An Improved Algorithm for the Call Admission Control in Wireless Network Using Multi-Agent System

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Abstract:
In this paper, the aim of providing mobiles with best services (e.g. needed bandwidth) can be achieved by supporting every cell that has a base station with an intelligent agent. Mobiles may enter a cell which does not have free bandwidth; we call this "Call dropping". Lower Call Dropping percentage means better wireless network service. A Multi-Agent system is used here to calculate the percentage of supporting a mobile with the needed bandwidth before it's reaching to next cells. A previous research in this area [1] found that agents could be used to predict if mobiles would complete their calls without dropping or not. The difference between this research and ours is that the first used "Shadow Cluster" technique where we used a technique called"Kalman Filter". We got better results because the cells that cooperate in taking the decision of supporting the mobile with the needed bandwidth were reduced.

This is because Shadow Cluster concept taking in account all surrounding neighbor cells (needed and unneeded cells). The results were about the percentage of Call Dropping at several cases. In addition to that we uses Dijkstra algorithm in order to find an alternative save way for the mobile if it does not get a positive response.

Key-Words: - Call Dropping, Hand off, Shadow Cluster concept, Kalman filter, Multi-Agent system, Dijkstra .

1. Introduction

Call Dropping is a problem that occurs when a mobile accesses a cell that does not have enough bandwidth. This lack in bandwidth is due to the large number of mobiles accessed that cell and used most of its bandwidth. Bandwidth works as a bus for data transferring, this put the bandwidth at the top of the wireless network dominator factor. A mobile may start its call in a cell that has enough bandwidth. But when this mobile travels to another cell during the call (Hand-Off process), this new cell might have no free bandwidth and so the mobile could not complete the call; Call Dropping problem. Each call to be initialized, needs a specific amount of frequencies for data transmission, this amount is called "bandwidth". These frequencies are broadcasted by special towers, which their technical name is "Base station". Each one of these Base stations supports a limited area with frequencies; this area is called "Cell". When a mobile reaches the edge of a next cell, it senses the strength of the frequencies of that cell to use a free one to continue its call. The process where the mobile changes its current cell with a one of the surrounding cells to complete the call is called"Hand off process". [2]

To avoid Call Dropping problem while hand off process, the base station needs to reserve resources for supporting mobiles that may emigrate from neighboring cells.

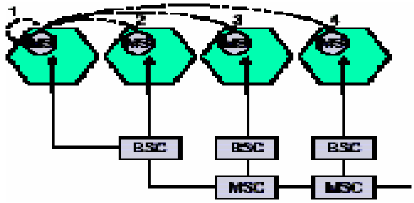

Figure 1:Hand off process

Mobiles may transmit traffic with different types: voice, data and video. Each needs different amount of frequencies. The small number of needed frequencies decreases the Call Dropping problem probability.

The type of traffic has a strong effect on Call Dropping problem. To decrease the probability of this problem, cells that may be visited by the mobile are supposed to reserve the required bandwidth for a mobile when it reaches them. Shadow Cluster concept is a technique that determines the cells that may be visited by the mobile. Shadow Cluster is a distributed algorithm in which the cell that the mobile wants to enter, cooperates neighboring cells to take the decision of supporting the mobile with a bandwidth [3].

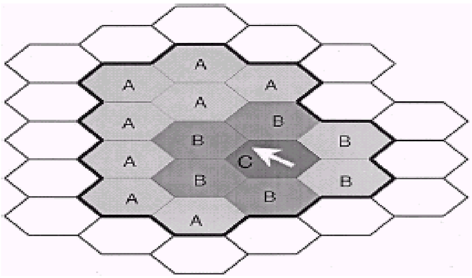

Figure 2: Hand off process

As we can see from Figure 2, the number of surrounding cells is great. Some of these cells have a small probability for being visited, but they participate in taking the decision. To avoid this unneeded number of cells, Kalman Filter is applied to predict the needed cells only.

This paper is organized as follows: Section 1, describtion of the problem we want to solve. Section 2 is a preparation section to discuss all concepts we use in our idea. Section 3, is a breif definition about our technique. Section 4, we examine the technique and obtain the results. Section 5, is some conclusions about this paper and hent to future works.

2. Preparation

Calculating the percentage of Call Dropping is a complex task which needs an intellegent system to perform it correctly. The system we suggest to use is "Multi-Agent system". This is because the wireless environment where mobiles are active is represented by Cellular Automata (CA) model. CA are discrete dynamic systems whose behaviour is completely specified in terms of a local relation [4]. CA models is more suitable for representing road traffic than other models where each part of road can be considered as a specific part then study this part behaviour. This model cells can be rectangular cells or hexagonal cells as the research needs. In this paper we took the rectangular shape for simplicity.

2.1 Multi-Agent system task:

Each cell has in addition to the base station an agent system [5,6] which is considered as the brain of that cell. Each agent communicates with other neighbouring agents with special frequencies.

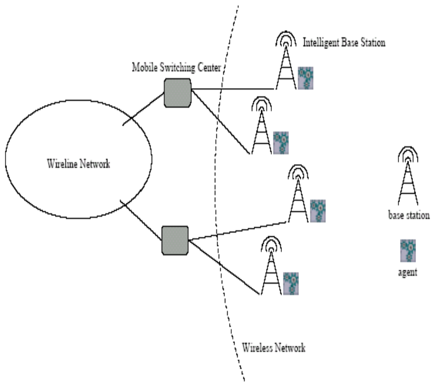

Figure 3: Agent system at the wireless network. This given in [1]

The cell which the mobile wants to occupy is the “Decision cell”, other cells which are predicted by this decision cell are called “Cooperation cells”.

Each cooperation cell sends the decision cell its calculations depending on some future parameters then the decision cell collects these calculations and apply some processes to compare the net result with a threshold value which is determined previosly by the user to make the decision to support or not to support the mobile with the needed bandwidth during its trajectory.

2.2 Kalman filter

In short, a Kalman Filter is a recursive data processing algorithm that estimates the state of a noisy linear dynamic system [7,9].

It uses knowledge of the system and sensor dynamics, probabilistic descriptions of the system and measurement noises, and any available data about the initial values of the state. The Kalman filter is essentially a set of mathematical equations that implement a predictor-corrector type estimator that is optimal in the sense that it minimizes the estimated error covariance when some presumed conditions are met [8,10]. Since the time of its introduction, the Kalman filter has been the subject of extensive research and application, particularly in the area of autonomous or assisted

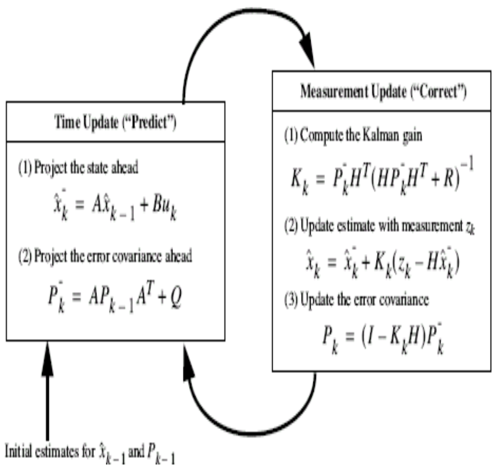

Fig. 4: Kalman filter Operation

Where mobile's motion is often cosidered as a linear system, the acceleration of mobile at some period of time becomes the noise of that linear system and these are the parameters which Kalman filter needs. The user gives the filter the mobile velocity, motion angle and the acceleration noise depending on the environment. The predection of mobile motion is the responsibility of the decision cell. That this step determines the cooperation cells. To have more accurate result, we took the upper and lower neighbours of each cooperation cell because of uncertainty of choosing the noise values.

		upper cell 1		upper cell 3
mobile	Decision cell	cooperate cell 1	upper cell 2	cooperate cell 3
		lower cell 1	cooperate cell 2	lower cell 3
			lower cell 2	

Fig. 5: Cells type

2.3 Dynamic Mobile Probability

Each cell that has been choosen gives the Decision cell its own result after applying some functions that predicts how far it can support the mobile with the required bandwidth when this mobile reaches it.

These functions can be categorized as follow:

1. the predicted cells have a probability of 95% "kalman confidence" where upper and lower cells 2.5%.
2. each predictive cell has a counter of times that the decision cell gives it a positive response when they were the decision cell.
3. residence time at each cell, this factor depends on the terminal speed and cell size.
4. number of free channels at the time of terminal arriving.

Now we are going to discuss each category in details:

For the first category, the probability of visiting a cooperating cell depends on the confidence of the filter, this confidence depends on the parameters that the user supports the filter with. To get a more accurate result, parameters have to be applied on the real world for several times until reaching to the desired values.

This application takes in account the velocity of mobiles, the environment feature, roads design mobiles profiles.

In second category, each agent stores the number of times that each agents gives it a positive response and so gives a high periority of supporting mobiles from that agent when this agent sends a request for preparing for the nomination.

Cell size, mobile velocity and the feature of that cell (e.g. downtown), these factores determines the third category which is about the residence time of mobile at that cell. Some researchs consider that the residence time (how much time the mobile will stay at that cell) is uniformaly distributed where we suggest that this factore would be near to the real world when we look to the three factores above. Here is the dominant category, where we mention before that the bandwidth is the most important resource in the wireless communication system. Here we gave each cell an equal number of channels, this number is called the "Total number of channels" ((Ctotal)), channels can be occupied ((Coccupied)) by hand off process or by a new call. So the remain (free number) channels ((Cremain)) can be calculated:

Cremain=Ctotal – Coccupied

3. Local Call Admission Decision

As we can see in Figure 6.a, Decision cell (cell1) sends a request to the cooperative cells (cell 3) where cell 3 sends this request to its upper and lower cells (cell 2,4). The packet of data that is received by each of these cells has the address of other cooperation cells which are choosen by cell1, so (Figure 6.b) cell 3 sends the request also to the next cell to it and so on until all the cells that have their addresses in the packet being online with cell 1 and each one of them behaves as cell 3. Each far cell sends its result to the cooperating cell that is before it. Each cell know the ideal time of mobile arriving and so predect the number of available resouces that may be reserved for this mobile. The cells calculation will be:

Local Decision= Pcell * Ar * Tr * C

Pcell: probability of being cooperation cell or neighbor cell.

Ar: probability of the available bandwidth. This will be discussed more in the performance section.
Tr: residence time.
C:depend on number of times that the decision cell gave a positive result to each cell in the cluster.

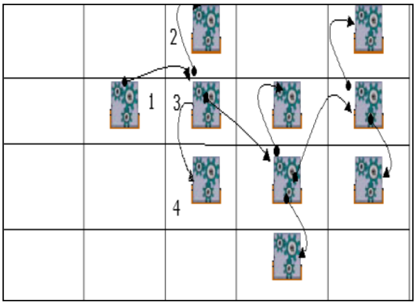

Fig. 6.a: Agent's Cooperation for the Admission of a User (request sending).

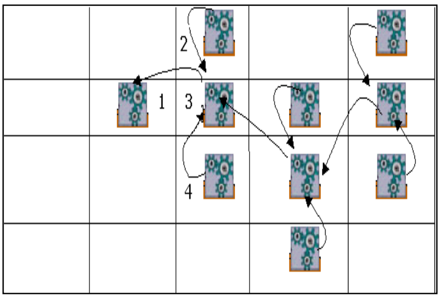

Fig. 6.b: Agent's Cooperation for the Admission of a User (result sending).

Final Decision

When the Decision cell collects all responses from cooperation cells and their neighbors it apply its own calculation:

Final Decision=
(Σagent (Local Decisionagent) /25
1:25

This final decision will be compared by threshold value determined before by the designer:

If result > threshold
Then accept hand off request
Else call drop

The criteria of choosing a threshold value may depend on some real world experience but here we use threshold values as suggested in [1] by taking different values ranged from (0 to 0.95).

4. Performance Evaluation and Simulation Results

For the sake of simplicity, we evaluate the performance of our Multi-Agent system for mobile terminals which are traveling in different directions. This means that our environment is representing a three-dimensional cellular system. In our simulation study we have the following assumptions:

1. The time is quantized in intervals T = 10s.

2. The whole cellular system is composed of 25 cells, laid at 1-km intervals (see figure 5). 9 cooperation cells, 16 neighbor cells.

3. During each time interval, connection according to Poisson process. Five users for hand off calls and one user for new calls.

4. Mobile terminals can have speeds of: 70, 90, or 105 km/h. The probability of each speed is 1/3.

5. Counter of serving times (C) is choosen by random function. When an agent gave the decision agent positive answer the decision cell increases the counter of that agent.

6. Three possible types of traffic: voice, data, or video.
The probabilities of these types are 0.7, 0.2, 0.1 respectively. The number of bandwidth units (BUs) required by each connection type is:
voice = 1, data = 5, video = 10.

7. Connection lifetimes are exponentially-distributed with mean value equal to 180 seconds.

8. Each cell has a fixed capacity of 40 bandwidth units.

9. The size of the cluster is fixed for all users and is equal to 25. This means that 10 cells in the direction of the user along with the neighbor cells .

10. The DMPs are computed as section 3.

11. All users have the same threshold.

5. Results:

Our simulation was a comparison between Shadow Cluster Concept and our concept which depends on mobile motion prediction. We found that our assumption gave until threshold=0.8 better results that the shadow cluster concept this can be obtained in figure 7, the simulation was applied for 100 turns for each threshold value taking in account the different type of traffic and the vehicle speed as mentioned before. Call dropping has a direct proportion with the threshold value. After threshold=0.95 the dropping percentage remain 0.98. In other hand, Shadow cluster concept has worse results beginning from threshold =0.55 in which the call

dropping percentage is equal 0.98.
In the time our technique has an equal dropping percentage at threshold value equal 0.85.

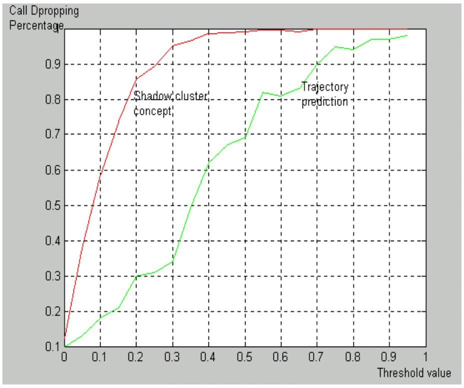

Fig. 7: The result of Call Dropping Shadow cluster vs. Trajectory prediction

As an improvement to our idea, when the Decision cell finishes its calculation and find that the result is greater than the threshold value ("serving the mobile"); it chooses the cells that can serve this mobile better than their neighbors. Here we apply the Dijkstra algorithm to find the trajectory with highest probability. But the difference is that Dijkstra algorithm find pathes with law weight, here it is used to find pathes with high weight so to avoid changing the principle of Dijkstra algorithm we calculate each link weight by:

Link Weight = 1- Link Probability.

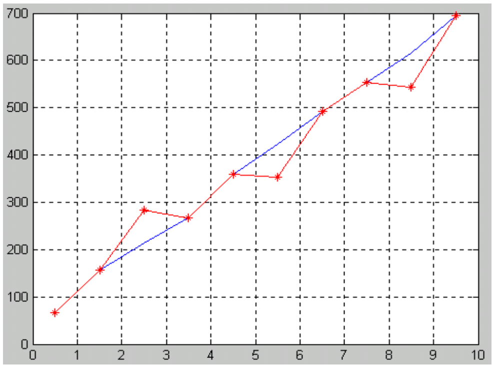

Fig. 8: Best path with low Call Dropping Probability.

-* line: Best path.
- line: Essential path.

6. Conclusion and future work

If we make a simple comparession between the two methods, we can find that our technique uses "25" cells; 10 cells along the predicted way of the mobile plus each cell's upper and lower cells. Where Shadow cluster technique uses "90" cells (each cell mobile reaches has 10 neighbors inside ring and outside ring (Fig. 1). The calculations was acheived one time at Trajectory because if the net decision was positive, each agent receives a message to accept this terminal when it reaches any of them. But this is not for shadow cluster where calculations was acheived each time the terminal changes its current cell because of the lack of knowledge about the next cell to be entered by the mobile in future. During simulation; kalman filter has scored best results on serving terminals where shadow has had a worse performance. When we return back to figure 7, we can see that the minimum call dropping percentage was zero in the time it was 0.1 for shadow cluster concept. If we draw a smooth curve for our technique depending on figure 7, we can see that the call dropping percentages increases slowly between threshold values from 0 to 0.3 then fastly between 0.3 to 0.7 then return slowly between 0.7 to 0.95. So this can give an indicator to concern with the process of choosing a threshold value. Our future work is to apply our idea on the real world and to put a criteria for choosing the threshold value.

About finding best path that has cells with high probability to support the mobile with the required bandwidth, we found that this improvement enhanced the performance of our technique. The value that Decision cell calculated by using the Dijkstra algorithm was 0.2169 and this is a small value which it is above the threshold values in general. Where it is not the same in the case of giving the decision to support or not to support mobiles by using the technique as it is, it gave 0.5716 which is nearly the double of the above value. This is an evidence that Dijkstra algorithm is better but this will need more time and more control on the mobile.

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