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## Agent Based Software Engineering



**Title: Multi Agent Inter – Network Handover**

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# Multi Agent Inter – Network Handover

## Abstract

The industry is facing a tremendous growth in data traffic and also the number of subscribers is increasing along with demand for more bandwidth to accommodate advanced services. Efficient use of resources has always been a bottleneck in networking systems, which agent technology promises to reduce through coordination among different cooperating software entities. The project is motivated by growing number of users on a wireless platform and their requirement of handover from one network type to another without any application failure. This project presents a scheme in which various agents communicate with each other to minimize the number of dropped calls during the inter-network handover. System was designed to support voice, file transfer and multimedia calls. Scheme promises to maximize successful inter-network handovers keeping internal call blocking rate low and also maintains QoS.

## 1. Introduction

There are number of problems associated with this growth such as requirement for more bandwidth, efficient resource management, providing QoS, etc. The key issue is to provide these services and maintain QoS in hybrid networks. A very interesting application would be managing radio resources in hybrid wireless network scenario. Agent programming technology has emerged as a flexible and complementary way to manage resources of distributed systems due to increased flexibility to handle dynamically changing requirements.

Wireless networks are no more used for transfer of only voice now. The objective of the project is to manage radio resources (bandwidth) so as to provide handover from one wireless platform type (WLAN, 3G) to another through use of Multi – Agents Systems and also maintain adequate QoS.

## **2. Agent**

Agent and Multi-Agent Systems (MAS) are a new software development paradigm geared towards solving more complex problems than those achieved by more conventional algorithmic programming. A MAS is a network of agents that interact to solve larger problems that are beyond individual agent's capabilities. This interaction involves collaboration and communication between the agents.

The project is an application based on Multi - Agent Systems. FIPA (Foundation for Intelligent Physical Agents) define an agent as an entity that resides in environments where it interprets “sensor” data that reflect events in the environment and executes “motor” commands that produce effects in the environment”. Wooldridge states agent to be an object with attributes like Autonomy, Pro-activeness, Reactivity and Social ability [2].

- 1) *Autonomy*: Operate without human intervention Control over its actions and internal state
- 2) *Social Ability*: Interacts with other agents via some kind of agent communication language
- 3) *Reactivity*: Agents perceive their environment and respond to changes

4) *Pro – Activeness*: Agents exhibit goal oriented behavior by taking the initiative.

For the purpose of this project we define an agent as a small, efficient, and autonomous software robot that works on behalf of a user to solve computing problems. It will generally consist of state information, behavioral routines, an autonomous nature and social ability. *Autonomy* and *Social Ability* are primary characteristics in this definition.

Autonomy allows an object act independently without human interaction based on the information collected from its environment. Artificial intelligence techniques are used to provide autonomous behaviors. Some applications like supply chain management and ubiquitous computing cannot be realized without accepting autonomy as a key feature.

Social ability gives rise to MAS (Multi Agent Systems). In a MAS environment, several agents work together to achieve some desired goals. This involves aspects of coordination, communication and hypothetical reasoning. It is a highly desirable characteristic in systems that require concurrent processing.

## 2.1 Classification Of Agents

There are several dimensions used to classify software agents. In essence, agents exist in a truly multi-dimensional space. However there are 7 types of identified agents [1]:

- 1) Collaborative Agents
- 2) Interface Agents
- 3) Mobile Agents
- 4) Information / Internet Agents
- 5) Reactive Agents
- 6) Hybrid Agents
- 7) Smart Agents

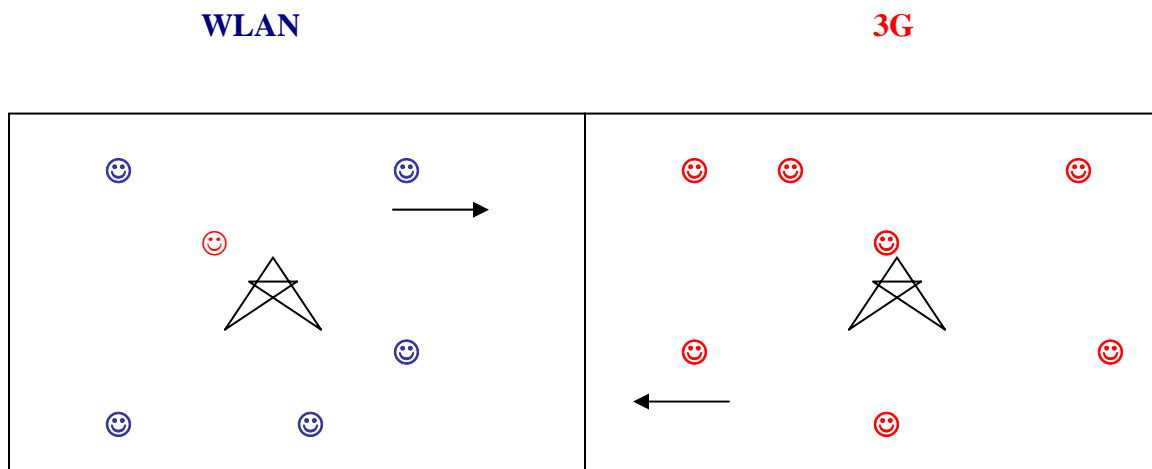
For this project, collaborative agents are mostly used. The issues such as scarcity of resources, distributed information cannot be resolved without collaboration. Collaboration agents work together by sharing resources and working at knowledge level to realize multi-agent system.

Employing an agent system to monitor the network and make changes to resource configuration encourages efficient use of resources. This approach promises to make the network easy to maintain and robust. Its importance has been realized academically as well as in real-world applications. For instance 'Big Brother' is a centralized LAN manager running at University of Michigan's Computer Aided Engineering Network. The Zeus project of British Telecom is another example.

### 3. Project Aim

Project provides a uniform service platform to users between 3G network and Wireless LAN network shown in figure 1. Users hop from one network platform to another and the scheme accommodates these alien users ensuring their running applications. Scheme is aimed: -

- 1) To maximize successful inter network handovers i.e. to minimize Call Dropping encountered while moving from one wireless network platform to another.
- 2) To minimize internal Call Blocking rate.
- 3) To maximize Quality of Service of all active calls.



**Figure 1**

#### 4. Traffic Model

Traffic model of WLAN Network and 3 G Network is shown in table 1 and 2 below.

##### *WLAN Network*

<b>Call Type</b>	<b>Bandwidth (Minimum)</b>	<b>Bandwidth (Minimum)</b>	<b>Call Arrival Probability</b>
Voice	30 Kbps	45 Kbps	33.3%
File Transfer	1000 Kbps	2000 Kbps	33.3%
Multi – Media	1000 Kbps	2000 Kbps	33.3%

**Table 1**

Total available bandwidth = 54 Mbps

##### *3G Network*

<b>Call Type</b>	<b>Bandwidth (Minimum)</b>	<b>Bandwidth (Minimum)</b>	<b>Call Arrival Probability</b>
Voice	30 Kbps	45 Kbps	60%
File Transfer	1000 Kbps	2000 Kbps	20%
Multi – Media	1000 Kbps	2000 Kbps	20%

**Table 2**

Total available bandwidth = 10 Mbps

## 5. Project Architecture

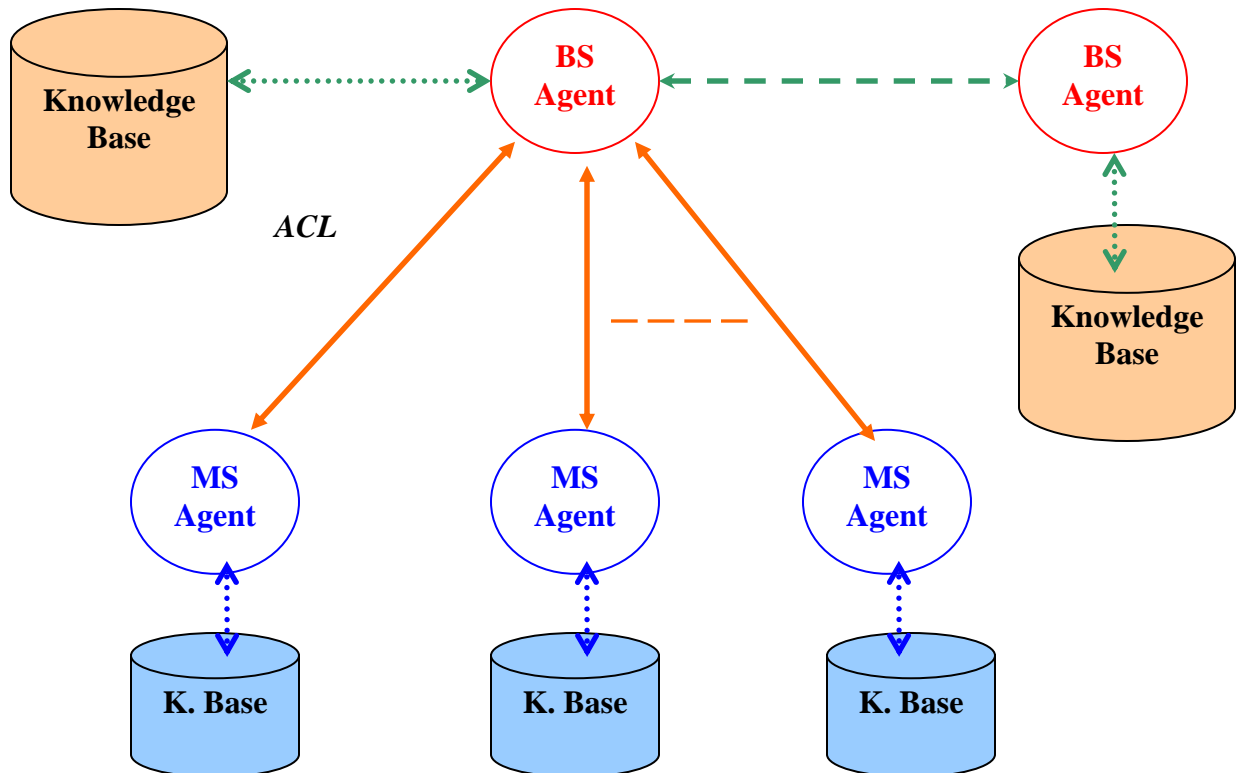


Figure 2

Each Base Station and Mobile Station is equipped with a software agent as shown in figure 2. BS agent acts as a central control entity. Each agent has its own knowledge base and its every decision is influenced on it. Each new call (MS agent) registers itself with BS agent. It puts a request for bandwidth which is between its minimum – maximum range and is random. The architecture is based on few assumptions:-

- Calls originate according to poisson process with a mean of 10 – 40 calls per minute.
- Cal Duration is assigned according to exponential distribution with mean of 3 minutes.
- Any call is randomly selected from 0 – 60 seconds to hop.
- Inter network is executed in such a way that hopping call is accepted in the destination network at minimum bandwidth.

Each call is given bandwidth which is usually more than its minimum bandwidth, this bandwidth is called 'Extra Bandwidth'. Base Station agent keeps the track of this extra bandwidth allocated to all calls which is nothing but the summation of extra bandwidth of all active calls

$$\text{Extra Bandwidth} = \sum_{i=0}^n \text{Bandwidth (alloc)}_i - \text{Bandwidth (min)}_i$$

n = number of active calls

## 6. Handover Process

As soon as a user enters the new network, MS agent communicates with the BS agent of the new network. This communication includes its call type, bandwidth requirement and minimum bandwidth parameters. BS station agent of this new network then checks for the total extra bandwidth that has been allocated to all the active calls. If available bandwidth is more than the minimum bandwidth of the hopped call, the call is accepted at min. bandwidth. Else a check is made to see whether sum of available bandwidth and extra bandwidth is more than the minimum bandwidth of the hopping call. If its more, then agent executes its bandwidth accumulator algorithm. Otherwise it simply drops that call and allocates a bandwidth of 10 kbps in order to make the call to stay in network and request later.

IF (Available Bandwidth) > Min\_Bandwidth (hopping call)

BS agent accepts the call;

ELSE IF (Extra Bandwidth + Available Bandwidth) > Min\_Bandwidth (hopping call)

Execute bandwidth accumulator algorithm;

ELSE

Drop the call

## 6.1 Bandwidth Accumulator Algorithm

1) Sorts the calls in descending order relative to the allocated extra bandwidth . This degrades the QoS firstly of the calls which have maximum extra bandwidth and helps to maintain the QoS of the system.

```
While (true)
{
    If (Extra Bandwidth of call I > 10)
    {
        accumulate 10 Kbps from call I;
        Increment Available Bandwidth by 10;
        Decrement Total Extra Bandwidth by 10;
    }

    Else
    {
        accumulate extra bandwidth from call I;
        Increment Available Bandwidth by extra bandwidth of call I;
        Decrement Total Extra Bandwidth by extra bandwidth of call I;
    }

    If (Available Bandwidth > required)
        Stop;

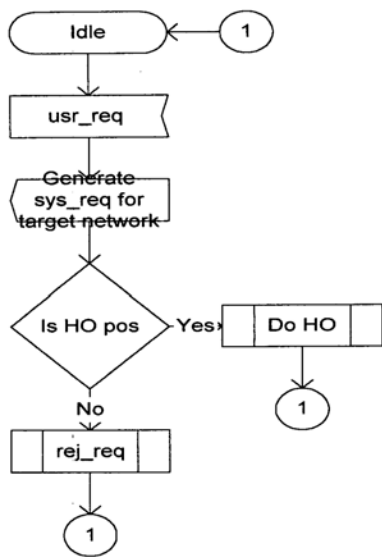
    increment I;
}
```

Though this algorithm is designed to be infinite, it will never run for ever as it is executed under the condition which makes sure at some point of time the stop condition will be met.

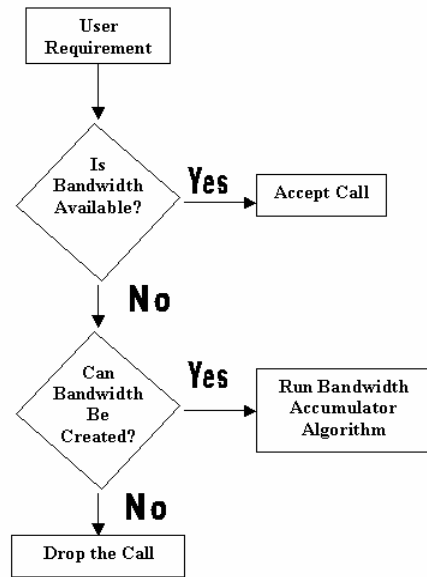
## **7. Advantages over traditional schemes**

- 1) The scheme ensures the Quality of Service of all calls.
  - a) Firstly the bandwidth accumulator algorithm never runs till its sure that its execution will create enough bandwidth to adjust a new call or hopping call. Thus QoS of any call is not degraded unnecessarily.
  - b) As calls are sorted in descending order relative to their extra bandwidth, the call with maximum extra bandwidth will be effected first and so on.
- 2) Executing bandwidth accumulator only in result producing situations, guarantees to minimize computaional overhead associated.
- 3) Accepting a hopping call at minimum bandwidth does not effect QoS of all other active calls to a much extent and also reduces internal blocking in the destination network.

Lets compare algorithm of the proposed scheme with [3] as shown in Figure 3.



[3] Scheme



Proposed Scheme

Figure 3

Comparing algorithms clearly show that in [3] QoS will be degraded no matter the results are produced or not. But in the proposed scheme, QoS is only degraded under a condition, which guarantees the result. This achieved by using agent at RAP that keeps track of extra bandwidth allocated. This further implies that average bandwidth allocated to each call would be higher in proposed scheme as compared. It also reduces computational overhead.

## 8. Simulation Results

Simulation was run for 3 hours for call arrival rates of 10, 20 30 and 40 calls per minute as shown in figure 4. Due to lot of randomness, it is necessary to reduce it for better results. Thus for each call arrival rate, it was run for 3 times and mean values of all parameters were considered for results.

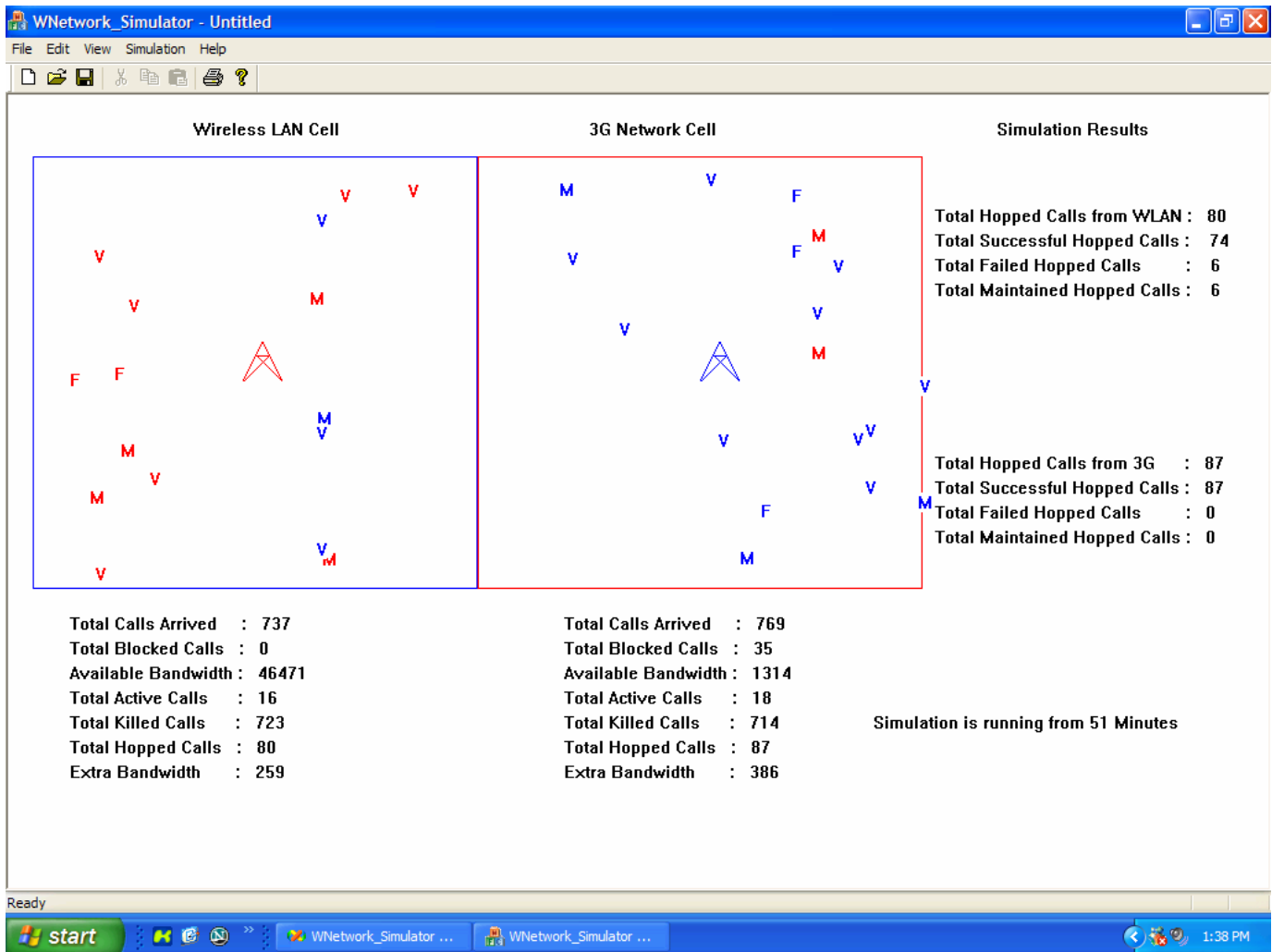
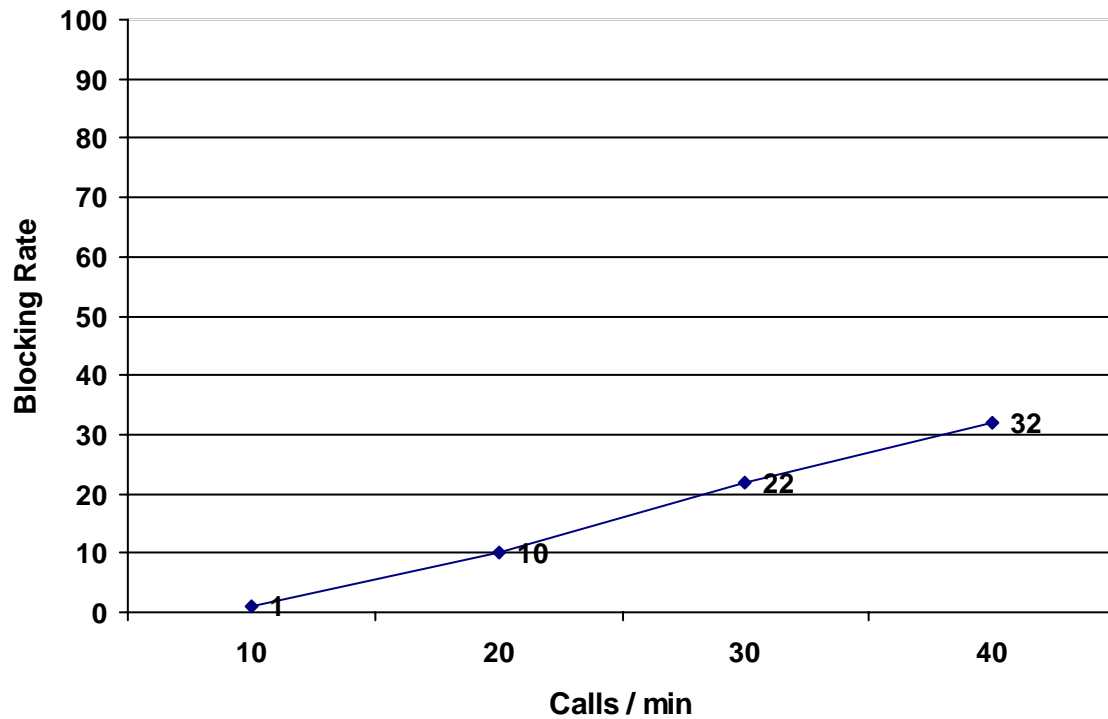


Figure 4

## Blocking Rate Vs. Call Arrival Rate



**Figure 5**

The results show that on increasing call arrival rate, blocking rate also increases. For optimal results, scheme holds good for 15 calls/min that keeps blocking rate almost 5% as shown in Figure 5 above.

## Dropping Rate Vs. Call Arrival Rate

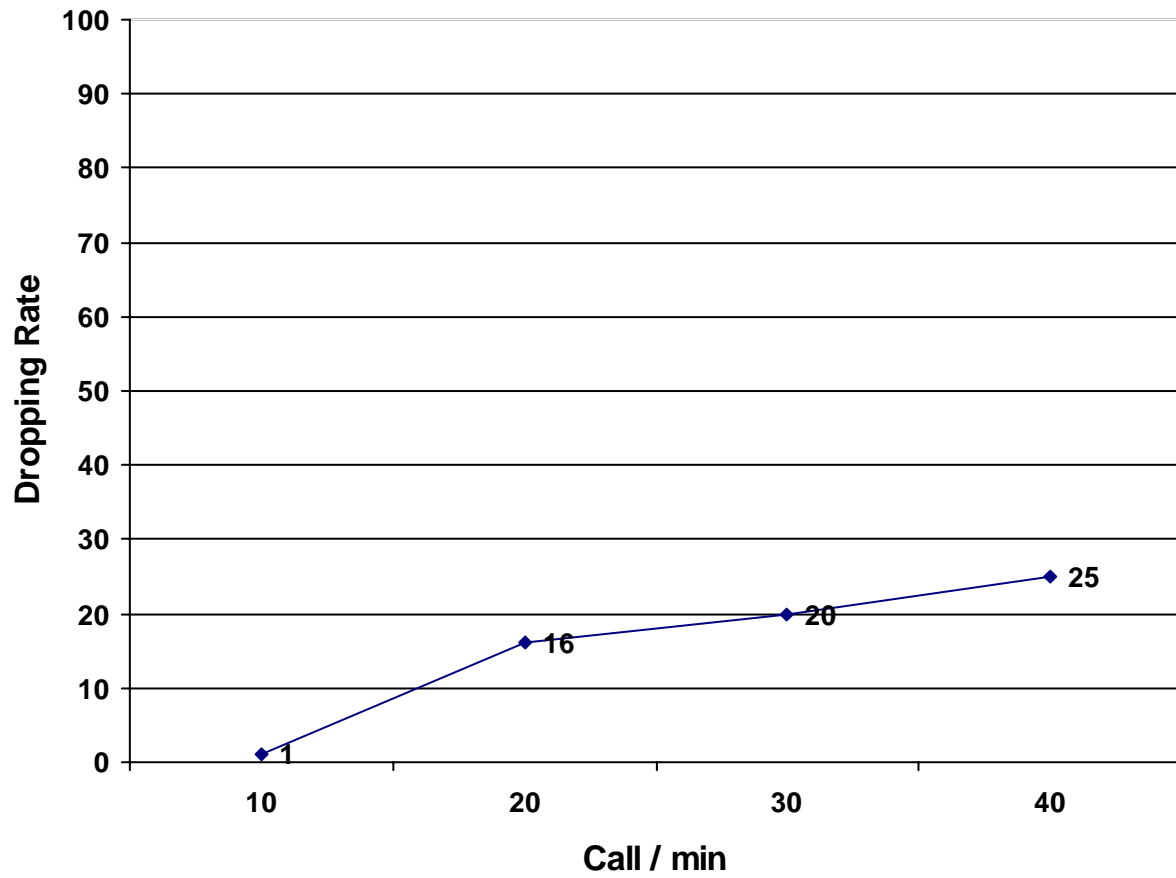


Figure 6

The results show that on increasing call arrival rate, dropping rate also increases. It also increases internal call blocking of the destination network as shown in Figure 6 above.

## 9. Conclusion

A new resource allocation scheme was presented using multi – agent systems which promised to QoS, low computational overhead, increased throughput, decreased dropping rate and decreased blocking probability. Though the cost of implementation would be more and also the complexity of system will increase, but it's all worth if all the advantages mentioned are justified. For optimal results, scheme holds good for 15 calls/min, which keeps dropping and blocking rate less than 5%.

If we provide more autonomy to MS agents, it could drastically change the performance of the overall system in which, MS will be able to choose a BS of their own choice.

### Reference:

- 1) Nicholas R. Jennings and Michael J. Wooldridge, *Agent Technology: Foundations, Applications and Markets*, Springer Verlag (1998)
- 2) Michael J. Wooldridge, *Reasoning About Rational Agents*, Springer Verlag (1998)
- 3) Reynolds, P., *Mobility management for the support of handover within a heterogeneous mobile environment*, 3G Mobile Communication Technologies, 2000. First International Conference on (IEE Conf. Pub. No. 471), 27-29 March 2000