ERROR CONTROL SYSTEM IN CELLULAR NETWORK

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ABSTRACT

In cellular communication networks, the geographical area is divided into smaller regions, called cells. In each cell, there is one Mobile Service Station (MSS) as well as a number of Mobile Hosts (MH). The communication between MSSs is, in general, through wired links, while the links between an MH and MSS is wireless. A Mobile Host can communicate with other Mobile Hosts in the system only through the Mobile Service Station in its cell. This kind of architecture is shown in Fig. 1. There are two kinds of channels available to an MH: communication channel and control channel. The former is used to support communication between an MH and the MSS in its cell, while the latter is set aside to be used exclusively to send control messages that are generated by the channel allocation algorithm.

1. INTRODUCTION

In this paper, henceforth, unless specified otherwise, the term channel or wireless channel refers to a communication channel.

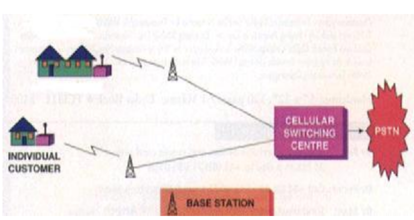

Fig1.1

When an MH wants to communicate with another MH, it sends a request message to the MSS in its own cell. The request can be granted only if a wireless channel can be allocated for communication between MSS and MH. Since channels are limited, they should be reused as much as possible. But, a channel cannot be used at the same time by two cells if they are within a threshold distance called the minimum channel reuse distance (Dmin), because it will cause interference. Such an interference is called co channel interference. A cell, say Ci, is said to be an interference neighbor of another cell, say Cj, if the distance between them is less than Dmin. So, if a channel r is used by a cell Ci, then none of the interference neighbors of Ci can use r concurrently. If using a channel in a cell causes no interference, then we say that this channel is available for the cell. When an MH needs a channel to support a call, it sends a request message to the MSS in its cell through a control channel. When the MSS receives such a message, it tries to assign a channel using a channel allocation algorithm.

Mobile Station (MS) : This is basically the mobile phone

Base Station (BS) : The covered area of a cellular network is divided into smaller areas called cells. Each cell has a base station which communicates simultaneously with all mobiles within the cell, and passes traffic to the Mobile Switching Centre. The base station is connected to the mobile phone via a radio interface.

Fig 1.2

<u>Mobile Switching Centre (MSC)</u> : This controls a number of cells (or cluster), arranges base stations and channels for the mobiles and handles connections.

<u>National Carrier Exchange</u> : This is the gateway to the national fixed public switched telephone network (PSTN). It handles connections on behalf of the national communication systems, and is usually integrated with the MSC.

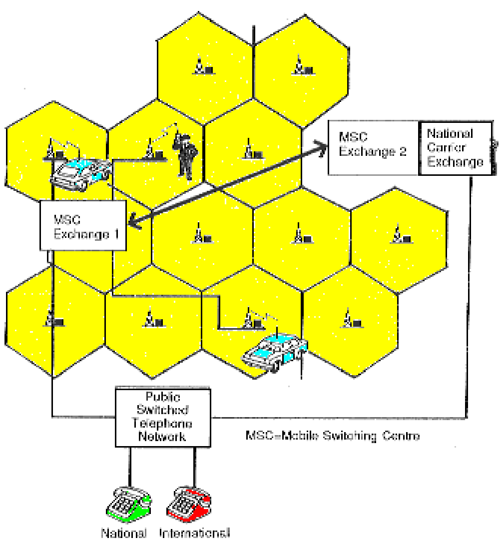

Fig 1.3

1. LITERATURE SURVEY

Two basic approaches to channel allocation are as follows:

1. Centralized approach: In centralized approaches , request for channel is sent to and processed by a central controller, called Mobile Switching Center (MSC). MSC is the only one that has access to system wide channel usage information. It allocates Channels and ensures no co channel interference occurs. But, this approach is neither scalable nor robust because the MSC could become a bottle-neck when the traffic load is heavy and the failure of the MSC will bring down the entire system.

2. Distributed approach: In distributed channel allocation algorithms, there is no central controller such as MSC. The MSSs share the responsibility to allocate channels. Each MSS makes decision independently based on its local information. They exchange information if necessary, in order to compute the set of available channels such that using them causes no co channel interference. In a distributed channel acquisition algorithm, one of the following two approaches is usually adopted: On demand/ reactive approach and Proactive approach.

On **demand/reactive approach**, when a cell needs a channel to support a call, it first checks whether there are available channels in the set of channels allocated to it. If such channels exist, then it picks one such channel to support the call. Otherwise, it sends messages to its interference neighbors, asking for their channel usage information. Based on the information received in the replies, it computes the set of available channels. It picks an available channel r using channel selection algorithm in such a way that using r achieves a good channel reuse pattern, and sends messages to its interference neighbors to borrow that channel. If all the neighbors to whom that channel has been allocated agree to lend that channel, the channel borrowing process is complete. Proactive approach: A cell notifies its interference neighbors about the channel usage information whenever it acquires or releases a channel.

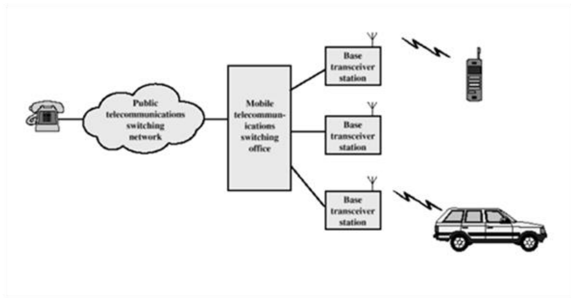

Fig 1.4

So, each cell is always aware of the set of available channels. When it needs a channel, it just picks one of the available channels using the underlying channel selection strategy and uses it to support a communication after ensuring that none of its neighbors are using that channel. Most algorithms using On demand/reactive approach require that a cell that wants to borrow a channel (we call it borrower hereafter) needs to get reply from each interference neighbor before using a channel. Under this approach, even if one of the neighboring cells has failed, a channel cannot be borrowed and, hence, this is not fault tolerant. The main contribution of this paper is that we propose a distributed and fault-tolerant channel allocation algorithm which reuses channels efficiently.

2. UTILISATION OF THE SPECTRUM IN CELLULAR NETWORKS

2.1 Frequency Re-use

In any radio network, the number of simultaneous calls that may occur is governed largely by the available frequency spectrum and the number of channels that can be supported by the available bandwidth.

In a conventional radio system (the previous modes of mobile communications) , groups (or areas) are allocated dedicated radio frequencies. In order to ensure that those channels are not affected by transmissions from other users operating at the same frequency, sufficient separation between the transmitters must be allowed for when allocating the frequencies.

In a cellular system, frequency re-use[5] is achieved by assigning a subset of the total number of channels available to each base station, and controlling the power output of the transmitters. In this way, cellular networks increases capacity (number of channels available to users).

Adjacent cells are not allowed to operate at the same frequency since this causes interference between the cells.

From the above argument, it would seem that increasing the number of cells in the covered area (i.e. by decreasing the cell size) would increase the capacity. But by doing so, a number of difficulties arise:

Interference : decreasing the cell size, especially with a low repeat factor increases the problems of interference between cells which are using the same frequency.

Handovers: Decreasing the cell size increases the frequency of handovers, since a moving cellular phone would be changing cells more often. Since the MSC needs time to switch (for handovers), increasing the handovers will increase that time delay.

2.2 Microcellular Systems

It has been pointed out that decreasing the cell size increases capacity but causes other problems such as increased interference and time to handle handovers. However having an intelligent cell, which is able to monitor

where exactly the mobile unit is and find a way to deliver confined power to that mobile unit, will increase channel capacity without causing these problems.
In a microcellular system[1], each cell is divided into a number of microcells; each microcell (or zone) has a zone site and the cell itself has one base station. It is necessary to note that all the microcells, within a cell, use the same frequency used by that cell; that is no handovers occur between microcells.

Locating the mobile unit in a cell
An active mobile unit sends a signal to all zone sites, which in turn send a signal to the BS. A zone selector at the BS uses that signal to select a suitable zone to serve the mobile unit - choosing the zone with the strongest signal.
Base Station Signals
When a call is made to a cellular phone, the system already knows the cell location of that phone. The base station of that cell knows in which zone, within that cell, the cellular phone is located. Therefore when it receives the signal, the base station transmits it to the suitable zone site. The zone site receives the cellular signal from the base station and transmits that signal to the mobile phone after amplification. By confining the power transmitted to the mobile phone, co-channel interference is reduced between the zones and the capacity of system is increased.

The benefits of Microcellular systems

Interference reduced (compared to decreasing the cell size).

Handovers reduced (also compared to decreasing the cell size) since the microcells within the cell operate at the same frequency; no handover occurs when the mobile unit moves between the microcells.

Size of the zone apparatus. The zone site equipment are small, so the can be mounted on the side of a building of on poles.

Increased system capacity. The microcell is an intelligent cell. The new microcell knows where to locate the mobile unit in a particular zone of the cell and deliver the power to that zone. Since the signal power is reduced, the microcells can be closer and therefore increase capacity

However, in microcellular system, the transmitted power to a mobile phone within a microcell has to be precise; too much power results in interference between microcells, while too little power and the signal might not reach the mobile phone**.**
This is a drawback of microcellular systems, since a change in the surrounding (a new building, say, within a microcell) will require a change of the transmission power.

2.3 Multiple Access Systems

In digital cellular networks, Multiple access systems[6] are used to allow simultaneous users to share the same channel within a cell. The common methods are time division multiple access **(TDMA)** and frequency division multiple access **(FDMA).**

In **TDMA**, the bandwidth allocated for the channel is divided into time slots - the number of slots depends on the system. Each user is then allocated a slot, and hence multiple users share the same frequency but at different times.

In **FDMA**, the channel is divided into frequency bands, and each user is allocated a frequency band.

3. PROBLEM FORMULATION & METHODOLOGY

This project analyzes a channel allocation algorithm in a cellular network. The system has been designed with focus on centralized approaches to allocating channels. But, centralized approaches are neither scalable nor reliable. Recently, distributed dynamic channel allocation algorithms have been proposed, and they have gained a lot of attention due to their high reliability and scalability. But, there is a need of algorithm that is fault-tolerant and makes full use of the available channels. It can tolerate the failure of mobile nodes as well as static nodes without any significant degradation in service.

3.1. THE CHANNEL SELECTION STRATEGY

When a cell Ci, which wants to borrow a channel from its neighbors, receives replies from neighbors, it begins to compute the set of channels which it can borrow. The goal of the channel selection strategy is to select a channel in such a way that selecting this channel will cause least interference to neighbors, thus maximizing the channel utilization. We adopt a priority-based strategy to assign each channel a priority. The cell Ci always selects the channel with the highest priority to borrow. Next, we explain how to compute the priority for each channel. For each primary channel r of cell Cj, Cj keeps track of the set of cells which borrowed r successfully from it and have not released r yet. When Cj receives a request message from Ci (i.e., Cj and Ci are interference neighbors), it computes the set of primary channels which can be included in the reply message to Ci. If it is using a primary channel r, or it has lent r to a neighbor Ck such that Ci and Ck are neighbors, then r will not be included in the reply message to Ci, thus, Ci will not be able to borrow r. Otherwise, Cj assigns a priority to primary channel r and includes r in the reply message to Ci. The priority of a primary channel r is assigned by Cj in the following way:

1) If Cj has lent r to some neighbors, and none of them is a neighbor of Ci, then it assigns a high priority H to r, i.e., Pr (j) = H
2) If Cj has granted some neighbors' request for the same primary channel r, and at least one such neighbor is a neighbor of Ci, then it assigns a low priority L to r, i.e., Pr (j) = L
3) If primary channel r is an available channel in Cj (i.e., Cj neither lent nor granted r to any of its neighbors), then Cj assigns medium priority M to r, i.e., Pr (j) = M (where H >>M > L).
By following the rules mentioned above, a cell Cj always encourages a neighbor Ci to borrow a primary channel r which it **has** already lent to a noninterference neighbor of Ci, because Cj cannot use r anyway. If Ci borrows r from Cj, then this borrowing does not cause more interference to Cj. At the same time, Cj discourages Ci to borrow a primary channel r which it has already granted to a neighbor Ck's request for the same channel r, where Ck and Ci are neighbors. The goal is to minimize the degree of contention.

3.2 CALL STAGES

1. **Call Blocking**
   - During mobile-initiated call stage,if all traffic channels busy,mobile tries again.
   - after number of fails,busy tone returned

2. **Call termination**
   - user hangs up.
   - MTSO informed.
   - traffic channels at two BSs released.
3. **Call drop**

- BS cannot maintain required signal strength.
- traffic channeldropped and MTSO informed.

4. Call to/from and remote mobile subscriber

- MTSO connects to PSTN
- MTSO can connect mobile user and fixed subsciber via PSTN
- MTSO can connect to remote MTSO via PSTN or via dedicated lines
- can connect mobile user in its area and remote mobile user

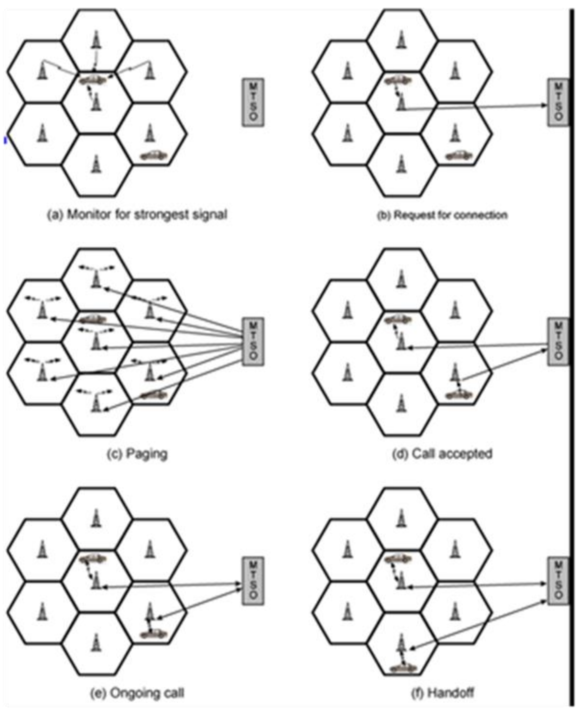

Fig 3.1

3.2 ERROR CONTROL MECHANISMS

❖ Forward error correction
- ➢ Applicable in digital transmission applictions.
- ➢ Typically, ratio of total bits sent to data bits between 2 and 3 .
- ➢ Big overhead
    - Capacity one-half or onethird.
    - Reflects difficulty or mobile wireless environment.

❖ Adaptive equalization
- ➢ Applied to transmissions that carry analog or digital information.
- ➢ Gathering the dispersed symbol energy back together into its original time interval.
- ➢ Techniques include so-called lumped analog cirecuits and sophisticated digital signal processing algorithms.

❖ Diversity
- ➢ Based on fact that individual channels experience independent fading events.
- ➢ Provide multiple logical channels between transmitter and receiver.
- ➢ Send part of signal over each channel.
- ➢ Doesnot eliminate errors.
- ➢ Reduce error rate.
- ➢ Equalization, forward error correction then cope with reduced error rate.
- ➢ May involve physical transmission path
    - Space diversity
    - Multiple nearby antennas receive message or collocated multiple directional antennas.
- ➢ More commonly, diversity refers to frequency or time diversity

3.3 ALGORITHM EXPLANATION

The proposed a fault-tolerant channel allocation algorithm for cellular networks, assumes the Resource Planning Model is used and adopts a proactive approach. In each cell, the primary channels have higher priority to be allocated.

a) When Ci needs a channel to set up a call: It computes Freei. If Freei = null, then Ci sets a timer and sends a request to each cell Cj belongs to INbi. Else, a channel r belongs to Freei is picked to support the call and added to Ui. When the call terminates, r is deleted from Ui.

b) When Ci receives a request from Cj: It computes Ri. If Ri not equal to null, then sends reply(Ri) to Cj; else discards the request.

c) After Ci gets reply from all its interference neighbors or times out: It sets a new timer, sets Availi = null, and does the following:

- **(c.1)** For every r , Availi = Availi U {r} if the following two conditions are satisfied:
  - **1.** r does not belong to Ui (i.e., r is not being used by Ci);
  - **2.** For every Cj belongs to IPCi®, Ci got reply(Rj) and r belongs to Rj.
- **(c.2)** If Availi not equal to null, then a channel r belongs to Availi is picked as per the channel selection strategy and Ci sends a transfer(r) to all cells in IPCi®. Otherwise, the call is dropped.

d) When Ci receives a transfer(r) message from cell Cj:

- **(d.1)** It computes Freei. If r belongs to Freei, then Ci sends Granti(r) to Cj and adds Cj to Granti(r).
- **(d.2)** Else if r belongs to Ui or Lenti(r) ∩T INbj not equal to null, then Ci sends refuse(r) to Cj.
- **(d.3)** Else let S = Granti(r) ∩INbj. If S = null, then Ci sends a grant(r) to Cj and adds Cj to Granti(r).
- **(d.4)** Else if for every Ck belongs to S, Cj's request timestamp is less than that of Ck's request, then Ci sends a conditional_grant(S,r) to Cj and adds Cj to set Granti(r).Otherwise, Ci sends a refuse(r) to Cj.

e) If Ci receives responses to its transfer(r) message from each cell in IPCi(r) before the timer expires, it checks for the following three conditions:

- **(e.1)** Each response is either a grant(r) message or conditional_grant(S,r) message.
- **(e.2)** There is at least one grant(r) message.
- **(e.3)** For every Conditional grant(S; r) and for every Cj belongs to S, a grant(r) from some Ck has been received by Ci, where Ck belongs to (IPCi(r) ∩ IPCj(r)).

If E.1, E.2, and E.3 are met, then Ci sends use(r) to each Cj 2 IPCi(r) and uses channel r to support the call. r is added to Ui. When the call finishes, Ci removes r from Ui and sends release(r) to each Cj belongs to IPCi(r).

4. WORK DONE

4.1. PREVIOUS WORK

The channel allocation algorithm in cellular network follows the centralized approaches, request for channel is sent to and processed by a central controller, called Mobile Switching Center (MSC). But, this approach is

- neither scalable nor robust because the MSC could become a bottle-neck when the traffic load is heavy
- And the failure of the MSC will bring down the entire system.
- Bad performance
- It will not co operate with failure of MSC case
- MSC make use of static information

4.2. PROBLEM RECOGNITION

Centralized approach: In centralized approaches, request for channel is sent to and processed by a central controller, called

Mobile Switching Center (MSC). MSC is the only one that has access to system wide channel usage information. It allocates Channels and ensures no co channel interference occurs. But, this approach is neither scalable nor robust because the MSC could become a bottle-neck when the traffic load is heavy and the failure of the MSC will bring down the entire system.

5. PERFORMANCE OF THE DIGITAL DATA CELLULAR NETWORK

The Digital Data Cellular Network has many limitations which affects its performance in transmitting data. These includes congestion at the base station, fading, breaks during handovers and co-channel interference. More emphasis is placed on the congestion limitation as it depends on the design of the cellular system. On the other hand the other limitations, such as fading and co-channel interference depend mostly on the nature of the radio signal.

5.1 Congestion

Congestion is said to occur at a BS when it does not have enough space in its queues to put the new arriving packets. These new packets would then be lost. Congestion leads to the packets already in the queue to wait the longest time before being transmitted.
So, congestion introduces unacceptable packet delay

This congestion problem cannot be completely avoided but it can be minimised by choosing the correct buffer administration technique. This reduces congestion at the BS transmit buffer.
Increasing the number of channels per cell. Doing this reduces congestion at both the receive and transmit buffer of the BS.
Reducing the rate at which BS informs MS to transmit data. This reduces congestion at the BS receive buffer

5.1.1 Choosing the Best Buffer Administration Technique

The best technique should be able to support a large rate of packet arrival without any queue overflow. It should also cause minimal congestion when both large and moderate amount of packets arrive (high and moderate incoming traffic). Therefore in order to identify the best technique, the different techniques discussed are compared with respect to the
maximum arrival rate it supports
its performance at moderate and high incoming traffic levels
This is followed by a discussion on methods that could be used to improve these buffer administration techniques in order to get better performance. (For the purpose of comparison, both Channel Splitting and Cyclic Polling Techniques are assumed to have the same queue capacity).

(a)Maximum Rate of Packet Arrival Supported

The maximum packet arrival rate supported is the maximum rate at which the packets can arrive without any increase in the number of packets stored in the transmit multi-level queue.
This occurs when the base station is operating at a steady state where the average number of arrivals in the system is less than the maximum number of departures during a time slot.

When the base station stops operating in the steady state, the amount of free queue space decreases and would eventually lead to queue overflow. This leads to congestion.

A mathematical analysis[3] of the system can show that the cyclic polling technique supports the highest arrival rate while still maintaining steady state operation of the BS. Both the Channel Split and the Reservation Techniques support the same rate of packet arrival for steady state operation.

WHY?

When the packet arrival rate is unequal in each queue (which is normally the case) , in both the Reservation and Channel Splitting Techniques, the transmitters allocated to the queues with lower arrival rate will be inefficiently used.
Meanwhile, the Cyclic Polling Technique would use all its transmitters efficiently since any one of these transmitters can be used to transmit the packets.

(b) Incoming Traffic Level Supported

The BS is said to support an incoming traffic level when it can operate without any queue overflow and the packets queued has acceptable mean waiting time in the queue.
The incoming traffic level considered here can be divided into moderate and high levels.
Mathematical analysis[3] shows that the results obtained for both moderate and high incoming traffic levels are the same.

The Reservation Technique gives the best support for both traffic levels without any possibility of queue overflow. The Cyclic Polling Technique gives the second best support followed by the Channel Splitting Technique.

WHY?

Since the queue capacity in the Reservation Technique is the largest, it can accommodate larger number of packets at both incoming traffic levels. Since both Cyclic Polling and Channel Splitting Techniques have the same queue size, the inefficient use of the transmitters in the Channel Splitting Technique causes the Cyclic Polling Technique to have a better ability to prevent queue overflow.

However, the reservation channel causes the highest mean waiting time of the packets in the queue. The Cyclic Polling Technique gives the lowest mean waiting time followed by the Channel Splitting Technique.

WHY?

The queues in the Reservation Technique which has a higher capacity than the rest causes more packets to be queued. So, any packet in the queue has to wait longer before getting transmitted. In the Cyclic Polling Technique, the packets have lower mean waiting time than the Channel Split Technique as it uses the transmitters more efficiently.

Final point on buffer administration techniques

The Cyclic Polling Technique supports the highest maximum rate of packet arrival without any possibility of congestion.
The Reservation Technique gives support to the highest number of arriving packets without any possibility of congestion at the expense of an increased packet delay.

Here, we can only conclude that there is no single technique that could be regarded as the best. The best technique to minimise congestion depends on the situation. Recall, there are two situations here; the incoming traffic level and the rate at which packets arrive. The cost factor has not been considered here. This could significantly affect the choice of the best technique as well. At the end of the day, it is up to the designer to weigh out what is of importance and what situations are more likely to happen to choose a suitable technique.

5.1.1.1 Improvement on the Buffer Administration Techniques to Reduce Congestion

In the techniques described above both the queue size and the number of transmitter channel allocated does not change. These are two main points that are improved upon below.

i. Dynamic changes in the queue size

The queue size is changed depending on the rate of packet arrival to the queue. In all three, techniques this would lead to reduction in queue overflow. The queue with a higher rate or number of packet arrival should be allocated a larger queue space. This could be obtained from the queues with lower rate or number of packet arrival respectively.

In order to do this extra intelligence to monitor the rates and number of packet arrival to all the queues is needed. The system should then be able to predict future arrivals based on the previous data obtained. This system should also be able to determine the optimal queue size needed as increasing the size too much would lead to an increase in the mean waiting time of packets.

ii. Dynamic Channel Assignment

One of the main reasons packet overflow occurs in both Reservation and Channel Splitting Techniques is because of the limited number of transmitter channels available in each group.

So an improvement would be to add intelligence that allocates channels to groups that has higher rate or number of packet arrival. Again the same intelligence, as discussed above, is needed.

Disadvantage of the Improvement Methods Suggested

Both dynamic channel and queue size assignment requires extra processing power. This could prove to be very costly to implement.
But on the other hand if these methods give an improvement that is more than proportionate to the cost increase, it would be prudent to implement a queuing system with these improved techniques.

5.1.1.2 Rate At Which BS Polls MS

The BS controls the rate at which a MS transmits data since the MS transmits data only if it had been polled to do so in the previous time slot. If the rate is too high the receive buffer for this MS in the BS would be congested.

Solution

Reduce the rate at which the BS polls the MS to transmit packets in the upward data transfer channel. Care must be taken not to reduce the polling rate too much as this can cause the transmit buffer in the MS to suffer queue overflow.

5.1.1.3 Number of Channels Per Cell

When the number of channels per cell is small (less transmitting channels) base station congestion is very likely to occur. Increasing the number of channels to solve this problem could be a problem since :-
the bandwidth allocated for uplink and downlink transmission is fixed. Therefore

increasing the channel number per cell would cause the channel frequencies used in a cell to be re-used in a closer cell. This increases co-channel interference.

Solution

Use a microcellular network since it can increase the number of channels per cell without an increase in co-channel interference .

5.1.2 <u>Fading</u>

This is the reduction of signal power. Fading is caused by many factors - the most important ones being multipath and shielding.

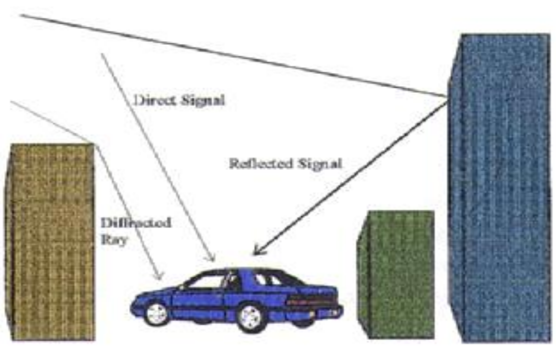

Fig 5.1

Multipath fading is caused by the transmission of the signal along different paths and resulting in simultaneous reception. Depending of the amplitudes and phase of the signal, the result of this could be that the signals cancel each other completely or significant attenuation in the resultant signal.
Shielding is the absence of field strength. Most common causes are tunnels, hills and inside certain buildings.

Solution
The receiver at the BS should have an Equaliser[7] circuit to compensate for fading. Equaliser finds how a known transmitted signal(transmitted with the desired signal)was modified by multipath fading and shielding. Using this information, an inverse filter is constructed and the desired signal is extracted.

5.3.3 <u>Co-Channel Interference</u>

Co-channels are the same channels (or frequencies) that are used by different cells. To avoid this kind of interference, it is necessary to separate the co-channels by as great distance as possible. But, by doing so, channel capacity will be compromised.

Solution

Here, microcells could be used to decrease co-channel interference for a particular capacity wanted. Alternatively, the Equaliser can also be used to minimise the effect of co-channel interference on the desired signal.

5.3.4 <u>Handovers</u>

Handover does not pose serious problems in Digital Data Cellular Networks.

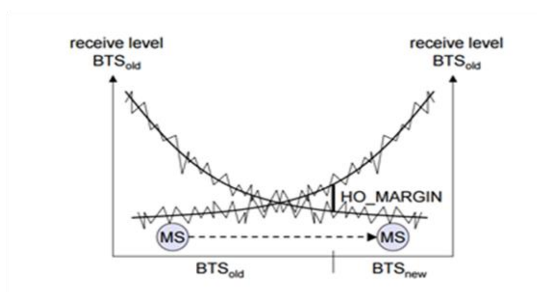

Fig 5.2

WHY?
In circuit-switch networks, handover is a major problem , because the radio link between the MS and the BS which is continuously available is lost. During the time in which the link is lost, both the MS

and the BS could be transmitting data which will be lost unless effective buffering is provided (see section 2.2).

In Digital Data Cellular Network considered, there is no continuous link between the MS and the BS. Packets are transmitted and received by the MS only after the BS informs it to do so. So, the link between the MS and the BS only lasts for one time slot (time in which a packet can be transmitted and received). Therefore, handover can only cause, if any, a few packet loss and does not pose a serious problem.

6. PROPOSED SYSTEM AND DESCRIPTION

In this project we are focused on the channel allocation issues in cellular networks where the Base Stations (also known as Mobile Service Stations) are mobile. This imposes more challenges since the neighborhood information changes dynamically. Here, we restrict our discussion to channel allocation in cellular networks where mobile service stations are static. We also discuss dynamic load balancing strategy for the channel assignment problem in cellular mobile environment. The proposed algorithm: load balancing with selective borrowing (LBSB) is a centralized approach. In this algorithm, a cell can be classified either as a hot or a cold cell according to the value of its degree of coldness. The degree of coldness of a cell is defined as the ratio of number of available channels in this cell and the number of channels which have been allocated to this cell beforehand. The goal of the algorithm is to migrate unused channels from cold cells to hot cells. This algorithm solves the teletraffic hot spot problem in cellular networks. A hot spot is defined as a stack of hexagonal rings of cells and is termed complete if all the cells within it are hot. Load balancing is achieved by using a structured channel borrowing scheme, in which a hot cell can borrow channels only from adjacent cells in the next outer ring. Thus, unused channels are migrated into a hot spot from its peripheral rings. We have to check whether a cell needs to borrow a channel, it has to wait until it gets reply messages from all its interference neighbors.

The proposed a fault-tolerant channel allocation algorithm for cellular networks, assumes the Resource Planning Model is used and adopts a proactive approach. In each cell, the primary channels have higher priority to be allocated. When a cell Ci needs a channel, it selects an available channel r. If r is a primary channel, then it marks r as a used channel, and informs all of its interference neighbors about this. If r is a secondary channel, then it sends a request message to each interference neighbor which has r as a primary channel. If all these neighbors agree to lend channel r to Ci, then Ci can use the borrowed channel r. Otherwise, Ci needs to find another secondary channel to borrow. Whenever a cell acquires or releases a channel, it informs all its interference neighbors about this. Due to this proactive approach, the algorithm achieves short channel acquisition delay at the expense of higher message overhead. The algorithm is fault tolerant because the number of Ci's interference neighbors which have r as a primary channel is small, compared to the total number of Ci's interference neighbors. In order for cell Ci to borrow a secondary channel from neighbors, Ci does not need to receive reply message from all of its interference neighbors. Even when most of Ci's interference neighbors fail, Ci may still be able to borrow channel r as long as its neighbors which have r as a primary channel do not fail and r is not being used by these neighbors.

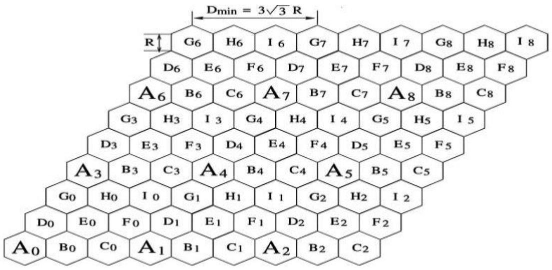

Fig 6.1: Partition of cellular network

In our proposed algorithm, we use the Resource Planning Model (shown in Fig. 2). Each message is time stamped. Outdated messages can be detected by comparing timestamps and discarded. For each primary channel r of cell Ci, Ci keeps track of the set of cells which borrowed the channel r successfully from Ci and have not released it yet. When cell Ci needs a channel to set up a call, it assigns a primary channel to support the call if there exists such a primary channel. Otherwise, it sends request message to all its interference neighbors. When such a request message is received, each cell Cj (j not equal to i) will check whether a certain primary channel r can be included in its reply message.

7. CONCLUSION

Distributed dynamic channel allocation algorithms have gained more attention because of their high reliability and scalability. However, some of them did not address fault tolerance issues very well. Most of them did not make full use of the available channels. In this paper, we proposed an efficient fault-tolerant channel allocation algorithm which makes efficient reuse of channels. Under our algorithm, a cell that tries to borrow a channel does not have to wait until it receives a reply message from each of its interference neighbors. A cell can borrow a channel as long as it receives reply messages from each cell in a subgroup in its interference neighborhood and there is at least one common primary channel which is not being used by any cell in this subgroup. Moreover, the channels are reused more efficiently.

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