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IMPROVING THE QOS IN A SIMILATED GPRS NETWORKS

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M.Sc. Thesis

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[IMPROVING THE QOS IN A SIMULATED GPRS NETWORKS]

by

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DEDICATION

I would like to thank God first and I would like to thank my father and mother for their continued support to me.

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I am thankful to Dr. Dogu Cagdas Atilla for guiding me in in this thesis. Without his support it would have been very difficult for me to prepare the paper so meaningful and interesting.

ABSTRACT

[IMPROVING THE QOS IN A SIMULATED GPRS NETWORKS]

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[The "General packet radio service" (GPRS) it's a 2.5 generations cellular technology that was introduced as an extension of Global System for Mobile (GSM) networks to address their limitations in providing packet-oriented services. The modern-day mobile devices allow their users to stay connected with the digital world and access a large variety of service. The nature of this service can't be described just as one global service because the capacity demand and time constraints vary from one type of services to another. Multimedia applications require soft Quality of Service (QoS) constraints. However, network traffic is highly diverse and each traffic type has unique bandwidth, delay, and availability requirements. A key problem in supporting multimedia applications is managing their different QoS requirements. This paper attempts to solve this problem by developing a multi-agent system (MAS) in a mobile network. Hybrid P2P and MASs are integrated by implementing Java agents on mobile devices. These agents voluntarily expose part of their memories as part of the total cache system, which coordinates the interaction among mobile devices to enable P2P file sharing.

This thesis also builds an agent platform for mobile devices by using software modules and the Java Agent Development Environment with the extension provided by the Lightweight Extensible Agent Platform. The proposed system achieves excellent quality and performance by

reducing the overhead traffic through the localization of data transfer, which affects the total bit rate, increases the availability, and reduces the latency.]

Keywords: GPRS, P2P, QoS, GSM

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LIST OF ABBREVIATIONS

ACL:	Agent Communication Language
AIDs:	Agent Identifiers
AMS:	Application Management Software
API:	Application Programming Interface
AuC:	Authentication Center
BSC:	Base Station Controller
BSSGP:	Base Station System GPRS Protocol
BTS:	Base Transceiver Station
CDC:	Connected Device Configuration
CLDC:	Connected Limited Device Configuration
FDMA:	Frequency Division Multiple Access
GGSN:	Gateway GPRS Support Node
GPRS:	General Packet Radio Service
GSM:	Global System for Mobile Communication
GSNs:	GPRS Supporting Nodes
GTP:	GPRS Tunneling Protocol
GUI:	Graphical User Interface
HLR:	Home Location Register
IMSI:	International Mobile Subscriber Identity
IP:	Internet Protocol
J2ME:	Java 2 Micro Edition
J2SE:	Java 2 Standard Edition
JAR:	Java Archive
LEAP:	Lightweight Extensible Agent Platform
Las:	Location Areas
LLC:	Logical Link Control
MMU:	Maximum Mobile Agent Use
MAC:	Medium Access Control
ME:	Mobile Equipment
MIDP:	Mobile Information Device Profile
MS:	Mobile Station
MSC:	Mobile Switching Center
MAS:	Multi-Agent System
NS:	Network Service
PDNs:	Packet Data Networks
PDP:	Packet Data Protocol
P2P:	Peer to Peer
PMU:	Percentage of Mobile Agent Use

PDA:	Personal Digital Assistant
PLL:	Physical Link Layer
PLMN:	Public Land Mobile Network
QoS:	Quality of Service
RFL:	Radio Frequency Layer
RLC:	Radio Link Control
RT:	Receiving Time
SGSN:	Serving GPRS Support Node
SIR:	Signal to Interference Ratio
SNDCP:	Sub-Network-Dependent Convergence Protocol
SIM:	Subscribers Identity Module
TDMA:	Time Division Multiple Access
TFT:	Traffic Flow Template
TCP:	Transmission Control Protocol
UDP:	User Datagram Protocol
URL:	Unified Resource Locator
USB:	Universal Serial Bus
VLR:	Visitor Location Register
Wi-Fi:	Wireless Fidelity
WT:	Waiting Time

1. INTRODUCTION

As the Internet grows increasingly mobile, cellular network driver need to develop their networks to enhance the performance of various Internet applications. Such improvements are also necessitated by the growing users demands for excellent Quality of Service (QoS). The first generation of the cellular mobile devices are analogous systems that are constrained by different standards. Meanwhile, the second generations GSM cellular devices are equipped with digital switches and circuits that are not suitable for Internet traffic and data service. These constraints only lead to the inefficient distribution of channels for the entire period. For burst traffic, packet-switched bearer services can efficiently utilize physical channels because the channels will just be appropriate when needed and it's will be discharged directly when the communication of data is done. In this way, multi users can contribution the same channel to send and receive packets.

To address these inefficiency in GSM networks, General Packet Radio Service (GPRS) was developed as 2.5 generation cellular packet data networks (PDN) for Global System for Mobile Communications (GSM). Through GPRS, the packets of users are direct routed from the mobile networks to a packet-switched network. GPRS has become increasingly familiar among GSM subscribers, and such popularity has necessitated the setting of certain QoS requirements for packet data services. However, packet data still have a lower priority than conventional circuit-switched voice communications in GSM network.

The increasing number of the GPRS users has also increased the demand for the excellent QoS of GPRS-based the Internet applications that are becoming increasingly mobile oriented. Therefore, GSM operators must improve the performance of GPRS to meet the QoS requirements of end users. However, they must face certain obstacles in implementing such improvements.

previously, mobile phone had a small limited memory, limited data communications capability, and closed, proprietary operating system; therefore, these devices seemed almost incapable of file sharing. However, as the present-day memory-intensive smartphones, which are set with a lot of connectivity options (i.e., GSM, GPRS, Wi-Fi, and Bluetooth) and using open software platforms (i.e., Windows Mobiles), peer-to-peer (P2P) the systems are ready now to invade the mobile realm.

1.1 P2P IN MOBILE NETWORKS

Mobile wireless communication systems differ from the fixed Internet in many aspects. The types of systems in which component knowledge and resources are dispersed continue to increase in number along with the popularity and usage of wireless technologies. As a result, distributed approaches to system design have become more relevant. Much of the communication activities being conducted over the Internet rely upon P2P systems than on classical client-server relationships. Given that mobile devices are becoming powerful tools for delivering content, creating a P2P system specifically for these devices seems to be logical.

A P2P system is a appropriated system that consists of particular users that associate to one another straight instead of connect to the central server. Given that all deal with and the messaging activities are being managed by the users themselves,

these clients also act as servers with equivalent software or functionalities. In other words, each client can make some type of appeal to other users and respond to the appeal of these clients. The main advantage of P2P systems is that processes and data can be appropriated to each user in the system slightly than at any central location. File sharing is the main application areas of Peer 2 Peer systems. In a P2P file sharing system, each client can store files that can be accessed by other clients as well as access those files that are being gathered by other users in the system. These users deal with one another and store their data in their own drives, thereby dispose of the need for a main file server that is available to all users.

nonetheless, Peer 2 Peer systems must be each end device to have a user interface and to run a backdrop service. Launching the P2P system also automatically launches the required user interface and backdrop services, after which P2P device begin to deal straight with one another. Some P2P systems using hybrid system where sources sharing is scatter and the indexes that refer to resource places are stored in a centralized index. In a hybrid system, each peer accesses an index server to obtain the place of a resource saved on another peer. The index server will help connect 2 peers, but once connected, these peers communicate with each other without the need to communicate with the index. Peer 2 Peer systems can we use it on P2P networks, client and the server networks, and in the Internet. This thesis plans to establish a hybrid system.

1.2 QOS IN MOBILE NETWORKS

In today’s networks where an increasingly large volume of audio and video data are being exchanged among users, ensuring an excellent QoS while maintaining a reliable network performance is very critical. In the context of packet- switched wired or wireless communication networks, QoS refers to the capability of assigning different priority levels to different users or applications in order to assurance a convinced level of real- time data flow performance. QoS schemes run a critical aspect in maintaining the performance of time- critical data, like real-time videos and audios, when the maximum network capacity is reached or exceeded. Several factors, such as throughput, delay, and frame loss, may affect QoS requirements as packets travel through a communication network from their source to their goals. Some approaches can be used to guarantee QoS in a communication network. QoS schemes can be implemented at different layers of the TCP/IP stack, such as at the data links or the networks layers, and can even be integrated within multiple layers. QoS can also be incorporated in the routing protocol or in the schemes for reservation and admission control. Congestion presents the most important challenge in guaranteeing excellent QoS. Given that the sources of traffic alter significantly between the wired and the wireless networks, different paths must be used to ensure excellent QoS in wireless networks. Properly, this thesis only focuses on the QoS in wireless networks.

1.3 LITERATURE REVIEW

This section reviews some published works related to this research. Many researchers have presented their own ideas to improve the QoS of GPRS.

Regentova E. et al. (2005) suggested a dynamic channel distribution planner for GSM/GPRS networks with keeper channels de-allocation/re-allocation for voice call and data queue. They also advanced an analytic type with a general GPRS channel to reform the execution of the suggested project. The numeral results explain that the project can adapt to the different QoS requirements of the system by setting the amount of guard channels and the size of the data queue. The proposed scheme outperforms some conventional schemes in terms of QoS provisioning.

Lollini P. et al. (2005) used several QoS indicators that measure service availability as perceived by users to analyze the congestion in a GPRS infrastructure that comprised partially overlapping adjacent cells. The effectiveness of specific resource management techniques for alleviating such congestion was also evaluated by considering one cell as affected by an outage and by conducting a transient analysis. A simulation approach was proposed to provide numerical estimates. The results show that behavioral trends are very useful for choosing the appropriate number of users to be switched and for determining the right amount of time that the system must spend in its decision-making processes.

Yang Y. et al. (2006) proposed a load balancing architecture constructed by distributed intelligent agents to support real-time or burst data services. They also employed a neural network approach and a simple decision mechanism to predict GPRS traffic by learning examples. This method could overcome some faults, such as long delay, and satisfy priority services.

Nogueira G. et al. (2008) proposed simple and careful analytical type to mobile cellular networks with QoS difference. QoS per applicative flow is usually defined in a GPRS system where running applications with real-time properties have to share radio resources. They also developed a generic QoS molding methodology in the context of GPRS network that could be adapted readily to several technologies. The model supplies the expecting adequacy and accuracy that are necessary for complex performance and dimensioning analyses. Its rapid computation allows not only the dimensioning of networks based on traffic load assumptions but also the fore modeling in an repeated dimensioning process.

Mallat Y. et al. (2011) discussed the application of various intelligent methods as a decision system support to authorize the calculation of key performance indicators (KPIs) and the evaluation of the state of the network. The problem of processing time for data volume makes it almost impossible for their analysis by a management system database classic. This study was based on some methods for restricting volume data after selecting some parameters to determine which of these methods could facilitate decision making with clear and simple data. The authors applied the Classification and Regression Tree method to improve performance by considering complexity, accuracy, and a low misclassification rate. This method achieved an optimal response to all patterns and found a favorable compromise among speed, accuracy, and error.

1.4 THE AIM OF THE THESIS

This thesis aims to integrate multi-agent systems (MASs) and P2P technology to create an intelligent P2P infrastructure. The main aims of this work are listed as follows:

First, this paper aims to improve throughput and reduce overhead traffic by localizing the data transfer process. This localization will reduce the total bit rate by reducing the paths and packet switching circuits that the data need to pass through before reaching their destination.

Second, this paper aims to reduce latency. Sending the entire service request across the network will eliminate the need to send queries outside the network, thereby reducing the amount of time needed to complete the task.

Third, this paper aims to increase reliability. The request from the mobile stations (MS; if available locally in the network) can be fulfilled without sending such request to the Internet.

Fourth, this paper aims to build a multi-agent distributed cache system integrated with q.

1.5 THESIS LAYOUT

This thesis is formed as follows:

Chapter One introduces the P2P network and describes QoS in mobile networks.

Chapter Two discusses the GSM network and presents an overview of GPRS networks, protocols, operations, QoS, handset software, and mobile device platforms.

Chapter Three discusses the development of MASs and the functionality of their components.

Chapter Four discusses the implementation of a MASs and all associated figures that are required to explain the implementation.

Chapter Five concludes the investigation on the proposed system and presents suggestions for future work.

2. GPRS MOBILE NETWORK

The wireless data service provide by GSM is established on circuit-switched radio transmission. On this detail, the whole traffic channel is appropriate for one user for the entire continuation of the client call. However, with burst influx (Internet influx), this allocation results in a highly disorganized resource usage. Packet-switched bearer services ensure very better usage of influx channels by allocating the channel just when desired and releasing it directly after the sending of packets. for solve the disorganization of circuit-switched radio transmission, GPRS is introduced as a novel cellular packet data technology that reuses the same GSM networks elements as much as possible. The standardization of GPRS primarily focuses on the development of services that can overcome the drawbacks of mobile Internet access over GSM networks.

This part of this chapter shows an overview of the GPRS network and its hardware components, protocols, operations, QoS, and handset. The second part discusses the GPRS software and the platforms for mobile device programming and agents.

2.1 GSM NETWORKS

The GSM is the bigger 2G cellular network that using circuit switched technology for the voice transmission. Unlike the first-generation network, a 2G network uses digital signals to transmit data. As shown in the Figure (2.1), a GSM network comprises several geographic areas, including units, Location Areas (LAs), Mobile Switching Center/Visitor Location Register (MSC/VLR) service areas, and Public Land Mobile Network (PLMN) areas. In cells, the radio coverage is provided by one Base Transceiver Station (BTS). The GSM network identifies each cell via their Cell Global Identity number. An LA comprises a group of cells where the subscriber will be paged. Every LA is served by one or more than one Base Station Controllers (BSCs) and a single MSC. Each LA is also appointed with an id number. An MSC/VLR service area is a reachable part of the GSM network that is wrapped by one MSC and is registered in the VLR of the MSC. The PLMN service area is work by one network operator.

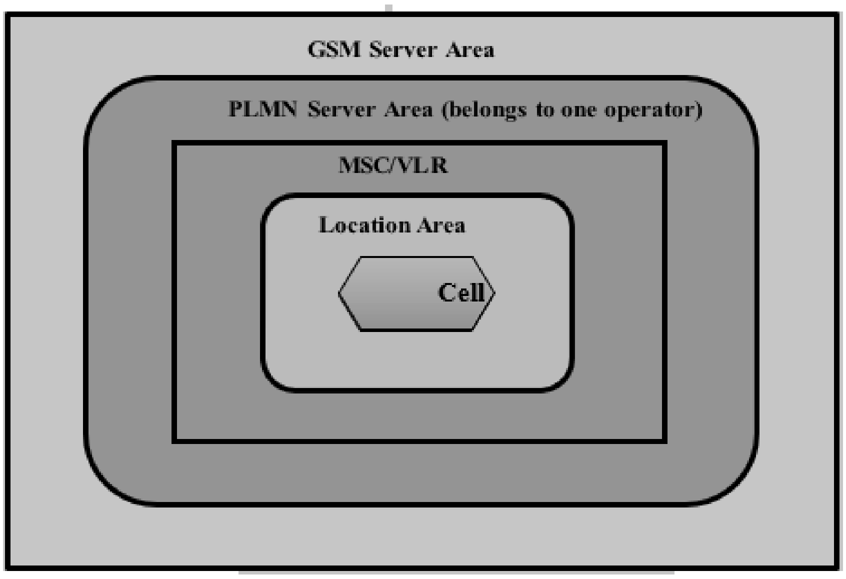


Figure 2.1 : GSM Network Areas

GSM employing a consolidation of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) schemes to connect to the radio channels. Through FDMA, the available frequency is divided into several channels with equal bandwidth as show in the Figure (2.2)A. Meanwhile, through TDMA, the frequency channel is divided into several time slots as shown in the Figure (2.2)B.

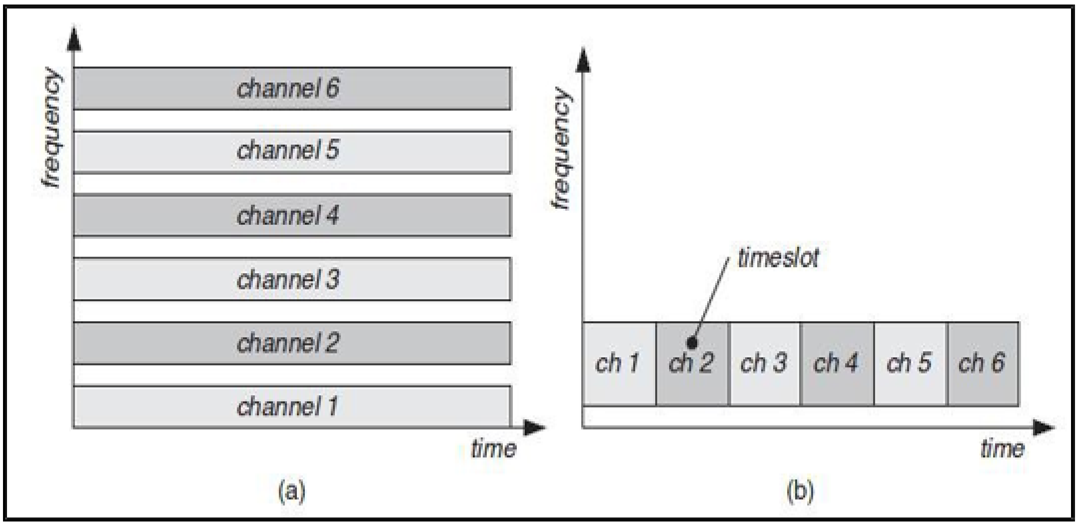


Figure 2.2 : FDMA and TDMA Schemes

Figure (2.3) shows how eight-time slots work. The first-time slot (time slot 0) starts broadcasting the system information by unit. This same time slot then transfers an SMS message to a single subscriber and provides a location restore for the new mobile that just entered the unit. The other time slots are can be used by users when they will make telephone calls (sound or data). The continuation of these time slots depends on the call .

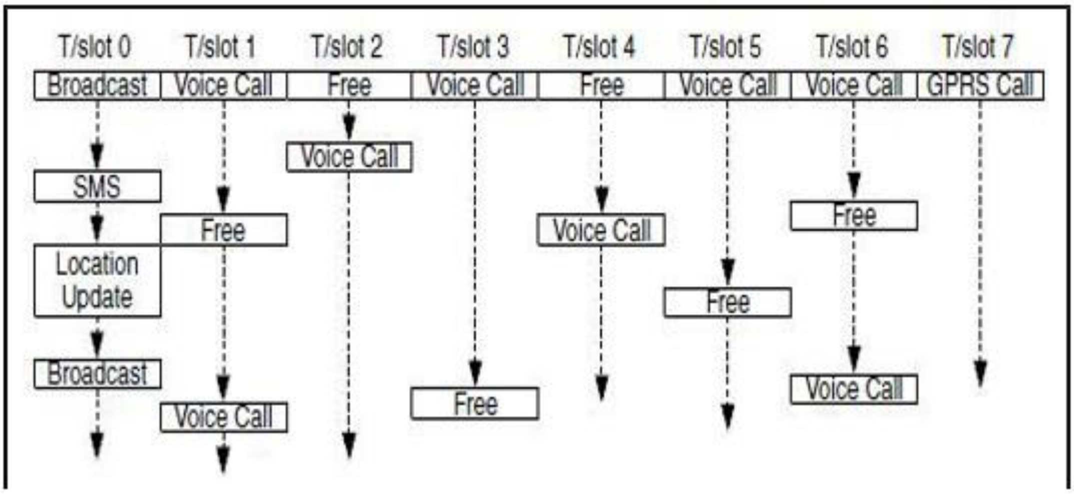


Figure 2.3 : Example Use of Time Slots

GSM is a radio-based cellular telephony system that uses the frequency bands 900, 1800, and 1900 MHz in this way, the operating area can be divided into cells, which are the smallest areas identifiable by the network. Few countries use the 900 MHz range, which is made up of two separate 25 MHz bands, namely, the 890 MHz to 915 MHz and 935 MHz to 960 MHz bands, where the former is used for uplink and the latter is used for the downlink. And these bands are further divided as 124 frequency channels that are separated by 200 KHz. The assigned spectrum of 200 KHz per channel is disjointed in time by use the fixed allocation or by applying the TDMA scheme. The time axis is disjointed into eight-time slots from time slot 0 to 7. However, these time slots only offer data communication rates of up to 9.6 kB/s, which are disorganized for variable bit rate the data transfers.

2.2 GSM INFRASTRUCTURE

The GSM network is collected of functional individuals. A simplified overview of GSM architecture is presented in Figure (2.4). A GSM system is divided into subsystems that are interconnected by using well-specified interfaces. These subsystems are further divided into the following network elements.

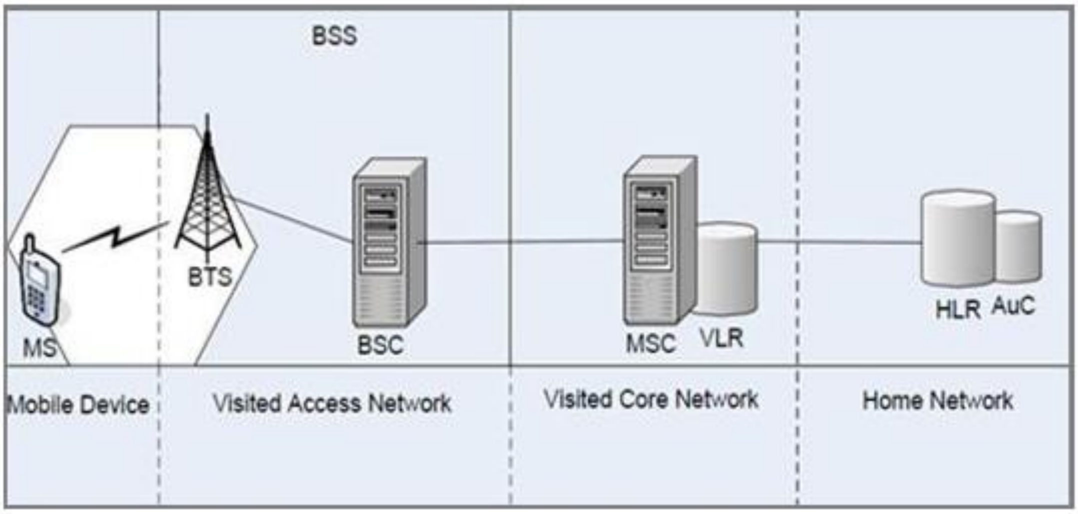


Figure 2.4: GSM Network

2.2.1 Mobile Station

MS allows users to deal with the mobile networks. This device dwell of two items, namely, Mobile Equipment (ME) and Subscribers Identity Module (SIM). An MS is a hardware of the mobile phone that needs to work with a GSM network on at least 1 frequency band. Each mobile phone is assigned by its manufacturer with a unique International Mobile Equipment Identity number, which allows for the identification of the device. SIM is a smart card that saves the International Mobile Subscriber Identity (IMSI) number of a GSM network subscriber.

2.2.2 Base Transceiver Station

The BTS is a radio equipment that sends and receives information by the radio interface to make the BSC to deal with MSs in its area. Groups of BTSs are controlled by one BSC. The BTS makes the speech encoding, encryption, multiplexing, and modulation/demodulation of the radio signals. This station usually comprises 1 to 16 transceivers depending on the needs in a particular location.

2.2.3 Base Station Controller

A BSC is the device who controls multiple BTSs and decides the radio channel allocation, frequency administration, power and signal measurements, and handovers of an MS from BTS to another (if both BTSs back to the same BSC).

2.2.4 Mobile Switching Center

The MSC serves as the main part of the GSM network that controls more than one BTSs and deals with other MSC stations. This center makes call routing, call setup, and basic switching functions as well as controling the handovers among several BSCs and MSCs.

2.2.5 Home Location Register

The Home Location Register (HLR) serves as the database of a subscriber that stores the phone number, mobile subscriber integrated services digital network numbers, IMSIs, current locations of MSs, roaming data, with a lot of other types of information.

2.2.6 Visitor Location Register

VLR it's the database that contains temporary information of all MSs in the area that are work with one MSC. The VLR is commonly achieved in the same node along with MSC.

2.2.7 Authentication Center

The Authentication Center (AuC) is the register who is reasonably part of the HLR. The AuC stores the authentication-specific data and secret key of a subscriber. This component also generates authentication parameters that are wanted in authentication and encryption, proves the identity of a subscriber, and provides conservation systems for SIM cards.

2.3 GPRS NETWORK

GPRS offers more efficient bandwidth utilization if we compare it with GSM by allotting the channels just when it's wanted and by deleting them directly after their use. GPRS also makes data services cheaper because the invoicing is based on the quantity of transmitted data rather than on the call time and negotiated QoS. GPRS and GSM networks are using the same infrastructure and the same radio resources. GPRS also try to use the original GSM network parts as much as it's can be.

To good make the packet-based mobile cellular network, the new networks items like, interfaces, and protocols that make packet traffic are wanted. Therefore, GPRS asks modifications to some network items. However, the integration of GPRS into GSM network requires to add two GPRS Supporting Nodes (GSNs) and some amendment to several existing nodes. These two GSNs, first one called Serving GSN (SGSN) and the second called Gateway GSN (GGSN), form the core of a GPRS network and enable end-to-end packet transfer as shown in the Figure (2.5).

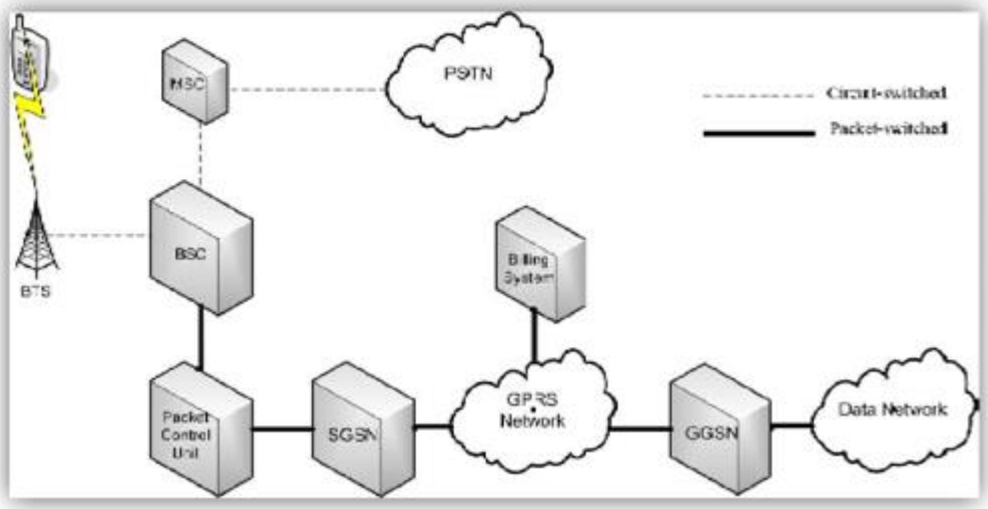


Figure 2.5 : GPRS Network

The SGSN routes packets to and from terminals inside its service area and deal with HLR to get the GPRS user profile. SGSN also stores the location of mobile users in addition to the performing mobility management, link management, security, and authentication.

Meanwhile, the GGSN work as a logical interface to the external PDNs, like the Internet. This node switches the GPRS packets which it's come from the SGSN to the appropriate Packet Data Protocol (PDP) format "like IP" before sending it out to the corresponding external network. The PDP address of the incoming data packets it's switched into the GSM address of the targeted client. The readdressed packets are then sent to the answerable SGSN. For that, the GGSN save the current SGSN addresses and the profiles of registered clients in its area register. Some existing GSM network elements must also be upgrade to support packet data.

A Base Station Subsystem is composed of BTS and BSC systems that need to be upgrade to recognize and send packet data. The BTS also needs to be upgraded to allow the transportation of user data to the SGSN. A new functional component, called Packet Control Unit, is also added to the BSS in the GPRS standard to help the handling of data packets. HLR needs to be enhanced to register the profiles of GPRS users and to respond to queries from GSNs regarding these profiles. The MS for GPRS differs from that for GSM.

2.3.1 The GPRS Protocol Architecture

The transmission plane has a layered protocol structure that allows the transfer, of user data as well as several linked steps that rule the information carry, such as flow control, error detection, and error correction. Figure (2.6) clarify the layered protocol build between MS and GGSN.

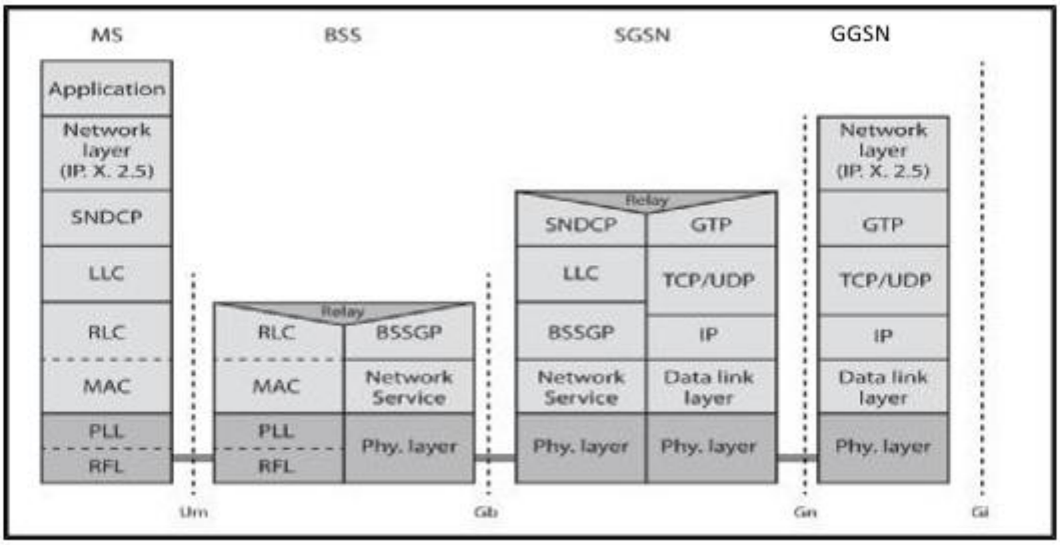


Figure 2.6: GPRS Protocol Architecture

GPRS Backbone

The GPRS backbone includes the transmission plan between SGSN and GGSN as well as the following protocols:

•Network Layer: GPRS supports two types of packets, namely, IP and X.25, which are transmitted and encapsulated within the GPRS backbone network.

•GPRS Tunneling Protocol (GTP): The GTP tunnels the user data and signaling among GGSNs in the GPRS backbone network.

•Transmission Control Protocol (TCP) and User Datagram Protocol (UDP): TCP and UCP carry GTP PDUs in the GPRS backbone network for those protocols that require and don't require a reliable data link, respectively. TCP also afford flow control and conservation to not lost GTP PDUs, while UDP affords protect from corrupted GTP PDUs.

•Internet Protocol (IP): The IP serves as the GPRS backbone network protocol that is using for routing client data and control signaling.

BSS-SGSN Interface

The BSS and SGSN interface is divided into the following layers:

•Sub-Network-Dependent Convergence Protocol (SNDCP): The SNDCP is used to transfer packets from the MSs to their corresponding SGSNs. Its process contains multiplexing the network layer messages on one virtual probable contact of the fundamental logical link control (LLC) layer, segmenting the network layer packets on one frame of the fundamental LLC layer, reassembling the receiver client, and compressing the user data.

•LLC: The LLC layer is giving a good reliable ciphered logical link and is liberated of the fundamental radio interface protocols to admit the introduction of alternative GPRS radio solutions.

•Base Station System GPRS Protocol (BSSGP): The BSSGP layer conveys routing and QoS-related information from and to BSS and SGSN.

•Network Service (NS): The NS layer transports BSSGP PDUs and is based on a frame relay relation between BSS and SGSN.

Air Interface

The air interface of a GPRS comprises the physical and link layer.

Data Link Layer

The data link layer between the MS and BSS is divided into the following sublayers:

• LLC: The LLC layer provides a reliable link between an MS and its SGSN.

•Radio Link Control (RLC)/Medium Access Control (MAC): The RLC function provides a radio-solution-dependent reliable link, while the MAC function controls the access signaling procedures for the radio channel and the mapping of LLC frames onto the physical layer.

Physical Layer

The physical layer between MS and BSS is divided into the following sublayers:

•Radio Frequency Layer (RFL): The physical RFL performs the modulation/demodulation of the input signal, interleaving, and congestion detection.

•Physical Link Layer (PLL): The PLL provides services that are required for transferring information over the air interface. This layer can also support multiple MSs that share the same physical channel.

2.3.2 GPRS Mobility Management

Main duty of mobility management it's the tracking of the current location of a user. The MS sends a location update message to the SGSN in order to alert the network about its current location. GPRS mobility management has three states, with each state having a different location information.

The MS enters the READY state by performing GPRS attach. When the MS does not send any packet for a long time till the READY timer it's will be expired, the MS enters the STANDBY state. Given that data can only be transmitted if the MS is in the READY state, the MS in the STANDBY state can change to the READY state if a PDU transmission occurs. also, if GPRS detach is performed in the READY state, the MS returns to the IDLE state and all PDP contexts will be removed. The GPRS state model it's show in Figure (2.7).

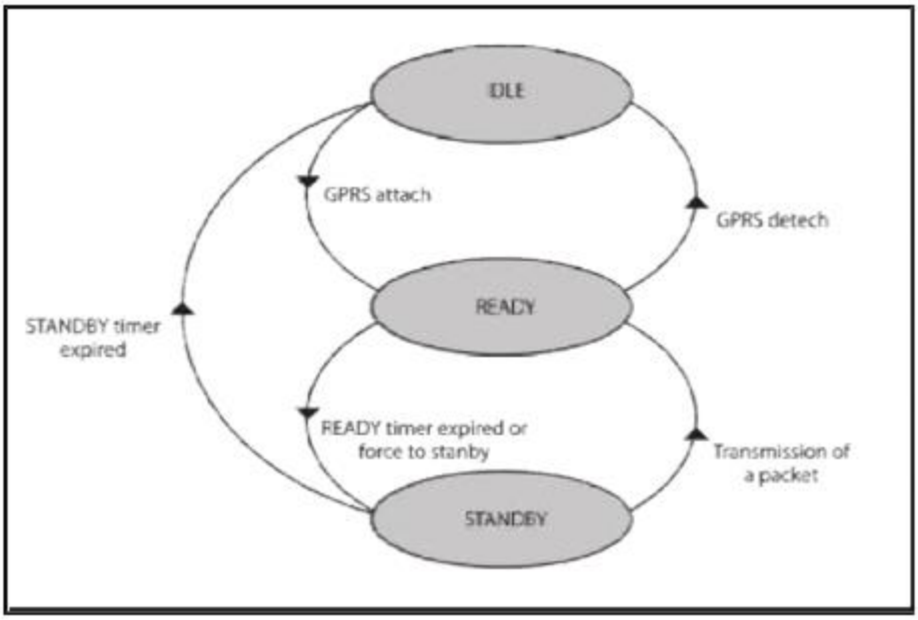


Figure 2.7 : State Model of a GPRS MS

The MS seldom sends a location update message in the STANDBY state. Therefore, its locations aren't exactly known and paging must be performed for each downlink packet, which only results in a significant delivery delay. In the READY state, the MS frequently updates its location.

Therefore, the location of the MS is precisely known and no paging delay occurs during the delivery of downlink packet. However, this process consumes much of the uplink radio capacity and battery life of the MS.

2.3.3 GPRS Session Management

Here we aim to backing the PDP context care of the client terminal. After done attaching the MS, a PDP context is built to characterize the session. To change a packet with external PDNs, an MS should apply for one or more than one addresses being used in the PDN. These address is called PDP address (or IP addresses in case of IP networks), and each address is defined by one or more PDP contexts in the MS or the network.

A. GPRS Attach and Detach Procedures Before using GPRS services, an MS must register with an SGSN of the GPRS network. The network then sees if the user is approved to use the service; if so, the network duplicates client profile from the HLR to the SGSN and then attach a packet temporary mobile subscriber identity to the client. This procedure's name is GPRS attach. Combined GPRS/IMSI procedures can be performed for MSs that use together circuit switched and packet switched services. The process of disconnecting from the GPRS network it's named GPRS detach, which can be proposed by either the MS or the network (SGSN or HLR).

B. PDP Context Activation and Deactivation Procedures

To interchange data packets with outer PDNs after a effective GPRS attach, an MS should stratify for one or extra PDP addresses. The creation of a PDP context is illustrated in Figure (2.8). A PDP context is formed to identify each session. This context contains the PDP type (e.g., IPv4), the PDP address assigned to the MS, the ordered QoS, and the address of the GGSN that serves as the access point to the PDN. This context is stocked in the MS, SGSN, and GGSN. With an strong PDP context, the MS becomes visual to the external PDN and can send and receive data packets. The mapping between these addresses, namely, PDP and IMSI, enables the GGSN to carry data packets between PDN and MS. A user can have sundry active PDP contexts at a given time. PDP context deactivation may also be performed to cancel an existing PDP context between the MS and the network. After canceling this context, data transfer is no longer possible.

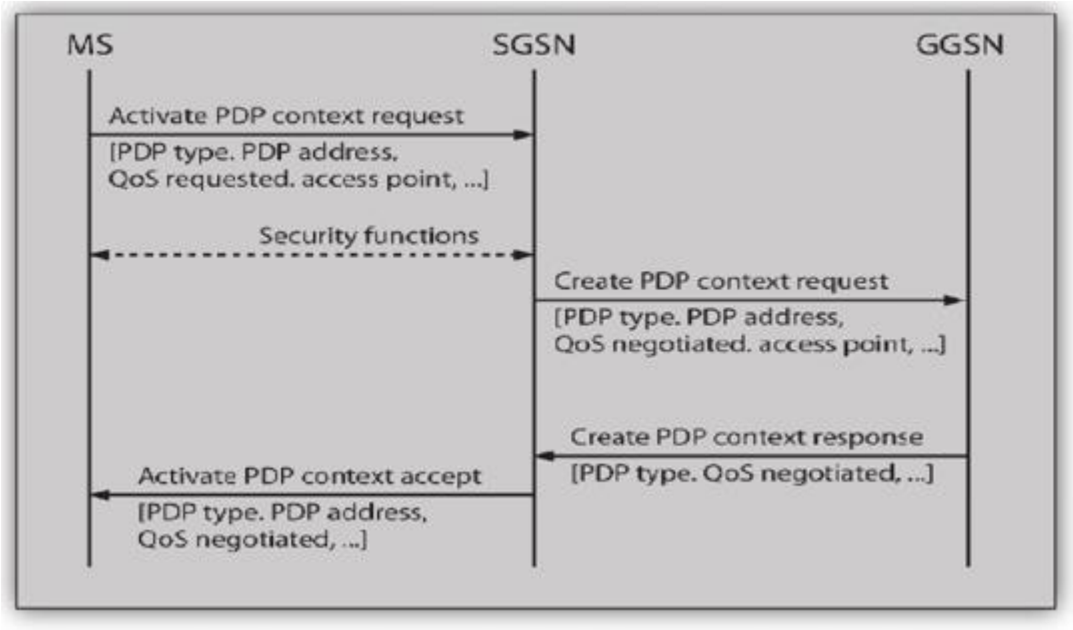


Figure 2.8 : PDU Context Activation

2.4 QOS IN GPRS NETWORKS

The QoS in cellular networks refers to the capability of cellular service operators to provide satisfactory services, such as voice quality, signal strength, low call blocking and dropping probabilities, and high data rates for multimedia and data applications. User satisfaction depends on certain propagation parameters, such as call admission, connection quality, and handover success. A network cannot satisfy all of its customers at low loads, and some of these customers may be dissatisfied as a result of signal outage and high interference.

2.4.1 QoS Requirements for GPRS

Typical mobile packet data applications have very diverse QoS requirements. Therefore, the support of different QoS classes, which can be specified for each individual session, is an important feature. In GPRS, a specific QoS profile is assigned to each subscriber upon attaching himself/herself to the network. As shown in Figure (2.9), the QoS profile Information Element consists of an information element identifier, a length field, five fields that contain the values of GPRS service classes, and three fields that are filled with spare bits.

A QoS profile defines the QoS within the range of the following service classes:

1-Precedence class: This class indicates the relative importance of maintaining service commitments under abnormal conditions, such as in the case of identifying which packets must be discarded when faced with certain problems, including limited resources or network congestion. Three precedence levels are defined, namely, low, medium, and high.

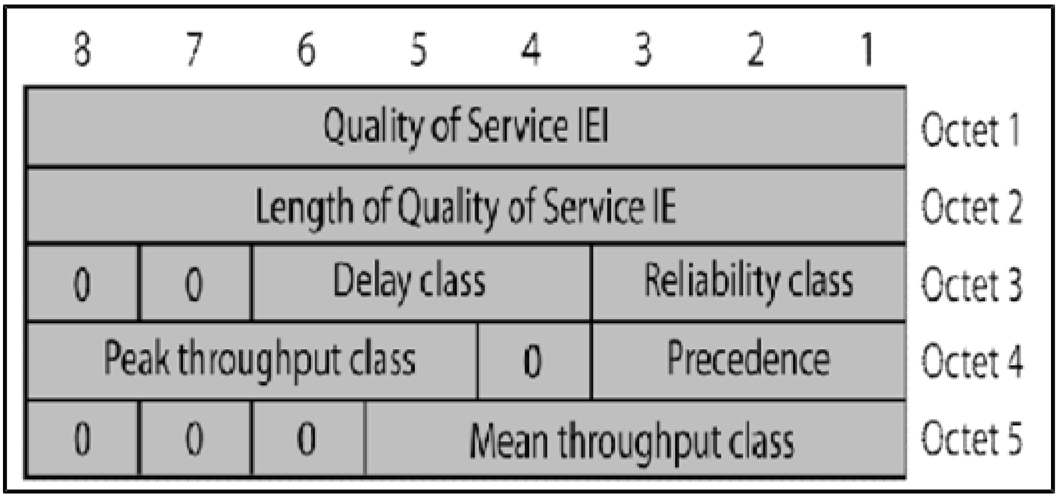


Figure 2.9 : QoS Profile Information Element

2.Delay class: Latency refers to the time spent by data packets to go in the GPRS agent and return to their original positions, while jitter refers to the variability in the time spent by these packets to complete a round trip. Several factors in GPRS contribute to the overall latency, including MS, radio resource procedures, effective data throughput, and GPRS core network nodes. Different types of end to end transfer delays occur during the transmission of PDUs across the GPRS network. These delays include radio channel access (on uplink), scheduling (on downlink), and transit delays (on uplink and/or downlink paths) as well as the GPRS-network transit delay (for multiple hops) but exclude the transfer delays occurring in external networks.

3.Reliability class: Data services generally need a small residual bit error rate. Erroneous data are often futile, and incorrectly received speech just takes to a poor perception. The reliability of data transmission is defined within the scope of the following cases:

•Probabilities of data loss,

•Probabilities of link frailer,

•Probabilities of out-of-sequence data delivery,

•Probabilities of multiple data deliveries, and

•Probabilities of erroneous data.

The reliability class not only specifies the requirements for the services of each layer by combining different types of operation of GPRS-specific protocols (e.g., GTP, LLC, and RLC) but also supports the reliability necessities of various applications (real time or non-real time).

4. Peak throughput class: This class puts the farthest rate (byte/second) at which data are foreseeable to be transferred across the network. Achieving or sustaining this peak rate for any period cannot be guaranteed and greatly depends on the power of MS and the available radio resources. The network can limit the user to a treated peak data rate even if additional sending spaces are available.

5.Mean throughput class: This class specifies the average rate (byte/second) at which data are expected to be sent by the GPRS network.

The GPRS QoS profile can be wanted by the mobile client during the PDP context activation phase or, in case there is no profile wanted, a default profile is assigned to the client upon its subscription. This default QoS profile is defined in the HLR along with another user information. The SGSN is responsible for fulfilling the QoS profile ask of the MS. After activating a certain profile, the MS cannot apply any modification as long as the current profile remains work. If the MS wants to adjust its QoS profile, then the MS should detach itself from the network and then re-attach itself by specifying a new QoS profile. Meanwhile, the SGSN can edit an active QoS profile every time rely on the network capacity and the available resources. Although a QoS profile is realized, the profile not differentiate the curing of data flows within the core GPRS network (i.e., between the SGSN and GGSN). All flows within the network are treated uniformly (best effort IP), and the mentioned QoS parameters are used to allocate resources outside the core network. Thus, after activating a specific QoS profile, the MS is responsible for manging the traffic to the negotiated QoS, while the GGSN is responsible for record the data flows to the MS based on its QoS profile.

2.4.2 Composition Rules of QoS Metrics

The path pick algorithm has a certain level of complication that depends on assorted aspects. Given that applications generate traffic and have very differing QoS requirements, the path pick algorithm should select those paths that content a set of conditions.

However, the path selection process has a high computational complication that depends on the rules of metrics composition. The value of a metric along a path is computed based on the nature (i.e., additive or multiplicative) and worth of this metric in each hop.

In additive metrics formation, the value of a metric along a path is computed as the total of values in hop. Lag and number of hops are some examples of additive metrics. Meanwhile, in multiplicative metrics composition, the value of a metric along a path is computed as the product of values in each hop similar to the case of losses. QoS metrics play a very important role in guaranteeing an excellent QoS. Therefore, these metrics must be selected carefully.

2.4.3 Traffic Flow Template

The Traffic Flow Template (TFT), also called an Application Template, comprises a series of filters that ensure that the traffic for a particular application does not share a connection with any other traffic.

A TFT consists of up to eight packet filters which its allow traffic that it's the same filters to be routed on a certain PDP context, and given a different QoS to traffic on other PDP contexts. When incoming data come to the terminal, a packet classifier chooses a PDP context based on the TFT and maps the incoming data packets to the right PDP context with fixed QoS attributes. By this, multiple PDP contexts (named secondary PDP contexts) can be linked with the same PDP address (set by the primary PDP context).

The TFT filters are used by the GGSN in the core network and by the terminal to discriminate different user payloads. By using packet filters, the GGSN allocate the incoming datagrams into the right PDP context.

2.4.4 Performance of QoS Routing in a Communication Network

Routing refers to the movement of information moving in network from its source to its goal(s). Therefore, the performance of QoS routing can be measured based on the movement of information moving in network from its source to its goal(s) while considering QoS requirements in order to enhance the satisfaction of customers and further optimize the usage of network resources.

QoS routing presents a key issue in supporting the QoS in communication networks. This process not only involves the selection of a path through which data are transmitted from their source to their destination(s) but also aims to satisfy constraints or optimize requirements. QoS routing often has one or more design goals. When performing QoS routing, the following concepts must be distinguished:

A.- The routing information, which includes the information about the topology and link states of the network.

B - The routing algorithm, which is usually employed to make a routing decision. This algorithm finds a feasible path for a new connection (or an existing path in case of handover or link failure problems) based on the collected information.

2.4.5 Maintenance of Quality

Maintaining QoS often entails many difficulties, especially in mobile networks. Given that QoS is mainly judged by users, such quality must be maintained from the perspective of customers. Many factors affect the QoS of a mobile network, and users often employ the following standard metrics when rating such quality:

1.Coverage: The signal strength in a certain coverage is measured by using test equipment, which can also be used to estimate the size of the cell.

2.Accessibility: Accessibility refers to the ability of establishing a communication link with the cellular network. This metric is often measured by dividing the number of times the phone or data card successfully connects to the network by the total number of attempts.

3.Audio quality: For a certain period, a successful call is monitored to measure the clarity of the communication channel.

The above indicators help the telecommunication industry in measuring the QoS of a network.

2.5 GPRS HANDSET

GPRS devices can be classified into classes (A), (B), and (C).

1.Class (A) mobile devices it's support connection in circuit switched and packet switched modes simultaneously. When idle, these devices can also detect an incoming call in both modes.

2.Class (B) mobile devices it's adjust an incoming call in the circuit- and packet-switched modes when idle but cannot work jointly. Circuit and packet calls are performed one by one. In some organizing specified by the client, a GPRS communication can be pending to allow a communication in the circuit-switched mode and may be resumed after the communication release in the circuit-switched mode.

3.Class (C) mobile devices support communication in either the circuit- or packet-switched mode but cannot simultaneously support communications in both modes. However, when idle, these devices are incapable of simultaneously detecting incoming calls in both circuit- and packet-switched modes. Thus, a class (C) mobile device must be manually (by the user) or automatically (by an application) configured in either mode.

2.6 MOBILE AGENT SOFTWARE

Mobile agents are used in many applications to perform certain tasks on behalf of the user under given instructions. These agents travel from one host to another, can communicate with other agents and systems even when performing their tasks at a remote location, and move within a heterogeneous network. They can be used for performing multi-processor calculations and can work around the many limitations of low-reliability, partially disconnected, and wireless networks. These agents can also determine the structure of the network and routing paths among many other tasks.

An agent must possess the following attributes:

•Autonomy: Mobile agents must be able to perform their tasks without direct and continuous guidance from the user.

•Learning: Mobile agents must apply machine learning techniques to automatically construct a user profile and adapt their actions to the preferences of the user.

•Proactiveness: Mobile agents must be able to anticipate the needs of users and perform tasks that may be beneficial to them without being explicitly instructed to do so.

•Social ability: Mobile agents must keep in touch with other agents that provide information about any domain in which the user may be interested (i.e., restaurants, cinemas, tourist events, medical centers, etc.). They must also be able to request the information that the user needs and present such information in a friendly and personalized way.

Mobile agents aggregate data and codes as they move from one host to another. Upon arriving at its destination, the agent continues with execution where it stopped, thereby reducing the amount of network overhead by keeping the data in their original location and only moving them when they need to be processed. These agents are also used to implement flexible scalable distributed object-oriented systems.

A MAS comprises two or more mobile software agents and serves as a natural model for solving distributed problems. Monitoring and fault diagnosis is among the many application areas for agent-based systems. The autonomy, proactiveness, intelligence, and mobility of agents make an agent-based system an appropriate tool for meeting the reliability and flexibility needs of an application.

In MAS, the agents can interact with one another to find results or reach their goals. These agents share common information and may achieve their goal collaboratively. Cooperation, including coordination of action and resolution, is a general form of interaction among these agents. MAS is one of the latest generations of intelligent systems that are often used in AI, distributed systems, software development, computer communications, and other fields. These systems are also used to decompose a complex problem into simple sub-problems. The agents solve the assigned sub-problems and interact with one another to provide a global result. The key trait of MAS lies in the fact that its agents can make autonomous decisions.

2.7 PROGRAMMING PLATFORMS FOR MOBILE DEVICES

The wireless mobile network system with a cellular framework make support to the mobile terminals that run programs suitable for GPRS. Anticipating that future 3G mobile devices will integrate a larger number of features, Sun Microsystems has selected Java 2 Micro Edition (J2ME) as their platform for such devices. Some GPRS devices support a mobile execution environment and facilitate the development of client applications that can be operated on these devices. The operation execution environments of these devices are also supported by J2ME, which provides a transported program situation for customers and embedded systems, inclusive mobile devices. A client with a J2ME mobile device able to download programs from an open network and use them on the device.

Given its many benefits, including safety, cross-platform accepting, object-oriented the programming languages, and all-around support from the builder community, Java presents an ideal norm program development language for wireless tool. Standardization is necessary to warranty the interoperability between the needs and capacity of mobile devices.

As clarified in Figure (2.10), J2ME is split into configurations, profiles, and elective APIs to set the Java running time environment. Configurations are device familiarized and supply a minimal group of lineaments that must be supported by all covered devices. These configurations, including Java virtual machine, core libraries, standard classes, and APIs, are designed for specific devices depending on their memory constraints and processing power. Two configurations are defined for this paper, namely, the Connected Device Configuration (CDC) and the J2ME Connected Limited Device Configuration (CLDC).

2.7.1 J2ME Configurations

CDC covers those devices by a huge range of client interface capability, 2 MB to 16 MB memories, big bandwidth, and make network connectedness. Set-top boxes, Internet TVs, and high-end communicators are among the many devices covered by CDC. Meanwhile, CLDC covers those devices by a very pure interface, low level memory (160 kB to 512 kB), not big screen size, low bandwidth, and intermittent network connection (mostly wireless). These devices generally include simple mobile phones, pagers, and personal organizers.

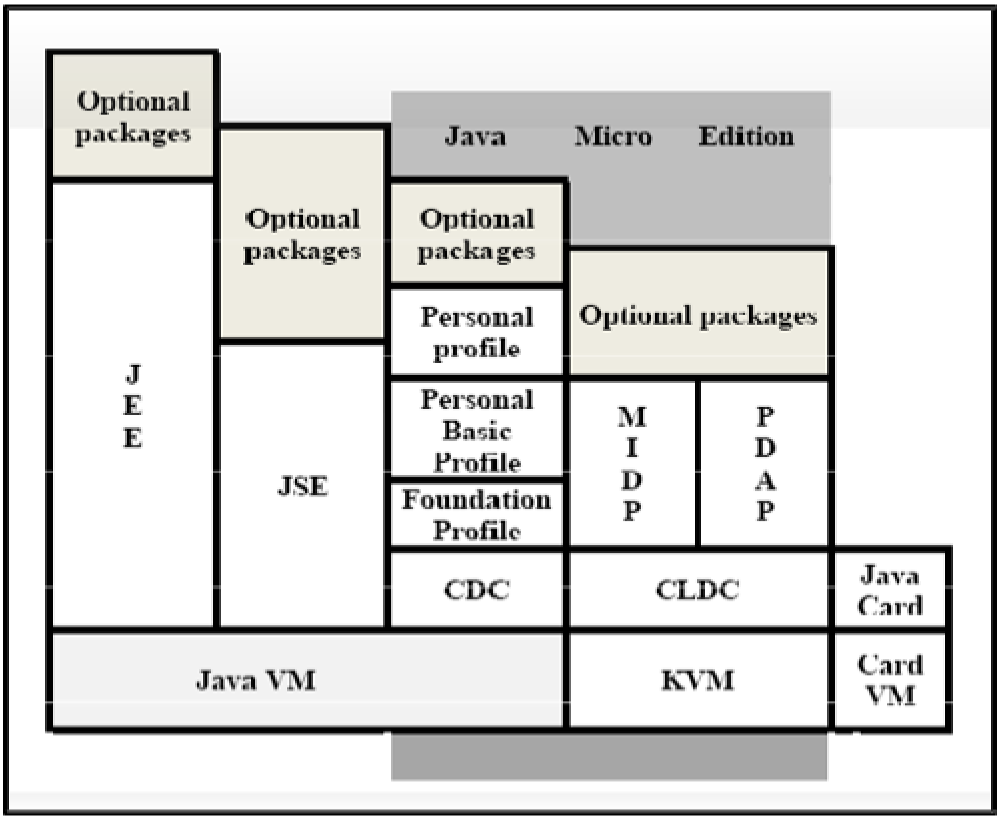


Figure 2.10 : Components of Java ME Technology

2.7.2 J2ME Profiles

The profile layers, which can be positioned on pinnacle of configurations, are utility oriented and offer APIs or libraries to develop packages for a sure circle of relatives of gadgets. those profiles guarantee the interoperability of a selected family of devices by means of defining a preferred Java platform for these devices. therefore, a utility is transportable to any device that helps a specific profile.

As proven in Figure (2.11), the main profiles constructed for CDC include the inspiration Profile (the base profile that does not assist person interface but caters to networking functions), non-public foundation Profile, far flung technique Invocation Profile, and game Profile. the 2 main profiles built for CLDC encompass the mobile information device Profile (MIDP) and the Personal Digital Assistant (PDA) profile, that is mainly built for palmtop devices.

MIDP applications are known as MIDlet, which might be Java applications that utilize the MIDP profile and CLDC. All MIDlets function beneath the manipulate of a Kilobyte virtual gadget, which in flip is controlled by way of the Application Management Software (AMS) of a device this is commonly furnished via its producer. AMS controls the complete utility lifecycle, including its installation, upgrade, version control, and elimination. A MIDlet is set up through deploying its class files to a device. those class documents are then packaged in a Java Archive (JAR) either as an unmarried utility or as a collection of MIDlets. An elective descriptor record called Java Application Descriptor (JAD) describes the contents of a JAR. A MIDlet can be deployed to a tool both by means of over the air downloading, USB, infrared or Bluetooth, serial cable, electronic mail and MMS, or MIDlet pre-deployment (i.e., putting the MIDlet suite installation package deal to a predefined folder in neighborhood media (user vicinity) or removable memory card).

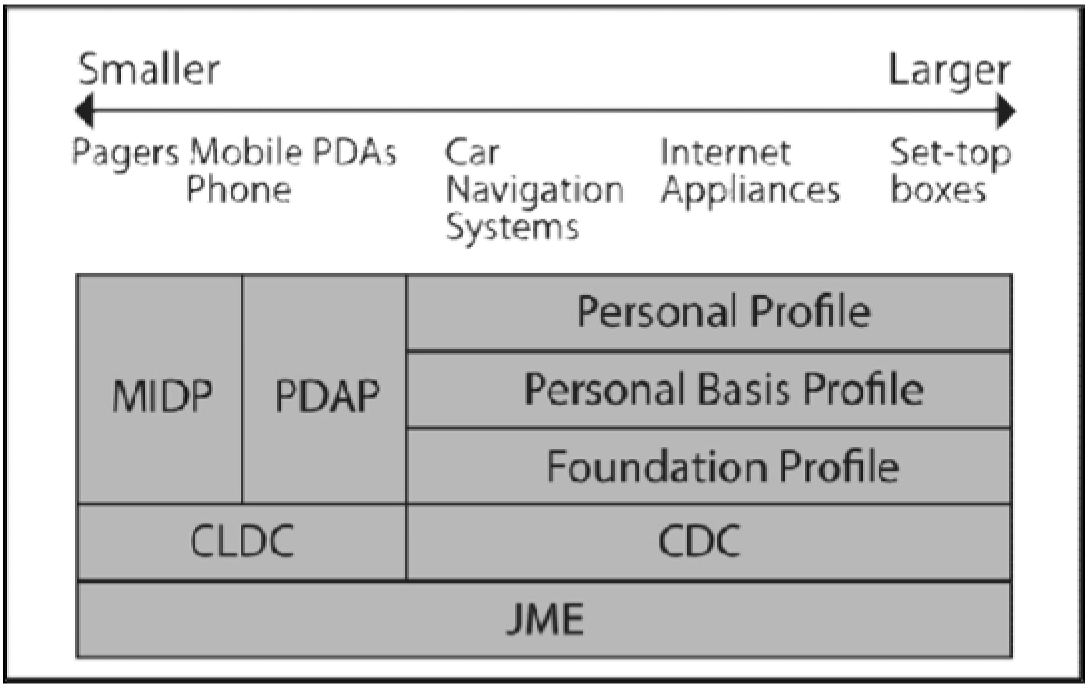


Figure 2.11 : The JME Universe

2.8 JADE AGENT PLATFORM FOR MOBILE DEVICES

The Java Agent Development Environment (JADE) is a software platform this is fully carried out in Java language. This platform simplifies the implementation of MAS thru its middleware-layer functionalities that comply with basis for sensible Platform seller's specs and through a hard and fast of graphical gear that guide the debugging and deployment stages. JADE retailers can speak with other marketers that observe the same popular. This agent platform may be disbursed across different machines irrespective of their operating systems, and the configuration can be controlled via a far flung Graphical user Interface (GUI). The configuration may be even modified at run time. The JADE platform is used to create P2P systems and to represent a Java framework for developing MAS. This platform aims to simplify the development of an interoperable sensible MAS while making sure widespread compliance through a comprehensive set of system offerings and agents. Lightweight Extensible Agent Platform (LEAP) is an extension of JADE that is designed to run on wireless devices, such as mobile phones, PDAs, and palmtops. This add-on replaces some parts of the JADE kernel to create a modified runtime environment that can be deployed on a wide range of devices, including servers and Java-enabled mobile phones. LEAP has the following modes of work that adapt to different circumstances:

•J2SE, which may use it at PCs and servers in a fixed network;

•J2ME CDC configuration (formerly called Personal Java), which able to use in handheld devices, such as PDAs; and

•J2ME CLDC/MIDP, which can run in devices that support MIDP1.0, such as mobile phones.

These three modes provide the identical API to developers, with MIDP showing a few minor variations from the opposite. Figure (2.12) suggests an example JADE-leap execution environment that includes a MAS with six dealers. Two of those retailers are strolling on the principle box of the platform, and this container connects with some other box on a pc that holds two other agents. those four agents can altogether talk wirelessly with agents that are running in mobile gadgets (one on a PDA and one on a cell smartphone), with each mobile tool having one box. those agents which might be jogging in mobile gadgets have to be capable of talk wirelessly with service-providing agents which are strolling in constant desktops.

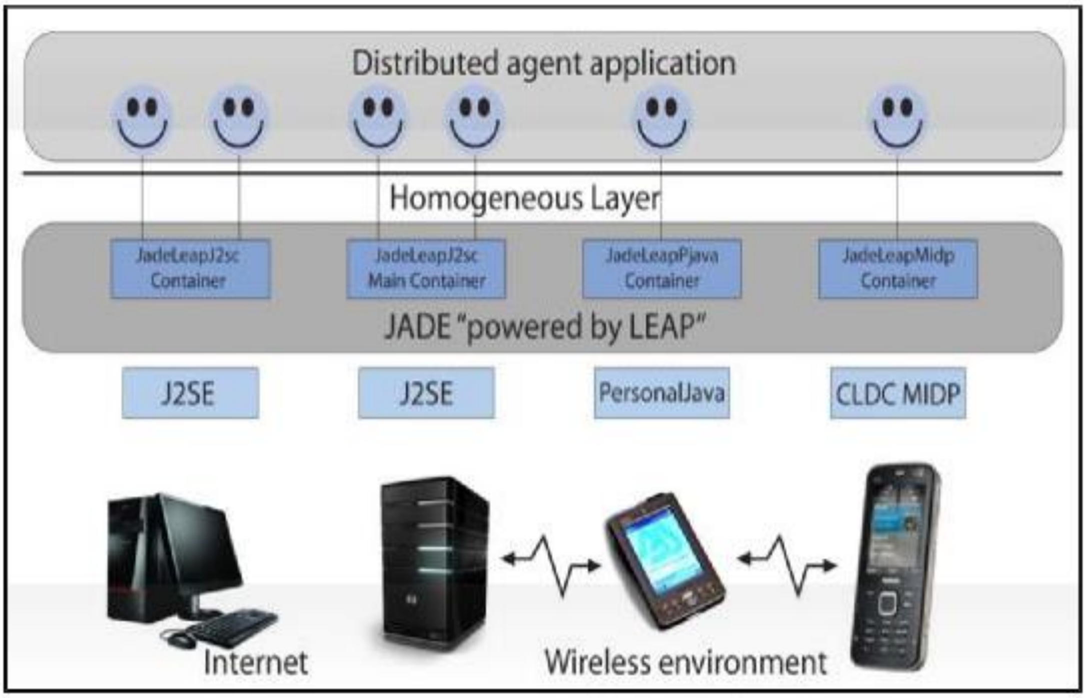


Figure 2.12 : The LEAP Execution Environment

JADE-LEAP run at a good communication level and establishes TCP/IP connections among containers without considering the physical means by which these connections are absolutely established. Accordingly, the application maker must chose a way to establish the connection.

3. DEVELOPMENT OF AN MAS OVER A GPRS NETWORK

This chapter discusses the proposed MAS, which aims to reduce the amount of payload in the GPRS backbone by relaying it to the smallest possible GPRS network zone sector. This chapter also identifies the components of the proposed system.

This chapter begins by presenting the proposed scheme, which merges the legacy architecture with the embedded proposed software components (Java agent). The functionalities of these components and their interaction with the whole GPRS environment are also discussed.

3.1 THE PROPOSED MAS

The proposed system is constructed based on the fact that mobile handsets can store a large amount of data ranging from kilobytes to gigabytes. The modern day mobile handsets operate in a programming environment that can support relatively complex programming techniques. The ultimate objective of this thesis is to build a multi-agent distributed cache system where all mobile devices voluntarily expose part of their memory as a part of the total cache system. The proposed MAS is a collection of agents that are built by using JADE, which is a very popular environment for developing MASs.

The software modules are built by using JADE with the LEAP extension, which is the most popular agent platform for small devices. JADE is an environment for developing J2SE and J2EE, but MSs demand a more suitable environment. Therefore, JADE-LEAP is installed to develop applications for the Java mobile edition, which is selected as the platform in this work due to its efficiency and wide usage.

J2ME brings the cross-platform functionality of the Java language to small devices, thereby allowing mobile wireless devices to share applications. Through J2ME, a Java platform is developed for consumer products that incorporate or are based on small computing devices. The proposed system comprises three main hardware components. Figure (3.1) shows three sensitive areas within the GPRS network architecture, namely, the mobile device (J2ME support), BSC, and GGSN.

Those Java agents that will be installed in each mobile device must coordinate the interaction among mobile devices by

1-establishing and terminating sessions among these devices;

2-indexing the contents of mobile devices; and

3- broadcasting requests and accepting replies.

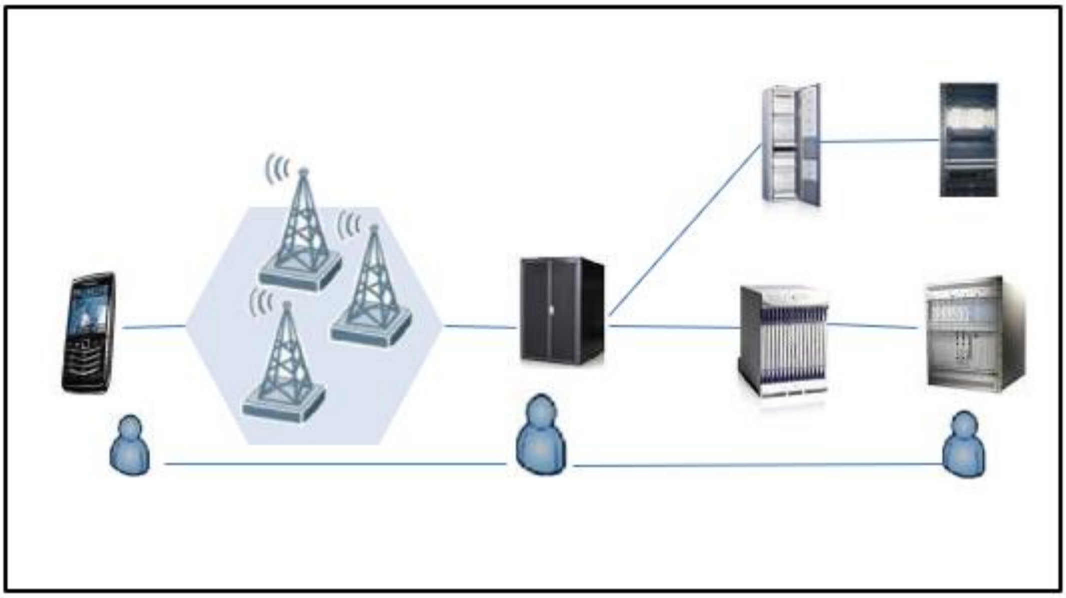


Figure 3.1 : GPRS Network with Distributed Agents

3.2 PROPOSED SYSTEM COMPONENTS

Three types of agents are built and three Java editions are used based on the hardware platform where this software will be installed. Figure (3.2) shows the main software components of the proposed system, where multiple software modules under various platforms are built by using different software technologies.

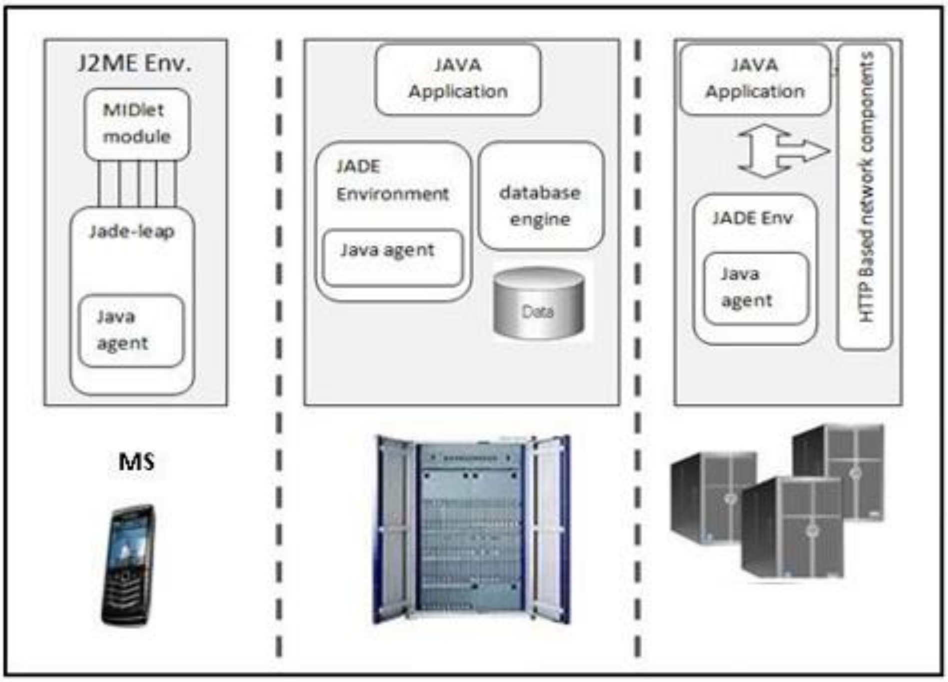


Figure 3.2 : Proposed Main Components and Platforms

3.2.1 BSC Agent

The BSC agent is designed as a Java program that plays a major role in the proposed system. Specifically, this agent implements the Request Analysis scheme to manage the distributed caches in mobile agents and to reduce the waiting time (WT) for implementing the Request Management scheme.

A database connection must also be established to support the BSC agent and guarantee an efficient access to the records stored in this agent. These records are stored in a relational database that appears the material being asked (URLs), the MSs that hold the instance of that material, and the time period. Figure (3.3) presents a flowchart of the Request Analysis scheme that is implemented by the BSC agent.

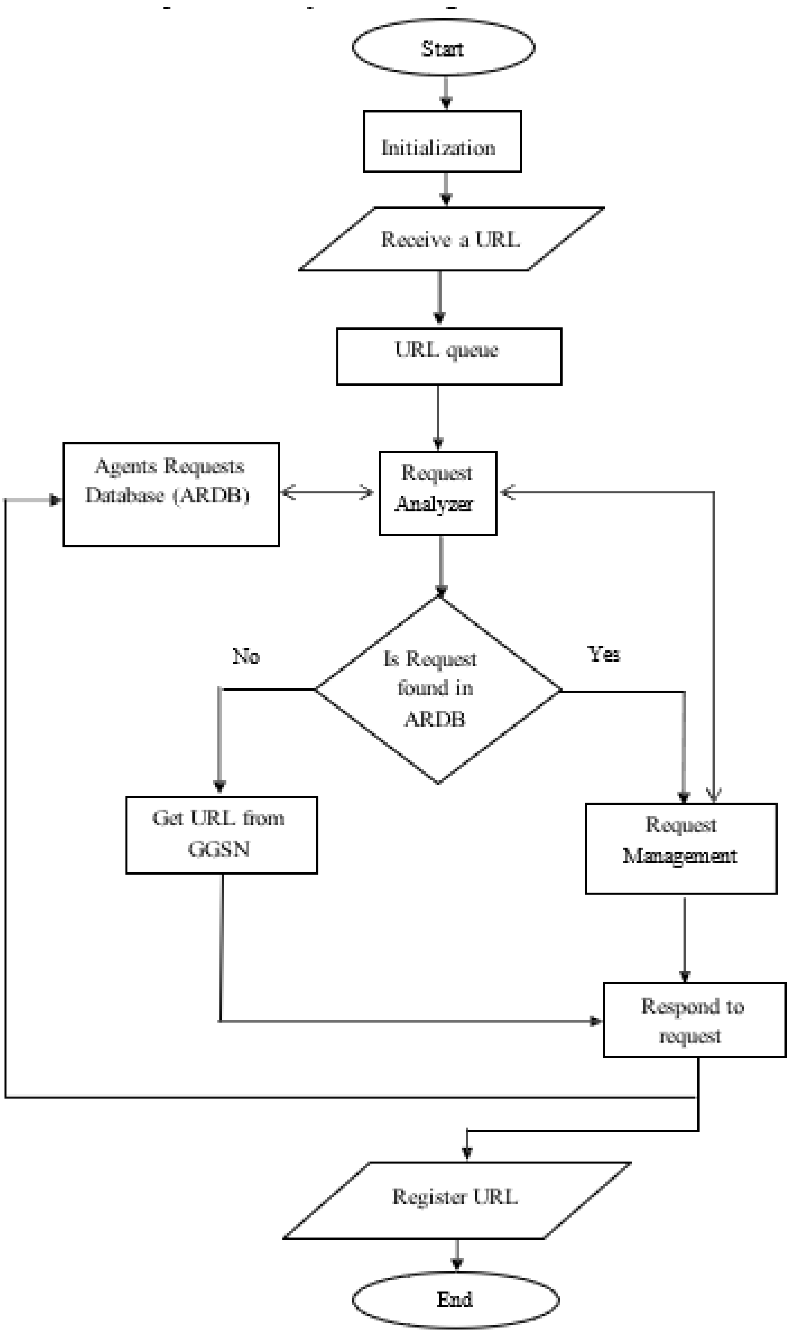


Figure 3.3 : Request Analysis Flowchart

The MS agent accepts requests for a URL and forwards them to the BSC agent, which will then process these requests by applying the Request Analysis scheme.

The entire process starts with a user who requests for a URL from his/her mobile device. This request is sent wirelessly to the BSC agent and is queued in a URL queue. The requests in this queue will be executed depending on the First in First Out scheduling. The BSC agent then searches for the mobile agent that has the requested URL. If the requested URL does exist, then the BSC agent obtains the related information from the agents' requests database and applies the Request Management scheme. Afterward, the BSC agent identifies the ID of the agent that owns the requested URL and sends this ID to the requesting agent. If the URL does not exist in the agents' requests database, then the request will be forwarded to the GGSN, which in turn routes this request to the public data network. The mobile agent receives the request from the GGSN agent and registers the URL to its requests database along with the ID of the requesting agent. The BSC agent then responds to the request by providing the IDs of those agents that own the requested URL.

•Request Management

Request Management is a part of the Request Analysis scheme that is applied after finding those agents that own the requested URLs. After these agents send their respective agent identifiers (AIDs), the BSC agent determines the number of agents that have the requested URL (denoted by (Z)). The BSC agent then asks the Request Analyzer for information about these agents and checks whether or not these agents are ready to serve the requests. The number of ready agents is denoted by (K). When (K) is larger than zero, this number is used to determine the number of agents that request for the same URL (denoted by (M)) as well as the minimum number (denoted by (N)) between (M) and (K). Figure (3.4) presents the Request Management flowchart.

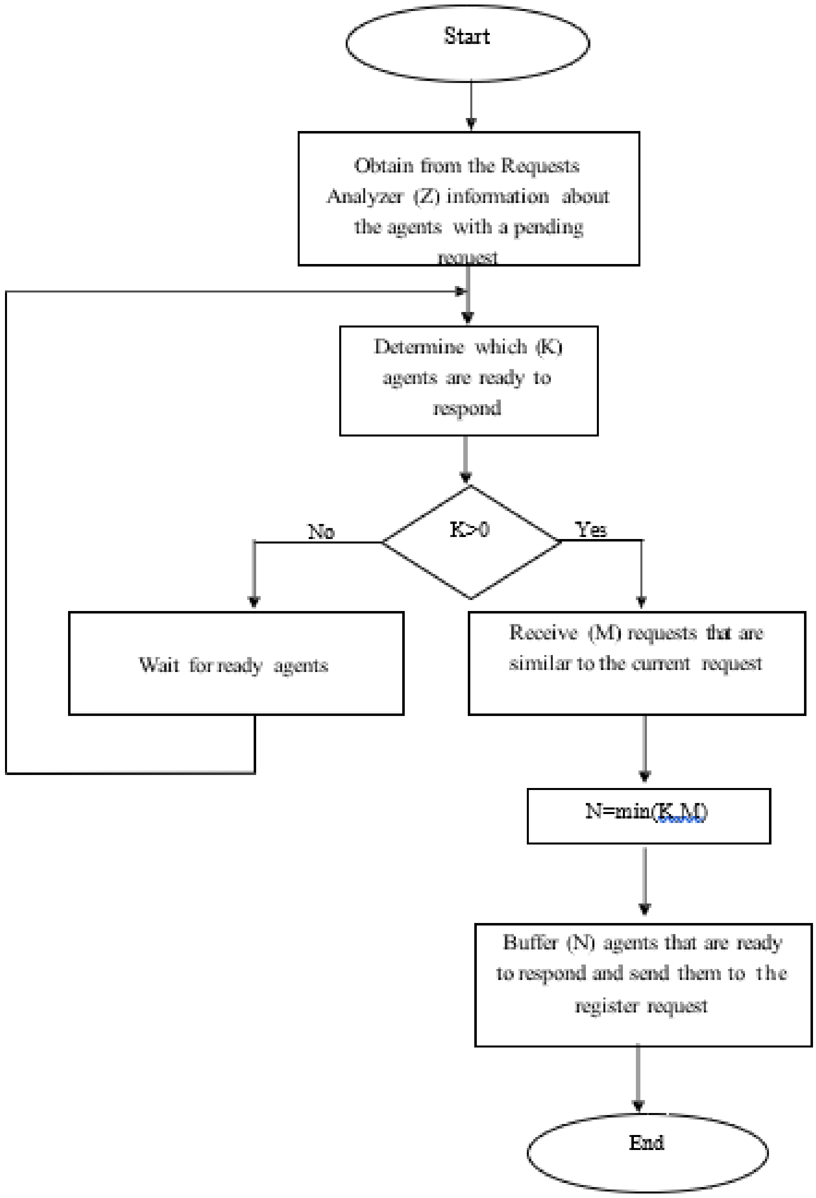


Figure 3.4 : Request Management Flowchart

The ready agents will respond to those agents that have requested for the same URL. The throughput of the system increases when many agents are responding to those agents that have requested the same URL. This procedure is much better than serving the requests one by one. Otherwise, an agent must wait for a non-busy agent to serve its request. Both the requests and the requesting agents will be registered in the agents' request database.

The above approach improves the performance of the system when many mobile users request for a URL at the same time; otherwise, only the first agent that receives the URL will serve all the other agents. To reduce WT, the number of agents who can respond to the requests of other agents is logarithmically increased, thereby reducing the amount of load placed upon the first agent.

Table (3.1) summarizes the performance of Request Management when seven agents request for the same URL. The first agent receives the request from the GGSN, while the other agents receive their requests from other mobile agents. Assume that transferring the same file from the mobile agent takes one minute.

Table 3.1 Summary of the Performance of Request Management

Requester	WT	Responder	Response time
Agent 1	-------	GGSN	--------
Agent 2	0	Agent 1	1
Agent 3	1	Agent 1	2
Agent 4	1	Agent 2	2
Agent 5	2	Agent 1	3
Agent 6	2	Agent 2	3
Agent 7	2	Agent 3	3

In P2P file sharing between mobile devices, agent 1 serves agent 2, and then both of these agents serve agents 3 and 4 that are requesting for the same URL. After receiving their responses, these four agents will altogether serve the remaining agents.

•Agent Request Database

The Request Analyzer is connected to a database that stores BSC records as shown in Figure (3.5).

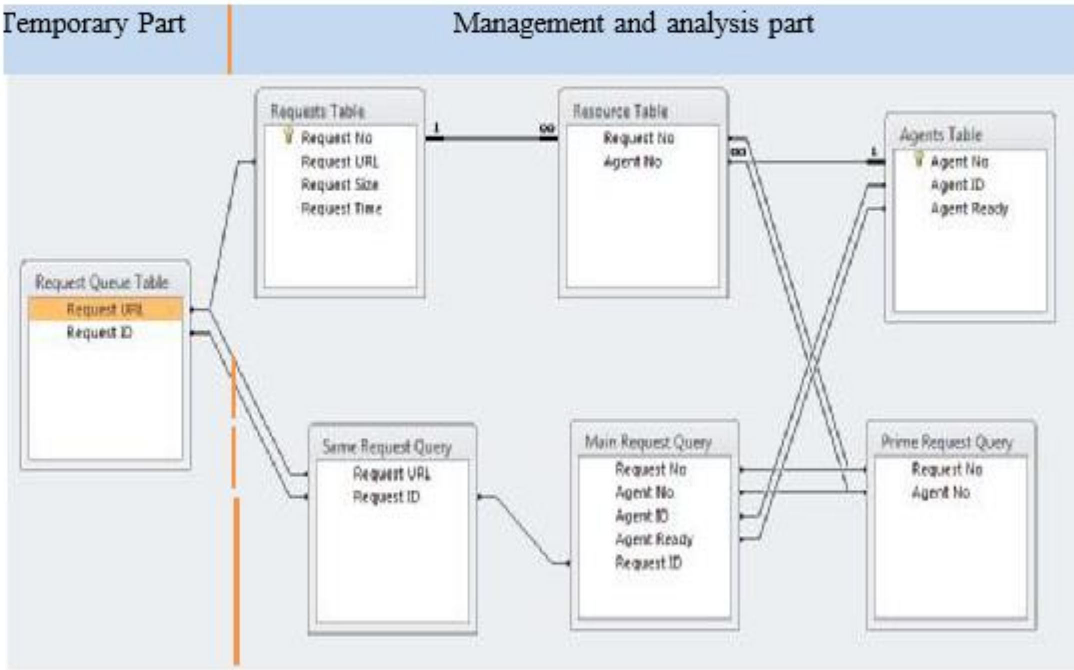


Figure 3.5 : Relational Database Managed in BSC

This database can be divided into the temporary registry part and the management and analysis part.

The temporary registry part is represented by the Request Queue Table, which accepts the requested URLs and contains the following fields:

a) request URL, which indicates the requested URL; and

b) request ID, which indicates the address of the agent that has requested for the URL.

The management and analysis part are represented by the following:

A - The request table, which contains the responded requests and the following fields:

1.request no., which is the primary key that identifies the URL;

2.request URL, which indicates the requested URL;

3.request time, which indicates the time stamp for the URL and determines its last usage; and

4.request size, which identifies the useful file size for the request analysis.

B - The resource table, which connects the previous two tables with many to many relationships through the primary keys. This table also specifies those agents that own the requested URL.

C - The agent table, which contains information about the agents and the following fields:

1.agent ID, which is a unique identifier for each agent;

2.agent no., which is the primary key for identifying each agent; and

3.agent ready, which indicates whether an agent is ready to serve the requests. This field takes a false value when the agent is currently serving the request of another agent and takes a true value when the agent is ready to serve a new request.

D - Prime request query, which specifies those agents that have the requested URL and denotes the number of these agents as (Z). This query contains the following fields:

1.request no., which is a unique identifier assigned to a URL; and

2.agent no., which is obtained from the resource table.

E - Main request query, which identifies those agents that can respond to the request (K) and contains the following fields:

1.request no., which is obtained from the prime request query and represents the current request.

2.agent no., which is obtained from the prime request query.

3.ready agents, which is obtained from the agent table. This field only selects the ready agents;

4.agent ID, which is obtained from the agent table; and

5.request ID, which is obtained from the same request query.

F - Same request query, which is used to determine the number of similar requests (M) that can be served and to find the addresses of agents that need to be served. This part contains the following fields:

1.request URL, which is obtained from the Request Queue Table; and.

2.request ID, which is also obtained from the Request Queue Table.

3.2.2 MS Agent

This software is installed in every MS comprises several software components, including Hello MIDlet, agent GUI, and agent GPRS. These components interact with one another to create the MS side of this system.

3.2.3 GGSN Agent

The agent setup in GGSN is a Java program that represents the point through which the GPRS domain is attached to external data networks (i.e., Internet) to emulate the real Internet. The mobile agents send their requests to the BSC agent, which responds with an Agent Communication Language (ACL) message that contains the IP of the gateway. Afterward, the mobile agents send their requests to the GGSN, which in turn responds with an ACL message that includes the content of the required URL.

3.3 BUILDING AGENT USING JADE

JADE is a Java library that is dedicated to the construction of a MAS. Therefore, JADE can be treated as a normal Java package that contains different classes. The traditional Java program can use this package without any restrictions. Written using Java, JADE is a fully object-oriented library due to the nature of its mother language.

Few considerations are observed during the implementation of the proposed system. These considerations enhance the overall performance of the system implementation and the debugging procedure. Some of these considerations are outlined as follows:

1.The entry point of the agent is the setup () method.

2.Java class represents a type of object.

3.JADE class represents a type of agent.

4.Agents interact by exchanging asynchronous messages instead of performing method calls.

5.The actual job that must be performed by an agent is typically carried out within “behaviours.”

6.The typical operations performed by an agent in its setup () method include

•presenting a GUI;

•establishing a connection to a database; and

•registering its provided services in the yellow pages catalog and starts the initial behaviours.

7.A class constructor is not used to start the initial agent behaviours due to the incomplete link to the JADE runtime library.

A Java agent passes through several states, and the transit between these states depends on the arrival of messages or events that urge the JADE environment to change the state of the agent.

Figure (3.7) shows the activation mechanism employed in the proposed system. In this mechanism, the behaviours usually enter a wait state after processing the incoming message. The *block* () method is also used to push the agent behaviour to a wait state.

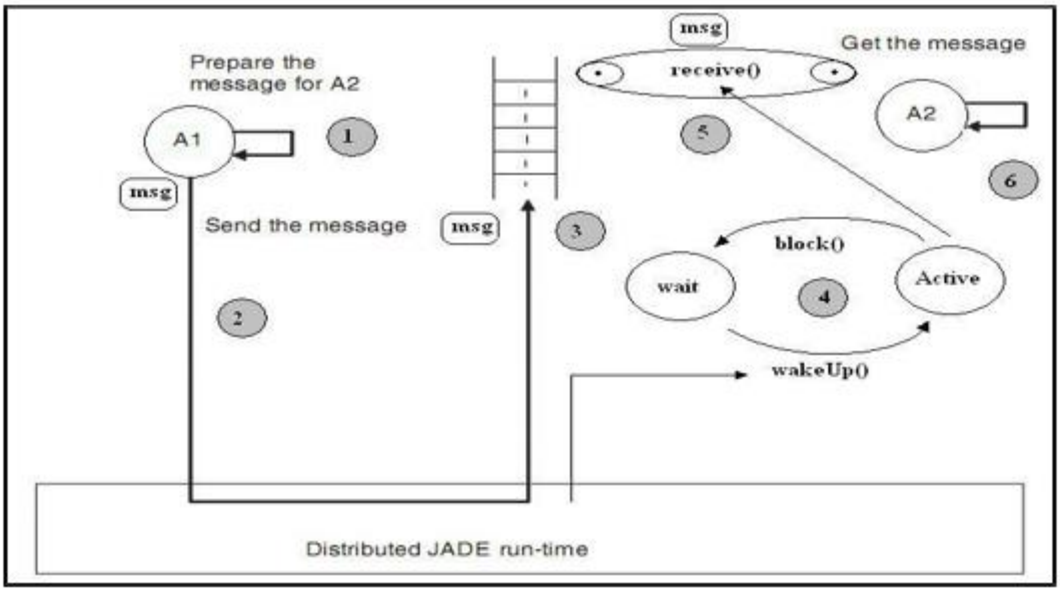


Figure 3.6 : An Agent Changing Its States upon the Arrival of a Message in a Private Queue

An agent will remain in the wait state until a message arrives in its private queue. Afterward, the JADE environment sends a wake message that moves the agent to the active state. The main processes of the agent are accomplished in special sections called behaviours, which handle the events that are initiated by JADE on the arriving message and changing states.

3.3.1 Agent Tasks

An agent performs its tasks within "behaviours," which might be implemented as gadgets of a category. To make an agent execute the undertaking applied through a behaviour item, the behaviour need to be introduced to the agent by using the use of the add Behaviour technique of the agent elegance. Behaviours can be introduced at any time while an agent starts within the setup () technique or inside other behaviours. every magnificence extending behaviour need to put into effect two abstract methods. First, the action () approach defines the operations to be executed while the behaviour is being executed. Second, the done () approach returns a Boolean fee that indicates whether or not a behaviour has been finished and wishes to be eliminated from the pool of behaviours which might be being performed by way of an agent. An agent ought to be capable of perform several concurrent responsibilities in reaction to one of a kind outside events. To decorate the performance of agent control, every JADE user is composed of a unmarried execution thread and all of its responsibilities are modeled and carried out as behaviour objects.

In a JADE environment, a behaviour is considered the super class of all agent behaviours. This thesis focuses on Parallel Behaviour and Cyclic Behaviour, which are illustrated in Figure (3.8). Given that Cyclic Behaviour should executed evermore, the done () method constantly returns a false value. Meanwhile, Parallel Behaviour is a composite behaviour that executes many objects concurrently. The object will be add with using the addSubBehaviour () method within the Parallel Behaviour class. Each behaviour will be executed in a separate thread, but JADE does not allow more than one execution thread at the same time. Rather, this library swaps behaviours as shown in Figure (3.9).

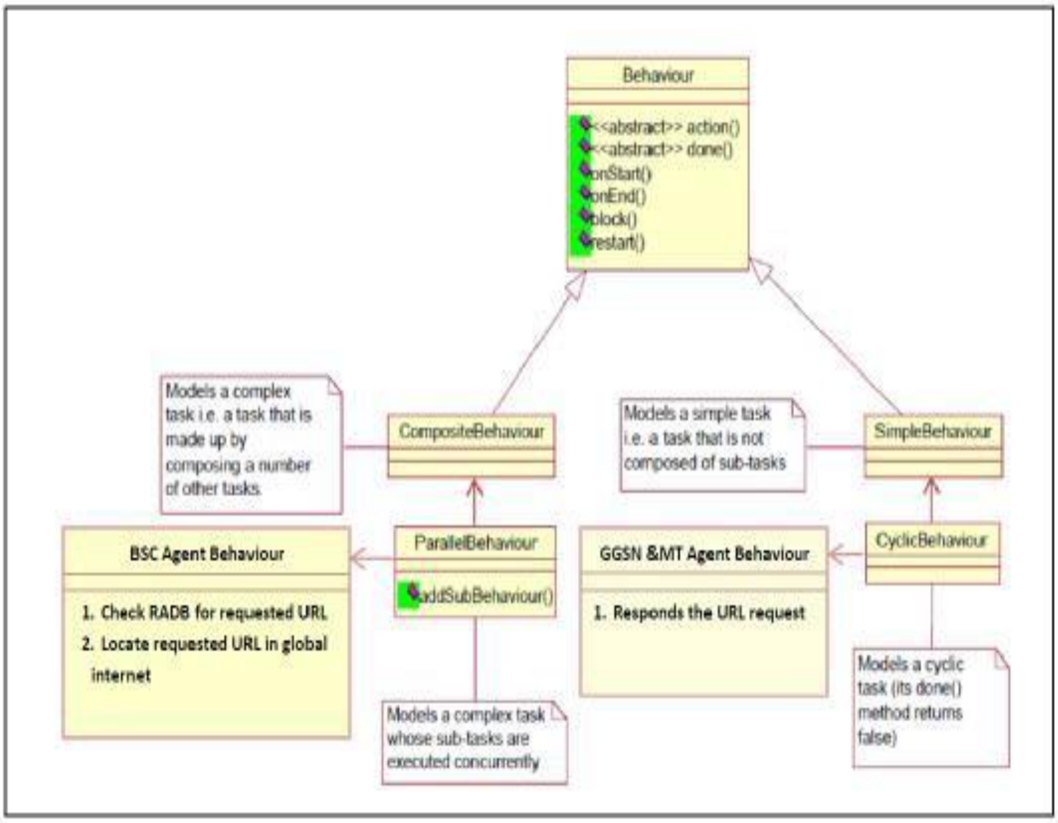


Figure 3.7 : An Agent Using Composite Behaviour to Accomplish Its Tasks

3.4 MS MIDLET MODULE

The operative part of the proposed system must be run on mobile phones. As we said in the previous chapters, a mobile phone is a computing device with limited resources. Java has a special edition called J2ME that can be operated in such an environment. This edition provides a Java Virtual Machine that allows developers to adapt Java applications to the mobile phone architecture. This thesis also uses such environment to build the mobile phone side of the proposed system.

Mobile phone application is an MIDP where Java is divided into configurations, profiles, and optional APIs. This MIDP is built according to the provided information about the device that hosts the application and the APIs that are used to build the application.

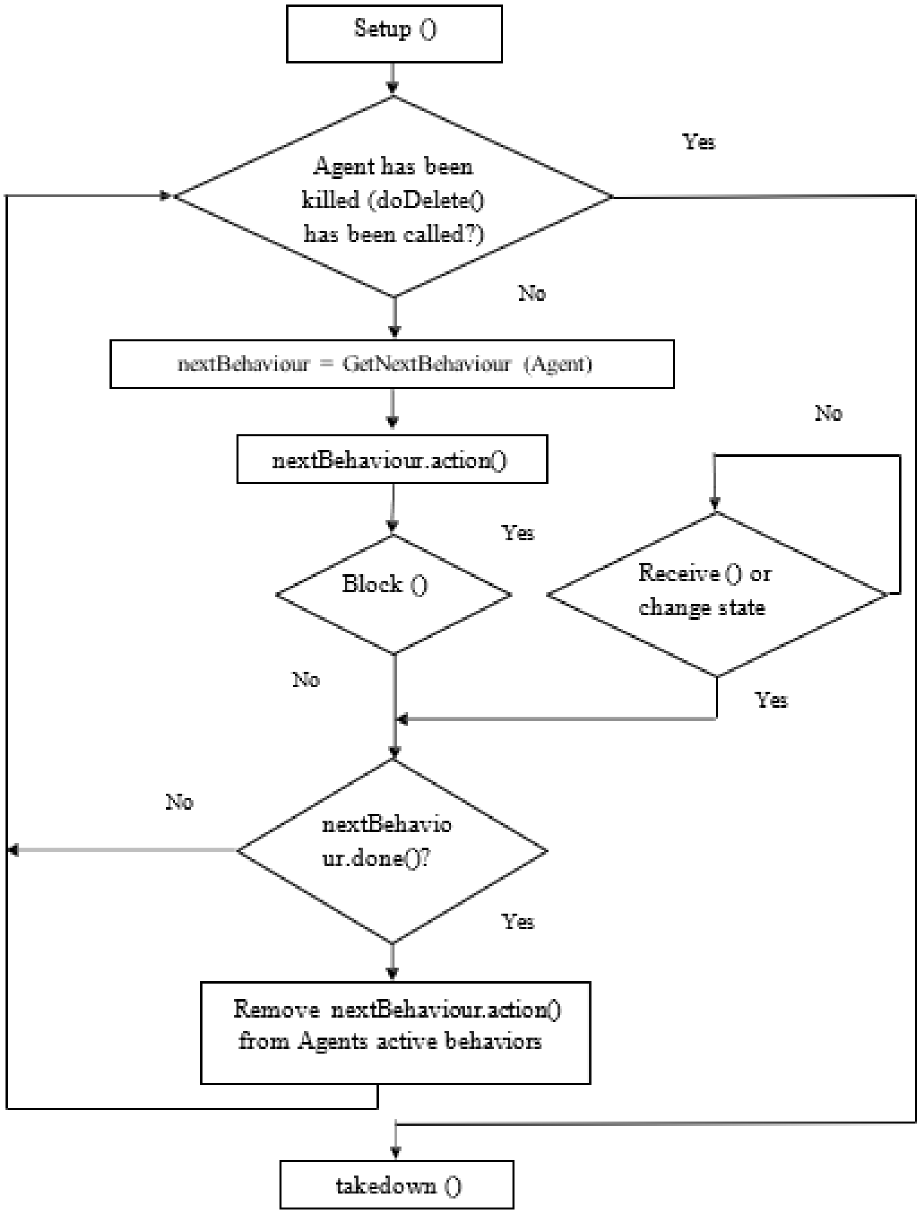


Figure 3.8 : An Agent That Sequentially Executes Behaviours in a Separate Thread

Accordingly, devices can be classified into CDLC and CDC. The MIDP module constructed by this proposal has two components, namely, an agent GUI in a mobile phone and an agent built by using JADE-LEAP.

Given the notification system of MIDlet programs, the proposed system uses MIDlet as a container to start the MS agent and the User Interface (UI). Figure (3.10) presents the mechanism of MIDlet.

Apart from perceiving the environment by interpreting Internet connection and requesting a certain URL, an MS agent also requires a MIDlet frame to interact with the user. MIDlet is a class of J2ME supporting-connection-limited devices where the MS (i.e., mobile phone) is a limited device while the screen and input methods (i.e., keypad, touch screen, and pen) are most crucial resources within the device.

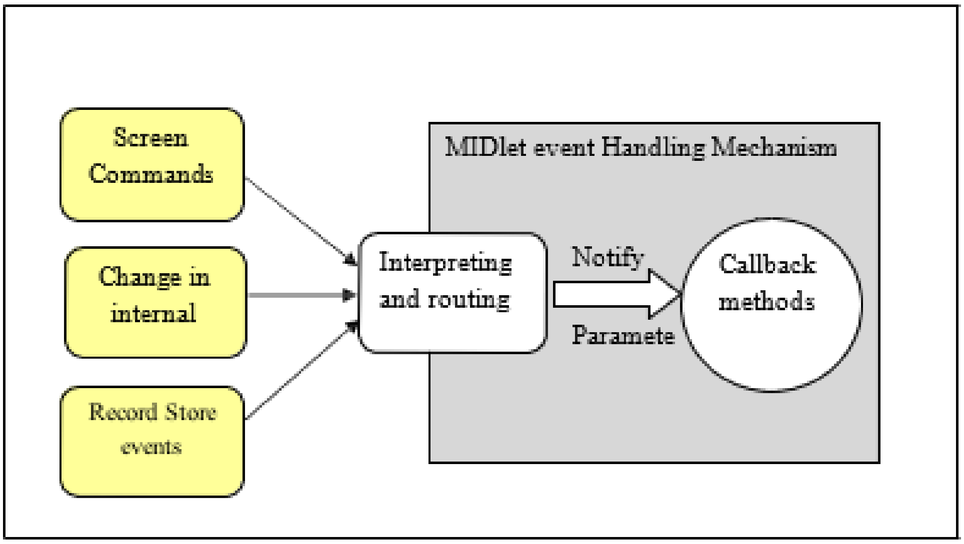


Figure 3.9 : MIDlet Event Handling Mechanism Deployed by the Proposed System

Figure (3.11) presents the general framework for implementing the MIDlet software module. Two MIDlet modules are designed and implemented; one of these modules represents the agent, while the other represents the agent GUI.

3.4.1 JADE-LEAP Agent

The proposed system is built based on the installation of Java agents in mobile devices. These installed agents have to communicate with one another across wireless media (e.g., GPRS, Wi-Fi, and Bluetooth) to accomplish their tasks. The proposed system focuses on communicating over GPRS as a final target, but the necessary GPRS equipment cannot be used due to financial constraints. Therefore, the proposed system has to be simulated over a Wi-Fi backbone.

JADE-LEAP abstracts the communication at a very high level by relegating to the other modules the responsibility of ensuring a valid communication. Therefore, the proposed system adds a communication layer based on socket programming to grant the JADE-LEAP agent with the ability to send and receive files over Wi-Fi communication media.

A GPRS network does not differ from a Wi-Fi network in terms of streaming datagram packets. After all, both of them are packet switching networks, which only difference lies in their protocol and physical layers. These networks also have no effect on the Java agent because JADE abstracts the communication at a very high level.

Figure (3.12) is a sequential diagram that represents the communication session initiated by the MS when requesting a URL from the Internet through a BSC agent.

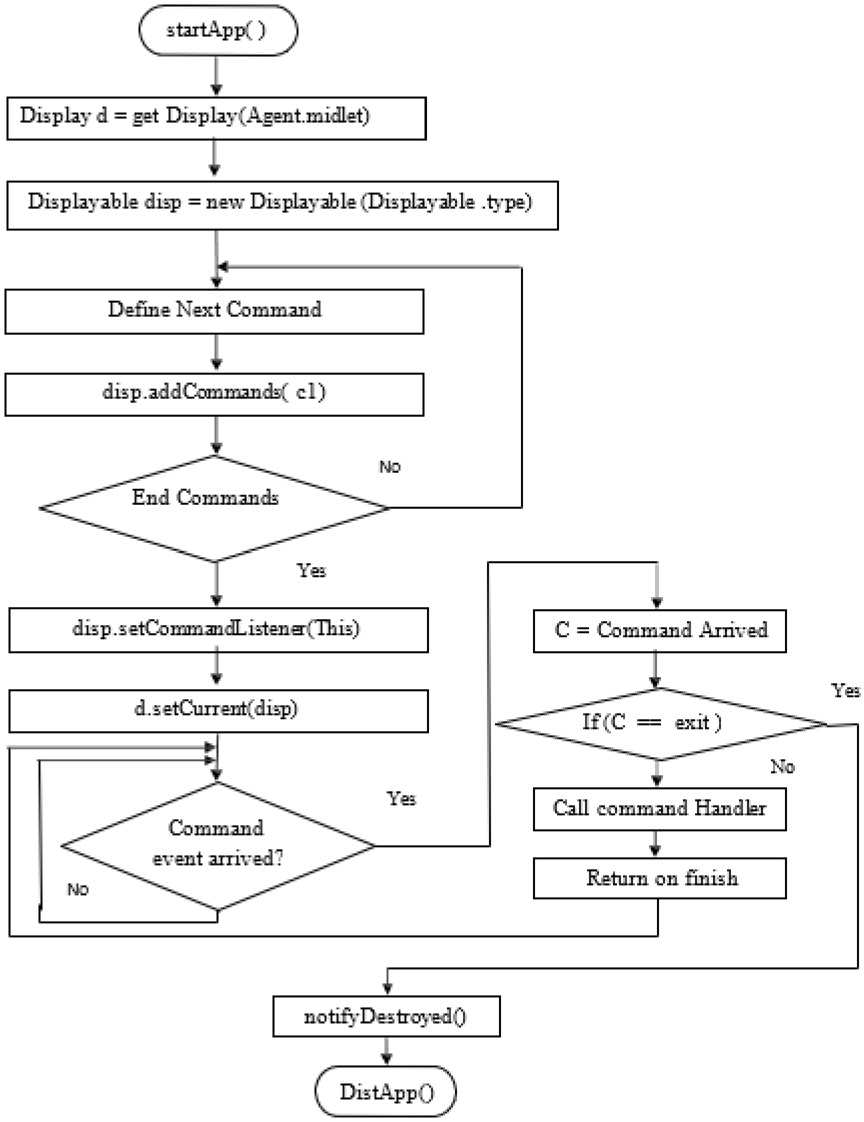


Figure 3.10 : MIDP Framework

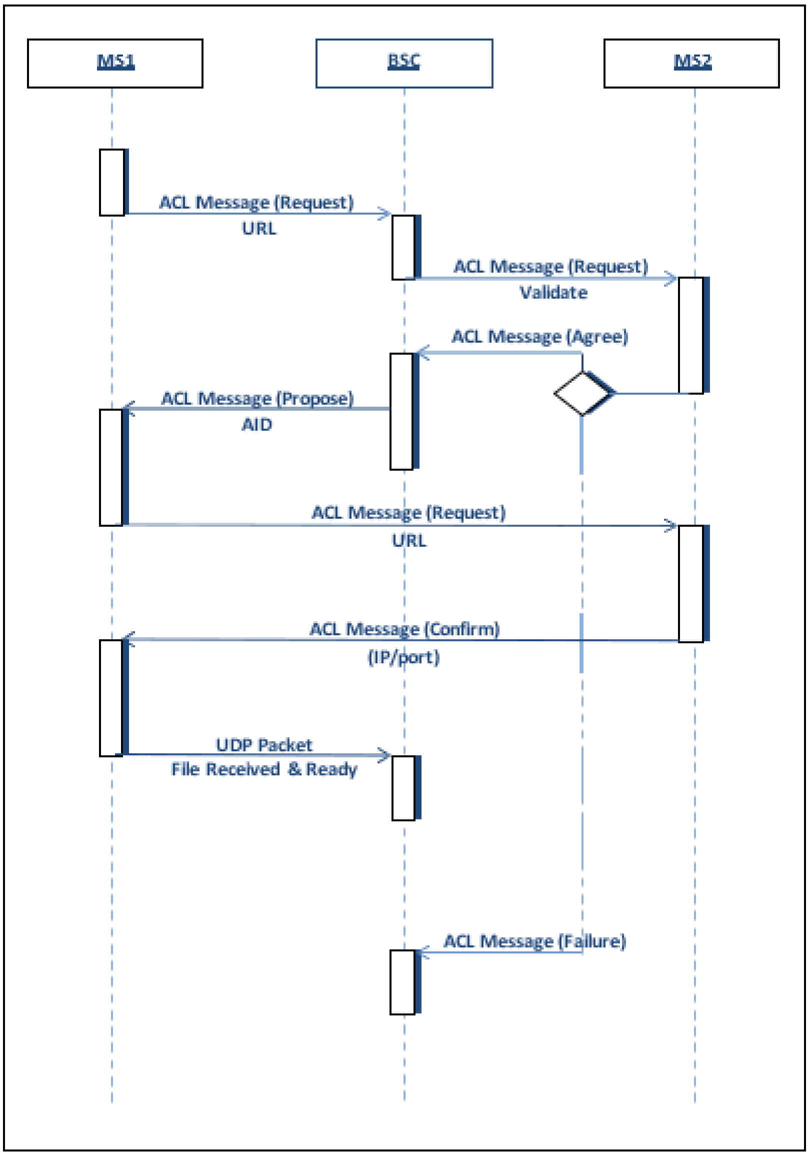


Figure 3.11 : Unified Modeling Language Sequential Diagram for a Communication Session

4. IMPLEMENTATION OF THE MAS OVER A GPRS NETWORK

This chapter discusses the implementation of the MAS presented in Chapter Three. The proposed system can be divided into GGNS, BSC, and MS, and this abstraction agrees with the GPRS/GSM network architecture. This chapter also presents the agent-based GPRS platform and illustrates the information flow among its agents.

The JADE sniffing tool is used to capture and analyze the ACL messages that are exchanged in each established session to request for Internet resources. A Wi-Fi network is used to simulate the GPRS network due to its cost effectiveness and because the Java agent is abstracted at every level in terms of communication media.

The Sun Java Wireless Toolkit for CLDC version 2.5.2, which is available on both Windows and Linux platforms, is used as the MS emulator to run the J2ME-based software component of the proposed system.

4.1 AGENT-BASED GPRS PLATFORM

This chapter starts by presenting the agent that is installed at the BSC. This agent joins the platform and is equipped with a GUI as shown in Figure (4.1). The BSC initializes its local database that will later be used to contain the descriptors for those resources that are requested by the agents in previous sessions.

BSC marks the point around which the agent platform is centered. The agent platform is then initialized.

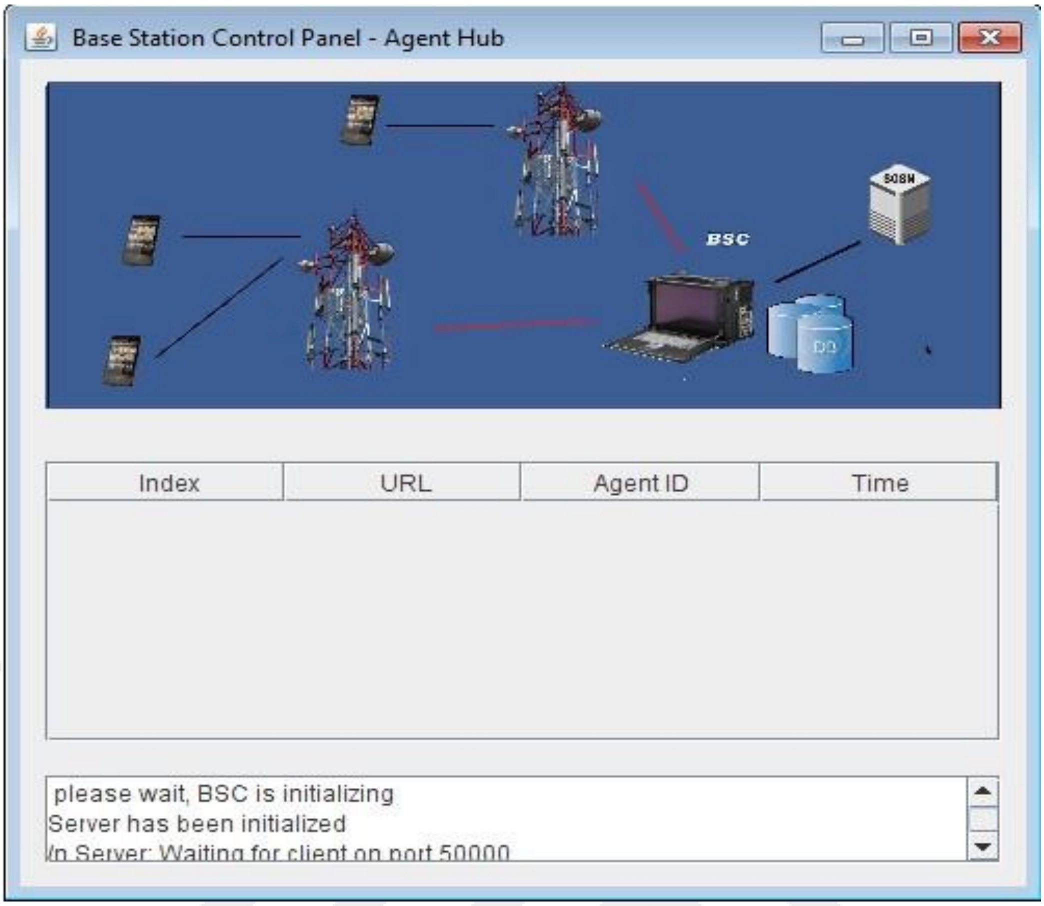


Figure 4.1: BSC Agent GUI Initialization

GGSN user represents the point through which the GPRS domain is attached to another data networks (i.e., Internet and corporate Intranets). Figure (4.2) presents the GUI for the agent that is installed in a computer to represent the GGNS. The services are provided through the GPRS network, and the agent installed on the GGNS provide services through "behaviours."

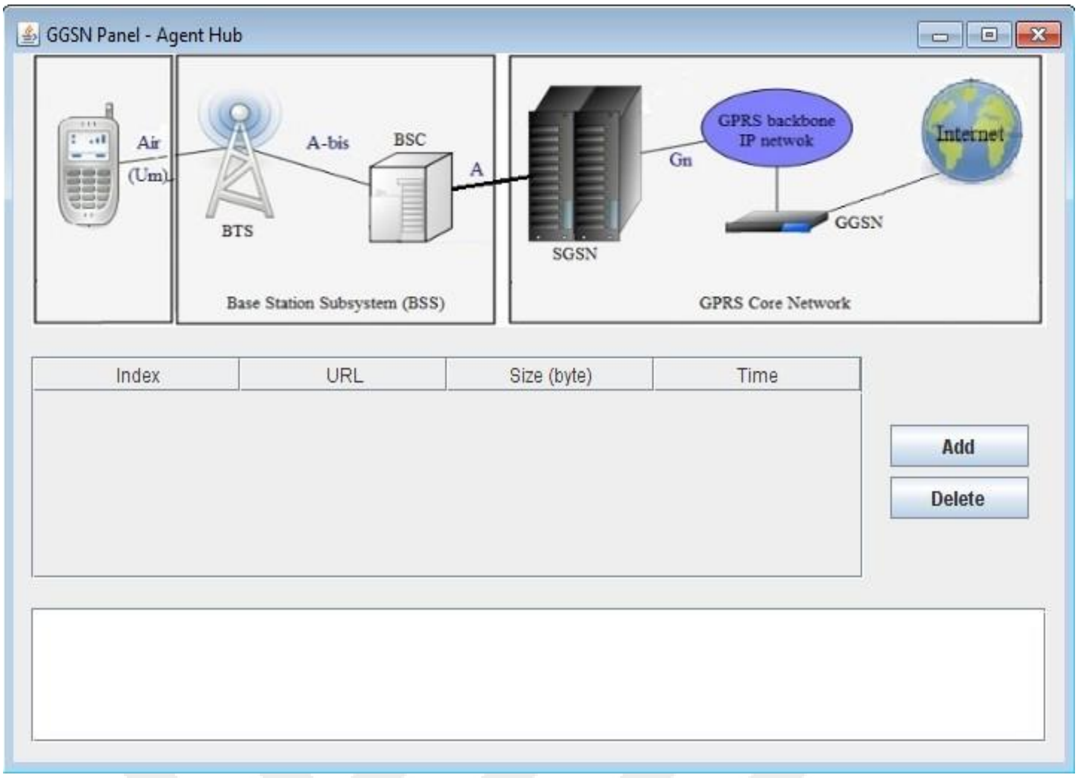


Figure 4.2 : Agent GUI at the GGNS Node in the Initialization Phase

4.2 AGENT REGISTRATION MANAGEMENT

The JADE Remote Agent Management (RMA) tool monitors the creation and initialization of all agents in the proposed platform. Figure (4.3) shows the output of JADE RMA after initializing the BSC agent. As can be seen in the figure, many agents have started themselves automatically. These agents also provide additional services to facilitate the remote monitoring of agent platforms. For instance, the AMS provides white page and life cycle services as well as maintains a directory of the AIDs and present states of other agents. Meanwhile, the Directory Facilitator is an optional component that provides yellow page services to all agents in the platform by maintaining an accurate, complete, and timely list of agents. This tool also provides authorized agents with the latest information about all agents included in its directory on a non-discriminatory basis.

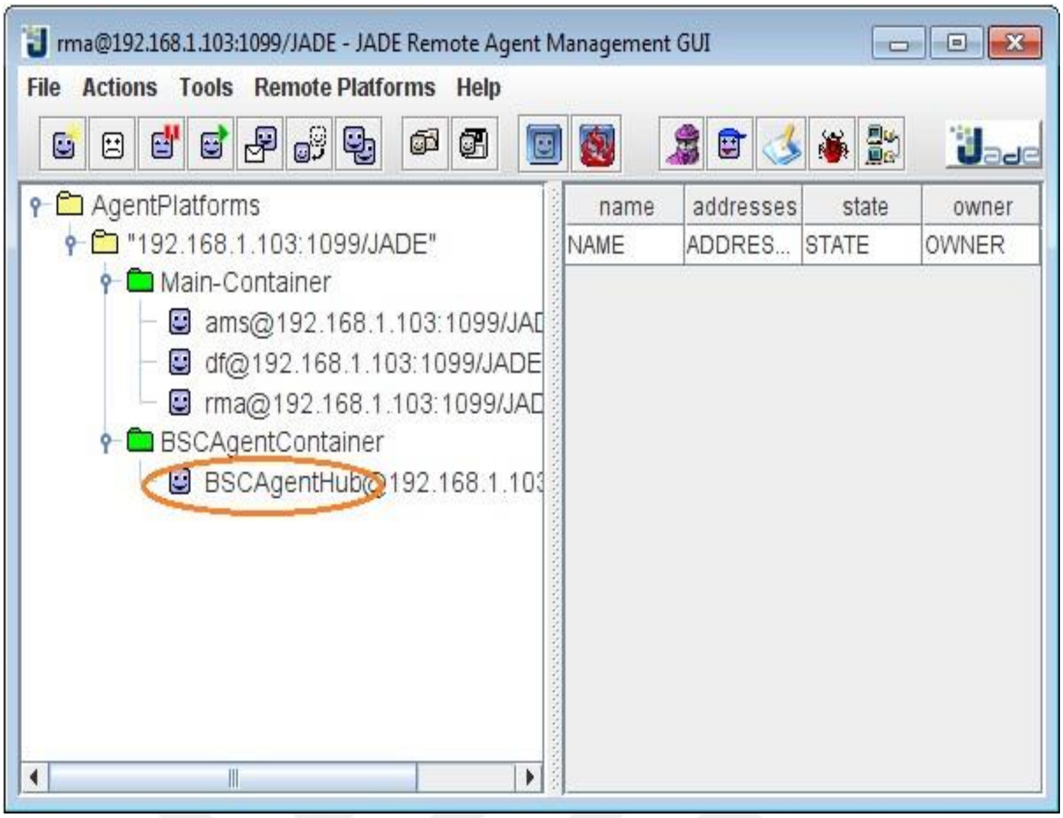


Figure 4.3 : A BSC Agent Joining the Agent Platform

After its initialization, an agent joins BSC platform. Upon joining the platform successfully, a new record is added to the RMA tool as shown in Figure (4.4).

After initializing the BSC and GGSN agents, the basic network architecture begins to accept the incoming MS agents that have joined the platform. Those MS agents from mobile devices must go inside two serious steps. In the first step (initialization), these agents register themselves in the platform by creating a container and an agent instance, while in the second stage, these agents begin to interact with the user and with the BSC agent that tries to complete the request by find the local host that has the requested resources. Figure (4.5) illustrates the first stage.

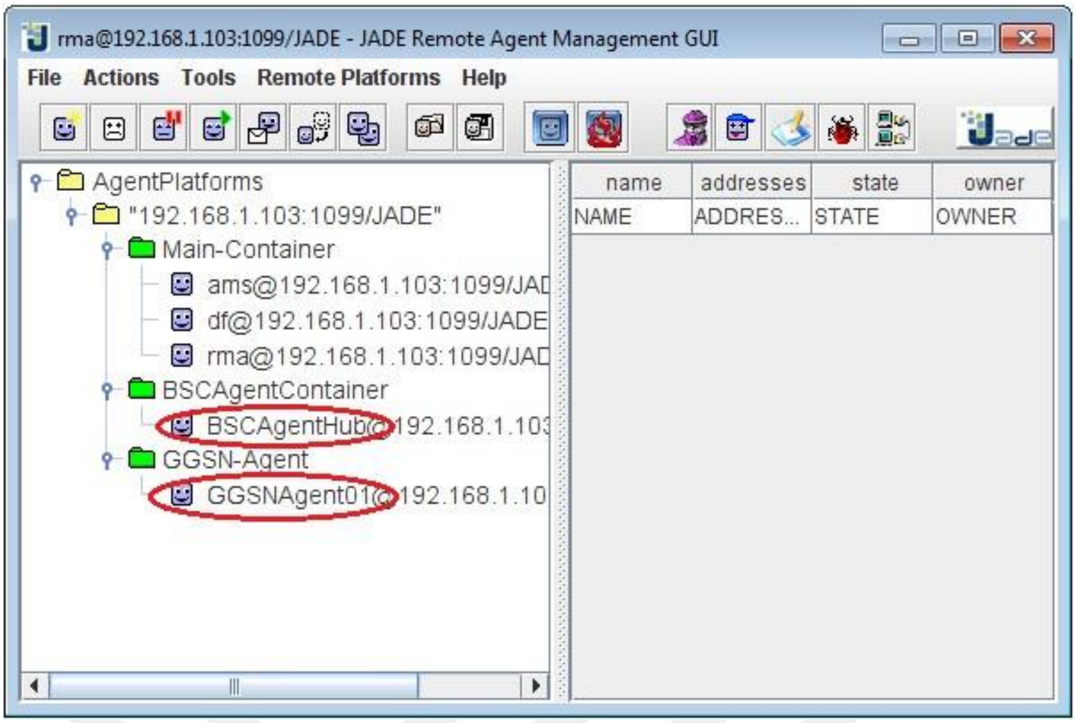


Figure 4.4 : A GGNS Agent Joining the Agent Platform

Figure 4.5 : A GPRS Agent Starting in a Mobile Device Emulator

In this implementation for the MS agent, only the agent name user can be changed, while the container name will be generated automatically because this name does not affect the locating of the agent.

After the user enters the agent name, the agent registers itself in the main container and the user is presented with a new interface where s/he can enter the name of the resources being requested as shown in Figure (4.6). The sniffing tool shows that two MS agents have joined the platform as can be seen in Figure (4.7).

Figure 4.6 : User Requesting for a Specified Resource

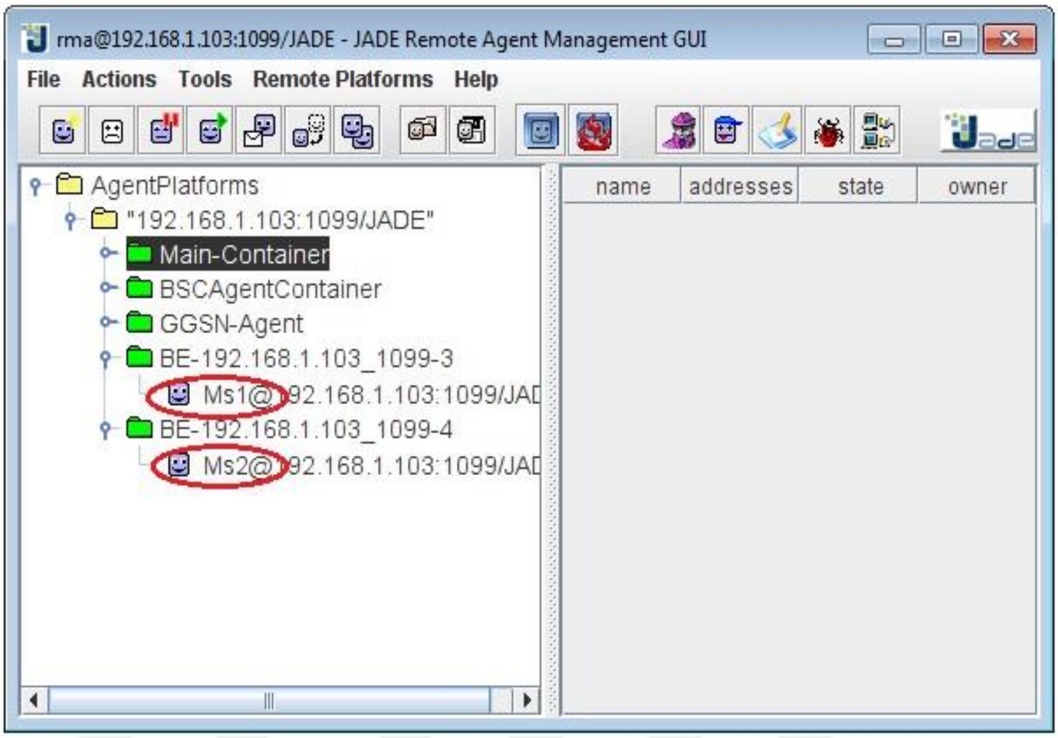


Figure 4.7 : Two MS Agents Joining the Agent Platform

4.3 MAS PERFORMANCE

After the user presses the “download” command shown in (4.6), the MS agent responds to the request by sending an ACL message to the BSC and asking for the requested resource. Upon the initialization of this system, the BSC does not have any records to show that the local hosts have downloaded any resources. In this case, the BSC agent forwards the request and starts downloading the required resources from the Internet. Figure (4.8) shows that the BSC agent starts downloading the requested URL from the GGSN agent.

The BSC agent then records the request, including the AID of the requesting agent, the time of the request, and the requested URL, in its internal table. These records will be used later to forward the requests for the same URL to the AID that is associated with such URL.

The BSC local table expands as the number of URL requests increases. Some requests are usually repeated where surfing the internet tends to cluster around specific document which grant this approach much credit.

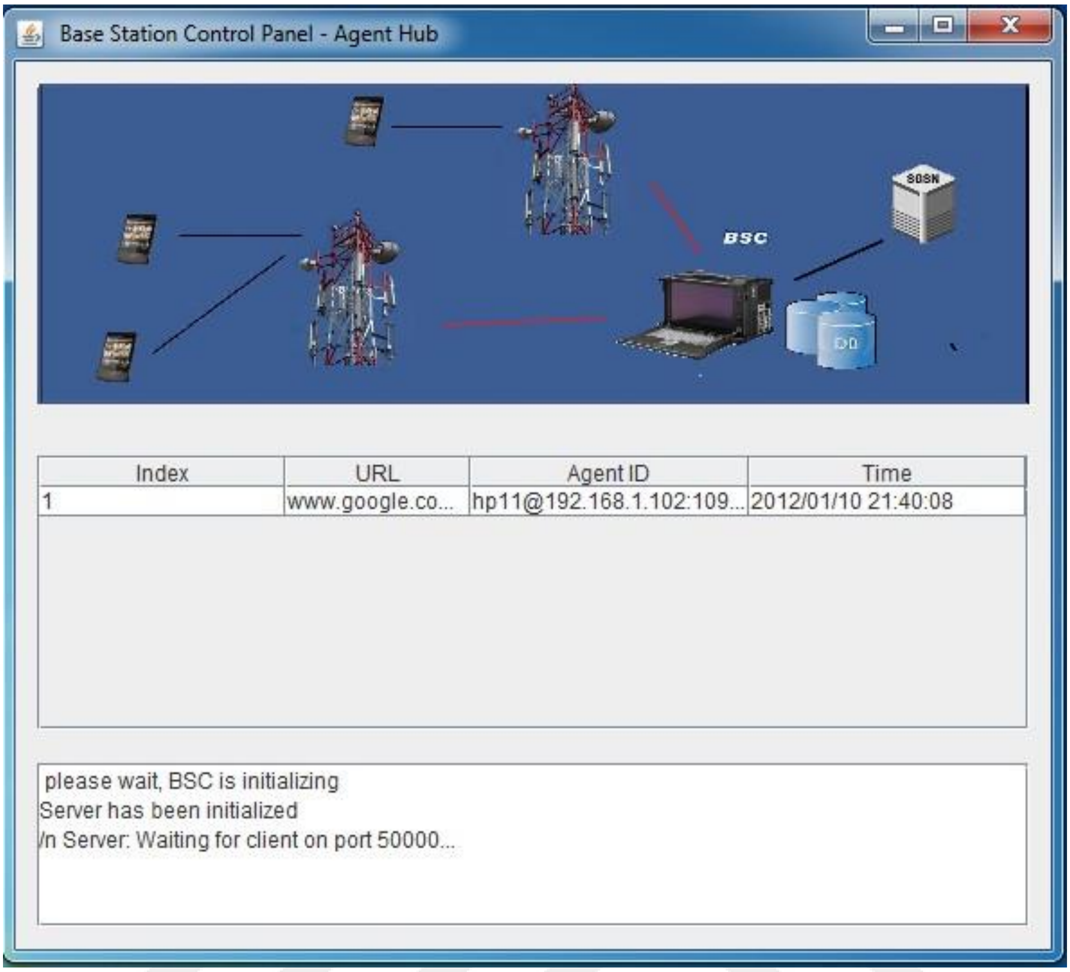


Figure 4.8 : A BSC Agent Registering the URL Request and Request Time

4.4 SNIFFING AGENTS PLATFORM

The sniffing agent provided by the JADE environment, which can efficiently validate the participants in a communication platform, is used to monitor the entire session. At the first stage of the session, the URL resources are located in a global source at the GGSN, while at the second stage, these resources are located in the local MS within the same BSC. Figure (4.9) presents a screenshot of the sniffing tool. Apart from the GGSN and BSC agents, two other MS agents are selected. The JADE sniffing tool does not give any information regarding the time required to transfer a file over the network. To promote objectivity in this thesis, the proposed system will be evaluated based on the communication and networking among agents.

4.5 THE IMPLEMENTATION OF GPRS CONNECTION

The proposed system assumes that the GGSN is connected to the Internet with a broadband interface of 1 Mbps and a maximum GPRS speed of about 20 kB/s. However, a 3G-enabled phone can have a maximum Internet speed of 300 to 305 kB/s.

GPRS has a standard bandwidth of 386 kB/s. This work focuses on overall throughput to facilitate the establishment of QoS conditions in the network environment.

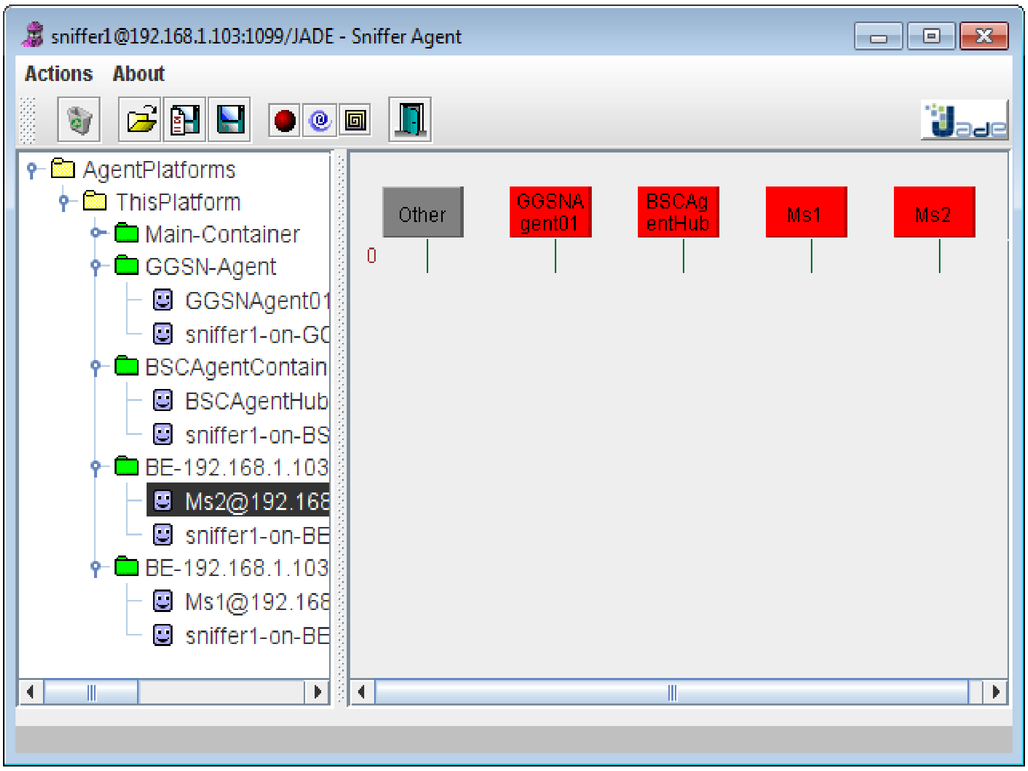


Figure 4.9 : Initializing the JADE Sniffer over the Entire Platform

As shown in Figure (4.10), the first call for a URL that is not located in the local cell (i.e., within the same BSC of the requester) will be managed given the lack of an agent platform. After transferring four messages over the GPRS network, the requested URL will be downloaded from the GGSN to a local cache server and will be subsequently streamed to the requester. Figure (4.11) shows the required time to download a file from the GGSN.

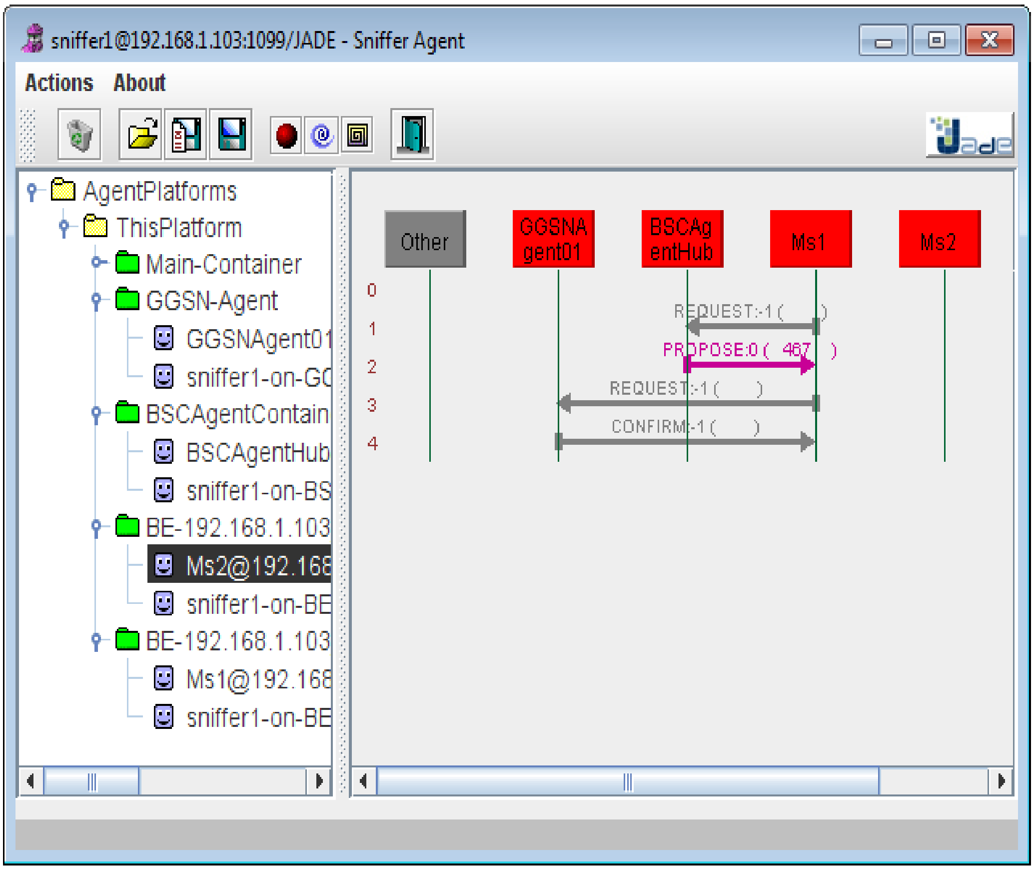
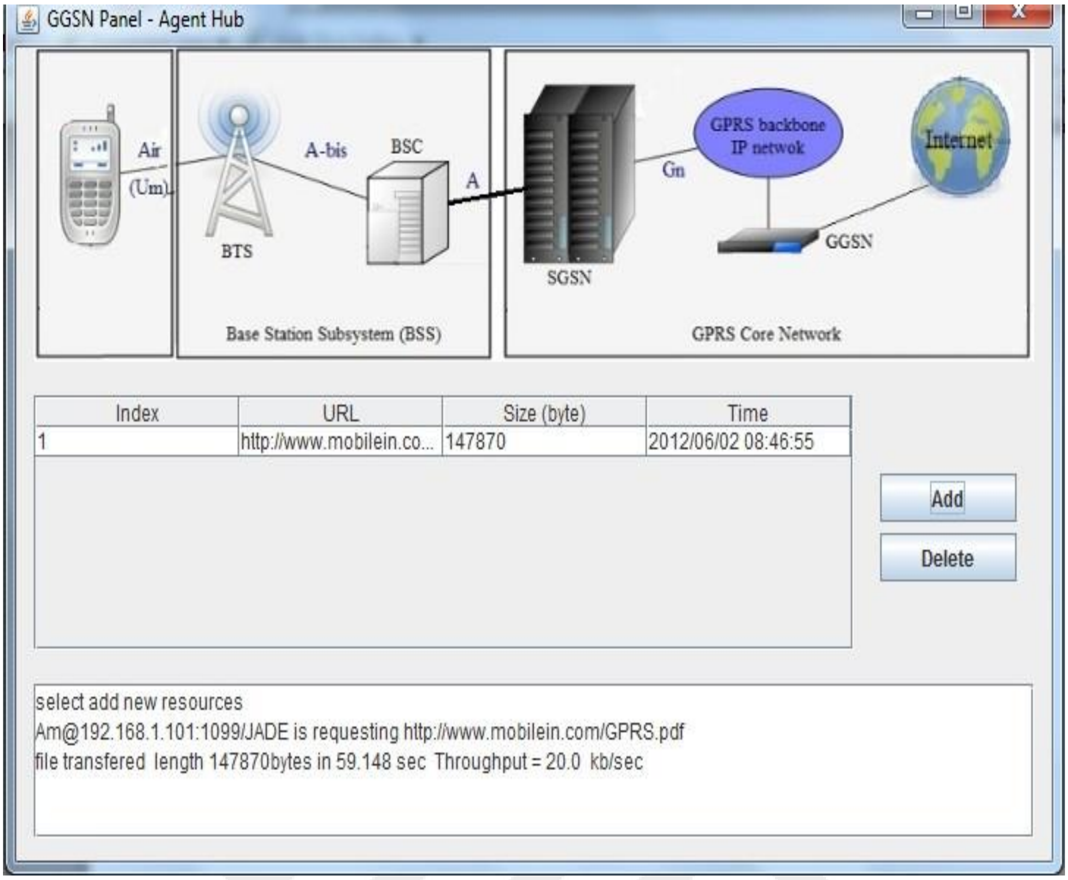


Figure 4.10 : Requesting a URL that Is Located Through the GGSN

4.6 SEGMENTATION IN THE GPRS NETWORK

Downloading URLs from caches has many drawbacks. For instance, a cache server requires a huge memory size considering the large number of URLs being requested by the clients, which can even reach millions. Moreover, the subsequent requests of those clients that request for confirmed URL sources in the cache system will affect the traffic of the entire GPRS networks as well as the overall throughput and QoS.



Index	URL	Size (byte)	Time
1	http://www.mobilein.co...	147870	2012/06/02 08:46:55

Figure 4.11 : An Agent GUI at the GGSN Node Finishes Downloading the Required Resources

Figure (4.12) shows that the traffic in the GGSN is not affected by subsequent requests for a URL that has been downloaded by one of the agents within the MS. In this way, no bottlenecks are encountered and the traffic is highly localized.

The subsequent request for a URL does not need to be sent to the GGSN; instead, the BSC agent request database responds to such request. This URL requires less time to download from an MS agent. The download time appears on the screen of the mobile device as shown in Figure (4.13). The packet transferring time of the MS is less than that of the GGSN.

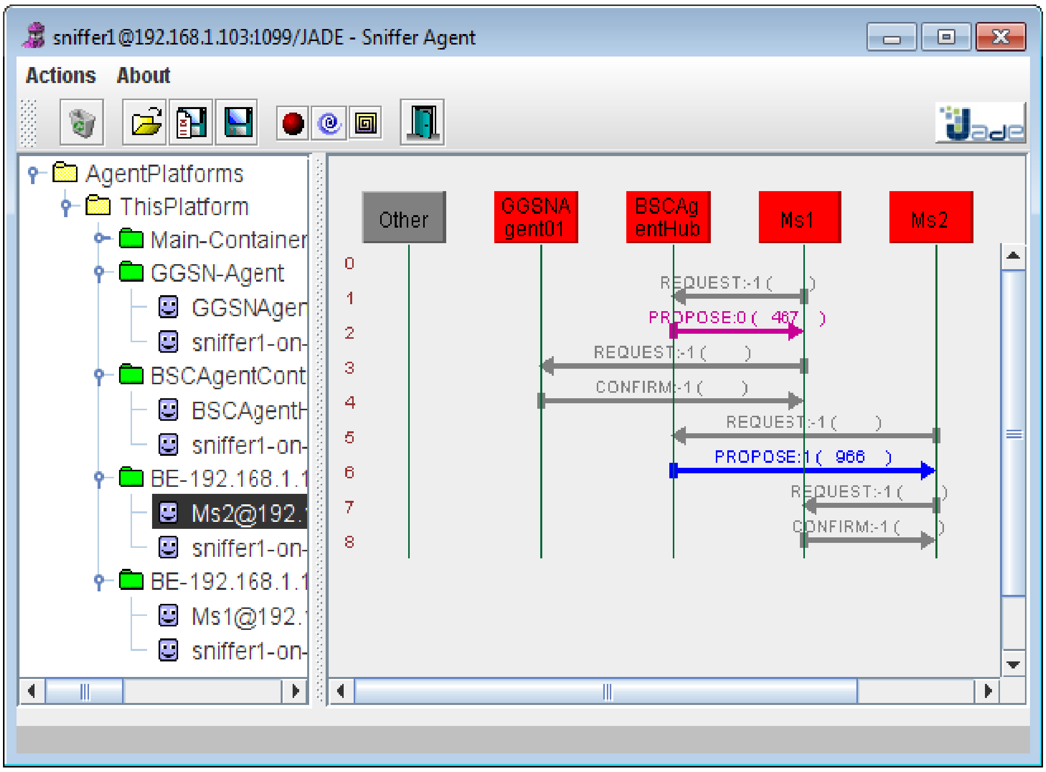


Figure 4.12 : Request for a URL Located within the Same BSC

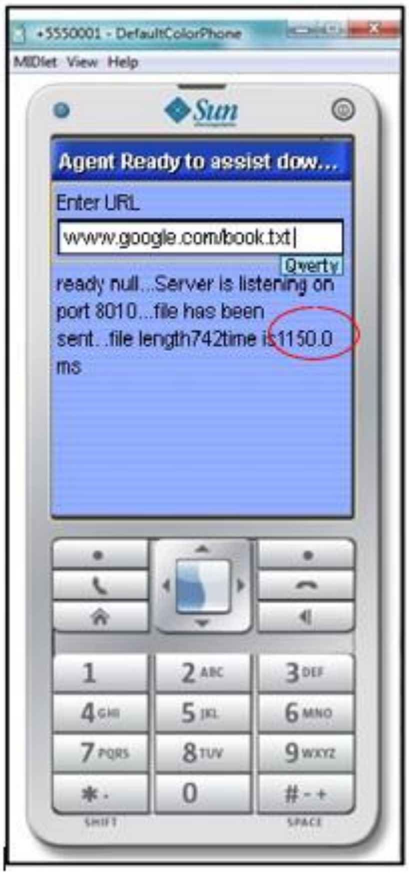


Figure 4.13 : Time Required to Download a File from MS

4.7 MONITORING AGENT MESSAGES

The JADE environment provides sniffing tools to monitor messages across the platform.

ACL messages are exchanged between BSC and MS agents. Specifically, the MS agent sends a client request for a certain URL to the BSC agent, and then the BSC agent replies to this request by sending the address of the GGSN. Afterward, the MS requests the GGSN to download the requested URL, and the BSC agent responds to such request by sending a message containing the AID of the agent that can provide the requested URL. The BSC agent adds this request to its local table for future reference. The RMA GUI double clicks an ACL message to view its contents in a new window as shown in Figures (4.14) and (4.15).

Each ACL message includes the message sender, the list of recipients, and the communicative (or "performative") act, which indicates what the sending side intends to achieve by sending the message. Specifically, if the performative is REQUEST, then the sender needs the receiver to perform an action. If the performative is INFORM, then the sender needs the receiver to become aware of a fact. If the performative is a PROPOSE, then the sender needs to enter a negotiation.

JADE has a class (jade.lang.acl. ACLMessage) that defines all types of messages being exchanged among agents. An agent can define the type of incoming message by using ACLMessage.setPerformative(Performative_type) and ACL Message.getPerformative(), which belong to the same aforementioned class.

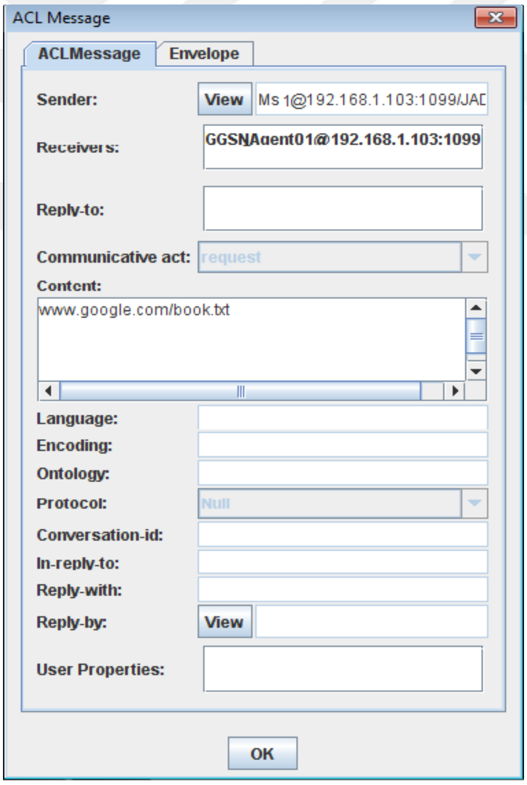


Figure 4.14 : ACL Message Sent to the GGSN Agent

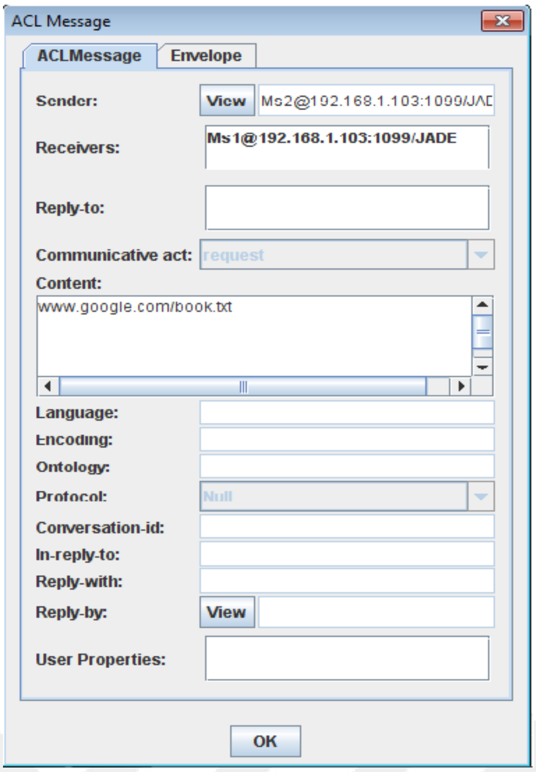


Figure 4.15 : ACL Message Sent to the MS Agent

4.8 SYSTEM PERFORMANCE TESTS AND RESULTS

Several tests are conducted to evaluate the performance of the developed MAS. The results of these tests, which show the effect of the proposed system on QoS, are listed below. The evaluations are based on the following equations:

$$TransfetTime = No. of\ Packet \tag{4.1}$$

$$Packet\ Time\ = \begin{cases} 25.6(ms), & Respond\ From\ GGSN \\ 1.67(ms), & Respond\ From\ MS \end{cases} \tag{4.2}$$

$$Maximum\ Mobile\ agent\ Use\ = \left| \frac{log\ No\ of\ Requests}{log\ (2)} \right| \tag{4.3}$$

$$AMU = \frac{1}{NoofAgent} \begin{matrix} NoofAgent \\ i = 1 \end{matrix} \quad MMUofAgent \tag{4.4}$$

4.8.1 Availability and Throughput Tests

Test 1: This test evaluates the availability of the system. Four requests are initially served through the GGSN. The subsequent requests of other mobile agents will be served by the first four agents even if the Internet connection is lost. When the GGSN is shut down, its color becomes yellow to indicate that the agents are still present in the sniffer agent window. The agents still communicate with the BSC as shown in Figure (4.16). Table (4.1) shows the amount of time spent to transfer a file from the Internet and from the mobile agent

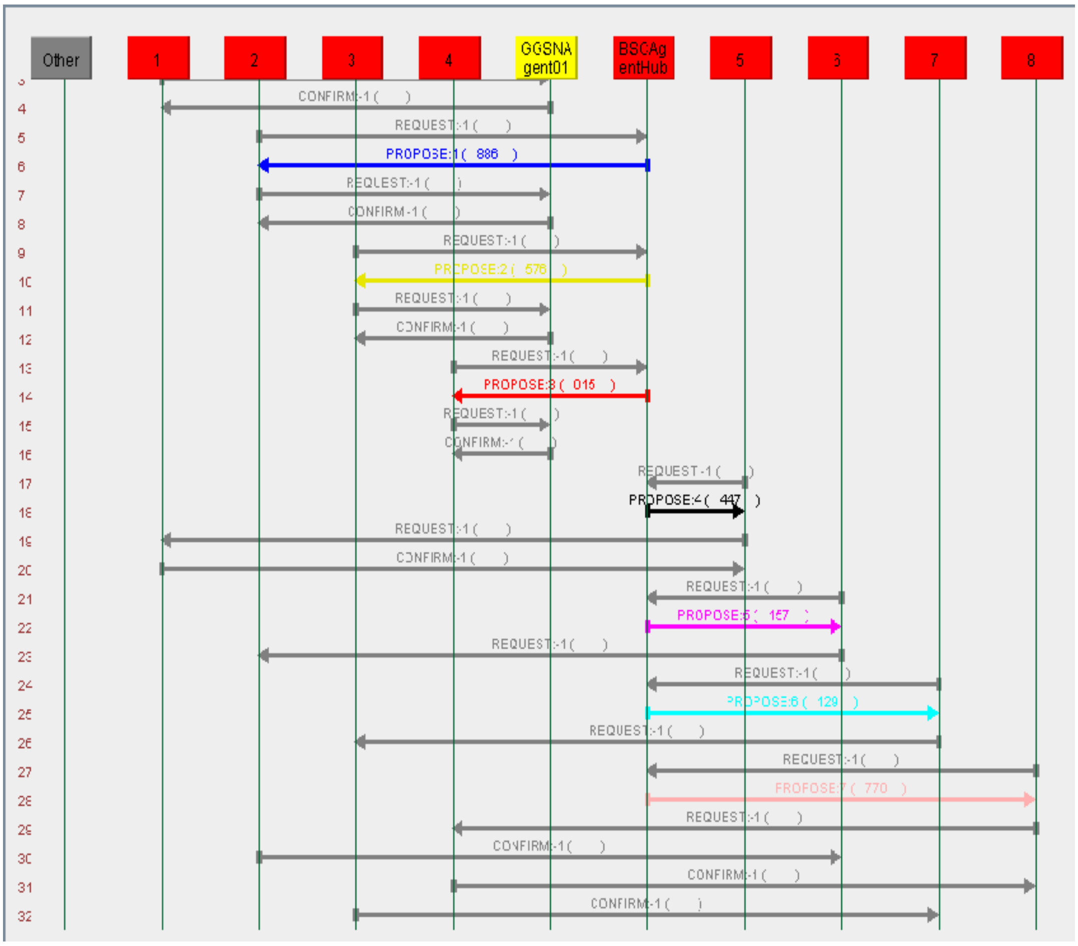


Figure 4.16 : Transferring of Files over the GPRS Network

Table 4.1 File Transfer Time and Throughput

File	Size (kB)	Agent	Time (s)	Throughput (kB/s)	
File1	10.08691406	Agent1	4.1316	20	Request from GGSN
File2	50.43457031	Agent2	20.658	20	
File3	80.6953125	Agent3	33.0528	20	
File4	40.34765625	Agent4	16.5264	20	
File1	10.08691406	Agent5	0.2703	305	Request from MS Agent
File2	50.43457031	Agent6	1.3515	305	
File3	80.6953125	Agent7	2.1623	305	
File4	40.34765625	Agent8	1.0812	305	

As seen in Table (4.1), the mobile agent has a better transfer time than the GGSN, thereby improving the throughput. Moreover, the failure to reach the GGSN will not affect the fulfillment of requests through the MS, thereby improving the availability of the network. Figure (4.17) shows the improvements in throughput when files are transferred from one mobile agent to another. These improvements are represented as fixed values because delays are not taken into account.

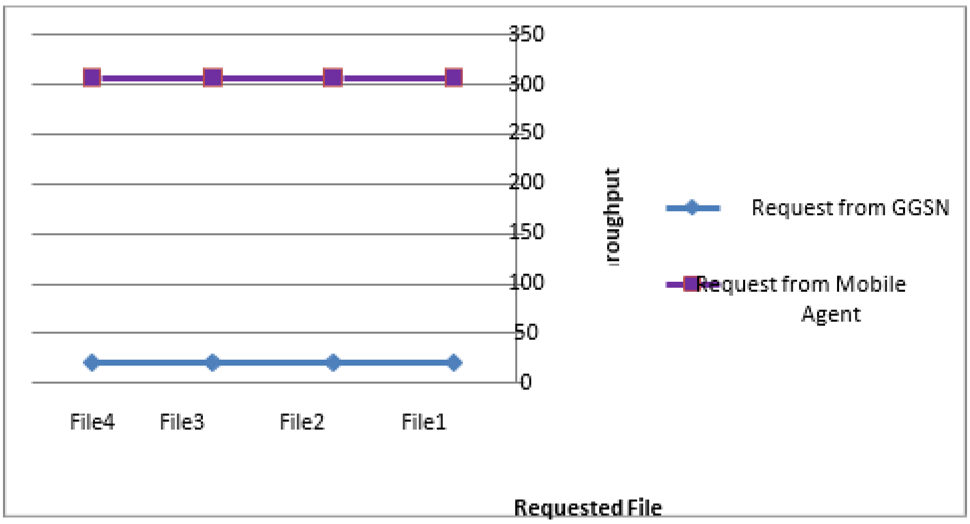


Figure 4.17 : Comparison of Throughput

The difference between the times of transferring a file from GGSN and from the mobile agent is shown in Figure (4.18).

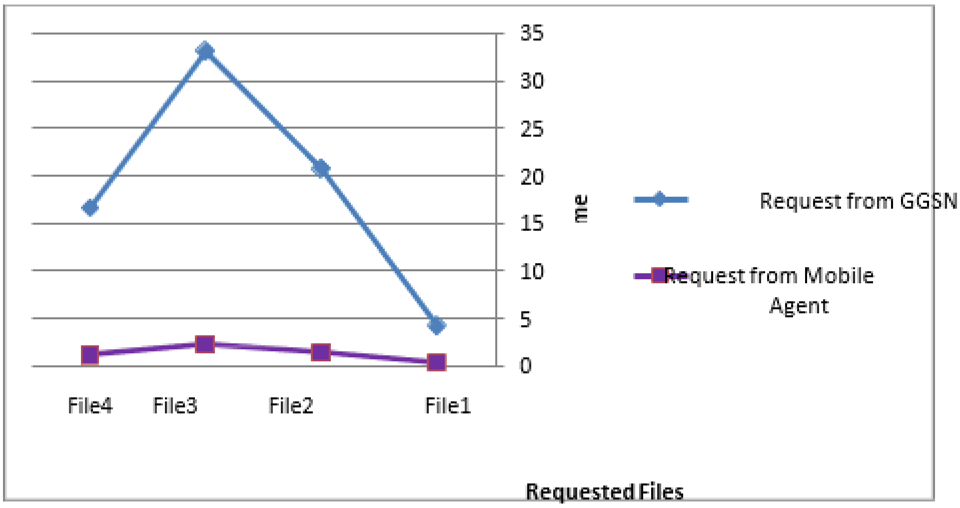


Figure 4.18 : Comparison of File Transfer Time

Test 2: The following test illustrates the success or failure of requesting files. In this test, eight users are requesting for different files, and these requests are served through the GGSN or the other mobile agents within the system. Table (4.2) shows that agents 6 and 4 receive the requests through GGSN, while agents 3 and 5 send their requests to the BSC. The BSC then replies by sending over the AIDs of agents 4 and 6, which will serve the requests of agents 3 and 5 sequentially. Meanwhile, agents 7 and 8 are requesting for files that do not exist in the server. In this case, the GGSN returns a message with 0 bytes. The GGSN serves agent 2, while agent 1, which has requested for the same file, is served by agent 2. Figure (4.19) shows how mobile agents communicate with one another to facilitate file sharing as well as presents the success and failure of file requests.

Table 4.2 Summary of File Transfer Time and Throughput

File	Size (kB)	Agent	Time (s)	Throughput (kB/s)	
File1	30.260	Agent2	12.3948	20	Request from GGSN
File2	20.173	Agent4	8.2632	20	
File3	10.086	Agent6	4.1316	20	
File4	------------------	Agent7	0.0256	--------------	
File5	------------------	Agent8	0.0256	--------------	
File1	30.260	Agent1	0.8109	305	Request from MS
File2	20.173	Agent3	0.5406	305	
File3	10.086	Agent5	0.2703	305	

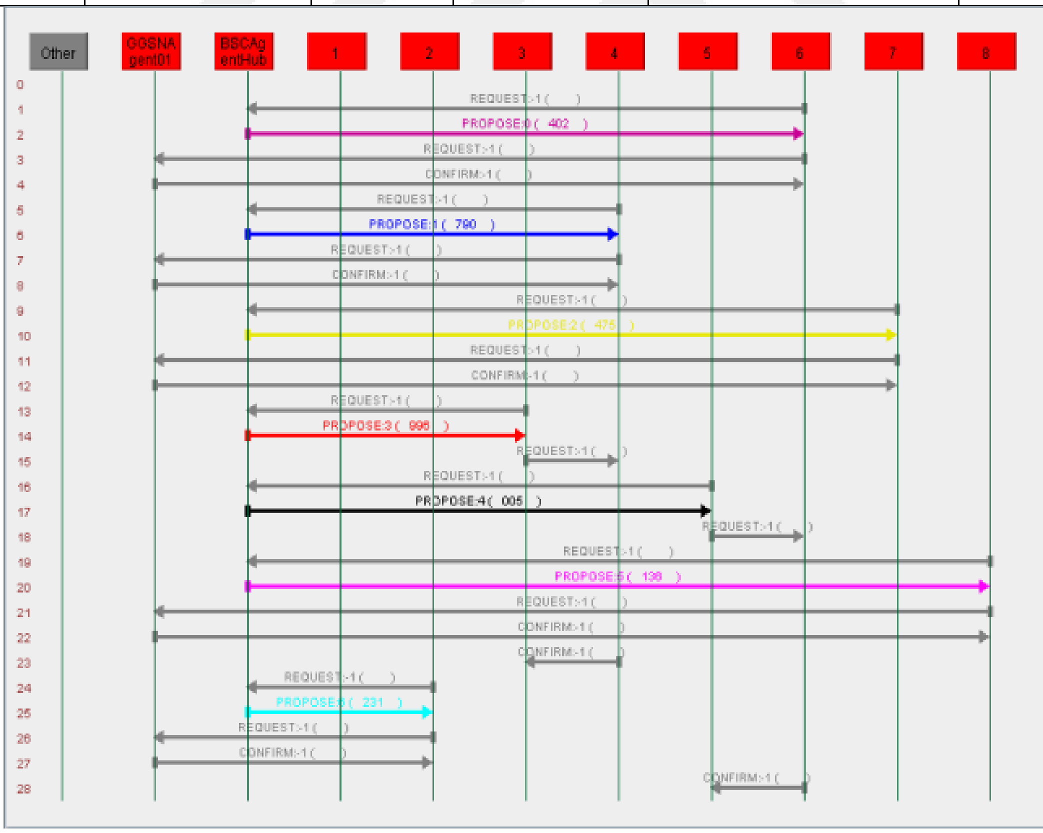


Figure 4.19 : File Sharing Among Mobile Agents

Figure (4.20) shows the difference between the times of transferring files from GGSN and from mobile agents, while Figure (4.21) compares the throughputs of transmitting files from GGSN and from mobile agents.

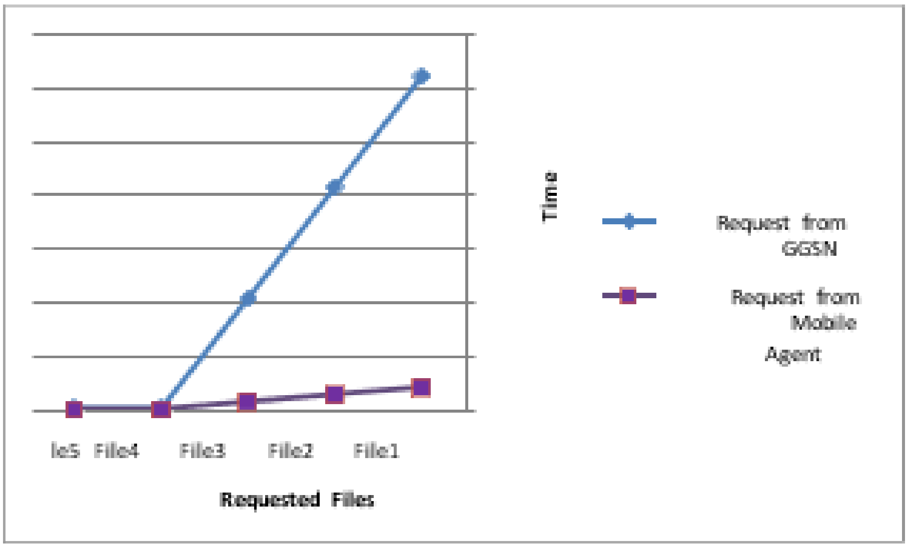


Figure 4.20 : Comparison of File Transfer Time

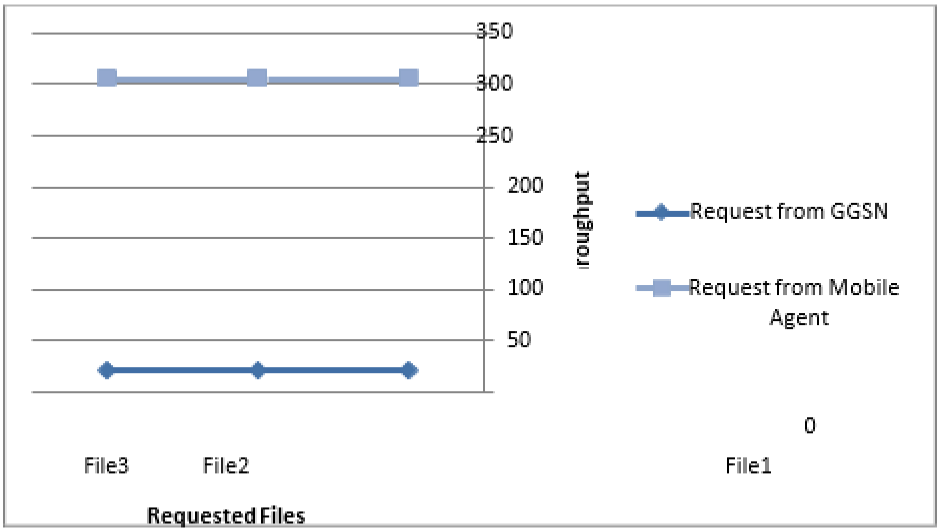


Figure 4.21 : Comparison of Throughput

Test 3: This test evaluates the relationship between file transfer time and file size. Table (4.3) lists the different file sizes, file transfer times, and file transfer throughputs from GGSN.

Table 4.3 Summary of File Transfer Time and Throughput from GGSN

File	File type	Size (MB)	Agent	Time (s)	Throughput (kB/s)
File1	TXT	0.27	Agent1	115.0976	20
File2	PNG	0.49	Agent2	203.9808	20
File3	JPG	0.85	Agent3	355.9424	20
File4	DOCX	0.90	Agent4	377.6512	20
File5	PDF	2.63	Agent5	1103.101952	20
File6	WAY	2.66	Agent6	1115.684864	20
File7	MP4	7.74	Agent7	3246.391296	20
File8	MP3	8.02	Agent8	3363.831808	20
File9	PDF	9.96	Agent9	4177.526784	20

Table (4.4) shows the file transfer time and throughput from mobile agents in the system. This test evaluates the efficiency of the system in transferring a large amount of data.

Table 4.4 Summary of File Transfer Time and Throughput from Mobile Agents

File	Size (MB)	Agent	Time (s)	Throughput (kB/s)
File1	0.27	Agent10	7.529	305
File2	0.49	Agent11	13.344	305
File3	0.85	Agent12	23.285	305
File4	0.90	Agent13	24.706	305
File5	2.63	Agent14	72.165	305
File6	2.66	Agent15	72.988	305
File7	7.74	Agent16	212.380	305
File8	8.02	Agent17	220.063	305
File9	9.96	Agent18	273.296	305

Figure (4.22) illustrates the efficiency of the system and how file size reduces the amount of time to transfer files from mobile agents.

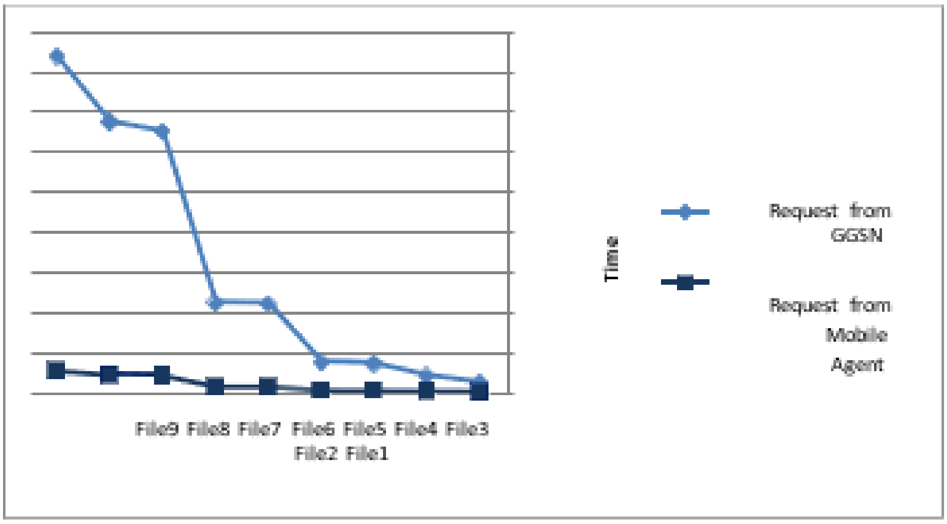


Figure 4.22 : Comparison of File Transfer Time

4.8.2 Delay Tests

Test 1: This test involves seven users that are requesting for a file with a size of 10.9 kB in the following cases:

•Case 1: Seven users request for the file from GGSN as shown in Figure (4.23).

•Case 2: The first agent obtains the request from the GGSN, while the other agents obtain their requests from the first agent as shown in Figure (4.24).

•Case 3: This case illustrates the system performance depending on request management and supposes that agent 1 owns the requested file as shown in Figure (4.25).

Table (4.4) summarizes these three cases and shows that case 3 outperforms the two other cases in terms of Receiving Time (RT).

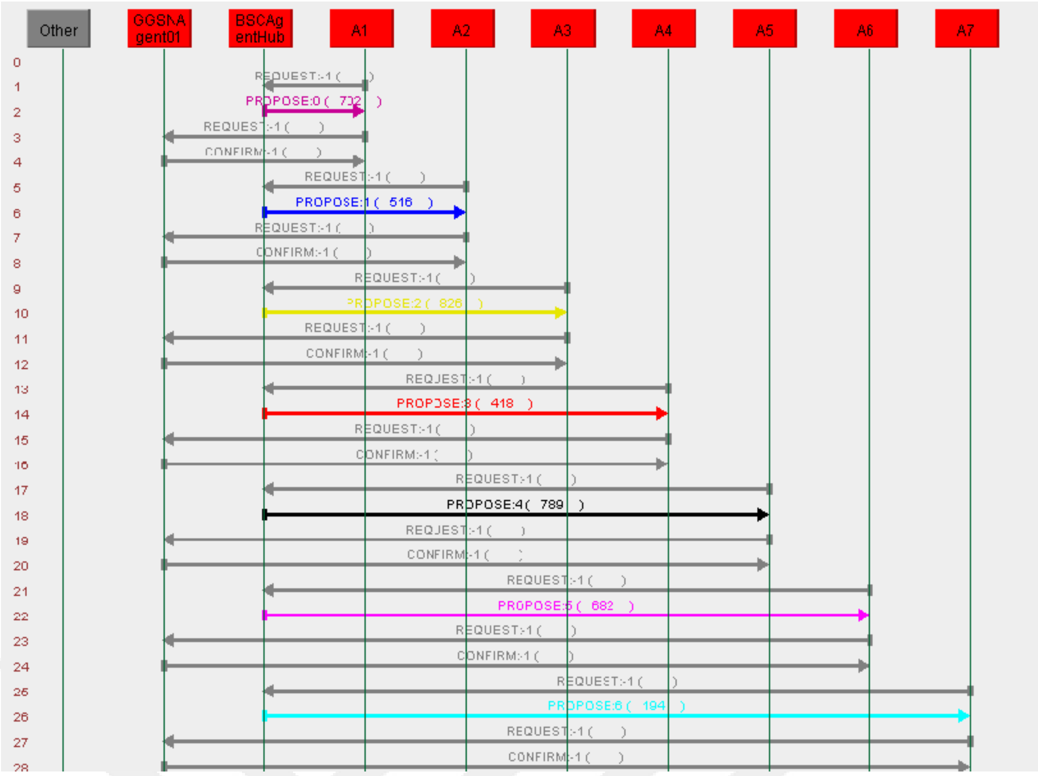


Figure 4.23 : File Transfer over the GGSN

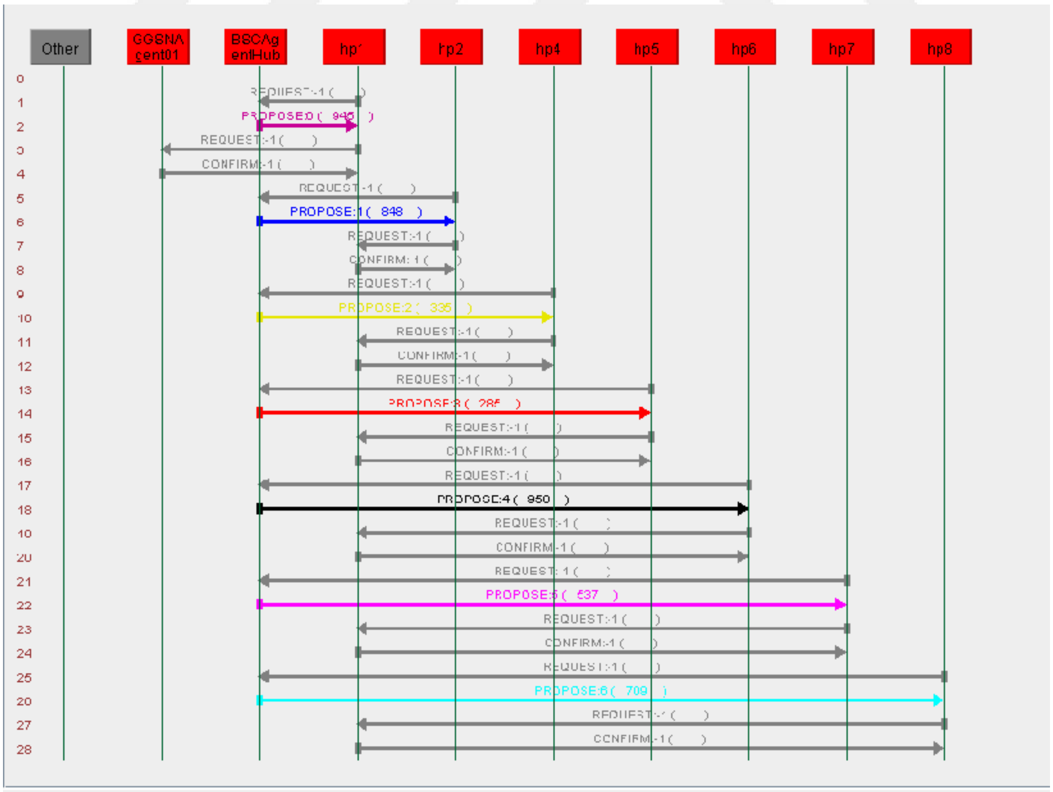


Figure 4.24 : Transferring Files from the First Mobile Agent

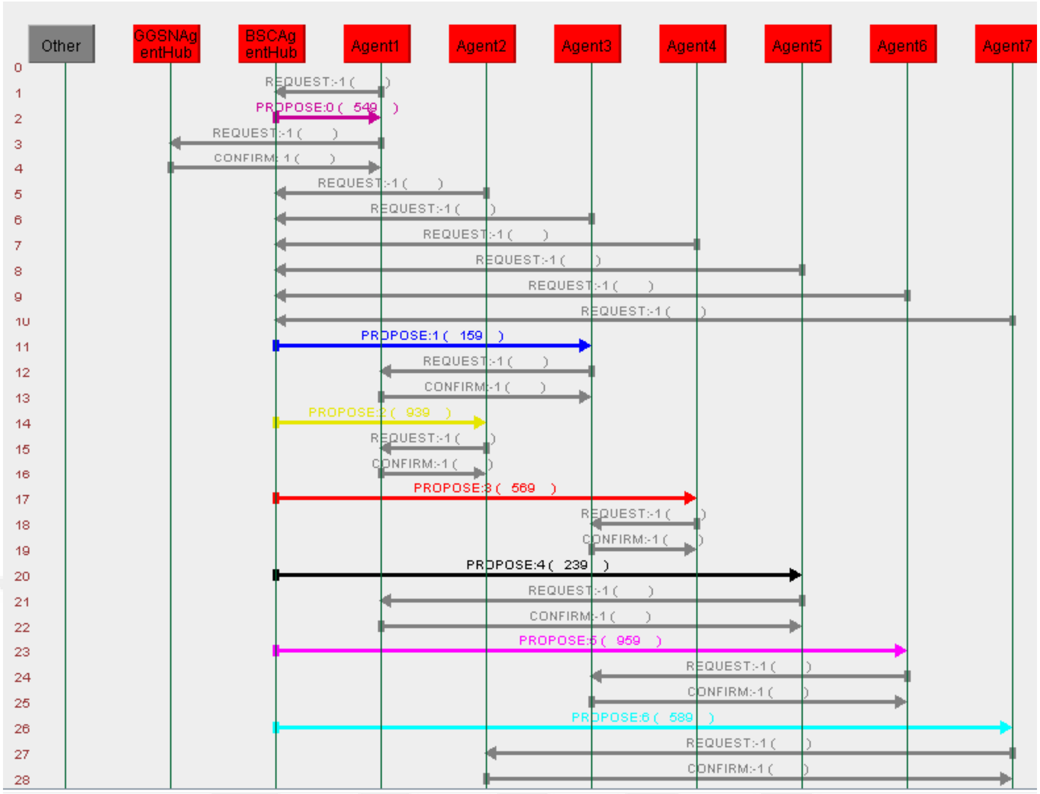


Figure 4.25 : File Transfer Depending on Request Management

Table 4.5 Summary of WT and RT of MS Agents

			Case 1
Agent	Response	WT (sec)	RT (sec)
Agent1	GGSN	0	4.1316
Agent2	GGSN	4.1316	8.2632
Agent3	GGSN	8.2632	12.3948
Agent4	GGSN	12.3948	16.5264
Agent5	GGSN	16.5264	20.658
Agent6	GGSN	20.658	24.7896
Agent7	GGSN	24.7896	28.9212
			Case 2
Agent	Response	WT (sec)	RT (sec)
Agent1	GGSN	0	4.1316
Agent2	Agent1	4.1316	4.401891589

Agent3	Agent1	4.401891589	4.672183178
Agent4	Agent1	4.672183178	4.942474766
Agent5	Agent1	4.942474766	5.212766355
Agent6	Agent1	5.212766355	5.483057944
Agent7	Agent1	5.483057944	5.753349533
			Case 3
Agent	Response	WT (sec)	RT (sec)
Agent1	GGSN	0	0
Agent2	Agent1	0	0.270291589
Agent3	Agent1	0.270291589	0.540583178
Agent4	Agent2	0.270291589	0.540583178
Agent5	Agent1	0.540583178	0.810874766
Agent6	Agent2	0.540583178	0.810874766
Agent7	Agent3	0.540583178	0.810874766

Test 2: Similar to test 1, this test uses a file with a size of 9.96 MB.

•Case 1: The file is downloaded through the GGSN.

•Case 2: The file is downloaded from the first agent, which in turn receives the same file from the GGSN.

•Case 3: The file download depends on request management.

Table (4.6) lists the mobile agents that request for the files as well as their corresponding WT and RT in the three aforementioned cases.

Table 4.6 Summary of WT and RT of MS Agents

			Case 1
Agent	Response	WT (sec)	RT (sec)
Agent1	GGSN	0	4177.527
Agent2	GGSN	4178	8355.054
Agent3	GGSN	8355	12532.58
Agent4	GGSN	12533	16710.11
Agent5	GGSN	16710	20887.63
Agent6	GGSN	20888	25065.16

Agent7	GGSN	25065	29242.69
Case 2			
Agent	Response	WT (sec)	RT (sec)
Agent1	GGSN	0	4177.5268
Agent2	Agent1	4177.5	4450.822946
Agent3	Agent1	4450.8	4724.119092
Agent4	Agent1	4724.1	4997.415237
Agent5	Agent1	4997.4	5270.711383
Agent6	Agent1	5270.7	5544.007529
Agent7	Agent1	5544	5817.303675
Case 3			
Agent	Response	WT (sec)	RT (sec)
Agent1	GGSN	0	0
Agent2	Agent1	0	273.2961458
Agent3	Agent1	273.2961458	546.5922916
Agent4	Agent2	273.2961458	546.5922916
Agent5	Agent1	546.5922916	819.8884374
Agent6	Agent2	546.5922916	819.8884374
Agent7	Agent3	546.5922916	819.8884374

Figure (4.26) shows the differences among the three aforementioned cases in terms of WT and RT. Case 3 clearly outperforms the other cases in terms of RT as shown in Figure (4.27).

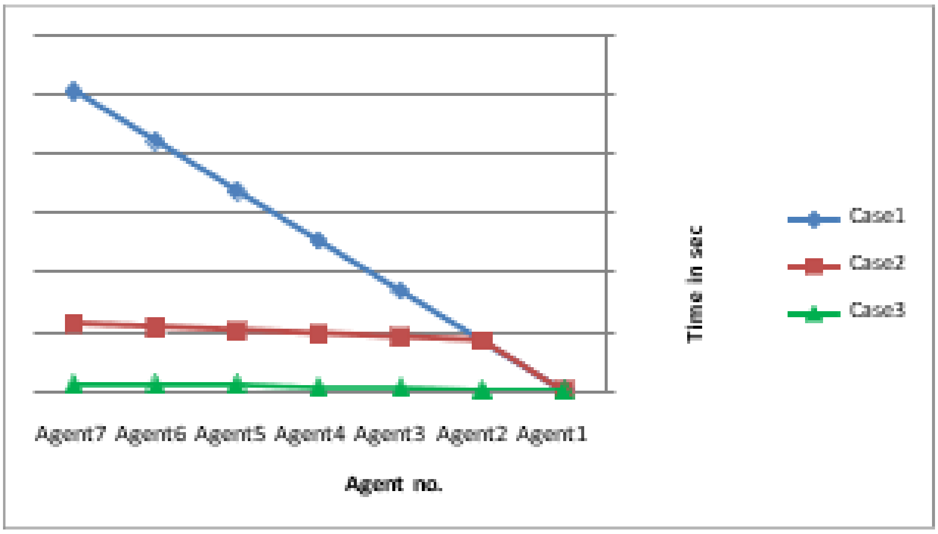


Figure 4.26 : Comparison of WT in Three Cases

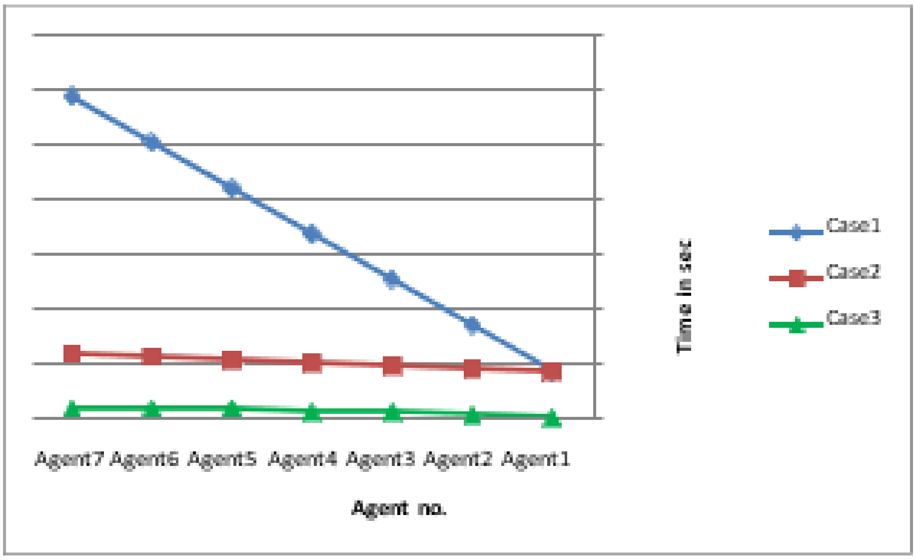


Figure 4.27 : Comparison of RT in Three Cases

4.8.3 Scalability Tests

Test 1: This test involves 100 requests for the same file with a size of 9.96 MB. The GGSN and MS agent have packet transferring times of 25.6 ms and 1.674 ms, respectively.

Assuming that all requests arrive at the same time and that the first mobile agent has the requested file, the request management is applied to calculate the WT, RT, and Maximum Mobile Agent Use (MMU) for each agent. Table (4.7) presents the results.

Table 4.7 Summary of File Transfer Time

Agent	WT (ms)	RT (ms)	Respond From	MU (Agent1)
1			GGSN	7
2	0	4.554935	Agent1	6
3	4.554935	9.109872	Agent1	5
4	4.554935	9.109872	Agent2	5
5	9.109871667	13.66481	Agent1	4
6	9.109871667	13.66481	Agent2	4
7	9.109871667	13.66481	Agent3	4
8	9.109871667	13.66481	Agent4	4
9	13.66480667	18.21975	Agent1	3
10	13.66480667	18.21975	Agent2	3
11	13.66480667	18.21975	Agent3	3
12	13.66480667	18.21975	Agent4	3
13	13.66480667	18.21975	Agent5	3
14	13.66480667	18.21975	Agent6	3

15	13.66480667	18.21975	Agent7	3
16	13.66480667	18.21975	Agent8	3
17	18.21975	22.77468	Agent1	2
18	18.21975	22.77468	Agent2	2
19	18.21975	22.77468	Agent3	2
20	18.21975	22.77468	Agent4	2
21	18.21975	22.77468	Agent5	2
22	18.21975	22.77468	Agent6	2
23	18.21975	22.77468	Agent7	2
24	18.21975	22.77468	Agent8	2
25	18.21975	22.77468	Agent9	2
26	18.21975	22.77468	Agent10	2
27	18.21975	22.77468	Agent11	2
28	18.21975	22.77468	Agent12	2
29	18.21975	22.77468	Agent13	2
30	18.21975	22.77468	Agent14	2
31	18.21975	22.77468	Agent15	2
32	18.21975	22.77468	Agent16	2
33	22.77468333	27.32962	Agent1	1
34	22.77468333	27.32962	Agent2	1
35	22.77468333	27.32962	Agent3	1
36	22.77468333	27.32962	Agent4	1
37	22.77468333	27.32962	Agent5	0

Agent	WT (ms)	RT (ms)	Respond From	MMU(Agent1)
38	22.77468333	27.32962	Agent6	0
39	22.77468333	27.32962	Agent7	0
40	22.77468333	27.32962	Agent8	0
41	22.77468333	27.32962	Agent9	0
42	22.77468333	27.32962	Agent10	0
43	22.77468333	27.32962	Agent11	0
44	22.77468333	27.32962	Agent12	0
45	22.77468333	27.32962	Agent13	0
46	22.77468333	27.32962	Agent14	0
47	22.77468333	27.32962	Agent15	0
48	22.77468333	27.32962	Agent16	0
49	22.77468333	27.32962	Agent17	0
50	22.77468333	27.32962	Agent18	0
51	22.77468333	27.32962	Agent19	0
52	22.77468333	27.32962	Agent20	0
53	22.77468333	27.32962	Agent21	0
54	22.77468333	27.32962	Agent22	0
55	22.77468333	27.32962	Agent23	0

56	22.77468333	27.32962	Agent24	0
57	22.77468333	27.32962	Agent25	0
58	22.77468333	27.32962	Agent26	0
59	22.77468333	27.32962	Agent27	0
60	22.77468333	27.32962	Agent28	0
61	22.77468333	27.32962	Agent29	0
62	22.77468333	27.32962	Agent30	0
63	22.77468333	27.32962	Agent31	0
64	22.77468333	27.32962	Agent32	0
65	27.32961667	31.88455	Agent1	0
66	27.32961667	31.88455	Agent2	0
67	27.32961667	31.88455	Agent3	0
68	27.32961667	31.88455	Agent4	0
69	27.32961667	31.88455	Agent5	0
70	27.32961667	31.88455	Agent6	0
71	27.32961667	31.88455	Agent7	0
72	27.32961667	31.88455	Agent8	0
73	27.32961667	31.88455	Agent9	0
74	27.32961667	31.88455	Agent10	0
75	27.32961667	31.88455	Agent11	0
76	27.32961667	31.88455	Agent12	0
77	27.32961667	31.88455	Agent13	0
78	27.32961667	31.88455	Agent14	0
79	27.32961667	31.88455	Agent15	0
80	27.32961667	31.88455	Agent16	0
81	27.32961667	31.88455	Agent17	0
82	27.32961667	31.88455	Agent18	0
83	27.32961667	31.88455	Agent19	0
Agent	WT (ms)	RT (ms)	Respond From	MMU (Agent1)
84	2277.33229961667	11.8888445555	Aggennt2200	0
85	2277.33229961667	11.8888445555	Aggennt2211	0
86	2277.33229961667	11.8888445555	Aggennt2222	0
87	2277.33229961667	11.8888445555	Aggennt2233	0
88	2277.33229961667	11.8888445555	Aggennt2244	0
89	2277.33229961667	11.8888445555	Aggennt2255	0
90	2277.33229961667	11.8888445555	Aggennt2266	0
91	2277.33229961667	11.8888445555	Aggennt2277	0
92	2277.33229961667	11.8888445555	Aggennt2288	0
93	2277.33229961667	11.8888445555	Aggennt2299	0
94	2277.33229961667	11.8888445555	Aggennt3300	0
95	2277.33229961667	11.8888445555	Aggennt3311	0
96	2277.33229961667	11.8888445555	Aggennt3322	0

97	2277.33229961667	11.8888445555	Aggennt3333	0
98	2277.33229961667	11.8888445555	Aggennt3344	0
99	2277.33229961667	11.8888445555	Aggennt3355	0
11000	2277.33229961667	11.8888445555	Aggennt3366	0

The last agent has an RT of 31.88455 ms with the worst better than the transfer of the file from GGSN 69.62545m.

Figure (4.28) shows the WT and RT according to the request sequence, while Figure (4.29) shows the MMU. Extending the request sequence increases the WT and decreases the MMU.

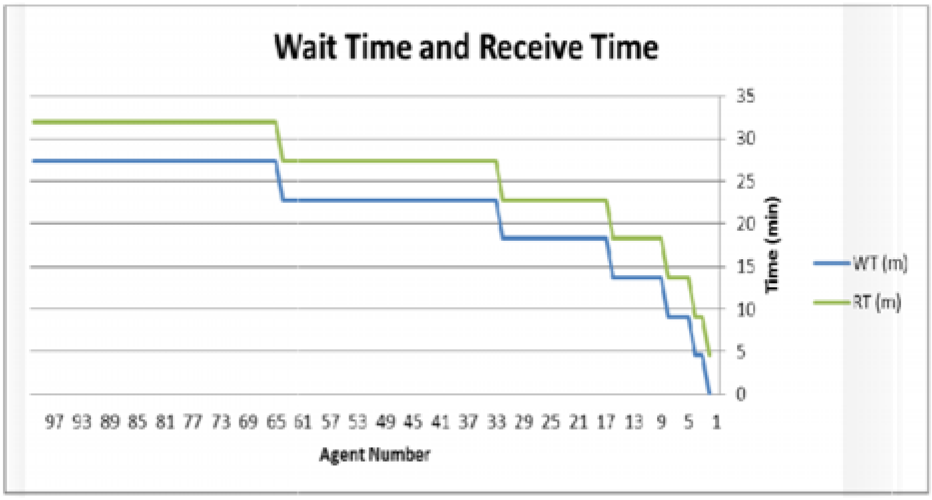


Figure 4.28 : Representation of WT and RT

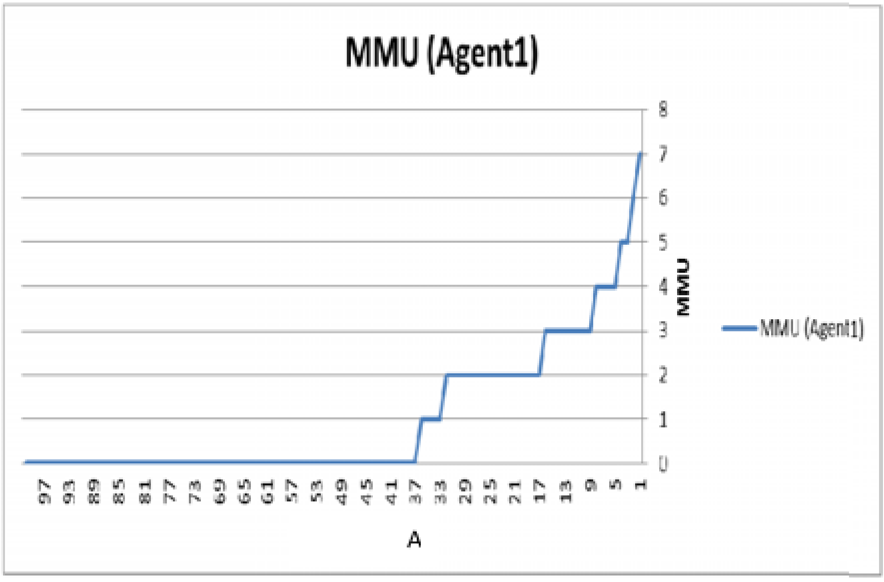


Figure 4.29 : Representation of MMU in File Transfer

Transferring a file from the mobile agent has an average throughput of 51.58178 kB/s, WT of 21.5904 ms, RT of 26.36342 ms. and MMU of 0.99. Meanwhile, transferring a file from the GGSN has an RT of 69.6254464 m and a throughput of 20 kB/s. Therefore, file transfer from mobile agents is much better than that from the GGSN.

Test 2: In this test, many agents are requesting for the same file with a size of 9.96 MB. The GGSN and MS agents have packet transfer times of 25.6 ms and 1.674766355 ms, respectively. This test computes for the average WT, RT, MMU, and Percentage of Mobile Agent Use (PMU).

Table (4.8) summarizes the requests and their effects on throughput. As can be seen in Figure (4.30), increasing the number of requests reduces the throughput yet increases both WT and RT.

The Average Use of Mobile Agents (AUM), PMU, and MMU to serve all other agents in the system are all presented in Figure (4.31)

Table 4.8 summarize file transferring time and waiting time

No. Of Request	Throughput (kb/s)	WT (ms)	RT (ms)	AuM	MMU (Agent)	PMU (Agent)
11000	52.10280724	211.559	2266.009	0.99	7	7.0000%
22000	44.39391932	266.009	3300.663	00.99995	8	4.0000%
33000	40.91582253	288.669	3333.223	00.999966	9	3.0000%
44000	38.65964724	300.663	3355.117	00.9999775	9	2.2500%
55000	37.4215505	311.779	3366.33	00.9998	9	1.8000%
1100000	33.25711755	366.333	4400.888	00.999	10	1.0000%
110000000	24.15113598	511.775	5566.330	00.999	14	0.1400%
100000	19.02884877	666.990	7711.446	00.999	17	0.0170%
500000	16.63094056	777.221	8811.776	00.999	19	0.0038%
1000000	15.7533853	811.776	8866.332	00.999	20	0.0020%
Average	32.2315175	455.227	4499.882	00.999	12.2	1.9213%

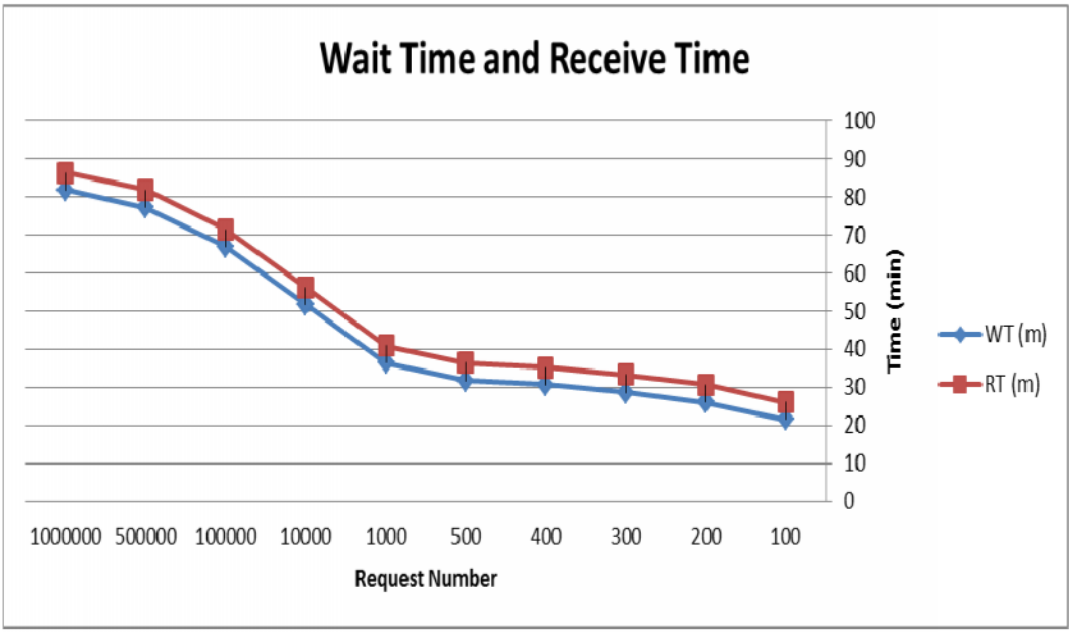


Figure 4.30 : WT and RT for the Implementation

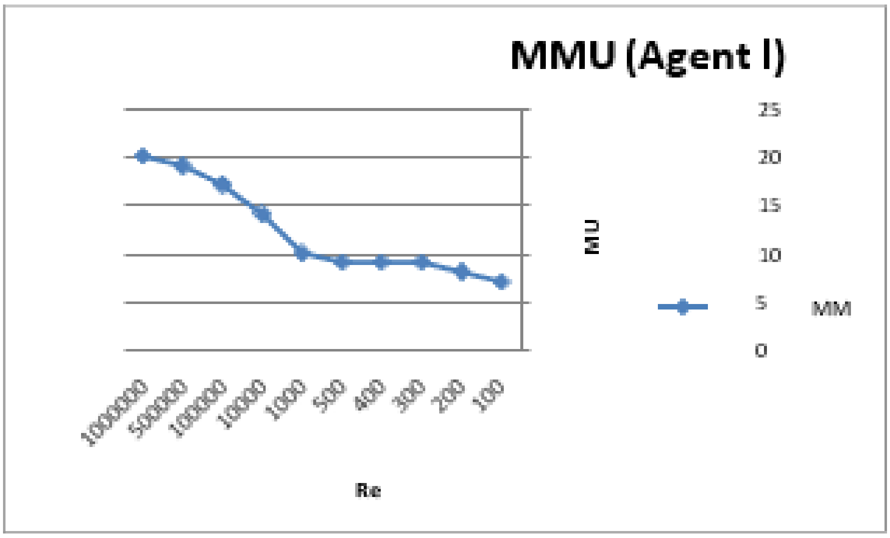


Figure 4.31 : Maximum MMU

The throughput of the system decreases along with the increasing number of requests as shown in Figure (4.32).

The test is performed on 10 different loads. The average throughput is 32.2315175 kB/s, the average WT and RT are 45.27923 ms and 49.82326 ms, respectively, while the average AMU, MMU, and PMU are 0.997605, 12.2, and 1.921%, respectively.

Transferring a file from the GGSN requires an RT of 69.6254464 ms and throughput of 20 kB/s

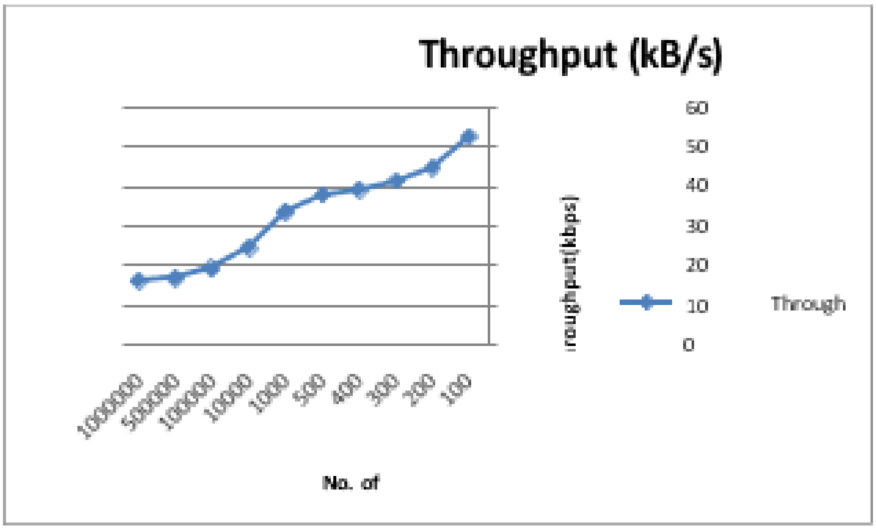


Figure 4.32 : Data Transfer Rate from the Mobile Agent

4.8.4 Summary of Results

This system trying to reduces the traffic by localizing the data transfer, which in turn going to change the total bit rate by reducing the number of paths and packet-switching circuits through which an agent needs to pass before reaching its destination. To demonstrate the performance of this system, many tests have been performed on the coordination and communication of mobile agents to facilitate file sharing. Some advantages of this system are listed as follows:

1.The average transfer time is reduced by 28.44%.

2.The throughput is increased by up to 161.15%.

3.The average MMU to transfer a file to another mobile agent is equal to 1 regardless of the number of requests. Therefore, the same mobile agent can be used to transfer other files, thereby reducing the amount of load placed upon the agents.

5. CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

The QoS over a GPRS network can be improved by using the proposed MAS, which has the following features:

Even if the connection to the GPRS backbone is lost, the mobile agents can still communicate with one another and with the BSC within their locations, thereby increasing the availability of the system.

Communication latency can be greatly reduced when the mobile agents communicate with one another to perform file sharing. The number of paths and packets is also significantly reduced by localizing the data transfer, and such localization also reduces the amount of overhead.

Resource management increases the throughput by 161.15% by segmenting the network.

The proposed MAS shows excellent performance in terms of file transfer time (with a 28.44% improvement) and end-to-end delay by localizing the data transfer. The packet transfer time from MS is less than that from GGSN.

In heavy traffic where thousands of agents are requesting for the same file, each mobile device has an average load of 1. The maximum MMU to serve the other mobile agents that are requesting for the same file is about 20 times.

This study proposes the following directions for future work:

1-The Request Management algorithm needs to be improved by increasing the number of orders to the GGSN; doing so can also reduce WT.

2-The FIFO algorithm can be used to schedule the requests in the BSC. However, another scheduling algorithm can also be used.

3-The genetic algorithm can be used to improve the selection of the best path to route the requested URLs.

4-An agent selector algorithm that specifies those mobile agents that can serve the other agents, determine those agents with the lowest or largest amount of files, and specify the maximum MMU must also developed in the future.

5-The MS agent needs to be updated with a search engine.

6-The URL search area can be expanded to the neighboring BSC.

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APPENDIX

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