Abstract—Multi hop cellular introduce the flexibility in recent cellular network. The main limitations of current cellular systems are avoided in the so-called multi-hop systems by distributing the communication task. Instead of having a peer-to-peer type direct communication between base station and mobile terminal, the transmission is spread out on several mobile terminals acting as repeaters. This approach has essentially the same effect as reducing the cell size while it does not require the number of base stations to be increased. In this paper, the channel assignment algorithm used for Code Division Multiple Access (CDMA) cellular networks using slot assignment algorithm.

Keywords—Cellular Networks, Wireless Ad hoc Networks, Multi-hop Relaying, CDMA and Slot Assignment, radio network controller .

1. INTRODUCTION

The very high data rates expected for fourth generation (4G) wireless systems do not seem to be feasible with the conventional cellular architecture. One reason behind this is that each communication will require a large peak transmit power from the mobile terminal (MT) to the base station (BS). One solution to this problem is the multi-hop cellular network, which was proposed to reduce the large peak transmit power, resulting from the high transmission rates expected for mobile communication systems beyond 3G. The fast communication system develops by multi hopping system using distributed fashion, without having to depend on an existing central controller or an infrastructure. In cellular networks, there are some areas where coverage is not be provided, referred to as dead spots, like subway train platforms, indoor environments, and underground areas. Also some area where coverage is provided but because of crowded area like downtown areas and amusement parks, known as hot spot where subscribers tend to experience higher call blocking. In this type of problem, multi-hopping technique provides a cost effective solution. Therefore, users in dead spots can still maintain connectivity with the BS by relaying their messages through other subscribers or by hopping to a user who has a connection with the BS. In hot spots, a user can still obtain a connection by hopping away from congested BSs to lightly-loaded ones.

The existing cellular systems suffer from interference problems related to the centralized nature of the radio communication. Typically, there are several mobile terminals in a cell that are communicating with the base station. As these terminals are likely to experience greatly differing propagation losses in the radio transmission, they are forced to use transmission power levels with a similar variance. This is the root of the so-called near-far problem where terminals nearby a base station become saturated by its communication with terminals further away. The near-far problem does not only place very stringent linearity requirements on the mobile terminals but it also limits the cell radius. This problem solved by multi-hopping technique. [1] [2] [3]

In wireless communication systems, two communicating terminals can be too far apart to reasonably allow direct communication at high data rates. Reducing this distance by relaying between intermediate terminals can be beneficial regarding the total capacity, even in cellular-type networks capacity here understood as the total amount of data transmitted by the access points(s) per unit time. The intuition for increased capacity is that over shorter distances, faster data rates can be realized. As long as the data rates over a, say, two-hop route are more than twice as fast as over a direct communication, capacity increases. This argument, however, only holds if distances are actually reduced by relaying, i.e., if the relaying case is supposed to cover the same area as the direct communication case. Multi-hop communication provides an additional advantage over direct communication: There are more sender-receiver pairs than in the direct case, where the access point always participates and there is only a single pair. Hence, relaying offers the possibility to increase capacity even further.
by concurrently transmitting data, in multiple hops, towards the access point [1].

II. MULTI-HOP CELLULAR SYSTEMS

A multi-hop scheme enables all mobile terminals as well as base stations to reduce their transmit powers while preserving range. As an example, let us consider the scenario illustrated in Fig.1, where a mobile terminal (MS1) is far from the nearest base station.

Fig1: reducing transmission distance by multi-hop scheme.

In a conventional cellular network MS1 is required to increase transmit power compared to MS2 and the same applies for the base station. In a multi-hop system the transmission takes place at a lower power level by allowing MS1 to communicate with a neighboring mobile terminal (MS2), which then relays the signal further to the base station. Naturally, there could be more than one relay-mode mobile terminal involved in the communication link. The amount of latency allowed for within the given cellular application specification places an upper limit on the number of relay points and thus limits the range per base station and same problem of corner of building [4].

III. NETWORK MODEL

Multi-hop CDMA cellular networks are considered. Cells are assumed to be hexagonal. A cell is divided into k concentric discs of equal width around BS. Discs are numbered 0 through (k-1), where 0 is the innermost disc and (k-1) is the outer-most one. MTs are associated with a certain disc based on their distance from BS. Only MTs, inside disc 0, are allowed to communicate directly with BS. All other MTs send their data using multiple hops. Maximum number of hops is k. In order for MTs in disc n (n>0) to send data to BS, they have to relay it through MTs in disc (n-1).

We assume that MTs are dense enough that any MT can find a relaying MT in the next disc within its transmission range. Each cell has original calls. MTs and calls are uniformly distributed over the cell [2][5].

A cell divided into 3 discs is shown in Fig2.

Fig2: Cell with 3 discs

IV. CHANNEL ASSIGNMENT

ALGORITHMS FOR CHANNEL ASSIGNMENT

There are different algorithms for channel assignment.

A. RANDOM SLOT ASSIGNMENT (RSA)

The allocation of slot in TDD (Time Division Duplexing) make problem. The switching point problem in TDD is the problem of deciding how many slots should be allocated to the uplink transmission and how many slots should be allocated to the downlink transmission. Random Slot Assignment (RSA) scheme can have adverse effects on the system performance. In RSA, channels are placed in a pool. RSA then randomly selects a channel from the pool if, and only if, that channel will not cause interference with ongoing transmissions. Channels are reassigned as needed. Once a connection is terminated, the corresponding channels are released and returned to the channel pool [2][6][7].

B. DELAY-SENSITIVE SLOT ASSIGNMENT (DSSA)

DSSA is a heuristic fixed slot assignment scheme that utilizes the architecture developed. It is composed of two phases, namely the elimination phase and the selection phase. In the elimination phase, a slot is eliminated if, and
only if, assigning that slot will cause a tangible interference with other ongoing transmissions. This is done based on the neighborhood information of the node requesting a channel. The DSSA algorithm is executed by the Radio Network Controller (RNC). The execution of the algorithm is triggered by the arrival of the RREQ (Route REQuest) at the RNC.

The algorithm determines the number of slots that should be allocated to the uplink and downlink transmissions. However, the purpose of DSSA is not to estimate the switching point but rather to assign the slots in an effective manner after the number of available uplink slots has been determined. This ensures that DSSA is compatible with any switching point algorithm. We allocated the maximum number of slots, which is 13 according to the 3GPP specifications, to the uplink transmissions. Since the BS is the destination of all source nodes, we need to make sure that all incoming connections to the BS utilize different channels. This is necessary to ensure interference-free connections at BS. If one channel is available then assign that channel; however, if more than one exists then select the one with the maximum slot number. The reason for this will be clarified when we discuss the slot selection procedure [6].

**DSSA IMPLEMENTATION**

To further demonstrate how DSSA works, consider the multi-hop cellular network in Fig.3. In this example, we only consider five slots and two orthogonal codes for simplicity. A dashed line represents an ongoing uplink transmission and the channel is represented by the pair \((x, y)\), where \(x\) is the time slot number and \(y\) is the code number. In this fig 3.(a) maximum 10 channels at a time available to the BS for connection of mobiles in first disk. The current state of the channel assignment table is also shown in Fig.3(b). A green shaded slot indicates that the channel does not belong to the set of incoming connections to the BS while a yellow shaded slot indicates the opposite.

MT1 is the source node in fig.3(a). Currently, channel \((5, 2)\) is the only channel that does not belong to the set of incoming connections to the BS. Initially, MT 1 broadcasts a Route Request (RREQ). MT 2 receives the RREQ and rebroadcasts it. This process will be repeated until the RREQ reaches the BS(Fig.3(a)). The BS will forward the RREQ to the RNC, which will then invoke the DSSA scheme and attempt to assign channels to these nodes based on the stored topology information. The process will first start by assigning a channel to MT 3. However, since in this case only one channel is available (i.e., channel \((5, 2)\)), it will only be temporarily assigned. Note that assigning any other channel to MT 3 will cause interference at the BS. The RNC will then execute the elimination phase of the DSSA scheme.
In elimination phase, all channels will be tested for validity. For instance, DSSA checks if any neighbor of MT 3 is transmitting on channel (1, 1).

In this example, none of the neighbors of MT 3 is transmitting on that channel. DSSA then checks if any neighbor of MT 2 is receiving on channel (1, 1). It can be seen that one neighbor of MT 2, namely MT 5, is in fact receiving on channel (1, 1). As a result, this channel assignment option will be eliminated as it leads to interference at MT 5. This process will be repeated for the remaining channels.

Eventually, channels (1, 1), (4, 1), and (5, 1) are eliminated (Fig.3(c)). The rest of the channels are then passed to the slot selection procedure.

The resulting assignment is shown in Fig.4. Finally, the slot with the minimum slot waiting time (i.e. channel (4, 2)) will be assigned to MT 2. In a similar manner, channel (3, 1) will be assigned to MT 1. Once all the nodes in the route are accommodated, a RREP will be sent back with the channel assigned to each node, as depicted in Fig.4. [6].

V. RESULT & SIMULATION:

The algorithm is simulated using the MATLAB tool.

This result is implemented on 5 slots & 2 code. So 10 total channels are available. Consider the cell where this algorithm is applied has area 1000km². The cell radius is approximately 18 km. The cell is divided into three disks. The first disk has radius 6 km, the second disk has radius 12 km & the third (final) disk has radius 18 km.

Channels are given: (slot, code)
\[
\begin{bmatrix}
(1, 1) & (2, 1) & (3, 1) & (4, 1) & (5, 1) & (1, 2) & (2, 2) & (3, 2) \\
(4, 2) & (5, 2)
\end{bmatrix}
\]

1 is indicates channel is available & 0 is indicate channel is not available. The mobile near to BS, select that channel which is available & not create interference to another channel. The mobiles in first disk directly connected to channel. So it does not need to find the waiting time. The mobiles in second & third disk, first check the channel availability and then check minimum slot waiting time (ms). The results are shown in table 1.

<table>
<thead>
<tr>
<th>Sr. no</th>
<th>Distance from BS (km)</th>
<th>No. of hopping</th>
<th>Channel availability</th>
<th>Selected channel</th>
<th>Disk 1</th>
<th>Disk 2</th>
<th>Disk 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>0</td>
<td>00101 00010</td>
<td>(5,1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>1</td>
<td>10100 01000</td>
<td>(2,2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>2</td>
<td>10100 10000</td>
<td>(2,1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 1: results of DSSA implementation

References:

[1] Abraham George and Anup Kumar, M3HN (2005), an Adaptive Protocol for Mobility Management in Multi-hop Heterogeneous Networks[1]


