Queue Length Based CSMA/CA Algorithm for Corn Using Channel Allocation Algorithm

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Abstract: **CSMA-type random access algorithms can achieve maximum possible throughput in wireless networks. Cognitive Radio Networks allow unlicensed users access licensed spectrum opportunistically without disrupting primary user (PU) communication. Developing a distributed implementation can fully utilize the spectrum opportunities for secondary users (SUs) have so far remained elusive. We are proposing a new algorithm channel allocation algorithm. The proposed algorithm achieves the full SU capacity region while adapting to channel availability dynamics caused by unknown Primary User (PU) activity. Extensive simulation results provided to illustrate the efficacy of the algorithm.**

Keywords **– CSMA, Channel Allocation Algorithm.**

I.INTRODUCTION

Wireless networks has limited resources, efficient resource allocation and optimization play an important role in achieving high performance providing satisfactory qualityof-service (QoS). In this paper, we study link scheduling (or Media Access Control, MAC) for wireless networks, where links (node pairs) may not be able to transmit simultaneously transceiver constraints and radio interference.

A scheduling algorithm (or MAC protocol) decides which links can transmit data at each time instant so that no two active links interfere with each other. The performance metrics of interest in this paper are throughput and delay. The throughput performance of a scheduling algorithm is often characterized by the largest set of arrival rates under which the algorithm can keep the queues in the network stable. The delay performance of a scheduling algorithm can be characterized by the average delay experienced by the packets transmitted in the network. Since many wireless network applications have stringent bandwidth and delay requirements, designing high-performance scheduling algorithms to achieve.

Maximum possible throughput and low delay is of great importance, which is the main objective of this paper. We also want the scheduling algorithms to be distributed and have low complexity/overhead, since in many wireless networks there is no centralized entity and the resources at the nodes are very limited. Maximum Weight Scheduling (MWS) algorithm and its variants achieve the full capacity region of the network, where a scheduling policy is said to achieve the full capacity region (or be throughput optimal) if it stabilizes the system for any arrival rate vector the system can be stabilized for by some scheduling policy. However, these algorithms require the knowledge of the entire network state and centralized processing to compute conflict free schedules. Similar algorithms have also been proposed for cognitive radio networks.

In, opportunistic scheduling policies are developed for multichannel single-hop CRNs subject to maximum collision rate constraints with PUs.

In scheduling algorithms are investigated in multi-channel multi-hop CRN overlayed with a PU network. The optimal throughput can be provably and asymptotically achieved in adaptive-routing scenarios. Both works require solving an NP-hard problem centrally. These centralized throughput optimal algorithms suffer from two main shortcomings. The first is the high computational complexity, and the second one is the cost associated with the collection of network state information at a central location. The first problem has been countered in the literature through lower complexity suboptimal algorithms.
They showed that the Markov chain describing the evolution of schedules has a product-form stationary distribution under an idealized continuous-time CSMA protocol (which assumes zero propagation/sensing delay and no hidden terminals) where collisions can never occur. This model was used in to study throughput and fairness issues in wireless ad hoc networks. The insensitivity properties of such a CSMA algorithm have been recently studied in Based on the results in a distributed algorithm was developed in to adaptively choose the CSMA parameters to meet the traffic demand without explicitly knowing the arrival rates. The results in make a time-scale separation assumption, whereby the CSMA Markov chain

converges to its steady-state distribution instantaneously compared to the timescale of adaptation of the CSMA parameters.

$C[t] = (C_l[t])_{l=1}^{N}$ are independently distributed random variables over links and identically distributed over time.

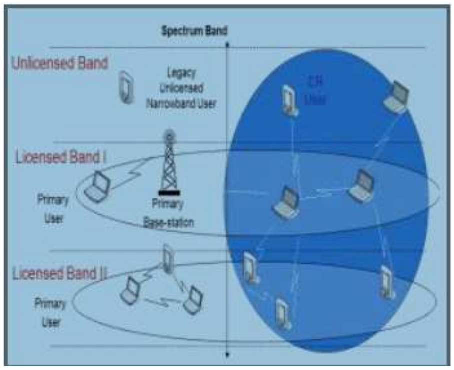


Fig 1 :System model

Where CR users are the users cognitive radio users in the first level the unlicensed Band will be used by the legacy unlicensed narrowband user and licensed band 1 &2 will be used by the primay users.

II. SYSTEM ARCHITECTURE

Devices with cognitive capabilities can be networked to create Cognitive Radio Networks (CRNs), which are recently gaining momentum as viable architectural solutions to address the limited spectrum availability and the inefficiency in the spectrum usage [5]. The most general scenario of CRNs distinguishes two types of users sharing a common spectrum portion with different rules: Primary (or licensed) Users (PUs) have priority in spectrum utilization within the band they have licensed, and Secondary Users (SUs) must access the spectrum in a non-intrusive manner. Primary Users use traditional wireless communication systems with static spectrum allocation. Secondary Users are equipped with CRs and exploit Spectrum Opportunities (SOPs) to sustain their communication activities without interfering with PU transmissions. Most of the research on CRNs to date has focused on single-hop scenarios, tackling PHYsical (PHY) layer and/or Medium Access Control (MAC) layer issues, including the definition of effective spectrum sensing, spectrum decision and spectrum sharing techniques [6,7]. Only very recently, the research community has started realizing the potentials of multi-hop CRNs which can open up new and unexplored service possibilities enabling a wide range of pervasive communication applications. Indeed, the cognitive paradigm can be applied to different scenarios of multi-hop wireless networks including Cognitive Wireless Mesh Networks featuring a semi-static network infrastructure [8], and Cognitive radio Ad Hoc Networks (CRAHNs) characterized by a completely self-configuring architecture, composed of CR users which communicate with each other in a peer to peer fashion through ad hoc connections. 9].

To fully unleash the potentials of such networking paradigms. Cognitive radio networks (CRNs) are composed of cognitive, spectrum-agile devices capable of changing their configurations on the fly based on the spectral environment. This capability opens up the possibility of designing flexible and dynamic spectrum access strategies with the purpose of opportunistically reusing portions of the spectrum temporarily vacated by licensed primary users. On the other hand, the flexibility in the spectrum access phase comes with an increased complexity in the design of communication protocols at different layers. This work focuses on the problem of designing effective routing solutions for multi-hop CRNs, which is a focal issue to fully unleash the potentials of the cognitive networking paradigm.

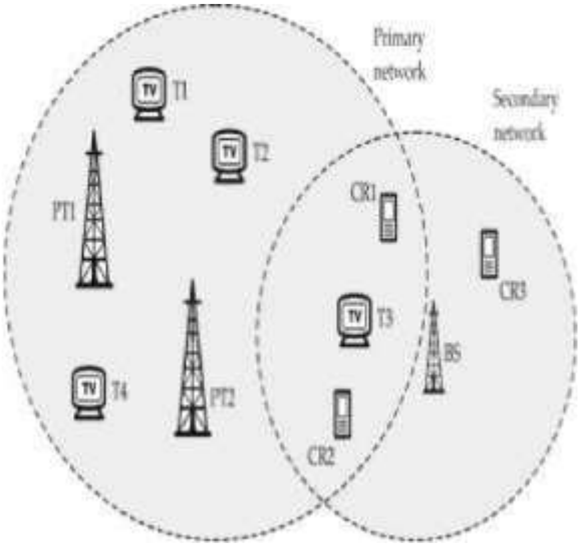


Fig 2: Cognitive Radio Network

Classification of cooperative spectrum sensing (left) centralized, (right) distributed.

The routing approaches building on this assumption leverage theoretical tools to design efficient routes, differentiating on the basis of which kind of theoretical tool is used to steer the route design. A first class encompasses all solutions based on a graph abstraction of the cognitive radio network. The second sub-class instead employs mathematical programming tools to model and design flows along the cognitive multi-hop network. Although these approaches are often based on a centralized computation of the routing paths, their relevance is in the fact that they provide upper bounds and benchmarks for the routing performance. On the other hand, routing schemes based on local spectrum knowledge include all those solutions where information on spectrum availability is locally ‘‘constructed” at each SU through distributed protocols. Thus, the routing module is tightly coupled to the spectrum management functionalities. Indeed, besides the computation of the routing paths, the routing module should be able to acquire network state information, such as currently available frequencies for communication and other locally available data, and exchange them with the other network nodes. While the network state in traditional ad hoc networks is primarily a function of node mobility and traffic carried in the network, network state in multi hop CRNs is also influenced by primary user activity. How this activity is and which are the suitable models to represent it are key components for the routing design.

Graph-based routing approaches Route design in classical wired/wireless networks has been tackled widely resorting to graph-theoretic tools. Graph theory provides extremely effective methodologies to model the multi-hop behavior of telecommunication networks, as well as powerful and flexible algorithms to compute multi-hop routes. The general approach to designing routes in wireless multi-hop networks consists of two phases: graph abstraction and route calculation. Graph abstraction phase refers to the generation of a logical graph representing the physical network topology. The outcome of this phase is the graph structure $G = (N, V, f(V))$, where N is the number of nodes, V is the number of edges, and f(V) the function which allows to assign a weight to each edge of the graph1 . Route calculation generally deals with defining/designing a path in the graph connecting source–destination pairs. Classical approaches to route calculation widely used in wired/wireless network scenarios often resort to mathematical programming tools to model and design flows along multi-hop networks.

III. Channel Allocation Algorithm

The bandwidth available to the cellular system is limited. Generally the total available bandwidth is divided permanently into a number of channels and these channels are allocated to cells without violating the minimum reusable distance constraint. Cells use the allocated channels for call handling. For better utilization of available channels, cellular communication system exploit the advantage of channel reuse, by using same channel simultaneously in different cells, where the cells are separated physically at least to minimum reusable distance, so that calls do not interfere with one another. In channel allocation, multiplexing, one of the basic concepts of data communication is used. Multiplexing uses the idea of allowing several Transmitters to send information simultaneously over a single communication channel. Concept of multiplexing, allows many users to share a bandwidth of frequencies. With the use of multiplexing, a given radio frequency signals/bandwidth available in cellular system, can be divided into a set of disjoint or non-interfering radio channels.

4.1.A Simple Channel Allocation Scenario For example let us consider a situation in which three cells A, B, and C share two channels, viz., channel1 and channel2. These three cells are in line and no two adjacent cells can use the same channel because of the channel reuse constraint. In a scenario of channel allocation, as shown in figure 4 (a) where, the cell A is serving a call on channel1 and cell C is serving another call on channel2. If at the same time, a new call arrives in the cell B, then it cannot be handled by cell B because of nonavailability of channel, as channel-1 and channel-2 are already in use by cell A and cell C respectively. Hence cell B cannot use any of these two channels, because of the reusable distance constraint. In this situation any new call arriving in the middle cell B must be blocked. This example provides some basic idea about the nature of the cannel allocation problem.

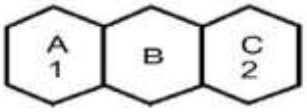


Fig 3.Channel Allocation Scenario-1

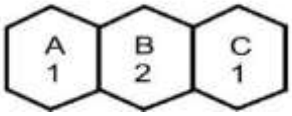


Fig 4.Channel Allocation Scenario-2

There would be a better scenario as shown figure 4(b) where both cell A and cell C use channel1, satisfying channel reuse distance constrains for their calls. Then a new call in cell B could be assigned channel2 while taking care of the channel reuse distance constraint. Such a solution of channel allocation is an attempt of possible optimization of typical of the channel assignment problem. In a real world cellular system with more realistic cases which have many-- cells, channels, and calls, along with the uncertainty about when and where a call will be arriving to or existing from a cell, calls will cross from one cell to another cell etc., the problem of allocating channels become complex. With added QoS parameters such as minimize call blocking probability and call dropping probability; channel allocation problem really becomes very complex, especially in cases of intense and dynamic traffic loads. One way of measuring traffic intensity in cellular system uses the erlang as parameter. One erlang is equivalent to number of calls made in one hour multiplied by the duration of these calls in hours. In real life scenario, each call may have a different duration or a different call holding time. In such cases, for traffic intensity calculation, the average call holding time is taken into consideration [12, 21]

4.2. Handoff Calls A connection request to a cell may be one of the two categories, it may be from a user in the current cell who wants to start the service, or it may be from a user who is currently connected to BS of a neighboring cell and have just got into the area of current cell. Also, it may be the case, where a currently active user in a cell may be replaced to another channel and cell may get back the channel currently in use, for allocating it to some other user in the cell or for lending it to some other cell. On the basis of request type of the connection, a connection may be either a new call or a handoff call. In a handoff process, the radio channel currently used by a connection is replaced by some other channel. In handoff process, if the new radio channel is allocated from the same base station then the handoff is called intracellular handoff [22]. Doing so, improves co -channel reuse. In intracellular handoff a channel currently used by some other call is assigned to a new call by reassigning new channels to calls already in progress. If in a handoff process, current allocated channel to a connection is replaced by some channel from a new base

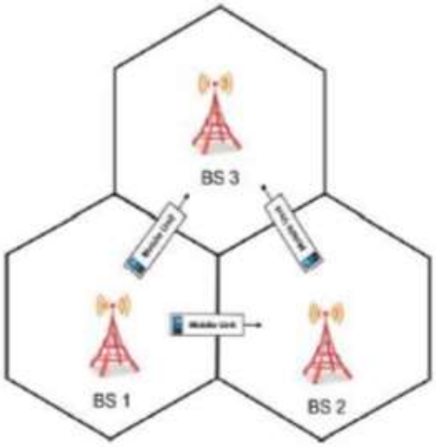


Fig 5: Intercell Handoff

Intracell handoff is a requirement for dynamic channel allocation (DCA) to adapt effectively to interference and variations in traffic. If intracell handoff is not permitted, DCA schemes follow inefficient reuse patterns, dictated by the specific pattern of call arrivals, call completion and intercell handoff. When intracell handoffs are permitted, complete reassignment of calls to channels can be performed system-wide.

4.3.Channel Allocation in Hierarchical Cellular Network (HCN) The HCN[92, 107-109], is a category of cellular network, which have three types of base stations (BSs)-- micro BSs, macro BSs and pico BSs. A HCN can be of-- single-tier, two-tier (consisting of macrocell and microcell), or three-tier (consisting of, macrocell, microcell and picocell), based on the configuration of the cells within it[110] and the way the base stations are loaded.

A structure of three-tier hierarchical cellular network is given in figure 10. A micro BS cover small radio coverage are called microcell, and macro BS cover large radio coverage are called macrocell. The microcells cover mobile MBSs, hence the geographical area covered by the cell changes dynamically with the location of BS of the cells

Fig 6.A three-tier hierarchical cellular network

changes dynamically. This dynamic change in location of the BSs, add more complexity in the system, as the neighboring information changes dynamically.

It is needless to mention that the channel-allocation schemes used for the traditional cellular networks do not work for cellular networks with MBSs. In MBS systems, all the decisions pertaining to channel allocations are taken based on the information available locally.

Because the base stations are mobile, the set of cells within the co-channel interference range changes with time. By doing this the channel reuse pattern is made very dynamic and almost unpredictable. In MBS situation, the problem of channel allocation become more complicated and challenging, and need to do the followings [117]:
i. Develop a dynamic channel allocation algorithm for backbone as well as short-hop links, ii. Make channel allocation decisions in distributed manner to make system more scalable and robust, iii. Reduce dependency on relatively resourcepoor mobile nodes (MNs) to a minimum, and Minimize overhead of channel rearrangements.

In MBS system the issue of co-channel interference can only be taken care at the time of channel allocation. In the case when any two MBSs using the same channel to support short-hop sessions move into co-channel interference range, one of the two MBS need to switch these channels to avoid the interference.

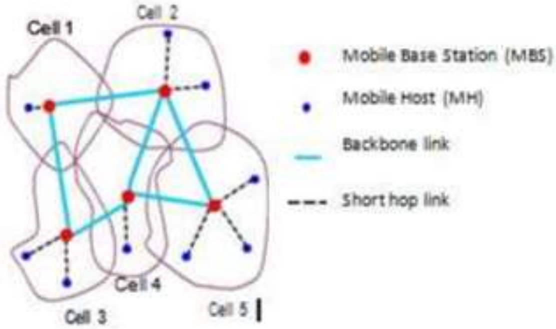


Fig 7.A fully wireless cellular network[117]

In mobile base station scenario, channel allocation is more complex than the conventional wireless system algorithms, because it does not have backbone wired network[117]. At the same time, the algorithm for channel allocation with mobile BS have many advantages, such as bounded latency, deadlock freedom, low system overhead and network traffic, and concurrency. The MBS systems definitely are not preferred in the environment where the existing cellular networks with fixed BSs are deployed. As in, convenient environment including towns, cities, plane areas etc; establishment cost, security, duration service requirement etc are always in favor of the fixed BSs system. The MBS systems may be applicable in areas such asmilitary use in battlefields and emergency condition such as disaster rescue including flood, earth quack, tsunami etc. Cellular networks with MBSs are similar to Mobile Ad Hoc Networks (MANETs)[118-119] with clusters and with rich in resource, having more energy, computational power, and memory.

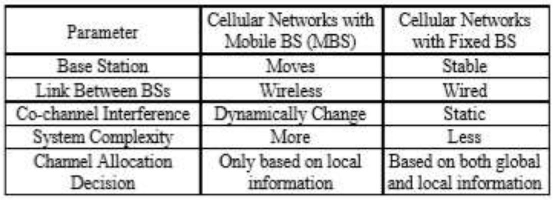
In MBS based, distributed channel allocation algorithm for cellular networks channels are allocated to support the links between MBSs, referred to as backbone link and the links between MBSs and MHs, referred to as short-hop links[115]. Where, channels used to support the backbone links and the short-hop links, is having no distinction. Hence, the same channel can be used concurrently for the two different types of links as long as they are not within co-channel interference distance. In[116,117], distributed dynamic channel-allocation algorithms for cellular networks with MBSs are proposed. In these algorithms, the set of channels is divided into two disjoint subsets: one for short-hop links, the communication between MBS and MH and the other for backbone links, the communication between MBSs. The algorithm consists of two parts:

4.4.SHORT-HOP CHANNEL ALLOCATION:
When an MBS, MBSi needs a channel, it first checks whether there exists an available channel allocated to it. If there such a channel exists, it can use this channel. Otherwise, it sends a request message to each neighboring MBS within the short-hop channel reuse distance. Upon receiving replies from neighboring MBSs, it computes the set of channels that can be borrowed. Depending on availability it selects a channel r from this set and consults with its neighbors, to which r has been allocated, on whether it can borrow this channel to use. It can use the selected channel if all the neighbors it consults grant its request. This approach is not fault tolerant because if any of the neighboring MBS fails channel allocation.

Backbone channel allocation: Whenever an MBS, MBSi wants to communicate with another MBS MBSj, all the BSs within the backbone channel reuse distance of either MBSi or MBSj are polled to gather their channel usage information. A channel is chosen to support the communication if the channel is not being used by MBSi, MBSj , and the BSs that are polled. When the communication between MBSi and MBSj terminates, the channel serving this call is returned to the system. In shorthop channel-allocation attempt, when an MBS does not receive a message from a neighbor within a timeout period, it is assumed that the neighbor either has crashed or moved out of its co-channel interference range.

In MBS based distributed channel allocation scheme proposed in[115], the responsibility for channel allocation is distributed among all the base stations. Doing so, this scheme becomes robust and scalable. The MBS's neighborhood is divided into three regions: no-use region, partial-use region, and full -use region. If a channel r is used by an MBS, MBSi, then r cannot be used concurrently by any other MBS, MBSj , which is in the no-use region of MBSi. When allocating channels, an MBS may need to take into account the neighbors in some or all of the regions. The algorithm in[115] is not fault tolerant because an MBS needs to get a reply message from each neighbor to borrow a channel. In MBS systems there is more likely that the MBSs may fail and degrade the performance of the cellular network. Therefore, it is desirable for MBS, that the channel allocation algorithm should be fault tolerant and may work even in the presence of failure of the MBSs, may be under more relaxed QoS parameters. Considering these issues, in[117] an efficient, fault tolerant, QoS based channel allocation algorithm for cellular networks with mobile BSs (MBS) is presented.

Table 1. Comparison between Cellular Systems with Mobile BS and Cellular Systems with Fixed BS



Parameter	Cellular Networks with Mobile BS (MBS)	Cellular Networks with Fixed BS
Base Station	Moves	Stable
Link Between BSs	Wireless	Wired
Co-channel Interference	Dynamically Change	Static
System Complexity	More	Less
Channel Allocation Decision	Only based on local information	Based on both global and local information

In this algorithm, MBSs exchange message with any of its neighbors by transmitting signal at a power level high enough to reach the neighbor. Also each MBS has the knowledge of the identity of its neighbors by listening to their beacons[115]. The MBS based channel allocation scheme in[117], divides the available wireless channel into two disjoint subsets. One subset used exclusively for backbone links and another subset used exclusively for short-hop links. As simulation result shows[117], the three QoS parameters, callblocking rate, handoff-drop rate, and call -failure rate, not only increase with the call arrival rate but also increase with the number of cell failures. This happens because when some cell fails then the demand for channels increases, then it is more difficult for a neighboring cell to find an available channel to borrow. Hence in the case of more cell failures it is very difficult for the neighboring cells to borrow channels [117]. This algorithm is fault tolerant because a cell does not need to get a reply message from each neighbor to borrow a channel.

IV. FIXED ALLOCATION

In the Fixed Allocation strategy every cell is permanently assigned a set of nominal channels according to interference and traffic constraints. The assignment policy is required to decide which channels should be assigned to which cells before activating the system. This policy will try to solve some variant of the problem formulation 2 .While we can safely suppose that interference constraints are available in advance (by accurate simulation or by field measurements), the traffic requirements (Ti) cannot be accurately foreseen, if not by statistical means. In its simplest form, an FCA algorithm will allocate the same number of channels to every cell. To do this, the channel set is partitioned into a number of subsets of equal cardinality and these sets are assigned to cells according to some possibly regular scheme. Consider, for example, the common hexagonal tiling. If the set of available channels is partitioned into three subsets, numbered 1, 2 and 3, then the regular pattern at left of figure 2.1 shows a possible assignment for a reuse distance equal to two. Note that the grey cluster is repeated over and over to build up an assignment where no adjacent cells are assigned the same set of channels. When a reuse distance of two hops is needed, the whole channel set must be partitioned into seven subsets, numbered from 1 to 7, and their assignment (together with the basic cluster) is shown on the right side.

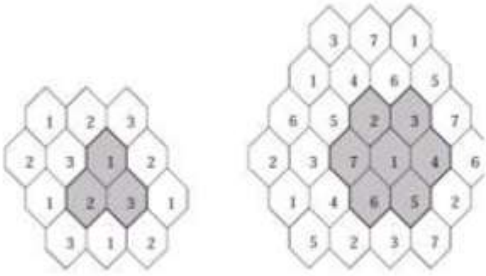


Fig 8.Reuse schemes for interference distance equal to one and two hops

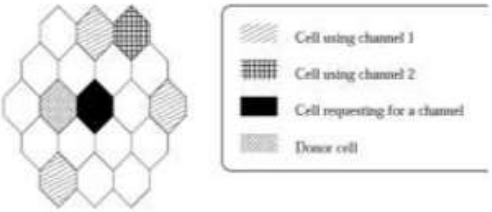


Fig 9.Taking channel locking into consideration

The function to minimize is clearly related to interference. It just counts the number of interference constraint violations: for every couple of adjacent (i.e. interfering) cells it counts the number of equal channels in use:

$$f : S \to \mathbb{R}$$

$$M \mapsto \sum_{i=1}^{n_{CE}} \sum_{i'=i+1}^{n_{CE}} \left(\mathrm{interf}_{ii'} \sum_{j=1}^{n_{CH}} m_{ij} m_{i'j} \right)$$

At every step, we choose the move with the highest decrease of interference (or the lowest increase, because we accept to worsen the situation), breaking ties at random. Not all moves between admissible configurations are allowed, because some of them are prohibited: some bits are locked to their 0 state for some number of steps. Suppose, for example, that cells i and i_ interfere (there is a 1 in the interference matrix) at the channel j, and that we decide to drop channel j replacing it with another one. Then we shall move the 1 from position j of row i to the nonprohibited position that guarantees the lowest interference count. Once done, the channel that has been dropped remains prohibited (frozen in its 0 state) for cell i for a certain number of steps

5.1.LOCALIZED CHANNEL SHARING (LCS) SCHEME: The LCS scheme proposed in[24] is a channel sharing based on FCA, in which channels between adjacent cells are shared with localized channel management within adjacent cells. This scheme uses the concept of meta-cells. A meta-cell is defined as a fixed collection of neighboring cells (typically a pair of two adjacent cells). Each metacell is designated by a pair (X, Y), where X and Y are individual cells called the component cells of that meta-cell. In this scheme, channels to metacells are allocated in such a way that a maximum number of channels can be assigned to each metacell while any two meta-cells assigned to the same channels satisfy the minimum reuse distance requirement. This scheme is having two advantages, first is sharing of resources between cells (in meta-cells) leads to more efficient utilization of the resources and reduces the probability of blocking a new call. The second is that when a user moves from one cell to another, under certain circumstances (from one cell of metacell to other cell of meta-cell) it may not be necessary to assign another channel to the user. This reduces the probability of blocking a handoff call. The LCS scheme does not require complex power control techniques, global channel coordination. Simulation results in[24] show that, LCS scheme can admit 20% more call into the network than a tightest FCA for call blocking probability Pb<= 10-2 . In 2-D case, for the minimum possible reuse factor R = 3, scheme [24] outperforms the fixed scheme by more than 10% and for the reuse factor R = 19, the improvement is about 30%. That shows, the LCS scheme is much better compare to tightest FCA for larger reuse factor.

V. SIMULATION RESULTS

In this section, we perform simulations to validate the optimality of the proposed FCSMA policy with deadline constraint 1 time slot in both fading and non-fading channels. In the simulation, there are N = 10 links. All links require that the maximum fraction of dropping packets cannot exceed $\rho = 0.2$. The number of arrivals in each slot follows Bernoulli distribution. For the simulations of a fading channel, all links suffer from the ON-OFF channel fading independently with probability p =

0.9 that the channel is available in each time slot. Under this setup, we can use the same technique in paper [16] to get the maximal satisfiable region: $X = \{\lambda : N(1 - \rho)\lambda < 1 - (1 - p\lambda)N\}$. Through numerical calculation, we can get $\lambda < 0.051$ in nonfading channel and $\lambda < 0.03$ in fading channel. We compare our proposed CSMA policy with f(x) = ex with QCSMA algorithm with the weight Xl[t]min{Cl[t],Al[t]} (In our setup, CSMA algorithm with the weight log log(Xl[t]min{Cl[t],Al[t]}+e) has much worse performance than that with Xl[t]min{Cl[t],Al[t]}). To that end, we divide each time slot into M minislots. In CSMA policy, if the link contends for the channel successfully, it will occupy that channel in the rest of time slot; while in CSMA policy, each link contends for the channel and transmits the data in 1 mini-slot. Here, we don't consider the overhead that the CSMA policy needs to contend for the channel, which will greatly degrade its performance.

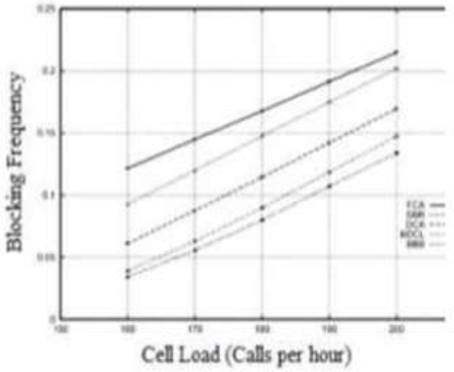


Fig10.Performance comparison among algorithms[60] between cell load and blocking frequency

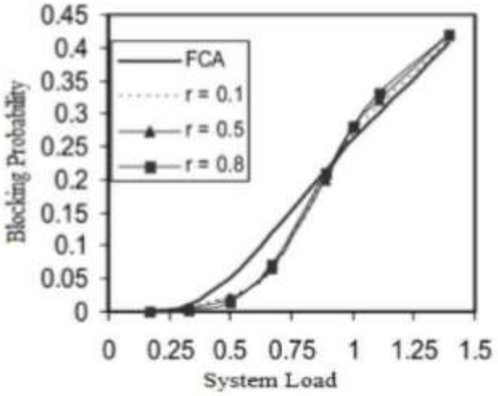


Fig11.Simulation Results of algorithm[51] for various values of ruse factor N for maximum hotspot level M=8, and their comparison with FCA

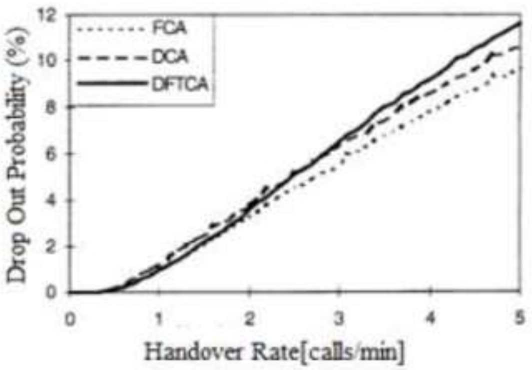


Fig 12.Effect of Handover Rate on overall Call Drop Out probability for FCA, DCA and DFTCA

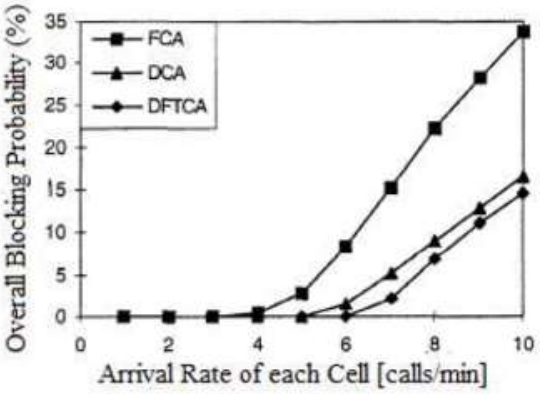


Fig13.Effect of arrival rate on overall blocking probability for FCA, DCA and DFTCA

The DCA scheme in is based on the concept of reconfiguring the network of cells to obtain a new assignment of nominal channels. In this scheme, channel allocation has been done in such a way that the minimum possible number of channels is used for the new load, and the number of different frequency assignments is minimum. For the general case of non-uniform traffic, the number of channel requirements in each cell is derived based on: i. the arrival rates of new calls and ii. Handover calls along with the expected grade of service.

VI. CONCLUSION

CSMA-type random access algorithms can achieve the maximum possible throughput in wireless networks. Cognitive Radio Networks allow unlicensed users to access licensed spectrum opportunistically without disrupting primary user (PU) communication. Developing a distributed implementation that can fully utilize the spectrum opportunities for secondary users (SUs) has so far remained elusive. We are proposing a new algorithm channel allocation algorithm. The proposed algorithm achieves the full SU capacity region while adapting to the channel availability dynamics caused by unknown Primary User (PU) activity. Extensive simulation results are provided to illustrate the efficiency of the algorithm.

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