and unsolvable instances.

Guohong Cao in [29] proposed to integrate distributed channel allocation and adaptive handoff management to provide QoS guarantees and efficiently utilize the bandwidth. First, they presented a complete distributed channel allocation algorithm and proposed techniques to reduce its message complexity and intra-handoff overhead. Second, they integrated the proposed distributed channel allocation algorithm with an adaptive handoff management scheme to provide QoS guarantees and efficiently utilize the bandwidth. Simulation results showed that the proposed solution can significantly reduce the message complexity and intra-handoff overhead. Moreover, the proposed scheme can improve the bandwidth utilization while providing QoS guarantees.

In the literature, two orthogonal approaches are used to address the bandwidth utilization issue and the QoS provision issue; that is, channel allocation schemes have been proposed to improve bandwidth efficiency, whereas handoff management schemes, based on bandwidth reservation, have been proposed to guarantee a low connection dropping rate. However, little effort has been taken to address both issues together. In this paper, they integrate distributed channel allocation and adaptive handoff management to provide QoS guarantees and efficiently utilize the bandwidth. Detailed simulation experiments are carried out to evaluate the proposed methodology.

We uncover that this scheme can significantly reduce the message complexity and intra-handoff overhead compared to previous schemes.

Marcos A. C. Lima et. al in [30] sighted a dynamic channel assignment (DCA) in mobile communication systems using genetic algorithm (GA). Two new strategies using GA are proposed. In the first one, the channels previously assigned are kept locked during the call holding time (GAL). In the second one, the calls can be switched to different channels during the connection time (GAS). The performance of the proposed GA is evaluated in a 49 hexagonal cell arrangement operating under uniform and non uniform traffic distributions. Numerical results show that the average call blocking probability of the GAS strategy is lower than the fixed channel assignment with borrowing directional channel-locked (BDCL) and DCA based on Q-learning.

So we find here that the performance of GAL strategy is better than Q-learning-based DCA for all the investigated cases.

Kambiz Shoarinejad *et al* in [31] proposed a distributed dynamic channel and power allocation (DCPA) scheme based on a novel predictive power control algorithm. The minimum interference dynamic channel assignment algorithm is employed, while simple Kalman filters are designed to provide the predicted measurements of both the channel gains and the interference levels, which are then used to update the power levels. Extensive computer simulations are carried out to show the improvement in performance, under the dynamics of user arrivals and departures and user mobility.

After going through this article, we have seen that the number of dropped calls and the number of blocked calls are decreased while, on average, fewer channel reassignments per call are required.

Kostic *et. al* in [32] examined techniques for increasing spectral efficiency of CCNs by using slow frequency hopping (FH) with dynamic frequencyhop (DFH) pattern adaptation. Their analysis and simulations considered the effects of path loss, shadowing, Rayleigh fading, co-channel interference, coherence bandwidth, voice activity, and occupancy.

We can see that systems using DFH can support substantially more users than systems using RFH.

Salmenkaita *et. al*. in [33] presented a practical DCA scheme for cellular GSM networks that is called a dynamic frequency and channel assignment (DFCA) scheme. They showed that the behavior of DFCA was satisfactory in very high load situations where the gain remains stable or is even increasing as happened with 50 km/hr mobile speed. In their model, a BS is capable of base band frequency hopping, and can only utilize part of the DFCA frequency band, therefore limiting the freedom of radio channel selection. Also Salmenkaita et. al. proved that in a typical case the gain of DFCA was reduced in a linear manner as the share of base band hopping BSs increases. Also DFCA can also be used to provide radio channel differentiation based on connection type, and this can be utilized to maximize the network performance when the frequency reuse does not have to be dimensioned from the worst case point of view.

Al-Agha in [34] proposed a multi agent solution for intelligent BSs in wireless networks to verify its feasibility as a main target. He found agents are able to combine knowledge and experience with neighboring agents to make the best decisions, also he demonstrated that, the intelligent agent approach to introduce the self-adaptive resource allocation feature in mobile networks remains an attractive and formal way of integrating intelligence in BSs.

Yubin *et. al*. in [35] discussed the problem of DCA in CCNs. They developed a simple but useful method to calculate the lower limit of call blocking probability of DCA. This method could be used to compare the performance of SCA with any kinds of DCA schemes easily and clearly. They found that the lower limit of blocking probability of DCA is related to the cluster size *N*, the lower limit of blocking probability of DCA will decrease if *N* increases. For example, they proved that in GSM system the application of DCA strategy would greatly improve the overall system capacity, while in CDMA systems in which *N* is less than 3 the improvement by DCA is not so obvious.

V. A LITERATURE REVIEW ON HCA

The problems which arise in DCA methods above under heavy traffic load could be reduced by a hybrid method introduced in [36]. Since the hybrid channel allocation method is a mixture of fixed and dynamic channel allocation, it performs well as a fixed channel allocation method under light traffic.

Geetali Vidyarthi *et al* in [36] developed an evolutionary strategy (ES) which optimizes the channel assignment. The proposed ES approach uses an efficient problem representation as well as an appropriate fitness function. The paper deals with a novel hybrid channel assignment based scheme called D-ring. They went through the related studies as follows.

An evolutionary strategy (ES) approach to the optimization of DCA and HCA has been proposed in [37]. Sandalidis *et al.* formulated the channel assignment as combinatorial optimization problem with solutions represented as vectors of binary digits. The size of a solution is always equal to the total number of channels available. They have shown that the proposed ES is better than the one proposed in Sandalidis *et al.* [37].

They propose a new distributed dynamic channel assignment strategy known as D-Ring HCA scheme. In this strategy, channel assignment is made by the controller of the concerned base station according to the knowledge about the neighbors of a given cell. The neighboring area of a given cell includes all those cells which are located at a distance less than the reuse distance. Conceptually, the neighboring area defines an interference region marked by grey cell belonging to *D* rings centered in a given cell *H* as shown in the Fig. 3. The channels are allocated to the host cell from a set of channels which excludes all those channels which are in use in the interference region. As such, the selected channels always satisfy the co-channel interference constraint. The channel usage information in the neighbors of a given cell is obtained from the allocation matrix.

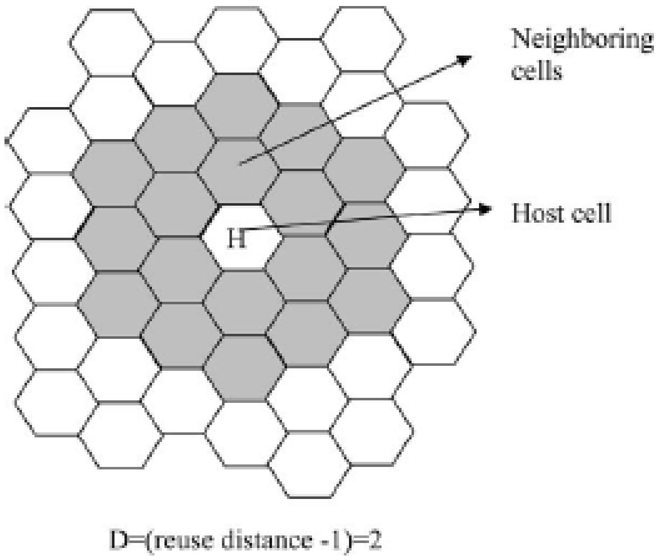

Figure 3: Neighbors of a given cell.

After investigation of this D-ring method, we uncover that this method yields a faster running time and simpler objective function. They also proposed a novel way of generating the initial population which reduces the number of channels reassignments and therefore yields a faster running time and may generate a possibly better initial parent. They have obtained better results (as well as faster running time) than a similar approach in literature.

VI. CONCLUSION

After a comprehensive survey of various DCA and HCA schemes, we can conclude that under low to moderate traffic loads, DCA strategies perform far better than FCA techniques. Because DCA is based on random arrivals of mobiles and random allocation of channels to them, unless maximizing the “packing” of channels is an optimization criterion, it is likely that distances larger than what is required may separate co-channels. This will prevent channels from being reused as often as possible, resulting in less capacity in larger loads. DCA however, reduces the fluctuations in the cell blocking probabilities, as well as forced call termination. DCA strategies need plenty of effort in real time for channel allocation. In addition, DCA schemes jointly optimize power control and handoff strategies. Indeed, HCA strategies have also been investigated. The total number of channels is portioned into fixed and dynamic sets. The ratio of fixed to dynamic channels becomes important in the performance of the system. HCA schemes have been shown to perform better than FCA schemes for load increases up to 50%. The D-ring method in HCA yields a faster running time and simpler objective function. Also this technique gives better performance, especially under heavy traffic loads, because they can balance the traffic load better. Under the hybrid method, when traffic load increases, the percentage of blocking channel rate increases more slowly than for the traditional methods.

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