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Handover Management using Adaptive and Prioritization Scheme in Cellular Mobile Systems

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Abstract: In cellular mobile communication system the large geographical area is subdivided into smaller regions called cell. This helps in effective utilization of bandwidth which is a scarce resource. A call originated in cell continues even when the Mobile Station has moved into the neighbouring cell. A channel from the neighbouring cell is allocated to the ongoing call. This process of allocation of available channel from neighbouring cell is called handoff. The numbers of approaches were proposed in order to provide handoff service in the literature. The proposed technique is used to reduce the load of base-station or mobile switching centres to provide better handoff service.

Keywords: Cell, Guard Channel, Handoff, Time Slice, Base Station

I. INTRODUCTION

The available spectrum is divided into frequency bands called channels. A set of channels is allocated to each cell and can be reused by non-interfering cells. A call can be initiated in any of the cells within the geographical area and due to small cell size, the mobile station (MS) may cross the boundary of the current cell and enter into the boundary of the neighbouring cell. The ongoing call continues in the neighbouring cell which is served by another base-station (BS)[1]. The base-station of the neighbouring cell assigns a channel to the handover call if free channel is available in the cell or handover call waits till an occupied channel is freed within definite time period. Otherwise the call is terminated forcefully. A new originated call is blocked when free channel is not available in the cell. The forced termination probability and call blocking probability are the parameters used to evaluate handover.

In the paper, we focused on adaptive prioritization handoff scheme to reduce the probability of forced handoff call termination and dynamic channel borrowing scheme to reduce new call blocking probability.

Handoff Initiation Techniques and Handoff Types

Received signal strength (RSS) [5] from the base-station decreases as MS moves towards the neighbouring base-Station. Thus the signal strength of neighbouring base-station gets stronger as MS moves towards it. As soon as the signal. Strength of neighbouring base-station becomes Stronger than the previous base-station, the handoff is requested.

Handoff initiation techniques [1] are classified as: Relative Signal Strength, Relative Signal Strength with Threshold, Relative Signal Strength with Hysteresis, Relative Signal Strength with Hysteresis and Threshold.

Prioritization Schemes

Forced termination probability can be lowered by assigning more number of channels using prioritization schemes. The two well-known prioritization schemes are: Guard channels and queuing handoff calls [2].

A. ***Guard Channels****:* In this scheme some fixed or adaptive numbers of channels are reserved for handoff calls only. The remaining channels are used by new and handoff calls. New call requests will be accepted only if the numbers of available channels are more than the number of guard channels while the handoff request will be accepted if there is any available channel in the cell. The effect of this scheme is twofold. On one hand it decreases the forced termination probability of handoff calls and on the other hand it increases the new call blocking probability.
The problem with a fixed number of guard channels is that it results in the increase in new call blocking rate.

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B. ***Queuing Handoff Calls****:* In this scheme the handoff calls are queued when all of the channels are occupied in a BS. When a channel is released, it is assigned to one of the handoff calls in the queue with highest priority. The handoff call which is closest to the receiver threshold will have the highest priority in the queue and the call which has just requested the handoff will have the least priority. A new call request is assigned a channel if the queue is empty and if there is at least one free channel in the BS. The time interval between handoff initiation and receiver threshold makes it possible for handoff calls.

Related Work

S. Tekinay and B. Jabbari et al. [3] proposed a method for queuing handover requests. In this method the power level that the MS receives from the base station of the current cell defines the priorities. Using this scheme, if all channels of a cell are occupied, calls originating within that cell are simply blocked and the handover requests to that cell are queued. This is a non-preemptive dynamic priority scheme. The power levels are continuously monitored, and the priority of an MS dynamically changes depending purely on the power level it receive while waiting in the queue. The MS's waiting for channels in the handover queue are sorted continuously according to their priorities. When a channel is released, it is granted to the MS with the highest priority.

P. Agrawal, Dinesh K. Anvekar and B. Narendran et al. [4] proposed Most Critical First Policy that is optimal with respect to handover failure probability. They have used non-reserving policies for efficient utilization of the scared resources. A non-reserving policy is one in which a free channel is never left unassigned if there is at least one call that requests it. Non-reserving policies are preferred because they maximize the channel utilization of the scarce radio bandwidth resource. Most Critical First Policy assigns a free channel to the handover request that would be the first to be cut off.

N. Zhang and J. Holtzman et al. [5] extends an analytic model used for evaluating the performance of handoff algorithms based on relative signal strength measurements. This extension includes additional criterion based on absolute signal strength to be used in the handoff decision algorithm. The use of the absolute signal strength levels results in avoiding unnecessary handoffs when the variations in the signal strengths is large.

Proposed Work

In the proposed work the number of guard channels is adaptive and will be adjusted based on the prediction of the motion of mobile stations in the neighbouring cells. This requires locating the position of mobile station in the complete duration of call, and the velocity of the mobile stations in neighbouring cells [6]. The direction of movement and the velocity of MS is determined when the call is initiated and also at the time when it enters into a new cell.

Network model:

The network model uses the cluster size of 3. Each cell has six neighbouring cells shown in Fig.1.

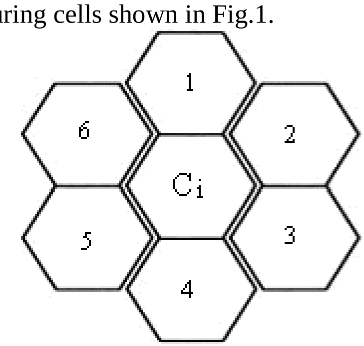

Fig.1 Network Model

Algorithm components:

The algorithm each cell C_i uses the following components:

a) Estimation of the call time, i.e., the expected service duration of a new call in the current cell. The estimation is carried out for accepted new call and handoff requests over a period of time T using the expected service duration, the probability of having a call terminated within the cell boundary can be estimated P_{Ter}.

b) Estimation of the probability of handoff from cell C_i to neighbouring cells x is P (C_i, x), x ϵ Adj(C_i) denotes the neighbours of C_i.

c) Estimation of number of incoming events and outgoing events in successive time intervals of length T. The incoming events are the expected new handoff calls coming from neighbouring cells during that interval. On the other hand outgoing events are the calls currently being serviced by the cell and may discontinue during the specified time interval.

Estimating the number of incoming and outgoing events:

This module will be executed at the start of every time interval T. This input time interval is divided into number of subintervals t, called the time slices. The BS of the cell C_i communicates with neighbouring BSs in order to predict the number of handoffs H_{OFF} (C_i) from those neighbours in time slice t.

$$\text{H Off(Ci)} = \sum_{x \in Adj\,(Ci)} I(x)$$

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The reply of neighbouring base station, say BS x, is a vector I_x containing the expected number of handoff events for the respective time slices $I_x = P(x, C_i) * \lambda(x)$, where $\lambda(x)$ denotes \the traffic load at station x.

Specifically the value of $I_j(t)$ corresponds to the number of mobiles with active connections which are expected to have handoff from base station j to the requesting base station during the time slice t, where t = 1,2,3 etc.

In addition to the vectors $I_j(t)$ obtained from neighbouring cells j, the base station of C_i also computes a corresponding vector $Out_i(t)$. $Out_i(t)$ represents the number of expected outgoing events from cell C_i. $Out_i(t) = \lambda(C_i) * P_{Ter}(C_i,t)$, where $P_{Ter}(C_i,t)$ is the probability that an ongoing call will terminate within before crossing the cell boundary.

The expected number of channels that will become free and released during time slice t is given by $Rel_i(t) = Out_i(t) - HO_i(t)$, where $HO_i(t)$ is the expected number of handoffs to cell I during time slice t.
The value of $Rel_i(t)$ could be negative indicating that additional channels are needed to cope up with the load demands during time slice t. The cumulative number of channels released by the end of m time slices since the beginning of the estimation period is

$$R(m) = \sum_{t=1}^{m} (\text{Rel } i(t))$$

Where R (m) is the total number of channels expected to be released at the end of the estimation period where m is the number of time slices.

Increasing the number of time slices m, the predictive algorithm obtains more accurate view on the order of incoming and outgoing events. Based on this number of incoming and outgoing events the number of guard channels adjusted dynamically.

Two protocols for new call admission and handoff calls are outlined as follows:
N_{free} is the number of free channels,
G_{ch} number of guard channels,
H_q is queue of handoff calls,
ReceiverTH is the receiver threshold and
RSS is the Received Signal Strength

```
NEW_CALL_REQUEST {
IF (N_free>G_ch&&H_q = = Empty) THEN

        ACCEPT_NEW_CALL;
N_free = N_free – 1;

ELSE
REJECT_NEW_CALL
}

HANDOFF_CALL_REQUEST {
IF N_free> 0 THEN
ACCEPT_HANDOFF_CALL;
N_free = N_free – 1;
ELSE
H_q[++i] = HANDOFF_CALL;
TIMER = SET_ON;
IF Wait_Time(H_q[i]) < Value(TIMER)
|| ReceiverTh = = RSS THEN
REJECT_HANDOFF_CALL;
DELETE IT FROM THE QUEUE;
ELSE
ACCEPT_HANDOFF_CALL;
N_free = N_free – 1;
}
```

Performance Evaluation:

A detailed Simulation model is written in C to test and evaluate the proposed algorithm.
Test was performed on 5x5 cellular patches, and radius of cell is considered to be 1km. The duration of each call is exponentially distributed with a mean of 180 sec. New calls arrive according to a Poison process and are homogeneous among all cells. The average speed of mobile station is 20m/sec.

TABLE 1
New Call Blocking Rates with Constraint = 0.0001 For Handoff blocking Rate

Scheme	40% load	50% load	60% load	70% load
Guard Channel = 5	0.01221	0.1411	0.2638	0.4399
Predictive Scheme	0.005236	0.029631	0.021104	0.030793
Improvement over Guard channel = 5	42%	21%	8%	7%

It can be seen from the Table1 that the improvement achieved by the proposed predictive scheme over the scheme using fixed number of guard channels.

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Fig. 2 gives the dropping probability of handoff calls. X-axis Represents the load on the system. The legend "Pred m" designates the cure of the algorithm using m time slices.

Fig.3 shows the graph for the probability of forced call termination. Fig.4 shows the new call blocking probability. The use of guard channels improved new call blocking rate.

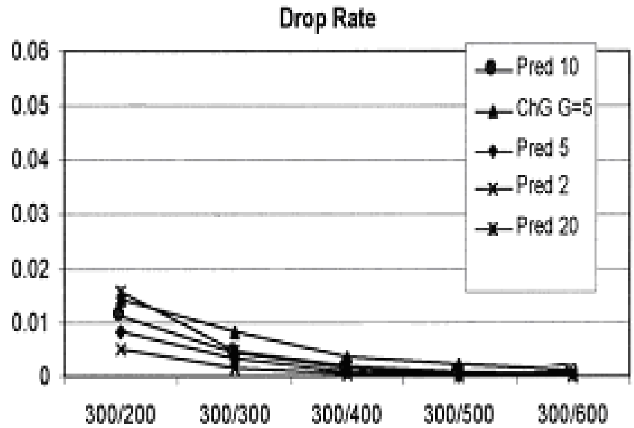

Fig.2 Handoff calls dropping probability.

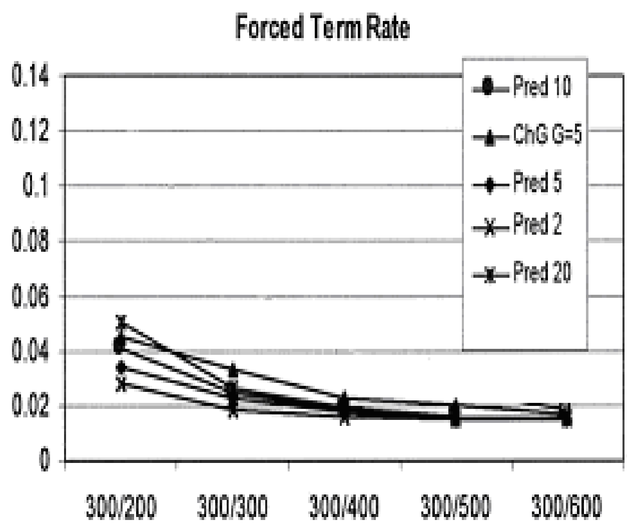

Fig.3 Probability of forced call termination

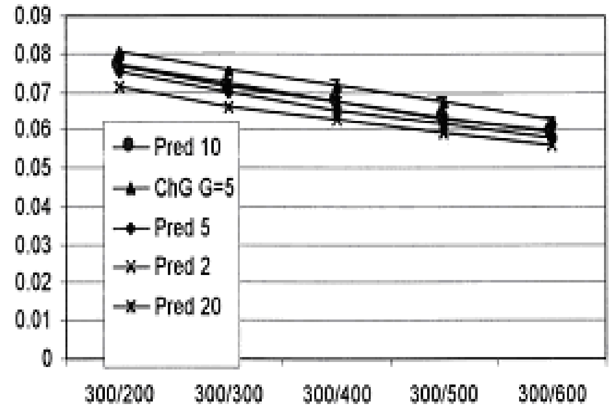

Fig.4 New call blocking Probability

CONCLUSION

In this paper, we proposed and evaluated the adaptive and prioritization scheme with the aim of improving quality of service of mobile calls. Based on the evaluation it seems that the adaptive adjustment of guard channels based on the traffic conditions in the busy hours is promising and looking into the technological advancement it is feasible to implement.

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