Performance monitoring and analysis of wireless communication protocols for mobile devices

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Abstract. Fixed to mobile convergence is a very promising field due to the success in recent years of mobile devices such as smart phones and PDAs. A wide variety of wireless technologies ranging from Bluetooth, Wi-Fi, Wimax, to GPRS, UMTS and its later releases, allow ubiquitous connectivity. Roaming between different access technologies will be an important area of activity. As a result of the heterogeneity of radio access technologies, there is a growing trend to use IP as underlying protocol. Analysing the behaviour of IP based protocols in this environment is necessary to optimize its performance. In this paper we present the development of a new tool which aims to capture and analyze traffic from different protocols and access technologies in existing mobile devices. In order to get the best results we propose using off-the-shelf mobile phones as instruments to obtain an accurate perception of the service performance offered to mobile users.

1 Introduction

GPRS and UMTS have enabled the use of mobile devices as computing elements in distributed systems. In addition, mobile networks are increasingly open, and include new functionalities like IMS (IP Multimedia Subsystem) to support the deployment of new IP based mobile services. Many opportunities are appearing for third parties such as content providers and application developers. However, the success of new services and applications will depend on the quality of service perceived by users. As a result, new tools are needed to check that communication performance fulfills users' expectations.

At the same time as new mobile services like POC (Push to talk Over Cellular) are developed, there is a heavy demand for killer Internet applications to migrate to mobile devices, this is caused by the users needs for always-on connectivity wherever they go. Nevertheless, most of these applications have been designed and tested to work in an environment that differs from the mobile one, where radio propagation conditions may vary due to effects like multipath fading and where network procedures like handovers may affect ongoing communications.

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Most SDKs (Software Development Kits) for mobile platforms provide emulators that help in developing applications. However, developers have to bear in mind when debugging that communication functions use the machine stack where the emulator is running, instead of the actual configuration that can be found in mobile phones. In some cases it is impossible to debug features such as the PDP (Packet Data Protocol) context which are not supported by the SDK emulator. So, to check communication applications for mobile devices it is necessary to analyze their behaviour in the actual mobile environment.

For monitoring traffic from mobile applications that connect with non -mobile devices like servers, one possible approach could be to sniff traffic on the server side, for example by installing a network analyzer in its local area network. But this configuration is only possible when this connection point is accessible, i.e., when connecting to our own servers. Furthermore, we can find other scenarios where new diagnostic tools are needed, like peer-to-peer applications [1] where connections can be established between two mobile devices.

Some commercial products are designed to help mobile operators monitor the performance of existing services from mobile phones [2][3]. These software applications typically have two operation modes, active and passive. In active mode the application itself generates traffic to test the services and monitors the established sessions, whereas in passive mode the application monitors less detailed information like service availability and coverage is provided without generating traffic. However, these solutions target operators, whose aim is to optimize the global network performance for the whole set of users, so there is still great leeway to optimize individual applications.

As operators do not carry out the development of applications for mobile phones, it is crucial to provide developers with tools similar to those used for local area networks (ping, tracert, netstat, sniffers).

In this paper we present the SymPA mobile application, which enables traffic analysis and monitoring of mobile devices in real operating conditions. With this tool it is possible to sniff all of the IP traffic that other applications running on a mobile phone receive from GPRS/UMTS connections. This makes SymPA especially suitable for studying the end-to-end performance of IP based protocols and for mobile peer-to-peer scenarios. In addition, the application provides useful information related to radio parameters and the state of the mobile device, which can be used to detect the cause of transmission problems.

The rest of this paper is organized as follows. In the next section we describe the tool. Section 3 shows some use cases of SymPA. Finally section 4 summarizes our conclusions and future work.

2. SymPA: Symbian Protocol Analyzer for mobile terminals

To the best knowledge of the authors, there are no monitoring tools of general use for capturing IP traffic over mobile networks in a mobile device. SymPA is an application developed on Symbian OS [4] to meet this need.

SymPA is a protocol analyzer for mobile phones that allows all the incoming TCP/IP traffic to be captured without interfering with the normal performance of the terminal. The main design goals for this tool have been the following:

– To capture all incoming IP packets, while avoiding information overload.
– To perform efficient resource management, according to constraints on power processing and battery life of mobile devices.
– To include basic functions for network management such as ping and tracert.
– To provide interfaces for processing captured information and for exporting it to other environments.

2.1 Symbian as execution platform

Symbian has been the chosen platform for the development of this tool because it has been designed with mobile devices in mind. Symbian provides support for wide area networking stacks including TCP/IP (dual mode IPv4/v6); personal area networking support including infrared (IrDA), Bluetooth and USB; support for multi-homing and link layer Quality-of-Service (QoS) on GPRS and UMTS networks.

In the initial phases of the development, we found that Symbian provides access to raw sockets; this kind of socket is traditionally used in the development of sniffers and tools such as ping and tracert.

The main problems found during the development had to do with the scarce documentation of APIs related with low level communication functions. Many efforts have also been made to manage the available resources in order to avoid packet losses.

The current implementation makes the capture of all incoming IP packets possible. At the same time, network parameters like received signal strength, radio access technology (GPRS/UMTS), cell ID and battery level are stored.

In the next section the main characteristics of SymPA and its operation (Fig. 1) are highlighted.

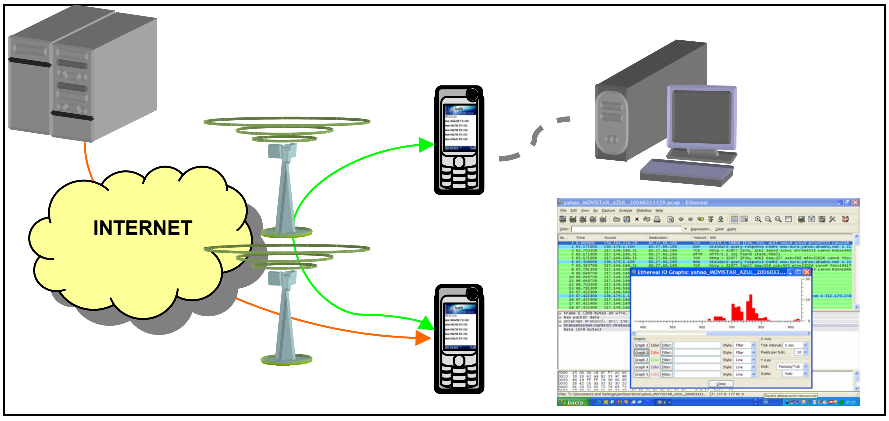

Fig. 1. SymPA working diagram

2.2 Capture and visualization

When SymPA is in capture mode, all IP packets that arrive to the mobile devices from GPRS/UMTS connections are saved in buffers in raw format. SymPA runs the background without interfering in the performance of active applications. In parallel, network parameters are observed periodically. When the capturing session finishes, the contents of the buffers is stored in files and later adapted to text2pcap input format, the lipcap format conversion tool is included in the free distribution of the Ethereal [6] analyzer. The files can be transferred to a computer via USB, infrared or Bluetooth, depending on the terminal availability of these technologies.

Lipcap files can be analyzed directly with Ethereal, taking advantage of the great variety of filtering options, statistical analysis and graph generation features of this application, as depicted in Fig. 1.

3 Scenarios and use cases

In the first scenario, emphasis has been placed on how handovers impact TCP performance. The second scenario focuses on a file transfer between two phones.

3.1 FTP

As an example of use case to illustrate the application of SymPA, this scenario is focused on how TCP traffic flow is affected during handover. We have transferred files of 200 KB from an FTP server located on a remote network connected to the Internet via a Fast Ethernet network. The Nokia 6680 has been the mobile phone used in this use case. The RSSI (Received Signal Strength Indicator) received on the mobile phone from the base station falls within the range of -77 dBm to -82 dBm.

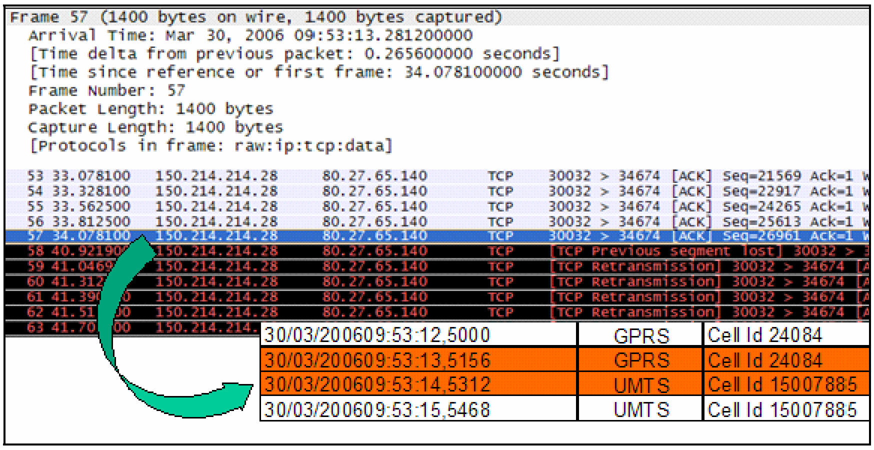

Fig. 2. Lost packet due to handover between GPRS and UMTS

In UMTS soft handover allows seamless handover. During soft handover, a mobile station is in the overlapping cell coverage area of two sectors belonging to different base stations. Communication between the mobile station and the base station take place concurrently via two air interface channels from each base station separately [6]. In GSM the macrodiversity cannot be used and the communication is interrupted. Where interruptions are lengthy, the buffered packets at network elements can overflow, and may result in packets loss. This behaviour is depicted in Fig. 2.

At the same time as the handover takes place, the reception of packets stops during 7 seconds. After that, the retransmission of packet loss is initiated.

3.2 Mobile-to-mobile communication

SymPA enables monitoring of mobile-to-mobile communications. In this way this tool allows the detection of anomalies and incorrect configurations in TCP implementations used in mobile terminals. These anomalies could appear due to degradation caused by factors which are only present in the mobile environment such as handover. This kind of scenario is therefore very difficult to reproduce. In this use case, it is especially important to use SymPA for real time monitoring.

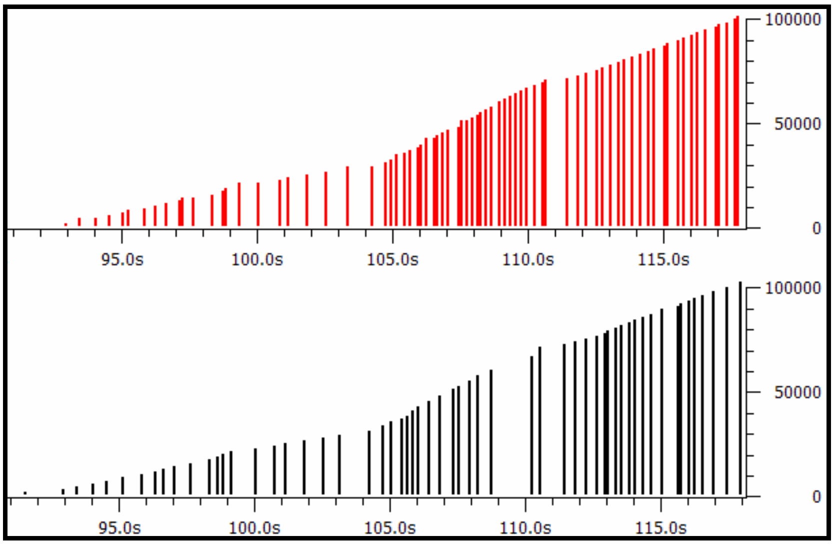

Fig. 3. File transfer between two mobile devices over TCP

In figure 3 an example of mobile-to-mobile TCP communication can be observed. In this use case, data flows in a single direction (client->server). The first graphic depicts the evolution of the sequence numbers in the packets received at the server. The second graphic depicts the evolution of the acks received by the client. It can be observed that when the client receives several acks consecutively their bit rate increases (105 seconds after the transference is initiated). When confirmations are delayed, the client bit rate is reduced (109 seconds and 110 seconds after the transference is initiated). This is an example of how SymPA makes it possible to observe very detailed protocol behaviour.

Tabla 1. Round trip times over measured over UMTS and GPRS

RTT	*Average (ms)*	*Max (ms)*	*Min (ms)*
GPRS-GPRS	2146	3343	1281
UMTS-GPRS	1334	3953	734
UMTS-UMTS	768	2421	468
GPRS-UMTS	909	1343	718

In table 1 delays measured by SymPA are shown in different mobile-to-mobile communication scenarios.

4 Conclusions and future works

In this paper we have presented the SymPA tool and its applicability to GPRS and UMTS data monitoring. In future work SymPA will be used extensively to analyse the performance of different protocol and applications on GPRS, UMTS and other technologies such as Bluetooth, Wi-Fi or HSDPA.With the aid of SymPA we will try to propose new configurations of protocols parameters in order to improve communications performance.

Another future line of work is centred on the development of an extension of Ethereal that allows us to visualize parameters of GPRS/3G connections such as the power of the received signal, the error rate, the cell identifier or parameters of the quality of service.

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