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Improving the QoS in a Simulated GPRS Network

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Abstract: *General packet radio service (GPRS) is a 2.5 generation 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 to the digital world and access a large variety of services. The nature of these services cannot be described just as one global service because the capacity demand and time constraints vary from one type of service 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 paper 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.

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I. Introduction

As the Internet grows increasingly mobile, cellular network operators need to improve their networks to enhance the performance of various Internet applications. Such improvements are also necessitated by the growing user demand for excellent Quality of Service (QoS) . The first generation of cellular mobile devices are analogous systems that are constrained by different national standards. Meanwhile, the second generation GSM cellular devices are equipped with digital switches and circuits that are not suitable for Internet traffic and data services . These constraints only lead to the inefficient allocation of channels for the entire period. For burst traffic, packet-switched bearer services can efficiently utilize physical channels because a channel will only be allocated when needed and will be released immediately after the

transmission of data. In this way, multiple users can share the same physical channel to transmit and receive packets.

To address these inefficiencies in GSM networks, General Packet Radio Service (GPRS) was developed as a 2.5 generation cellular packet data network (PDN) for Global System for Mobile Communication (GSM). Through GPRS, the packets of users are directly routed from the mobile network to a packet-switched network. GPRS has become increasingly popular 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 communication in GSM networks.

The increasing number of GPRS users has also increased the demand for the excellent QoS of GPRS-based 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.

In the past, mobile phones had limited memory, limited data communication capabilities, and closed, proprietary operating systems; therefore, these devices seemed almost incapable of file sharing. However, as the present-day memory-intensive smartphones, which are endowed with several connectivity options (i.e., GSM, GPRS, Wi-Fi, and Bluetooth) and running open software platforms (i.e., Symbian and Windows Mobile), peer-to-peer (P2P) systems are ready to invade the mobile realm.

II. Materials and methods

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 (1) shows three sensitive areas within the GPRS network architecture, namely, the mobile device (J2ME support), BSC, and GGSN

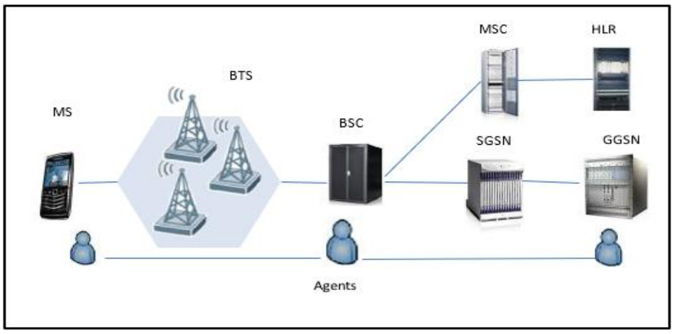

Figure (1)

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

- MS Agent
  The software package installed in each 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 the proposed system.
- GGSN Agent
  The agent installed at GGSN is a Java program that represents the point through which the GPRS domain is attached to external data networks (i.e., Internet) to simulate 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.
- 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.
- The JADE Remote Agent Management (RMA) tool monitors the creation and initialization of all agents in the proposed platform. Figure (2) shows the output of JADE RMA after initializing the BSC agent. As can be seen in the figure, many agents have started themselves automatically.

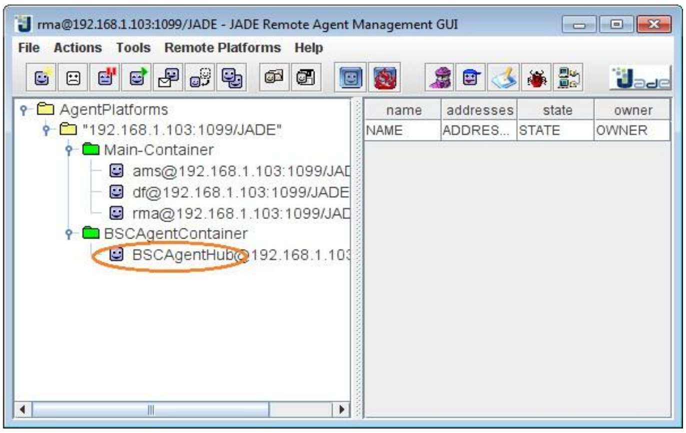

Figure (2)

- 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. 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.

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:

$$TransfetTime = No.of\ Packet$$

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

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

$$AMU = \frac{1}{NoofAgent} \quad \frac{NoofAgent}{i = 1} \quad MMUofAgent$$

III. System Performance Tests and Results

The Figure 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.

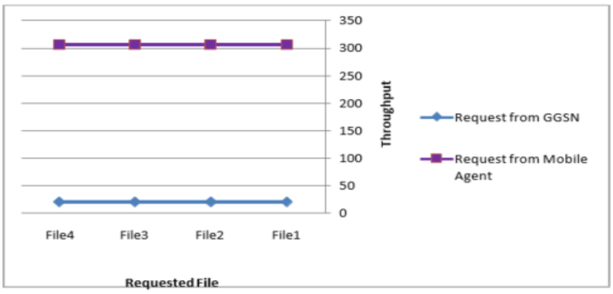

Figure (3) Comparison of Throughput

The difference between the times of transferring a file from GGSN and from the mobile agent is shown in Figures below

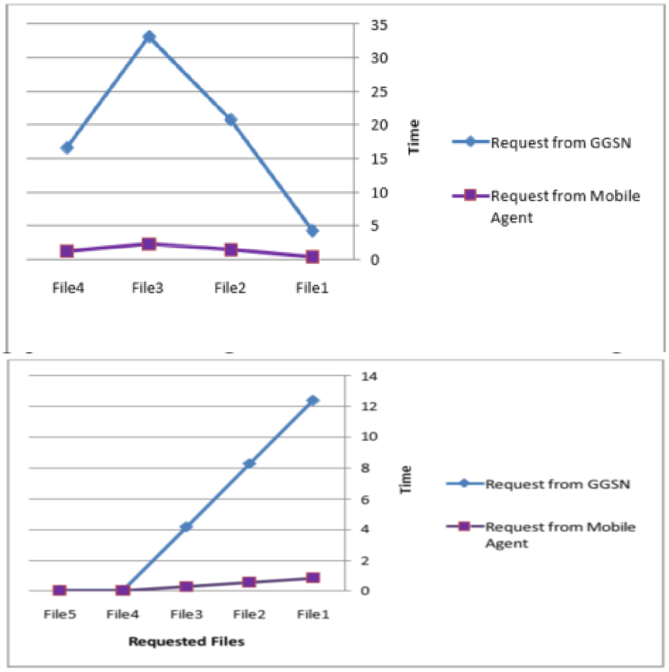

Figure (4) Comparison of File Transfer Time

As seen in these Tables, the mobile agent has a better transfer time than the GGSN, thereby improving the throughput.

File	Size (kB)	Agent	Time (s)	Throughput	
File1	30.260	Agent2	12.3948	20	**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	**MS**
File2	20.173	Agent3	0.5406	305	
File3	**10.086**	**Agent5**	**0.2703**	**305**	

File	Size (kB)	Agent	Time (s)	Throughput (kB/s)	
File1	10.08691406	Agent1	4.1316	20	**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	**MS**
File2	50.43457031	Agent6	1.3515	305	
File3	80.6953125	Agent7	2.1623	305	
File4	**40.34765625**	**Agent8**	**1.0812**	**305**	

Table (1) Summary of File Transfer Time and Throughput

the test below uses a file with a size of 10.9 kB.
Case 1: Seven users request for the file from GGSN.
Case 2: The first agent obtains the request from the GGSN, while the other agents obtain their requests from the first agent
Case 3: This case illustrates the system performance depending on request management and supposes that agent 1 owns the requested file.
Table below summarizes these three cases and shows that case 3 outperforms the two other cases in terms of Receiving Time (RT).

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**

Table (2) Summary of WT and RT of MS Agents

The proposed MAS reduces the overhead traffic by localizing the data transfer, which in turn will affect 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.

IV. Conclusions

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 amount 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.

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