Accessing Educational Services through Computer Networks and Mobile Telephony

Vittorio Ghini[+], Giovanni Pau[*], Paola Salomoni[+]

[+] Dipartimento di Scienze dell'Informazione, Università di Bologna
Via Mura Anteo Zamboni 7, I-40127 Bologna, Italy

[*] Dipartimento di Elettronica, Informatica e Sistemistica, Università di Bologna
Viale Risorgimento 2, I-40136 Bologna, Italy
Email: ghini@cs.unibo.it, giovanni@csr.unibo.it, salomoni@cs.unibo.it

KEYWORDS: Computer Networks, Mobile Telephony, Interoperability, Educational Applications, Distance Learning,

ABSTRACT

In the most part of the organization a set of systems is used to send and manage notices. For example inside Universities, notices are used to call a meeting of teachers or to give exam results to a students. Our aim is to define an architecture that realizes the integration between a set of Internet/intranet services provided by a University and mobile telephony. The described model is particularly suitable for environments that need strong personalization of the services, offered both to staff people and to students. Different services, developed using the defined architecture, are described.

1. INTRODUCTION

Telecommunications and computing technologies are rapidly converging. The future network architecture needs to satisfy many requirements as user ubiquity, user mobility and interoperability [DEC97]. In this context, this paper describes an architecture suitable for the integration of Internet-based applications and mobile telecommunication services [FAG98] in a University information system. For example by using such one architecture, the following services may be accessed by users by either IP-based or mobile telephone units:

- exam registration or communication of exam results,
- meeting call,
- remote evaluation of test results,
- delivering of e-mail and fax.

Traditional network applications are classified in the following two classes with respect to the temporal relationship in the interaction [MES96]:

- *immediate*, i.e. user may interact with a server or another user within a maximum delay bound,
- *deferred*, i.e. user may interact with another user or a server without a maximum delay bound.

Our architecture implements *deferred* applications by using a so called Multi-Gateway (MG) (to be described below) and *immediate* application by using a Wireless Application Protocol (WAP) Proxy system [FAS99]. Figure 1 shows the general system architecture. As seen from the figure:

- the WAP proxy gives to the mobile telephone the functionality of a simple browser and permits to the user to access directly the University intranet pages.
- the MG provides interoperability among all the following subsystems:
- the mail system,
- schedulers of teacher and staff people,
- the didactical information provided by the teacher,
- other information (such as seminar date, exam date, telephone number, ..)

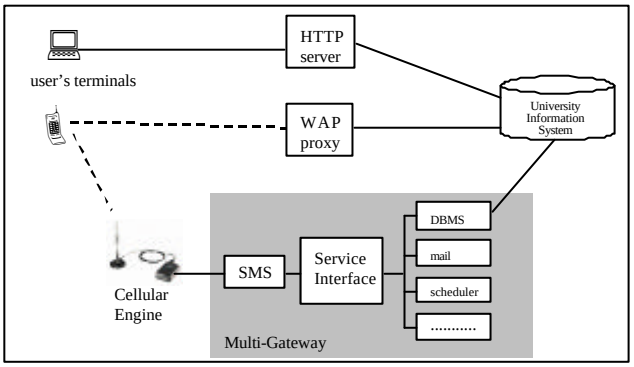


Figure 1: The general architecture

All the subsystems for which the MG provides interoperability may be seen as entities that are producing or consuming messages. The MG implements a mechanism which is able to accept a message from one of the above mentioned subsystems, and redirects it towards another one. For example an e-mail can be accepted by MG and then redirected towards the Short Message Service (SMS) subsystem in the appropriate form. This

kind of approach can also be applied to immediate applications, such as a DB query, that are considered as deferred operations by the MG. For example suppose that a student wants to know an exam date using a mobile telephone. He sends an SMS to the MG that redirects the message querying the DBMS. When the DBMS finishes to execute the query and produces a result, the MG redirects it to the SMS subsystem and then the result is displayed on the student's mobile unit.

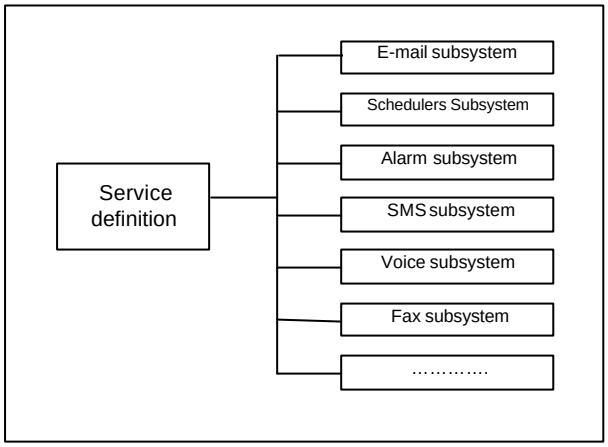


Figure 2: MG's functionality scheme

The functionality scheme of the MG is depicted in figure 2. Note that the SMS subsystem is considered like all the other subsystems. The service definition describes how a message arriving from a certain subsystem will be redirected to another one. Some subsystems offer only output features. For example the fax can be used efficiently only to display messages. On the other hand some other subsystems are able both to produce and to send the messages (for example the SMS or the mail exchange subsystem).

2. ARCHITECTURE

Each service provided by MG is based on the use of two different planes (see figure 3):
a) the *Control Plane* that really implements the gateway between a subsystem and an internal intermediate protocol,
b) the *Service Plane* that exploits the control planes to implement an interoperable system service.
Different Service Planes are used to implement different services and each Service Plane may use more than a Control Plane.

The Control Plane, is structured in different layers:

- An *Interface Layer* that provide an interface between our system and the underline subsystem (for example the SMTP service or the SMS queue module).
- A *Service Selection Layer* that provides service selection policies, coding/decoding functionality and a mechanism for low level billing.
- A *Control Management Layer*, that provides is used to configure both the Interface Layer and the Service Selection Layer.

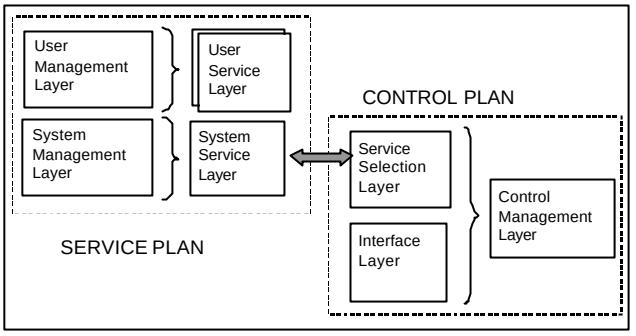


Figure3: Service Plane and Control Plane

Each user of a service needs a personal service definition that can be managed and changed directly by the user. Therefore the Service Plane use multiple layers to implement the user service definition. In particular, the Service Plane is structured in the following layers.

- A System Service Layer that is responsible for general policies of the service. This layer implements also billing and accounting policies and authentication policies.
- More User Service Layer that define the personal redirection policies for the service. Each user of the service has got a personal User Service Layer.
- A Service Management Layer, that provides primitives and interface to configure the System Service Layer. Note that only the administrator can use this layer to define general policies and user management.
- A User Management Layer, that provides primitives and interface to configure the User Service Layer. Note that each user can configure only his User Service Layer to define personal redirection policies.

The Control Plane and the Service Plane communicate using the interface between the System Service Layer and the Service Selection. The interface primitives are the same for all the services and for all Control Planes.

All the notification exchange subsystems are classified as Deferred User to User application. This means that the communications between the control plane and the service plane are asynchronous in both the directions:

- when a Service Plane asks to a certain Control Plane to dispatch a notice, the Control Plane attempt to send the

message and can give back a result only after an unpredictable delay;

- when a Control Plane asks for a redirection to a certain Service Plane, the Service Plane redirect the message to another Control Plane and waits for a result that can arrive after an unpredictable delay.

3. INTERFACE PRIMITIVES

The interface between the Control Plane and the Service Plane in the MG is based on the two following primitives:

3.1 SendMSG

This primitive is used by the Service Plane to ask to a certain subsystem to dispatch a message. The primitive specification is the following:

`SendMSG(<SendID>, <senderService>, <msgContent>, <priority>)`

where:

- `<SendID>` is the ID of the `SendMSG` command, which is used to associate each command with the proper return-call; it is a unique identification number.
- `<senderService>` identifies the service that ask for the call;
- `<msgContent>` content of the message coded in a format that depends from the contacted Control Plane.
- `<priority>` defines the priority for the redirection call.

All the Control Planes provide a server process that is waiting for `SendMSG` the requests. Each Control Plane accepts `SendMSG` with the appropriate `msgContent` type.

The `msgContent` can contain a verify request, for example in the mail message a receipt request can be included. All this kind of information and all the error messages are redirected to the Service Plane using the `RedirectMSG` primitive.

3.2 RedirectMSG

This primitive is used by a certain Control Plane to submit a new message to a certain Service Plane. The primitive specification is the following:

`RedirectMSG(<RedirectID>, <senderControl>, <msgContent>)`

where:

- `<RedirectID>` is the ID of the `redirect` command, which is used to associate each command with the proper return-call; it is a unique identification number.
- `<SenderControl>` identifies the Control Plane that will redirect the message;
- `<MsgContent>` content of the message coded in a format that depends from the Control Plane that asks for the `RedirectMSG`. All the redirection information are include on the `msgContent` and are coded in a service-dependent protocol.

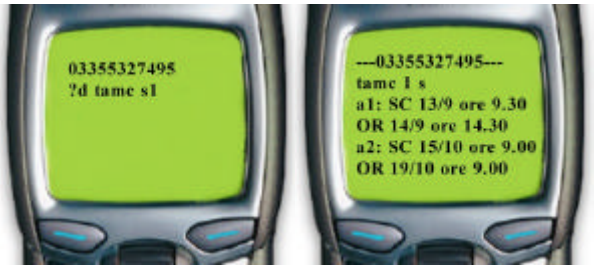
Both for the `SendMSG` and the `RedirectMSG` a correct execution involves only that the system attempts to manage the message. All the information about the reception of the message are sent with a second interaction. The interface defines also a set of primitives used to verify the Control Plane and the Service Plane status.

4. IMPLEMENTED SERVICES

A first set of University mobile services has been realized using the MG architecture. The Control Plane for mobile services has been implemented using a Siemens© M1® engine [SIE97] working with the GSM [ITU96] protocol, that actually is the Italian digital cellular standard. The GSM Short Message Service (GSM-SMS) is an integrated paging service that lets GSM cellular subscribers send and receive data up to a maximum of 160 characters. The GSM Control Plane identifies the Service Plane responsible for a certain incoming SMS by looking at the first character of the message. Next paragraphs describe four different services implemented and currently tested on a subset of students and teachers (selected from the Department of Electronics and Engineering and from the Degree in Computer Science located in Cesena).

4.1 Exam registration and result

The first example of services set, gives mobility to management of exams. Different Departments of the University of Bologna give information about examinations to the students using a web interface. Some of these also permit to students to know their results in the same way. The date/registration/result system is implemented using a DB. In the MG, all the services are provided by the same Service Plane identified by the "?" character.



(a) (b)

Figure 4: Exam date query

The implemented services are:

- *Exam date*: the student can ask for exam date sending to the GSM Control Plane a request. The GSM

Control Plan redirects the request to the Exam Service Plan that directly queries the DB. The results are given back to the student as SMS. Figure 4 above shows the two messages: the request (a) in which the student specifies the exam code (tamc) and the session (s1), and the replay (b) given by the MG that reports the two possible dates.

- *Exam registration*: to register himself to an exam the student has to provide a username and a password. Figure 5 below shows the SMS interaction between the student and the system: first the student asks for the registration (a) specifying the exam code (tamc) the session (s1, a1), the username and the password, then the system sends back a confirmation (b) for the registration. A similar interaction occurs when a student wants to unsubscribe the registration.

(a) (b)

Figure 5: Exam registration query

- *Exam Result*: the student can ask for an exam result using an SMS. Figure 6 below shows the SMS communication: the student asks for an exam result (a) specifying the exam code, the session, the username and the password, then the system queries the DB and sends back an SMS (b) indicating the result (28/30).

(a) (b)

Figure 6: Exam result query

4.2 Personal Information Manager and Meeting Call

This second example of services set is implemented with the aim of using the GSM telephone to remember to staff people their appointments. The system is based on the integration of two applications. The first one is the extension of a commonly used Personal Information Manager (PIM) that advises the user with an SMS for each near appointment. In particular the used PIM is Microsoft© Exchange® and Figure 7 below shows the scheduler application interface.

Figure 7: SMS extension to Microsoft© Exchange®

To call institutional meetings an ad-hoc system is used: a web interface permits to send to all the people of a specific group (for example the Department or the Faculty) a meeting call. The list of the official members of the group is managed by using a DB. The following Figure 8 shows the interface of the call meeting system.

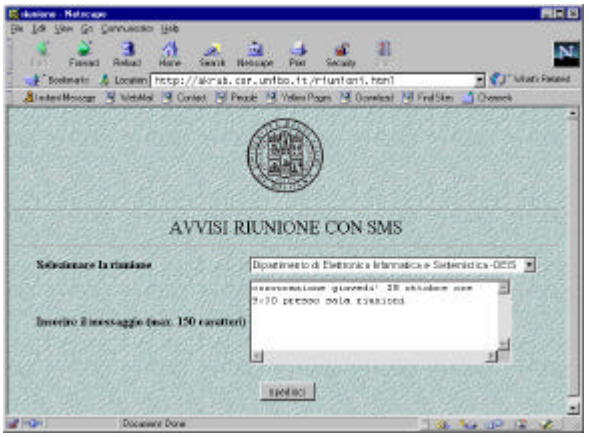
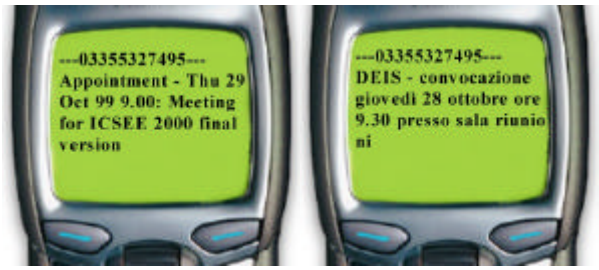


Figure 8: Web interface for meeting call

Figure 9 below shows how the two different SMS will appear: the first one (a) is the appointment notice corresponding to the one depicted in Figure 7, the other one (b) is the call for the Department meeting obtained with the form shown in Figure 8 below.

4.3 Mail-SMS Gateway

This extension and personalization of Internet e-mail is provided to teachers and staff people. The mail system usually maintains a user mailbox and when a new mail arrives, the MG sends a SMS message to the destination user.



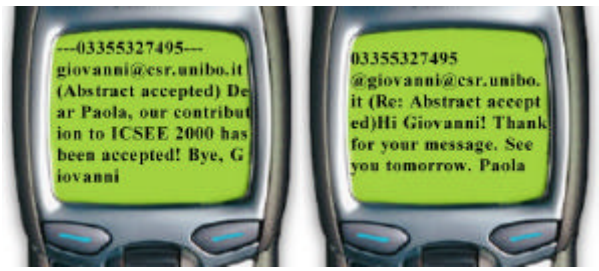
(a) (b)

Figure 10: Meeting calls

This system involves two Control Planes (one for SMS and one for the mail-SMTP [POS82]) and a Service Plane that defines the redirection conditions. The character that identifies this Service Plane is "@".
The user can define the set of criteria used by the system to filter the mail messages and redirect to the SMS only a part of the incoming mail. The user can also subscribe a "digest" service to receive in the first time only a set of mail headers and then to ask (with a SMS message) for one or more mail bodies. This strong personalization can be done by using a Java applet (see Figure 10) that configures the system to follow user requirements.

Figure 10: Snapshots from the Java applet that configures the mail-GSM gateway

On the other hand the user can use the SMS system to send e-mail; the e-mail message is composed by using the cellular telephone and is sent to the MG telephone number. The MG recognizes the send-mail request, extracts the e-mail data and sends it to the destination using the SMTP.



(a) (b)

Figure 11:GSM-mail conversion

Figure 11 above shows an interaction between a user with a GSM telephone and a user using the e-mail. The two messages reproduce respectively an e-mail received and an e-mail sent by using the telephone device. The following Figure 12 shows a digest message.

Figure 12: Digest message

4.4 University Phone Book

The last presented service permits the users to look up the University phone book by using SMS messages. This feature is developed on an existing web-based service that is currently available in the University site (http://www.unibo.it/avl/persone/persone.htm). The user has to fill the form depicted in Figure 13 with the name and/or the surname of a staff member. The web server redirects the query to the DB, and produces a HTML page (see Figure 14) that contains the telephone number and other information about the staff member.

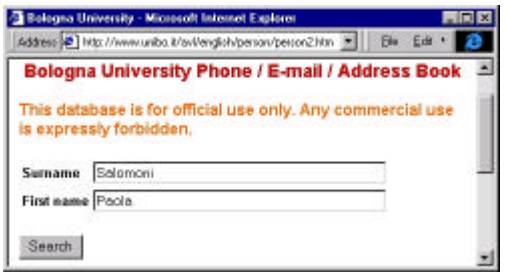


Figure 13: Web query to University Phone Book

Figure 14: Query results

The MG architecture extends this service, in order to satisfy the requirements of user mobility. The Phone Book Service Plane provides the interface for this web service and is identified by the "#" character. This module sends the query to the web server, and receives back the HTML page with the query results. The page is parsed and the

information are sent back to the user into an SMS. Figure 15 below shows the two SMS messages:

- the request (a) in which the user specifies the telephone number of the MG, the surname (Salomoni) and the name (Paola) of the staff member;
- the response (b) that contains the requested telephone number (0547 642830). The "#" character followed by "1" indicates that there is only one staff member matching the query.

(a) (b)

Figure 15: SMS interaction to look up the phone book

5. CONCLUSIONS

There are a large number of applications in the educational environment that can use MG to provide mobility and ubiquity features. We have integrated different services provided by the information system of our University with the GSM Interface. The above mentioned set of services shows different features of the MG architecture:

- the MG can easily work integrating application running on different platforms (i.e. Microsoft and Linux platform),
- the MG architecture can interact directly on a DB based information system or re-using the web code, querying the HTTP sever,
- the MG architecture permits a strong personalization of services.

A more complete set of services will be realized in near future. Our further work will mostly concentrate on the didactical services and in particular we are working on a system that gives remote support to test correction and evaluation.

REFERENCES

[SIE97] Siemens – *User Guide GSM Module M1*, Siemens© AG, 1997.

[DEC97] M. Decìna and V. Trecordi,"Convergence of telecommunications and computing to networking models for integrated services and application", *Proceedings of IEEE*, vol.85, no.12, pp.1887-1914, 1997.

[MES96] D .G. Messerschmitt, "The convergence of telecommunications and computing: What are the implications today?" *Proceedings of IEEE*, Vol. 84, no. 8, pp. 1167-1186, 1996.

[ITU96] European Telecommunications Standard Institute, "GTS-GSM 01.02", European Telecommunications Standard Institute, Upper Saddle River, fifth edition,. 1996.

[FAS99] A. Fasbender et al, "Any Network, Any Terminal, Anywhere", *IEEE Personal Communications*, 1999.

[POS82] J. Postel, "Simple Mail Transfer Protocol" STD 10, RFC 821, USC/Information Sciences Institute, 1982.

[FAG98] N. Faggion and T. Hua, "Personal communications services through the evolution of fixed and mobile communications and the intelligent network", IEEE Network, pp. 11-18, 1998.

BIOGRAPHY

Paola Salomoni is currently an Assistant Professor of Computer Science at the Department of Computer Science of the University of Bologna. Her research interests include Distributed Multimedia Systems, teaching/learning Environments and Integration of services in Computer Networks and Systems.

Giovanni Pau is Ph.D. student in "Telecommunication Engineering" at University of Bologna, Italy. His research interests include: Distributed Multimedia Systems, Quality of Service, Mobile and Wireless Communications. Since 1998 he collaborates to the "Programme on Networking" of the Abdus Salam International Center for Theoretical Physics of Trieste (Italy).

Vittorio Ghini is Ph.D. student in "Computer Science" at University of Bologna, Italy. His research interests include: Distributed Multimedia Systems and Quality of Service over IP networks.