A Novel Mobility Based Bandwidth Reduction Algorithm in Cellular Mobile Networks

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Summary

Due to the rapid growing rate of mobile users and the wide range of service provided for the users, traffic control in mobile networks has become unavoidable. This wide range of services includes multimedia applications. The key characteristic of multimedia applications is that they require different QoS. For the better management of resources and satisfying the QoS requirements, admission control algorithms are used. A novel algorithm that combines the resource reduction principle and the concept of Mobility is developed and implemented, and a comparison is made with existing AC algorithm. It is proved that the proposed algorithm decreases the call dropping probability where by more number of hand-off call requests are accepted.

Key words:

Cellular networks, linear programming, bandwidth, mobility call admission control.

1. Introduction

In mobile communication, efficient management of resources and QoS guarantee for all users require a better admission control algorithm. This paper explains the implementation and the results obtained from three different Call Admission Control algorithms. One with LP-RR, second without LP-RR and third algorithm includes the concept of mobility and LP-RR. LP-RR is Linear Programming Resource Reduction technique, which minimizes the resources allocated to the running applications and increases the availability of resources to other applications. Mobility concept involves reservation of resources to the future hand-off applications thus minimizing the call dropping probability.

2. Literature Survey

The tremendous growth of mobile network technology has increased the need for better admission control strategies and efficient utilization of resources such as channel or bandwidth to provide a better Quality of Service (QoS). In particular, QoS provisioning in Third Generation (3G) and Fourth Generation (4G) mobile networks is a challenging problem due to the scarcity of wireless resources and different QoS service class requirements.[8-15]. CAC is a fundamental mechanism used for QoS provisioning in networks. Admission control for mobile networks based on thresholds were addressed in papers [13-20], where different admission policies are applied to different regions and the regions are separated by thresholds. But determining the values for the thresholds that separate those regions is a critical problem. Another AC method by the authors of [10] use a decision-theoretic approach based on Markov Decision Process (MDP). But large number of states in Markov model makes it unsuitable for real-life problems. This can be eliminated by a fuzzy logic based admission control method which is less computationally intense and it also allows embedding initial knowledge about system behavior by means of its membership function, antecedents and consequence of fuzzy rule. Paper [10] focuses on fuzzy CAC, which estimate the effective bandwidth of call request from mobile station and its mobility information, and makes a decision to accept or reject connection request based on estimation and resource availability. In papers [19] the authors addresses the optimal number of guard channels in a base station to make an effective use of resources.

Providing better resource utilization [bandwidth, buffer, power] and ensuring QoS `guarantees to various applications is an important objective in 3G and next generation 4G cellular networks. Because it targeted at supporting various applications like voice, data, image with enhanced data rate, QoS, security, location awareness etc., a number of bandwidth adaptation techniques exist in the literature. The papers [16-17] dealt with the bandwidth estimation for multimedia networks in distributed network environment. Levine et al [14] proposed predictive resource allocation which dealt shadow cluster concept. The major limitation of this method is with large overheads. Priority based AC was proposed in [2]. The better utilization of network bandwidth using measurements based methodology is dealt in [1]. In [18], bandwidth reservation method was suggested but it has the drawback of unfair bandwidth utilization. Papers [3-7] mainly deal with a much

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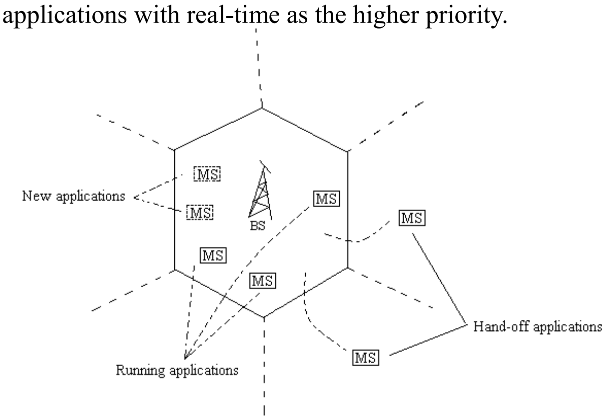
complex mathematical model with only minimum improvement in the overall performance of cellular mobile and adhoc networks. The papers [5-12] use various channel allocation scheme with the objective of increasing capacity and minimizing interference.

3. Cellular Network System Model

A typical multimedia wireless cellular network system is composed of hexagonal shaped cells as shown in the figure. Each cell is having a base station (BS), which allocates and reserves bandwidth for mobile stations (MS). The MS communicate with their home BS's via the air interface and number of BS's are connected to a Mobile Switching Centre (MSC), which in turn connected to the backbone wire line networks. The bandwidth can be shared for 3 types of applications namely Running, Hand-off and New applications.

Already scheduled applications of any type are called as running applications, while the calls from adjacent cell to the reference cell are called as hand off applications. The new calls from the same reference target cell known as new applications. The design of effective CAC should admit calls based on two QoS classes: hand off calls and new calls. Here the admission is based on real-time or non-real time applications with real-time as the higher priority.



MS: Mobile Station
BS: Base Station

Figure 1. Cell Network Model

3.1 Types of Applications and Their Priorities

The Admission control algorithms are designed in order to accept various types of applications with different QoS requirements. The types and the order of priorities are mentioned below.

Hand-off real time Applications

This type of application deals with calls arrival from neighboring cells in real-time. It includes Voice Service, Audio Phone, Video Phone, and Video Conference. These are Constant Bit Rate (CBR) services. This type has the highest priority among all the other applications.

Hand-off non- real time Applications

These type of applications deal with call arrival from neighboring cells in non real-time. It includes Email, Paging, Fax and File Transfer. These are unspecified Bit rare (UBR) services of large bandwidth requirement. This type takes up the second highest priority.

New real time Applications

These types of applications deal arrival within the target cell in real-time. It also includes Audio Phone Video Conference services. Third priority is assigned to this.

New non- real time Applications

These are calls arrival within the target cell in non real-time. The weights assigned are little less than Hand-off non- real time since handoff call is given higher priority than new incoming calls into the cell.

4. Call Admission Control

CAC denotes the process of making a decision for every new call admission according to the amount of available resource versus users' QoS requirements, and the effect upon the QoS of the existing calls imposed by each new call. Whenever a new MT (either a new request or an inter cell handoff) arrives in a BS, the RRM system has to decide if this particular MT may be allowed into the system. An algorithm making these decisions is called a *CAC algorithm.*

Traditional approaches normally use simple threshold strategies on the available channels in each cell. This traditional CAC algorithm is known as the *guard channel algorithm*. There are also some non-traditional methods proposed recently. They are based on adaptive techniques, where channels are allocated and reserved in a dynamic way using tele traffic analysis, prediction of injected traffic and prediction of MT movement. In some prediction schemes, it is sufficient to reserve the radio resource that the MT will need in the predicted location. In general, the resource reservation mechanism consists of two parts; i) some of the bandwidth reserved in the next cell the MT is likely to visit, and ii) a common pool of dynamically adjusted bandwidth used to accommodate other unpredicted flows. The next cell is predicted based on the mobility pattern observed in various cells. Other similar approaches include schemes, which rely on the extended location information (from adjacent cells) to make the CAC decision. The bandwidth reservation could be estimated based upon the history of the nominal cell and neighboring cells. Queuing of a handoff request is more sensitive to delay in service than queuing of a new call, leading to queuing of new calls rather than handoff calls. One of the key points of using queuing in CAC is that service differentiation can be managed with queuing discipline. Instead of FIFO queuing strategy, other prioritized queuing discipline can be used to maintain priority level in each service class.

There are various mobility prediction schemes available. Among those Prediction schemes based on user movement history, Prediction based on Signal Strength Speed and Direction of Motion, etc., are commonly used.

5. LP Based Admission Control Algorithm

The first part includes the implementation of the Admission control algorithm by B.P.Vijay Kumar and P.Venkataram. They have proposed an LP based admission control for integrated services in mobile networks. This algorithm maintains QoS guarantees to the existing applications and increases the percentage of call admission. Resource reduction principle is used in order to deploy fair resource allocation with improved resource utilization.

This scheme is restricted to applications running within a cell without loss of generality, by considering the local information of unused resources and allocated resources to the running applications. With all these it is decided whether to accept or reject the requesting applications for scheduling based on their QoS requirement. As mobile networks have to support multiple classes of services with widely different traffic characteristics and QoS requirements. To ensure these users have to declare their traffic characteristics in terms of traffic descriptor parameters, which can be mapped to appropriate traffic classes. With all the information provided by the users at the connection setup time, the network uses an Admission Control to determine whether the new request for a connection can be accepted or rejected. This decision made by AC is based on the availability of resources (bandwidth, buffers, etc.) to ensure the resources requested by the new application can be guaranteed, without degrading the QoS requirement of applications that have already been admitted.

This algorithm uses Linear Programming resource reduction technique. The LP-RR reduces the allocated quantity of each resource of already scheduled applications in a cell without affecting their QoS requirement and allocated resources. This helps in obtaining large quantity of available resources for scheduling the remaining hand-off and new applications.

6. Admission Control Algorithm Integrating the Concept of Mobility

There are several mechanisms to increase the QoS level of mobile networks and here we use the underlying mobility prediction method (i.e. a means to predict a mobile's next access router). The concept of mobility includes prediction of the next cell to which a user may move to. In this way the current call is a running application in the present cell and when it moves to the next cell it becomes a hand-off application.

Once the mobile has entered the current cell, after a certain time period, a prediction trigger is emitted. The prediction scheme predicts the behavior of the mobile until its next handoff. This trigger produced is used to reserve the required resource in the predicted cell. Information like next predicted cell, expected hand-off time, time spent in the current cell before hand-off etc., are tracked. If the prediction is accurate the reserved resource is utilized. If a wrong prediction is made the reserved resources are de-allocated. Then the mobile enters the unpredicted cell as regular hand-off application. This concept is explained in the figure below.

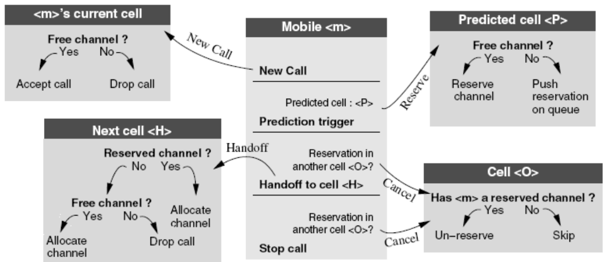


Figure 2. Mobility prediction scheme

Algorithm

IF(h H and n N Application request) THEN

BEGIN

FOR all H appln with reservations

BEGIN

$R^{alloc}_{(r+i)j} = A_{ij} \quad \forall\ j \in [l,q];$

$R_{Pj} = R_{Pj} - A_{ij} \quad \forall\ j$ € $[l,q]$

END

IF$(\theta\ j \geq (\sum^{h}_{i=1} H_{ij}^{alloc} + \sum^{n}_{i=1} N_{ij}^{min})) \quad \forall_j \in [1,q]$

THEN

Begin

Admit all h and n applications;

Resource allocation for all admitted applications reduces to an LP Equation

End

ELSE

Begin

Admit possible h and n and allocate the resources by maintaining the order of priorities;

WHILE $(\theta_j \geq A_{ij}) \quad \forall\ j \in [1,(h+n)]$

Begin

$R^{alloc}_{(r+i)j} = A_{ij} \quad \forall\ j \in [l,q];$

$\theta_j = \theta_j - A_{ij} \quad \forall\ j \in [l,q]$

where { $A_{ij} = H^{alloc}$ if $i \leq h \neq 0$;

$A_{ij} = N_{ij}^{min}$ else}

end;

where i gives the number of applications admitted;

if the WHILE *loop executed twice then* STOP.

CALL LPRR;

Admit possible remaining handoff and new applications using above while loop.

end;

FOR *remaining H and N appln*

begin

IF((Eht_i+Mt)>T)

BEGIN

$R^{alloc}_{(r+i)j} = A_{ij} \quad \forall j \in [l,q];$

$R_{Pj} = R_{Pj} - A_{ij} \quad \forall j \in [l,q]$

end

The RP is updated as and when resources are available

IF*(Trigger)*

begin

Reserve resources for the handoff applications.

end

IF*(Wrong Prediction)*

begin

Deallocate the reserved resources.

end

END.

The problem with the mobility concept is that the reserved resource may be idle till the expected mobile enters the cell. So there is no efficient utilization and hence in the novel algorithm developed, we use the reserved resources for the other applications when the expected hand-off time is more than the current time by a threshold limit. And later the same amount of resource is allocated to the reservation pool when there are available resources.

7. Comparisons and Simulation Study

The above algorithms are implemented and the results are analyzed. For comparison, the same algorithm is implemented without LP-RR. The following results are obtained.

Call dropping probability is the probability of a hand-off call to be rejected. As hand off calls have higher priority it is necessary to maintain this probability as low as possible. The comparison made shows the following result.

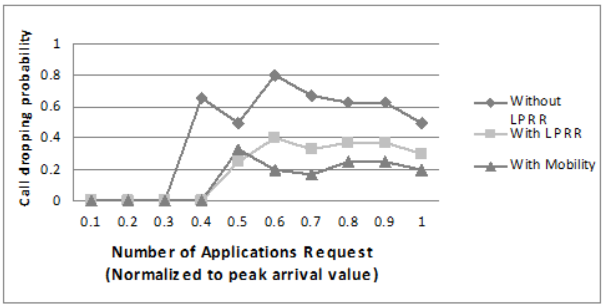


Figure 3. Comparison of call dropping probability of all the three algorithms

From the above graph it can be noticed that call dropping probability is high for the algorithm without LP-RR. The probability decreases for the algorithm with LP-RR and it still decreases for the one implemented with mobility. The variations in the curve is due the timing of the calls which is due to the fact, when an application ends the resources are added back to the resource pool.

Now, the call blocking probabilities of the algorithms are compared. Call blocking probability corresponds to the probability of rejection of a new call. New calls include real time as well as non real time applications, with more priority given to the real time applications.

The following graph shows the results obtained. It is inferred that the call blocking has decreased for the algorithm with LP-RR when compared to the one without LP-RR. But in the algorithm with mobility the call blocking probability has increased by 7% which is due to the reservation made for the future hand-off calls.

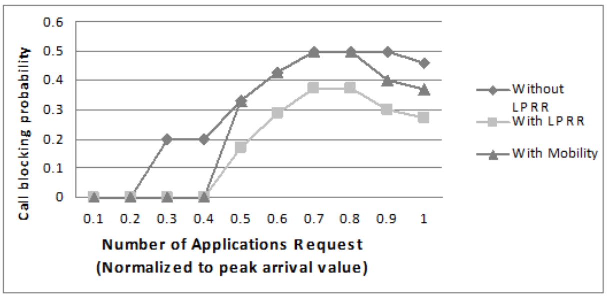


Figure 4. Comparison of call blocking probability of all the three algorithms

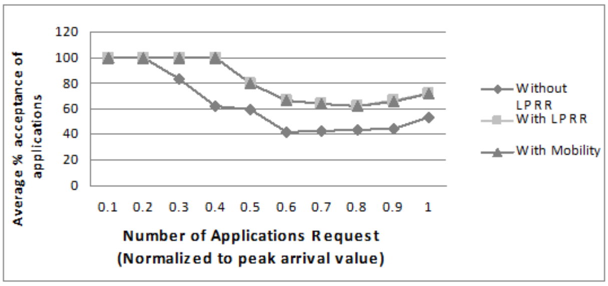


Figure 5. Comparison of call acceptance of all the three algorithms

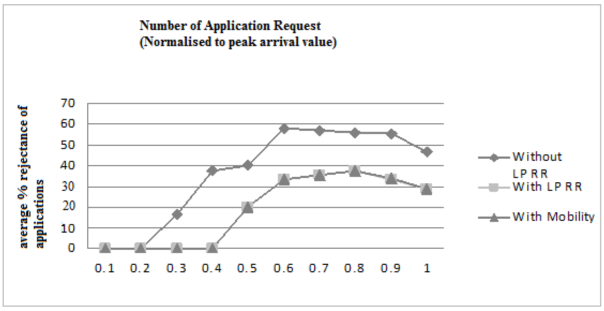


Figure 6. Comparison of call rejection of all the three algorithms.

From the above two graphs it is noticed that acceptance percentage has improved and rejection percent has decreased for the other two algorithms when compared to the one without LP-RR. Also same acceptance and rejection percent is inferred for both.

7.1 Improvements Shown

The novel algorithm developed includes the concept of mobility. The required resources are reserved for the future hand-off applications. This algorithm concentrates mainly on hand-off applications due to which there are more number of hand-off calls accepted than the new applications.

The algorithm without LP-RR accepts 56% of the hand-off applications. The algorithm with LP-RR has shown an improvement of 24% with an average acceptance of 80% and the algorithm with mobility accepts 86% of the hand-off applications with an improvement of 6%.

The algorithm without LP-RR accepts 69% of the new applications. The algorithm with LP-RR has shown an improvement of 24% with an average acceptance of 82% and the algorithm with mobility accepts 75% of the new applications with a decrease of 7%.

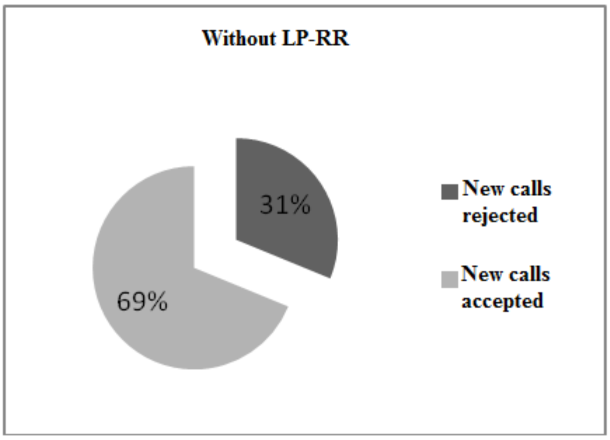


Figure 7. Acceptance and rejection of new calls using the algorithm without LP-RR.

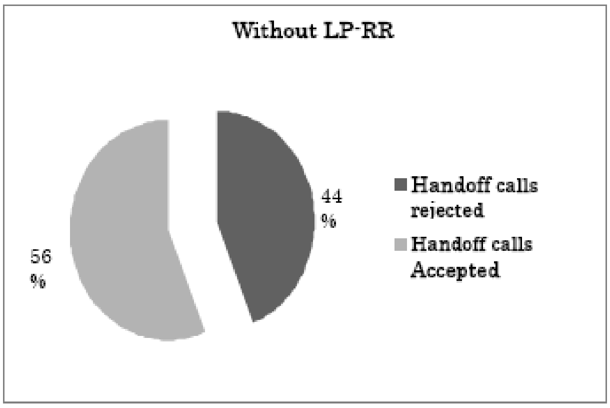


Figure 8. Acceptance and rejection of hand off calls using the algorithm without LP-RR.

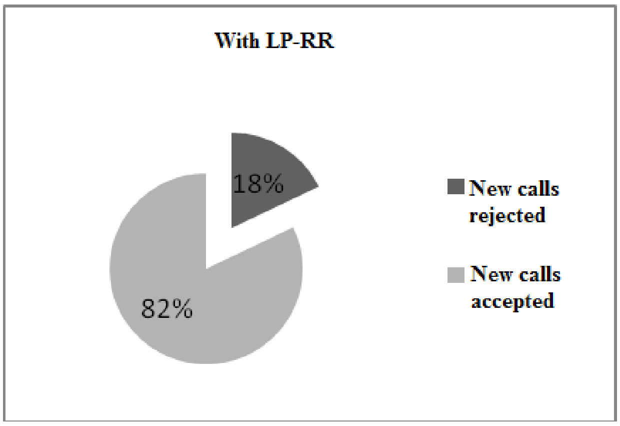


Figure 9. Acceptance and rejection of new calls using the algorithm without LP-RR.

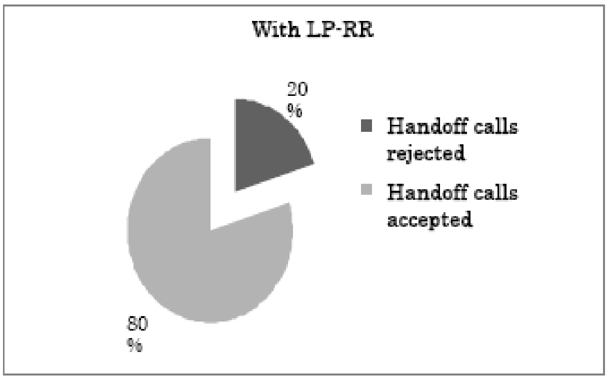


Figure 10. Acceptance and rejection of hand-off calls using the algorithm with LP-RR.

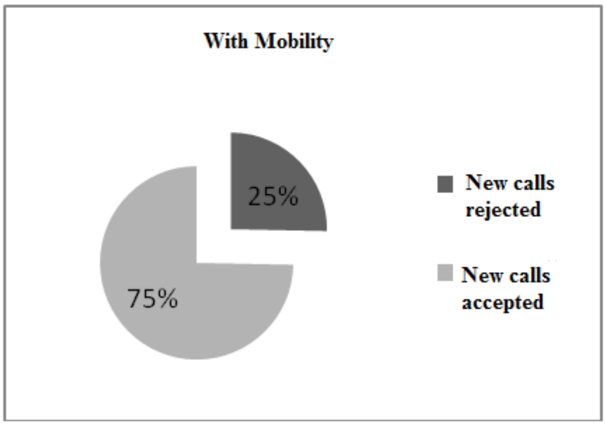


Figure 11. Acceptance and rejection of new calls using the algorithm with mobility.

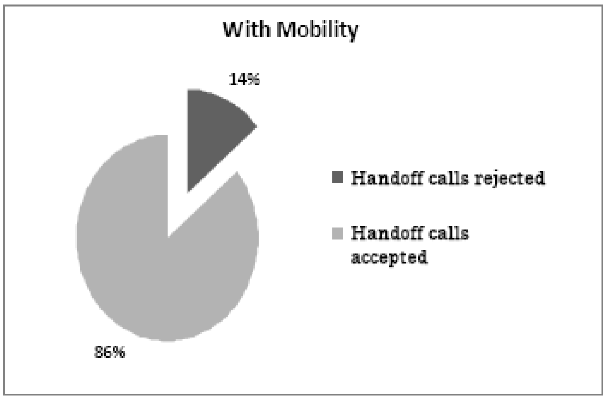


Figure 12. Acceptance and rejection of hand-off calls using the algorithm with mobility.

The overall results of all the algorithms are depicted in the following charts. These charts show the total number of new applications accepted, total number of new applications rejected, total number of hand-off applications accepted and the number rejected.

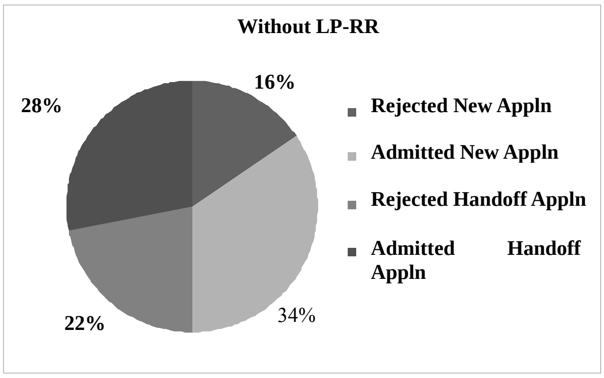


Figure 13. Total percentage of accepted and rejected hand-off and new applications without LP-RR.

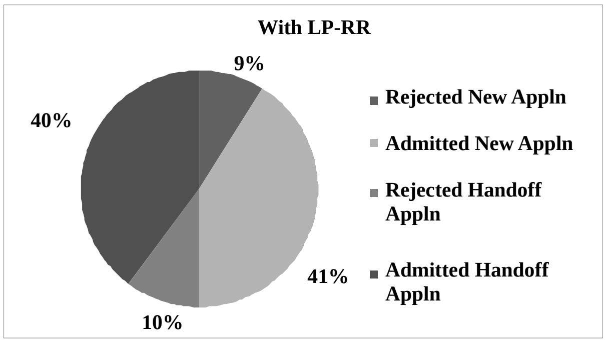


Figure 14. Total percentage of accepted and rejected hand-off and new applications with LP-RR.

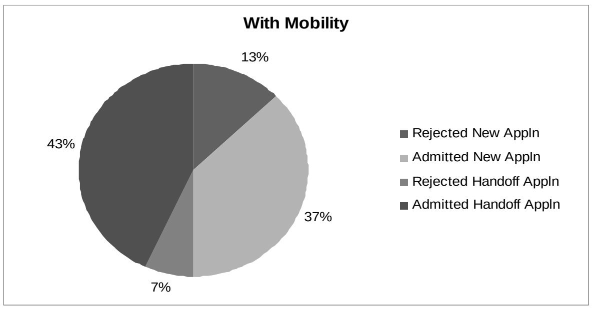


Figure 15. Total percentage of accepted and rejected hand-off and new applications with mobility.

Thus so far all the improvement factors on Mobility Algorithm which decrease the call dropping probability with its trade off in slight increase in the call blocking probability which is because of reservation of resources by prediction before the actual handoff arrives.

8. Conclusion

The novel algorithm developed includes the concept of mobility. The required resources are reserved for the future hand-off applications. This algorithm concentrates mainly on hand-off applications due to which there are more number of hand-off calls accepted than the new applications.

- The algorithm without LP-RR accepts 56% of the hand-off applications.
- The algorithm with LP-RR has shown an improvement of 24% with an average acceptance of 80%.

- The algorithm with mobility accepts 86% of the hand-off applications with an improvement of 6%.

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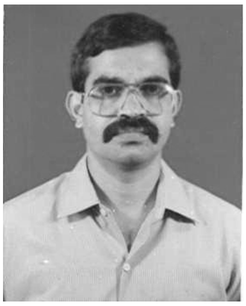

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