

x-AppMonitor μ Agent: a tool for QoS measurements in cellular networks

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Abstract—Design, optimization and assurance of GSM and 3G networks are becoming increasingly costly as a consequence of factors such as the high numbers of subscribers, the new and complex traffic patterns and the coexistence of different radio access technologies. One interesting indicator of network performance in a particular area is the quality of service perceived by the final user for specific services. This user perception is gaining importance with regard to services like short messaging or IP-based applications. In this scenario, traditional measurement tools employed by operators could be replaced by the new mobile phones, because they can be used as an environment where measurements can be done directly. This paper reports our experiences developing x-AppMonitor μ Agent, a network performance monitoring tool which is executed in off-the-shelf mobile terminals and measures quality of service perceived by users. Practical results will be provided.

I. INTRODUCTION

Performance measurement of cellular networks has traditionally been done at service and at network level. At network level, the objective is to ensure that the network as a whole is working at its optimum capacity. At service level, the aim is to characterize the performance of a given service across the whole network. These kinds of processes require information obtained from statistics provided by the network elements and probes performed at different network interfaces. Data collection at these two levels is used to make better use of the network resources. However, optimizing the network performance does not guarantee an optimum end-user experience. Customers are not interested in network performance. They simply demand that the particular service they use perform correctly.

In order to enhance user experience it is necessary to carry out measurements centered on the quality of service which is perceived by users.

The performance perceived by the subscriber can be affected by factors which are beyond the control of the mobile operator, such as Internet latency, downlink air interface or the behavior of other applications running in the terminal. However, the correlation of measurements at different levels could provide a powerful tool for anticipating service performance issues before they become customer issues.

Drive tests are only useful for service verification and trialing once the service is launched. Monitoring user and

service level performance regularly, inside the network, is expensive, time consuming and is not statistically relevant. In this paper we propose an alternative non-expensive solution.

x-AppMonitor μ Agent is a software tool developed as a result of the collaboration between OPTIMI and the University of Malaga, which forms part of the advanced network-wide monitoring solution named x-AppMonitor.

x-AppMonitor μ Agents are units for data collecting that work automatically at user terminals. μ Agents execute measurement campaigns and collect end-user performance statistics. This new approach to the end-user measuring process improves user data collection due to cost reduction (subscriber terminals are used in the collection process) and data relevance (this tool enables the regular collection of end-user performance indicators in a simple way).

II. XAPPMONITOR μ AGENT

The performance analysis of voice cellular networks is carried out using models and simulations[1]. These models are well-known and can be used to generate realistic traffic patterns. But in packet switched mobile networks there are a lot of factors that affect the final service experience of customers, such as radio propagation conditions, packet routing, and protocol performance over cellular networks. As a result, simulation in these kinds of networks is a difficult task, even without considering the complexity of modeling 3G signalling stacks and issues such as "cell breathing".

Before current smart phones were available, many studies focused on analyzing end-to-end service performance[2]. Some methods for traffic analysis found in the literature are based on a client-server architecture [3][4] in which the client machine is a notebook that uses a mobile phone as a modem and connects by means of GPRS (or another cellular technology) to a server machine. Although this configuration may be interesting for experimental purposes, because capture software can be used to capture the traffic, one usual problem is that participating machines may lack mobility due to the use of additional hardware.

Results obtained with this configuration may not be statistically representative because measurements are not taken in the same conditions as those which users may experience when moving. To achieve more meaningful results, measurement

solutions should be able to collect information from multiple distributed sources and to cover the entire network taking advantage of the intrinsic mobility of mobile subscribers.

The total impact of all factors on quality of service parameters such as access time, transfer rates or service accessibility can only be quantified with a statistically valid number of samples obtained in real conditions of network load and radio propagation.

μ Agent is a tool designed to provide an automatic measurement system for performance analysis and monitoring of voice and data services in mobile networks anywhere at anytime without interfering with the network operation. It is a useful tool for network operators and regulators to help them analyze existing services.

μ Agent is a software application which is installed on end-user terminals and runs in background mode. Its execution does not interfere with the normal operation of the terminals and customers do not need to be trained. In this way it is very easy to obtain a widespread base of measurements with no effort and without additional hardware. A possible scenario of use could be to deploy μ Agent in mobile terminals in a fleet of vehicles, such as taxis.

This solution has several advantages, on the one hand it allows us to obtain useful information for network dimensioning tools and on the other, network problems can be detected in real time.

Once μ Agents have been deployed, their execution can be managed remotely. The X-AppMonitor server configures and manages their operation see Fig. 1 so that measurement campaigns can be launched from the server side depending on the location of the terminal. This allows us to focalize data collection on problematic coverage areas.

μ Agents do not require user intervention to run, although measurements can be executed from the terminal by a trained user. In this case, flexibility for specific measurements is increased. This functionality is similar to what we can obtain in a drive-test, with the difference that in a drive test we need to use a special mobile phone and additional equipment.

In both cases measurement results are obtained by a mobile

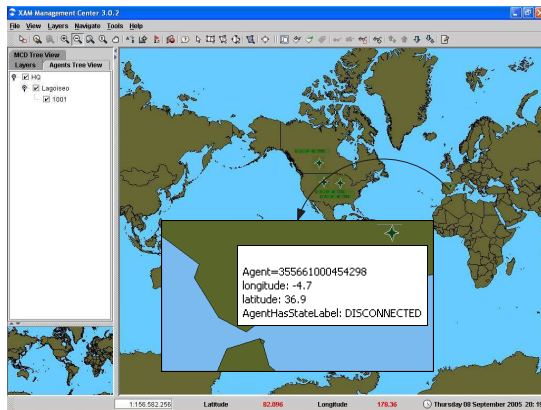


Fig. 1. μ Agents are localized from server side anywhere at anytime

device and transferred to the server. In this way the mobile terminal is only used to collect information and the server, which usually is a more powerful machine, to store and analyze the data obtained.

A. Features

μ Agent enables performance measurements of voice and data services with a very scalable topology, because it is not necessary to deploy a complex and costly infrastructure.

μ Agent functionality is not only limited to traffic monitoring. It can also be used for traffic generation, where suitable deployment of the tool enables specific traffic scenarios to be planned in order to analyze problematic situations of network load.

μ Agent has the following remarkable characteristics:

- End-user quality of service monitoring
- Scalable topology
- Essential tests are executed on real network loads
- Traffic generation
- Real time network diagnosis
- Service performance degradation monitoring
- Service availability monitoring

III. SERVICE PERFORMANCE MEASUREMENTS

The x-AppMonitor μ Agent supports a wide range of services including FTP, HTTP, SMS and MMS.

μ Agent includes a FTP client (Fig. 2) with typical FTP commands. This client is used for measuring FTP performance on mobile packet switched networks. FTP is an IP protocol that has traditionally been used for traffic pattern analysis[5], and the results obtained are used as performance indicators of a data network.

In order to monitor typical mobile services such as SMS or MMS μ Agent uses mobile messaging modules.

PDP (Packet Data Protocol) context monitoring is a μ Agent built-in functionality. It is used to monitor the control connection established with the server in order to avoid μ Agent

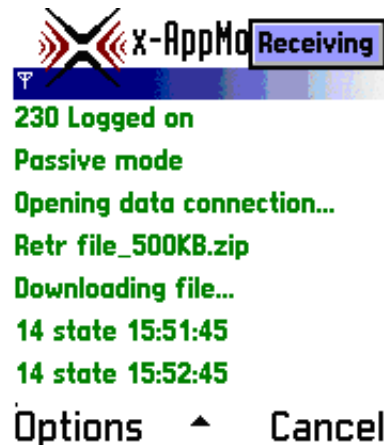


Fig. 2. Ftp Service

missing the connection. On the other hand this functionality is used to calculate the service independent quality of service parameters such as radio network availability and network accessibility. PDP contexts are continuously monitored and automatically reestablished in cases where problems arises.

This mechanism converts a user terminal into an automatic and robust measurement tool whose data can be used to obtain coverage maps, status maps, and quality of services maps of services provided by mobile operators.

For each service key performance indicators (KPI) have been identified based on the ETSI 102-250 specifications defined by the ETSI Technical Committee Speech Processing, Transmission and Quality Aspects[6]. The aim of the ETSI is to make a set of KPIs available to the industry that enable direct comparison of measurements obtained with different equipment and to establish a common understanding of the meaning of certain KPIs. These KPIs are particularly focused on quality parameters such as accessibility, delays and transfer rates.

KPIs used to evaluate quality of service of FTP are:

- FTP Service Accessibility Ratio. The service accessibility ratio denotes the probability that a subscriber can establish a PDP context and access the service successfully.
- FTP setup time. The setup time describes the time period needed to access the service successfully.
- FTP Ip- Service Access Ratio. The IP-Service access ratio denotes the probability that a subscriber can establish a TCP/IP connection to the FTP server successfully.
- FTP IP-Service Setup Time. The IP-Service setup time is the time period needed to establish a TCP/IP connection to the server (Fig. 3).
- FTP Completed Session Ratio. The completed command ratio is the proportion of completed FTP sessions and FTP sessions that were started successfully.
- FTP Session Time. The session time is the time period needed to successfully complete a PS (Packet Switched) data session.
- FTP Mean Data Rate. After a data link has been successfully established, this parameter describes the average data transfer rate measured throughout a successful data transfer (Fig. 4).
- FTP Data Transfer Cut-off Ratio. The data transfer cut-off ratio is the proportion of incomplete data transfers and data transfers that were started successfully.

Fig. 5 depicts the time evolution of transfer rates of ten μ Agents located at different sites in the same city during a FTP session. This allows detection of low throughput zones, which can be related with packet routing problems at the core network. An SLA (Service Level Agreement) is defined for each service, specifying the level of the different KPI associated with a service. A server alarm is set off when SLA violation occurs. With this functionality the system obtains greater autonomy. Once measurement campaigns are scheduled, the system can monitor quality of the different services in a continuous way, human intervention is only needed when an alarm is generated.

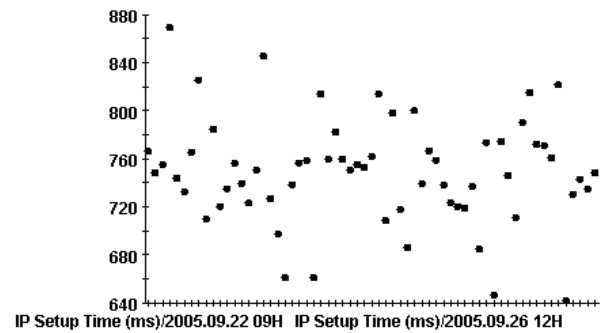


Fig. 3. Ftp Ip Setup Time

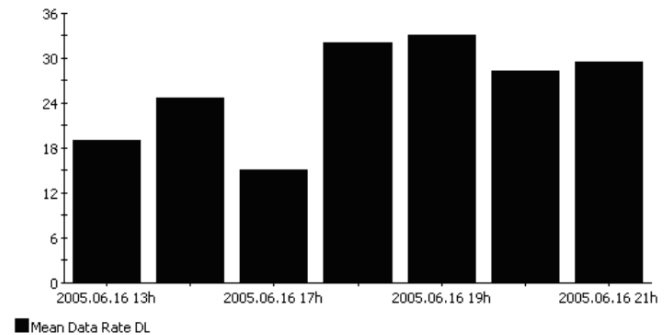


Fig. 4. Ftp Mean Data Rate

IV. SYSTEM TOPOLOGY

A client-server architecture is used to manage the μ Agents operation more securely.

As shown in Fig. 6, end-user performance indicators are regularly sent to the Management Center, which then performs analysis, post-process and visualization of collected data.

μ Agent communicates with the server using a proprietary protocol based on TCP. Measurement campaigns are generated at the Management Center to schedule the μ Agent behavior. A measurement campaign consists of the execution of different services. Each service has several configurable parameters that are specified in a script file named measurement campaign descriptor (MCD). Scripts can be edited on the server side and later sent, via FTP, to the μ Agents. μ Agents are able to interpret MCDs, launch the services and monitor the parameters needed to calculate KPIs associated with each service. Finally, collected data are reported, via FTP, to the server. A MCD contains information about timing, in this way we can specify the time at which measurement can be executed.

Configurable parameters for a FTP session are server ip address, port number, mode, user, password, and the FTP commands that we want to execute. The following example script executes ten FTP sessions with a pause of fifteen minutes. During each FTP session a file named file_1KB.zip is downloaded.

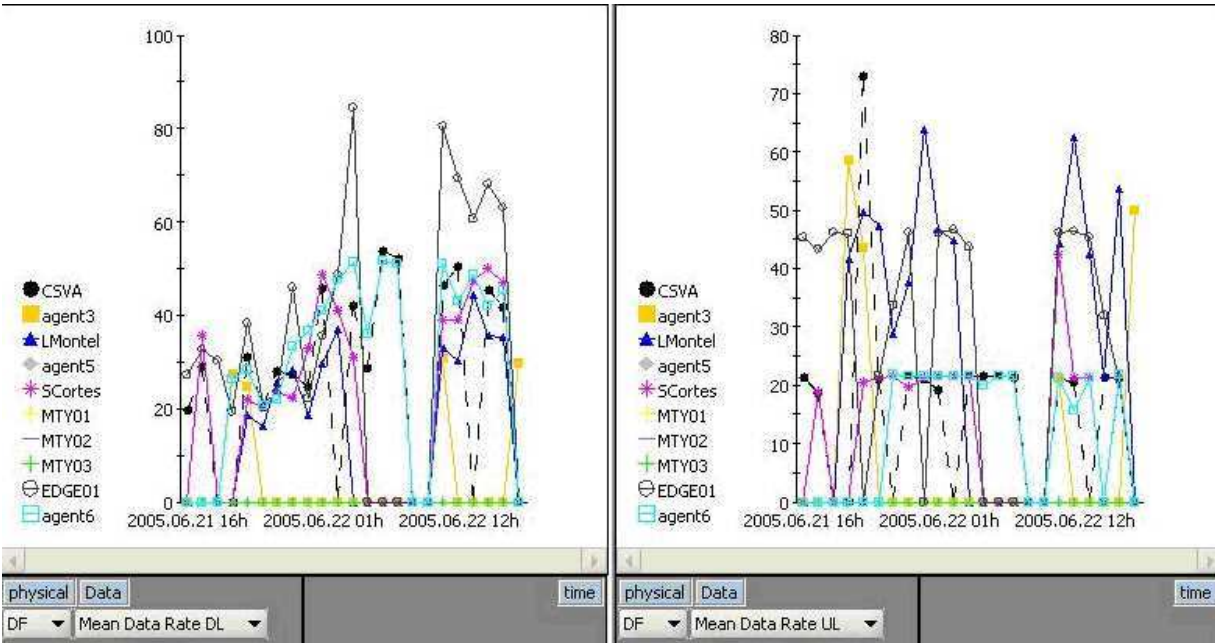


Fig. 5. Measurements from deployed μ Agents

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loop 10

ftp 192.168.2.1 21 passive
user name
pass 123
get file_1KB.zip
bye
end_ftp

pause 900

end_loop

```

Reports generated during script execution are stored temporarily in the terminal.

Another possibility is edit and execute measurement campaigns at the terminal by a trained user.

An alternative operation mode allows the services executed by the users of the devices to be monitored. It is possible to extract information about the perceived quality of service and the type of traffic generated by the users in the normal use of the phones.

V. IMPLEMENTATION

Before undertaking the development of a software tool like xAppMonitor μ Agent it is essential to carry out a study of existing platforms for the deployment of applications in mobile terminals. There are a lot of initiatives from different vendors such as Qualcomm (Brew), Microsoft (.Net Compact Framework), Sun Microsystems (J2ME), Symbian (Symbian OS).

xAppMonitor μ Agent runs within Symbian OS[7] based smart phones and the Nokia series 60 platform[8]. C++ code has been used during its implementation in order to access native APIs of Symbian.

This operating system offers a unified set of native APIs that improves efficiency. Other platforms, such as Java or BREW, provide high level APIs offering restricted access to actual functionality, which can be accepted for general purpose software but could reduce global performance. When performance instead of portability is the main goal, native programming is more appropriate than using virtual machines. xAppMonitor μ Agent must be executing permanently while minimizing the use of resources and without interfering with other operating applications.

"Symbian Os is considered the de facto standard operating system for the new generation of advanced mobile phones"[9], being the one that has been deployed the most. We highlight this because for a massive deployment the amount of existing terminals it is an important factor. The Symbian OS consortium is made up of by the main manufacturers of mobile phones, including, amongst many others, Nokia, SonyEricsson, Samsung, Siemens and LG.

Symbian OS is an operating system specially designed for wireless information devices such as communicators and smart phones. Symbian OS includes support for leading standards of wireless industry such as WAP, XHTML, J2ME, MIDP, MMS, Bluetooth, GPRS, CDMA, WCDMA, WLAN, IPv6, IPsec, etc.

To collect information about the current location, in Symbian, parameters like the cellID can be obtained in quite a straightforward manner. More accuracy can be achieved

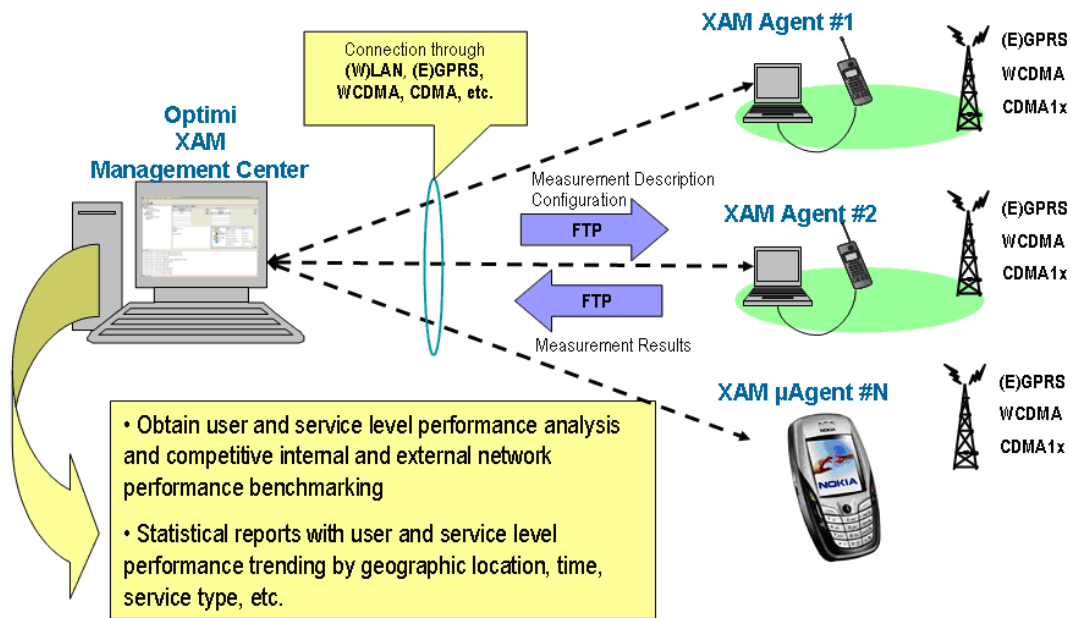


Fig. 6. System Topology

with integrated GPS receivers. The number of GPS-enabled terminals is expected to grow in the next few years, and the evolution of communication standards will allow interaction between networks and mobile devices to help them locate the serving satellites more efficiently.

VI. CONCLUSIONS

In this paper we present x-AppMonitor μ Agent, an integrated automated solution for the analysis of quality of service perceived by end-users of GSM and 3G networks.

x-AppMonitor μ Agent takes advantage of the capacities present in new mobile terminals, named smart phones. These capacities allow user terminals to be used as measurement devices. In fact smart phones provide this solution with the intrinsic mobility of mobile subscribers.

Performance indicators are collected at the end-user point using a very simple and scalable solution in order to analyze the reliability of mobile network from a user's perspective. No other measurements can include the effects that the downlink air interface and the application running the service have on the customer's experience. The same tool will also work for future new technologies (Beyond 3G and 4G systems).

One of the most powerful features of this tool is traffic generation. This capability can be used to analyze the behavior of the network under high load conditions and can reproduce particular traffic scenarios. μ Agents inside the area of interest can be configured to perform stress tests and analyze network problems.

In future releases of this tool, new services will be supported among which those based on protocol SIP (Session Initiation Protocol) such as POC (Push-Talk over Cellular) such be emphasized.

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