Voice and Data Traffic Classes Management for Heterogenous Networks Enabled by Mobile Phones

Flavio Esposito, Francesco Chiti, Romano Fantacci
Universitá di Firenze
Dipartimento di Elettronica e Telecomunicazioni,
Via di S.Marta 3, I-50139 Firenze, Italy
Email: {esposito,chiti,fantacci}@lart.det.unifi.it

***Abstract*— This paper proposes an approach for the management of differentiated traffic classes by effectively resorting to different radio channels on the same mobile phone. It focuses on an application developed in Symbian OS for mobile phone. In particular, the proposed approach uses both a middleware to enable data to transfer along a heterogeneous network (comprised of Bluetooth and the GPRS technologies), and the UMTS radio channel to run a video-call. The mobile device establishes the best connection available at the moment for data transferring. These access channels are continuously monitored, allowing the device to switch to the Bluetooth interface, whenever this lower-cost alternative is available. Further, the middleware architecture that allows the transparent interoperability among two different wireless networks during the file transfer is shown. To validate this result, a trial session has been set up, and the packet latency with and without a video-call running is shown, quantifying the delay to accept the call and the packet delivery ratio during a file transfer.**

I. Introduction

In recent years, following the idea of Mark Weiser [1], research in the field of the ubiquitous computing, has been subject to a dramatic growth. In particular, the present proposal is concerned with the context-aware in ubiquitous computing. The main requirement for realizing a pervasive communications system is providing a seamless environment for connectivity, provided various wired and wireless networks. As a consequence, the interest in developing new middleware to optimize future mobile hybrid communications is continuously growing. The developed application is able to support two separate channels running at the same time. In this way the mobile user is allowed to make a typical video-call, and a file transfer on the same mobile device at the same time. In particular, a mobile device resorts to the UMTS radio interface for a video-call.

On the other hand, the data transfer has been realized by means of a new middleware architecture which allows transparent roaming within a non-homogeneous wireless infrastructure. The different technologies involved in such heterogeneous network are the piconet Bluetooth (IEEE 802.15.1, BT) and the General Packet Radio Service (GPRS).

Two novel issues are addressed in this paper: the first one is related to the simultaneous management of two traffic classes, while the second one is the functional architecture to enable the heterogeneous network. The proposed scheme for the data traffic management is basically based on maintaining an air interface by dynamically selecting a communication channel between a GPRS and BT. When a mobile device equipped with multiple interfaces enters in an heterogeneous network, it copes with two separate problems: establishing a connection with the available access system, selecting the best interface at that moment, and keeping it, whenever one of the non-homogeneous network elements is no longer available. To this purpose,a mobility management scheme is proposed, focusing on the handoff mechanism jointly with the different traffic classes management: the software implemented uses two different logical channels on the same device, $i.e.$, a mobile phone.

Finally, the provided middleware easily cooperates with existing solution at the OS, network, and application levels, respecting the requirement of QoS.

The paper is organized as follows: in Section II the overall approach is presented, giving more details on the scenario and the proposed solution to attain an heterogeneous network that support two different traffic classes. Section III shows the practical software design and implementation, focusing on the data transfer that triggers the vertical handoff. The experimental assessments are highlighted as far as the handoff latency and the data transfer performance with respect to the buffer size to store data on the server side are concerned. Afterward the trade-off between the speed of the data transfer and the packet delivery ratio has been analyzed. Finally, some considerations concerning the delay obtained during a call acceptance have been presented.

Summary and conclusion are presented in the last section.

II. System Description

The principal idea behind the present proposal is based on the new paradigm enabling an heterogeneous network. A global network might be obtained by joining different architectures instead of following the concept of *universal* network adopted within 3G technologies. In this sense, heterogeneous networks apply the concept of cooperation instead of competition, as used within the universal-based networks.

An architecture that follows that concept of cooperation is presented in figure 1.

The middleware implemented allows the two separate architectures (BT and GPRS) to communicate each other; the communication is triggered by means of a Symbian OS

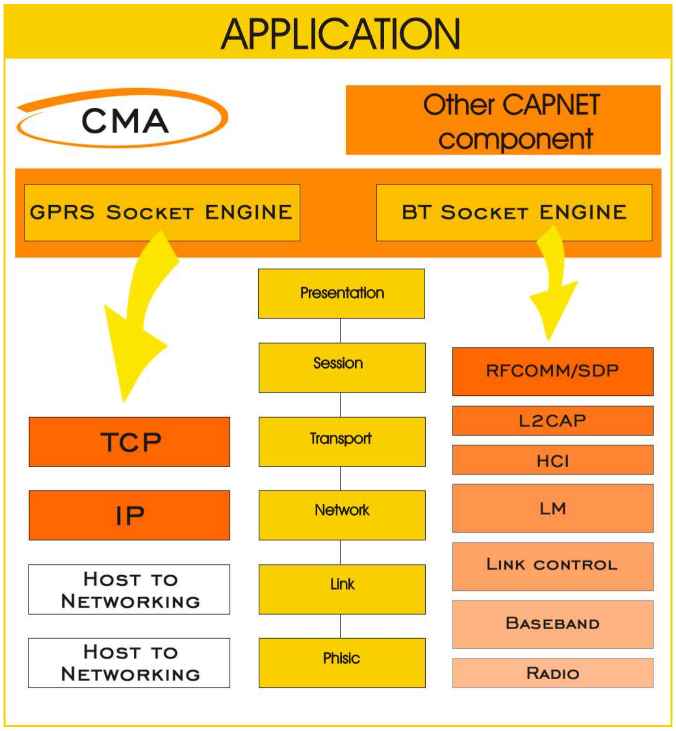

Fig. 1. Proposed Architecture: the component CMA is the core or the innovation as it allows the integration of two protocol stacks. The overlaid application is a simple file transfer that allows the simultaneous traffic classes management as voice.

applications for mobile phone. The Connectivity Management Agent is main agent responsible of the logic channel set up, that is the creation of two different physical connections, one for each socket (BT and GPRS).

A simple algorithm has been adopted to decide when the handoff procedure has to be started, based on cost minimization. In fact, during the file transfer, whenever the cheaper alternative is available, it is convenient to select it.

A. Application Scenario

Two main issues have to be taken in account in designing a network: the first concern is related to the network requirements, in terms of both software or hardware constraints, while the other one is the QoS user requirements.

If a pervasive environment is achieved through an heterogeneous network, the network designer has to take care of the non-invasive character that every ubiquitous computing system requires [1]. Therefore the first issue in designing the application for mobile phones is how to manage the invisibility of the application, enabling the pervasive environment. In this specific case, two threads, one for each traffic class must be managed independently by the mobile device. The Symbian OS *CActive* class, which the class CMA inherit, let the applications be active together.

The second task is to provide a seamless channel by switching between networks on the fly, without significant connection breakdowns or delays. This means vertical handoff between GPRS and BT interfaces.

The first thread management, such that the call management, is on the lower layer; therefore the focus of this work is on the new middleware used for data transferring.

III. Design

The application, realized in Symbian OS series 60, following the CAPNET Service Discovery Protocol engine philosophy, allows the context-aware paradigm. During a phone call a file transfer is permitted using another channel, as another traffic class on the same device.

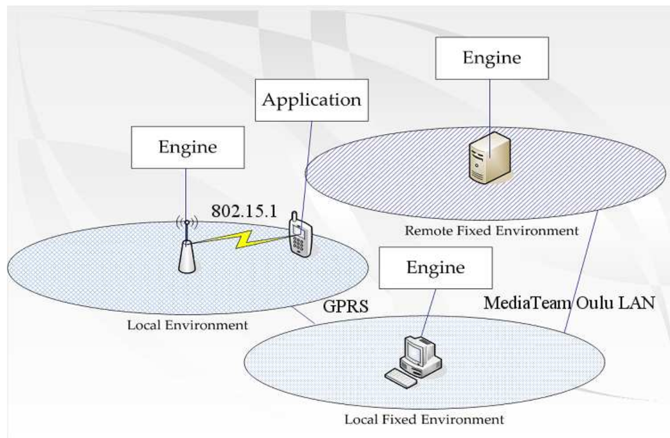

Fig. 2. Context-aware pervasive network based scenario: A differently located engine triggers a Client-server communication. Channels themselves are capable of seamless harnessing of two sockets, one for BT and one for GPRS.

In figure 2 is shown the scenario of the data transferring through a middleware. When a mobile phone is within a BT covered range, the application chooses the best (fastest and cheapest) connection available for transferring data [7]. If the user moves out of a zone when the BT is not available any more, CMA, shown in Fig. 1), allows the handoff. In particular, the handoff between BT and GPRS is a hard handoff, such the previous physical connection is broken before creating the new one. That implies some data loss, but it reduces the handoff latency, a critical aspect for the handoff management.

The packet delivery ratio has been measured during the file transfer and it is exactly the packet size used for the data transfer. The reason for that is pointed out Fig. 3.

The method really responsible for the writing is the method that calls the object of the Symbian OS class RSocket (step 4 in the diagram). After a waiting time, enough to assure that the entire packet has been sent, the framework trigger the method SendNextPacket (step 9 in the diagram).

Considering the simple data transfer as a queue system, should be notice that there is no waiting time in the packet sending procedure. The SendNextPacket method is not called if the previous sending process is not complete. Therefore, we can obtain directly the bandwidth considering only the transmission latency.

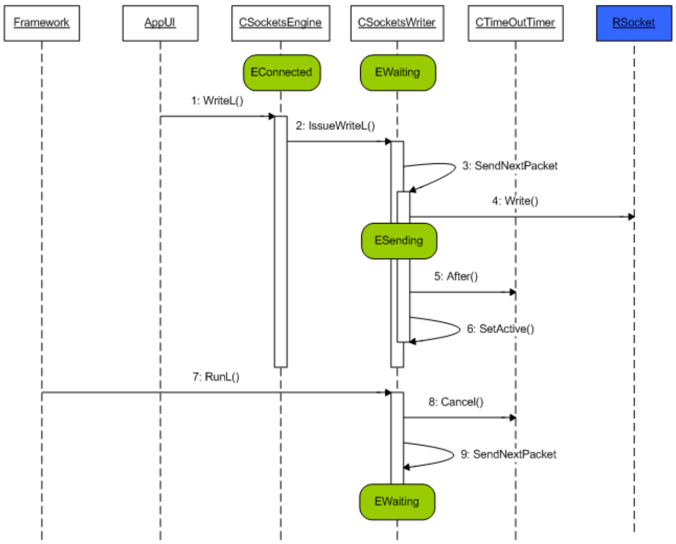

Fig. 3. Server Writer Dinamic diagram:Asyncronous request by means of Symbian Socket API.

A. Experimental Results

Considering the application as a Client-Server managing two different threads, to measure the packet latency transmission it has been used a server side software J2SE 1.4.2. The client side is a Symbian OS 7.0 application realized using C++.

During the data transfer on the socket BT the memory has to be released completely to the more important data transfer thread, but only at the moment in which a call is accepted. Afterward, it simultaneously manages both threads. Two attempts had been made measuring the transmission latency with the maximum and the minimum dimension of the buffer, but only one case has been reported. Figure 4 shows the small delay present during the realization of a call when the file is transferred. In particular they have different curves in relation to the percentage of the transfer. The figure present the same curves (at the beginning of the transfer, at 25% and at 50% of the transfer) considering the smallest size of the transfer buffer, i.e., the worse bandwidth case. As a matter of fact, the smaller the buffer the higher are the writing method calls; therefore the bandwidth decreases along with the packet size.

As we can see from the Fig. 5, there is a slight variation of slope between the latency curve without call and the other ones. This shifting produces a decrease of band even though is a very negligible. In the previous graphics it is worth noticing also that the latency and the bandwidth decrease is more evident if the call arrives, as the mobile device gives the priority at the beginning of the call. The higher delay measured during the call acceptance was 1.59 s and the average is about 1.5 s. The limited mobile phone's random access memory has to be used in that moment only for that reason.

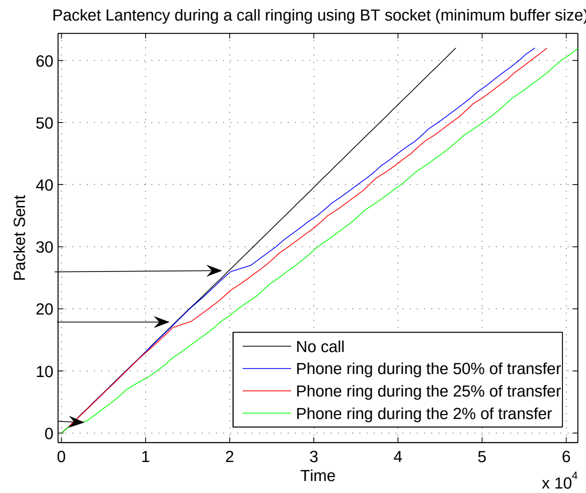

Fig. 4. Transmission latency during the video-call acceptance.

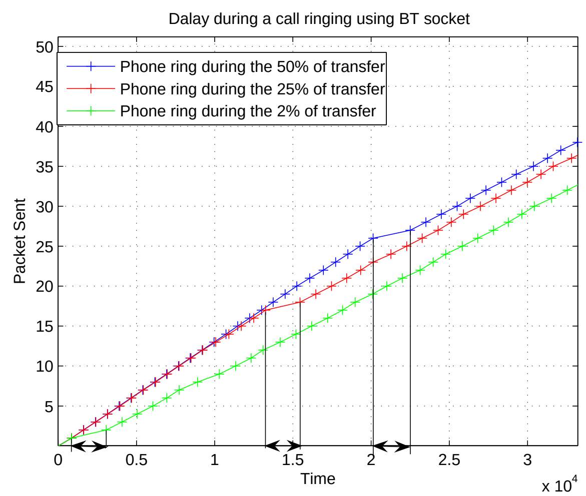

Fig. 5. Delay quantification with two different threads active.

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