Dynamic Bandwidth Reservation for Multimedia and Data Applications In Mobile Wireless Cellular Networks

Khaja Kamaluddin, Muhammed Yousoof
Computer Science Department
Dhofar University, Salalah
Sultanate of Oman

Abstract: - In order to meet the ever increase in users' demand, and to accommodate more number of users, the cell size in mobile wireless cellular networks is being reduced. Because of that bandwidth in each cell has become limited. Due to decrease of cell size more number of handovers takes place. If bandwidth allocation to these handover calls is not done properly then dropping probability of handover calls will be increased. Also if sufficient bandwidth is not available to new calls, then blocking probability for newly generated calls will be increased. Dropping of handover calls is less desirable than blocking of new calls. Many schemes have been proposed to solve the problem in resource allocation. Presently available solutions are not enough to provide and maintain QOS (Quality of Service) for multimedia handover calls.

In this paper we propose the GPS based handover mechanism which will reserve bandwidth in one cell and unnecessary reservations at many neighboring cells are avoided. Also we propose bandwidth reservation and allocation to handover calls using sliding bandwidth window method. In this method, bandwidth window size will change according to network traffic conditions and it is maintained flexible in changing its size. Based upon the expected number of handover calls, the window size changes its capacity, so that more number of handover calls can be accommodated. In order to maintain QOS (Quality of Service) for multimedia handover calls, our focus, in this paper, is to allocate required bandwidth to this call. For lower priority handover call (data call), at least minimum bandwidth will be allocated in worst case scenario. In the mean time, we maintain the balance with locally generated calls in allocation of bandwidth.. In this method dropping probability of handover calls is reduced to minimum and blocking probability of new calls is also maintained to minimum.

Key-Words: - Bandwidth reservation, handover, Bandwidth allocation, QOS, GPS,

1 Introduction

Bandwidth allocation in mobile wireless cellular networks is a complicated issue due to scarcity of bandwidth in cell. Unpredictable movement of mobile node and decrease of power intensity due to signal interference will create more difficulty in allocation of bandwidth. Day by day decrease of cell size creating more handovers and the network has to handle these handover calls in efficient way.

If we are dealing with multimedia call (video), QOS has to be maintained during the connection life time of mobile node. In order to maintain QOS, the constant bandwidth has to be allocated and maintained properly. To do this we must strictly follow the QOS parameters throughout the connection time.

Many solutions have been proposed for providing resources to handover calls. In [1] distributed adaptive bandwidth allocation and admission control scheme is proposed, where authors tried to limit the dropping probability for handover call based upon number of successes and failures of handover calls. The dynamic bandwidth reservation scheme based on incoming, out going handoff predictions and road topology is proposed in [7]. Scalable QOS architecture for mobile adhoc networks is proposed in [2]. On line load balancing solution for multimedia cellular network proposed in [3], in which traffic load is balanced among cells in network. Adaptive bandwidth allocation to increase system utilization with degradation of QOS is shown in [4]. Increase of utilization of resources by accurate prediction using mobile tracking method is mentioned in [5].

2 Wireless Mobile Cellular Network Architecture

All the cells in network equipped with base stations covering fixed geographical area. All the base stations are connected together, and connected to broadband network. Each base station maintains its bandwidth table, where the utilization and freely available bandwidth information is stored in the table. All the base stations communicate to one another, exchange bandwidth information and update their tables.

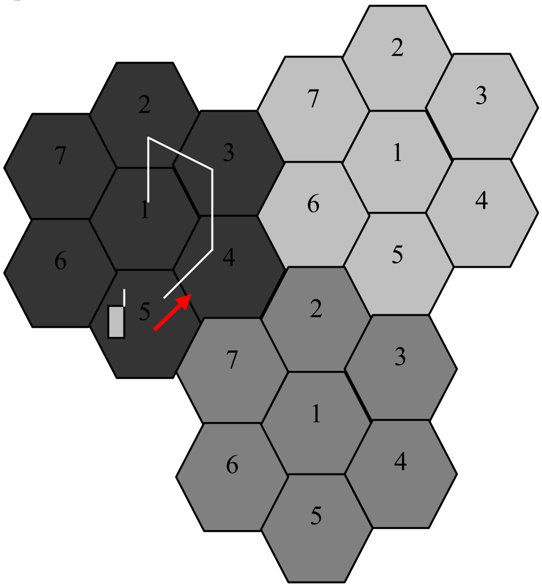

Fig.1. Cellular structure

In our architecture, we considered two types of handover calls. First one is multimedia call, we call it as Class – I call. This call is delay sensitive. QOS requirements have to be fulfilled throughout the connection period. It is considered as higher priority call. Second one is data call, we call it as Class – II call. This call can tolerate delay. It is considered as lower priority call.

We used bandwidth window, whose size is flexible in changing its capacity according to changing network load. The purpose of using the bandwidth window is to reserve bandwidth only to Class – I calls and not to allow this reserved portion to be allocated to Class – II calls or locally generated calls. Window size is reduced to maximum if there is no Class – I call and increased to maximum if Class – I calls are maximum in number.

Total bandwidth in a cell is divided into two parts. First part is window part, where the bandwidth is reserved and allocated to Class – I calls. Second part is window free region, where the bandwidth is allocated to Class – II calls and locally generated calls.

When a mobile node wants to migrate from one cell to another cell, base station for current mobile node in a cell will inform to the base station of cell where mobile node will be expected to handover. This base station will check whether this call is Class – I call or Class – II call. If it is Class – I call, then it will check its QOS requirements and follow the procedure shown below.

First, it will check the enough bandwidth availability for this call in the cell. If available, then that will be transferred to bandwidth window and reserved for this handover call. Window size will be increased after this bandwidth transfer. As soon as handover call arrives, this bandwidth will be allocated. If the enough bandwidth is not available for Class – I handover call, then portion of bandwidth from window free region calls will be added to freely available bandwidth and allocated. Window free region calls include both Class – II calls and locally generated calls (explained in detail in section 5).

If the call is Class – II type, then bandwidth will be allocated from window free capacity. Minimum resource will be allocated in worst case scenario (mechanism is explained in section 6).

If handover call will not arrive within predefined time, then bandwidth will be returned back from bandwidth window to window free region. The size of window will be reduced.

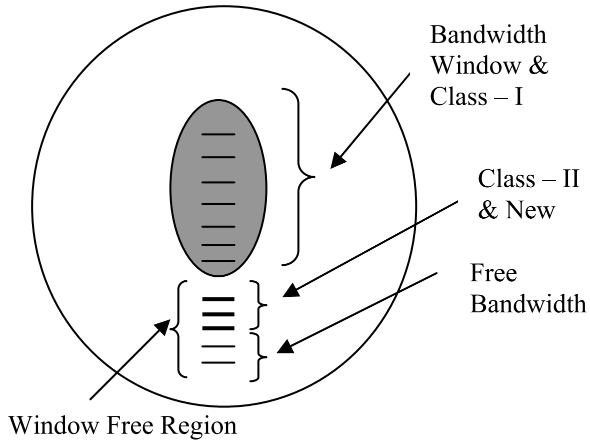

Fig.2. Bandwidth Window in cell

3 Prediction of Handover call using GPS (Global Positioning System)

When a mobile node travels from one location to another, it is difficult to predict its movements and difficult to find the exact cell where the mobile node will be expected to migrate. Inaccurate prediction of handover call will lead to unnecessary reservation of resources at neighboring cells. Many schemes have been proposed for prediction of handover calls and reservation of bandwidth at neighboring cells for these calls. We proposed a scheme for accurate prediction for handover call based upon GPS (Global Positioning System).

In our proposal all mobile nodes are GPS based and communicating with respective base stations regarding their speed, distance, position and direction of travel. Base station will take action based on information provided by mobile nodes. We are assuming that mobile node is traveling similarly to cars moving on highway

At every averaging interval, as mentioned above, mobile node in cell will send the information about its speed, distance, position and direction of travel to its base station. In each cell, threshold distance from base station is maintained. The positions for mobile node are stored at base station. When mobile node reaches the threshold distance from base station, then base station will check this mobile node's previous positions and it will draw a parabola based upon those positions.

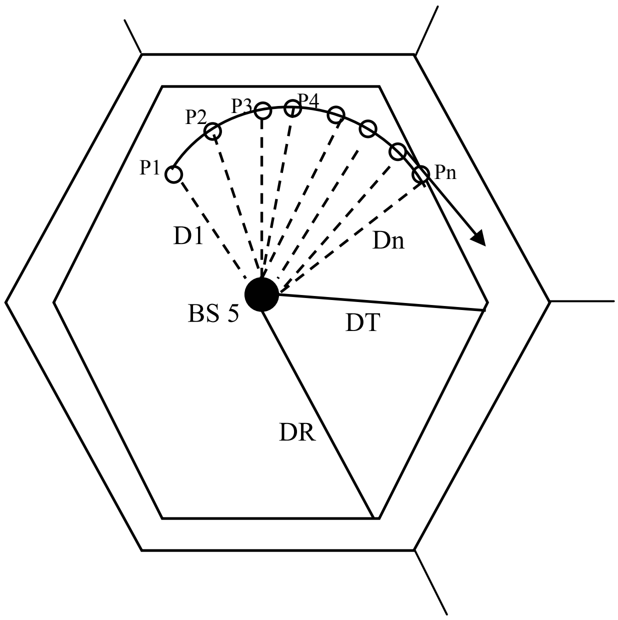

Fig.3. GPS based prediction of handover call

Vector will be drawn at threshold edge point. Direction of vector will be considered in finding the next nearest neighboring base station where the mobile node is expected to handover. Base station in current cell will inform to this neighbor regarding bandwidth reservation for handover call. In this method, bandwidth will be reserved at only one base station. Unnecessary bandwidth reservation at many cells is avoided which is wastage of resources.

In fig.1 the mobile node is traveling in cell 5 and its positions are stored at base station which will help in predicting the new cell for handover call. We have drawn the parabola as shown in fig.3 by joining the positions, and extended to cell 4 using vector, and base station in cell 5 will inform the base station in cell4 for the reservation of bandwidth. Cell 4 will reserve bandwidth and as soon as handover call arrives that will be allocated. If handover call does not reach to cell 4 in predefined time, then this reservation will be cancelled.

Radius of Cell = DR

Threshold distance from Base station = DT

Distance from mobile node to Base Station = Dn

Distance at different Positions = [D1, D2, …..DT]

If Dn ≥ DT then

D1 = BSP1; D2 = BSP2; ……Dn = BSPn

Mobile Positions = [P1, P2, P3, …….Pn]

Parabola = [P1, P2, P3, ….Pn] ----------------------(1)

Vector on Dn at Pn = (DT, DIRECTION) ---------(2)

New Cell ← Direction ------------------(3)

3.1 Proposed Algorithm for Handover mechanism

Begin

Store positions & distance at Base station memory

If distance of mobile node from Base station is equal to or greater than threshold distance then

Draw parabola and draw vector at threshold edge

Endif

End

4 Proposed Scheme for Bandwidth Reservation

Cell measures the distance from mobile node to its base station. If measured distance is equal to or more than threshold distance, then vector will be drawn at the edge according to the movement of mobile node. Based upon the direction of vector, base station will inform to its neighboring base station where the mobile node will be expected to migrate about the reservation of Bandwidth.

Base station will first check whether this handover call is Class – I type or Class – II type. If it is Class – I call, then following procedure will be applied.

Total capacity of Cell = C
Bandwidth utilised in window = Bin
Bandwidth utilised outside window = Bout
Bandwidth freely available = Bf

C = Bin + Bout + Bf -------------------(4)

Bandwidth requested = Breq

Normally, Bandwidth will be reserved if
Bf ≥ Breq

5. Bandwidth Reservation to Class – I (multimedia mobile node) call

Since Class – I call is a multimedia call, delay sensitive and requires strict quality of service. QOS has to be maintained throughout connection period. Care must be taken in reservation, allocation and maintaining the capacity for this call. Dropping of this call is less desirable. Base station will check the requested bandwidth for this handover call. If enough bandwidth is available in window free region, that will be transferred and reserved in bandwidth window. Bandwidth will be reserved only if the requested bandwidth (Breq) is less than or equal to freely available bandwidth (Bf). If this condition is not met, then part of bandwidth from window free region will be reserved and allocated.

In this paper, we are following the FCA (Fixed Channel Allocation) type method in reservation and allocation of resources. In next paper we will extend our work using DCA (Dynamic Channel Allocation) and HCA (Hybrid Channel Allocation) methods in solving the above problem. Since calls in window free region are lower priority one and data calls, can tolerate delay.

Bandwidth requested by Class – I = Breq
C = Bin + Bout + Bf

If Breq > Bf and Breq < Bout

Portion of Bandwidth from window free calls = Bout * δ ---------------------------(5)

where δ = 0.1, 0.2, …..0.9
Breq =Bf + Bout * δ ----------------(6)

6. Bandwidth Reservation to Class – II (lower priority mobile node) call

Class – II call is a data call and delay tolerant.
When this call wants to handover to neighboring cell, base station in current cell will inform its neighbor about the type of call and its current data rate. Neighboring cell will check freely available bandwidth in window free region. If available, that will be reserved otherwise Class – II call has to negotiate the bandwidth. Since it is a handover call, the minimum bandwidth is reserved and allocated temporarily. As soon as resource is available, data rate will be increased for this call. In worst case scenario minimum bandwidth will be reserved for Class – II call.

Minimum data rate has to be maintained for this call during its connection life time. During under-load condition these calls utilize maximum available bandwidth and in over-load condition these calls reduce their rates in order to accommodate more number of calls, especially Class – I calls. Also if network faces congestion, these calls will be asked to reduce their data rates.

Bandwidth requested by Class – II = Breq
Minimum Bandwidth reserved = Bmin
C = Bin + Bout + Bf
If Breq > Bf
Bmin = Bf
Breq ← Bmin -------------------------(7)

7. Proposed Algorithm

```
Begin
   Check the type of Call & QOS requirements
   If Call is Class – I then
      If Breq ≤ Bf then
         Reserve Breq
      endif
        else
         If Breq > Bf & Breq < Bout then
            Breq = Bf + Bout * δ
            Reserve Breq
          endif
    endif

  else
     If Call is Class – II & Breq > Bf then
        Bmin = Bf
```

Reserve Breq = Bmin
endif
End

8. Conclusions

In this paper, we proposed GPS based handover mechanism, which will avoid unnecessary reservations at many cells. Resources can be utilized properly without being wasted. Also, we proposed a window based bandwidth reservation and allocation mechanism for multimedia and data calls. With this method dropping probability of both types of calls can be reduced and better QOS can be provided and maintained throughout the connection period. Locally generated calls will not be much affected. Solution proposed in this paper is based on FCA method and in our next paper DCA and HCA methods will be applied for bandwidth reservation to multimedia calls.

References:

[1] Hong Bong Kim, An Adaptive Bandwidth Reservation Scheme for Multimedia Mobile Cellular Networks, *Proc. of IEEE International Conference on Communications (ICC 2005),Seoul, Korea.*

[2] Kiaxin Xu, Ken Tang, Rajive Bagrodia, Adaptive Bandwidth Management and QOS Provisioning In Large Scale Adhoc Networks, *Proceedings of the IEEE Military Communications Conference, 2003, (MILCOM 2003).*

[3] Sungwook Kim, Pramod K.Varshney, Adaptive Load Balancing with Preemtion for Multimedia Cellular Networks, *IEEE Wireless Communications and Networking Conference (WCNC), vol.3 pp. 1680-1684, March, 2003.*

[4] Chun-Ting Chou, Kang G. Shin, Analysis of Adaptive Bandwidth Allocation in Wireless Networks with Multilevel Degradable Quality of Service, *IEEE Trans. Mob. Comput. 3(1): 5-17 (2004)*

[5] Subbiah Shenbagaraman, B.Prabhakaran, S. Venkatesan, Mobile Tracking and Resource Reservation Scheme for Cellular Networks, *Proc. of Vehicular Technology Conference, 2003. VTC 2003-Fall. 2003 IEEE 58th, 6-9 Oct. 2003, Volume: 2, On page(s): 1273- 1277*

[6] Sridhar Machraju and Siva Ram murthy, An Adaptive Hirarchical Scheme for Bandwidth Allocation in Cellular Networks, *Proceedings of 13th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), Lisboa, Portugal, September 2002.*

[7] Wee-Seng Soh and Hyong S.Kim, Dynamic Bandwidth Reservation in Cellular Networks using Road Topology based Mobility Predictions, *Proc. of IEEEinfocom 2004.*

[8]. Atilla Eryilmaz and R.Srikant, Fair Resource Allocation in Wireless Networks using Queue-length- based Scheduling and Congestion Control, *Proc. of INFOCOM 2005: 1794-1803*

[9] Samrat Ganguly, Badri Nath and Navin Goyal, Optimization Based Bandwidth Allocation in Mobile Cellular Networks, *Proceedings of IEEE infocom2000.*

[10] Sunghyun Choi and Kang G. Shin, Bandwidth Reservation in Mobile Cellular Networks Using ITS Navigation Syatem, *Proceeding of IEEE/IEEJ/JSAI ITSC'99, Tokyo, October 1999.*

[11] Mung Chiang and Jason Bell, Balancing Supply and demand of Bandwidth in Wireless Cellular Networks: Utility Maximization Over Powers and Rates, *Proceedings of IEEE INFOCOM, Hong Kong, China, March 2004.*

[12] Sunghyun Choi and Kang G. Shin, Adaptive Bandwidth Reservation and Admission Control in QoS-Sensitive Cellular Networks, *IEEE Transactions On Parallel And Distributed Systems, Vol. 13, No. 9, September 2002.*