MUSE: An integrated system for mobile fruition and site management

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ABSTRACT

MUSE[1] (standing for Museums and Sites Explorer) is an experimental mobile multimedia system for cultural settlements. The system is based on a hand-held computer connected to a site control center by a wireless link. It provides interactive learning and entertainment to the visitor, as well as site monitoring and control functions to the management. Thematic visits with virtual access to physically unavailable items are supported. During the tour the visitor can create his/her personalized multimedia memory that can be e_mailed or saved on a CD to be collected at the end of the visit. The system provides logistic information; for example alternative routes may be dynamically suggested to the visitors in order to avoid congestion and increase the sustainable site fruition level. The system is user-centric and its interface supports self-orienting on the site while encouraging unexpected discoveries and experiencing of CH based emotions.

Several information technologies cooperate to narrow the gap between the cultural items and the public. Specifically the system relies on emerging data models, on the integration of state-of-the-art software technologies and on next generation tablet computers. The intended hand-held device should combine its low weight and low power requirements with nearly PC-like 3-D rendering capabilities.

The paper discusses the main design issues, as well as the conditions that should be met to turn this class of experimental systems into a real industrial product.

KEYWORDS: Interactivity, Connectivity, Multimedia, 4-D modeling, Dublin Core

INTRODUCTION

In the times of mobile phones, videogames, car navigation aids, home automation, real time publishing, on-demand video and computer assisted education, only the human imagination can limit the variety of toys and gadgets for the permanently connected Information Society. This paper concentrates on an interactive mobile multimedia system devised to enhance

[1] This project is funded by MURST (Ministero dell'Università e della Ricerca Scientifica e Tecnologica) within the framework of the National Research Program Parnaso. It is conducted by a private company (Boconsult) in cooperation with the University of Bologna, Cineca, and Sinet.

education and entertainment during the visit to a museum, an archaeological site or many other cultural heritage establishments. To the user the system should appear as a friendly hand-held device that complements the site's physical reality in turning his/her visit into a deep and emotional learning experience.

In the following paragraphs the expected terminal functionality together with the related motivations are reviewed and the supporting architecture and technologies are briefly described. Afterwards the tools and the procedure devised to set up and run the system at candidate sites are introduced. Eventually the design framework and the challenges faced by the design team are summarized.

THE PERSONAL TOUR ASSISTANT AND THE SITE NETWORK

A lot of research is currently underway to investigate on how Information and Communication Technology may impact on the development of "cultural tourism".

In [10] Sparacino demonstrates that the experience of the public visiting an exhibit can be greatly enriched by adding technology both on the site space and to the visitor.

In [4] Hildebrand shows how a clever selection and integration of cutting-edge Information & Communication technologies can provide nearly science-fiction-like visual and audio experiences to the visitors of an archaeological site.

In [1] Bocchi shows the power of historical-sources-based digital modeling in the historical reconstruction of ancient towns and in [3] Guidazzoli shows how this methodology may be extended to the design of virtual tours that may be customized to different classes of users.

In [5] Kiang marvelously demonstrates that digital modeling and VR, although intended for historical reconstruction of towns, nonetheless can create masterpieces of moving and deep poetry.

In [7] Matthews R. explains the key role of the publishing system in the set up of a multimedia fruition tool and demonstrates the invaluable impact that the accumulation of well organized databases of multimedia assets has on the continuity of a product line across technology innovation.

In [8] Oppermann shows how the experience of visiting a site can start at home before the visit and can be extended back home after the visit; the web and a combination of knowledge based user profiling tools and user tracking technologies converge to turn this paradigm into an exciting, rich and easy experience.

MUSE relies on most of the above mentioned concepts and contributions and addresses on-site fruition from two points of view: the visitor and the site manager.

According to Zan, the site manager objective is the protection of the site, but the number of people visiting the site is also of his/her concern [11]. The site organization should be tuned to maximize the "*sustainable fruition rate*" [9] and additional services should be made available to meet the visitors satisfaction and maximize the revenue originating from the site. A comprehensive fruition system has the potential to give a significant contribution in this respect, by providing facilities addressing both the quality of the visit and the site management. Let's try to identify these facilities by listing both the visitors needs and the site management issues addressable by the fruition system.

The fruition system should address the following main "visitor needs":

- self-orienting on the site
- resource discovery (supported by physical or thematic tours, or suggested by information on site events)
- entertainment (to be enhanced by media-rich and user-centric fruition)
- learning (provided by historical, artistic, architectural and social information with appropriate reference to the "sources")
- recalling (provided by a personalized memory of the visit that may be e_mailed or saved on a CD)

In addition to the above needs, the fruition system could also address the following issues that limit the sustainable fruition rate and negatively affect the quality of the visit:

- site congestion (compromising site preservation)
- unbalanced distribution of visitors (that may be due to the lack of flow control tools or to asymmetric access rates: sometimes not all of the available resources are as popular as they should be)
- temporarily closed areas (due to on-going works)
- temporarily unaccessible resources (due to dangerous conditions, restoration or occasional export to temporary exhibits)

The first two of the above mentioned "needs" are only relevant to the major sites, while the others affect them all.

Let's see how all of the above mentioned issues may be addressed by an integrated and modular approach.

Optimizing the flow of visitors in order to minimize queue lengths while limiting the number of people admitted simultaneously to certain areas requires site monitoring for decision support and real time warning and/or redirection capabilities.

Helping the visitor in moving around and understanding what the site has to offer may be provided by an interactive personal aid (a *virtual guide* acting as "personal tour assistant") that should accompany the visitor along his/her entire visit. Such a device may offer additional services including building up a memory of the visit or providing occasional access to a Call Center for special needs.

Limiting the inconveniences due to temporarily closed areas or unavailable resources requires the availability of proper (multimedia) surrogates. On archaeological sites this feature could be used to "augment the site reality" by "contextualising absent items" that is by providing virtual access to items that disappeared or were removed in the past.

Learning and entertainment may be greatly enhanced by interactive multimedia (IMM); thanks to multiresolution virtual models, navigation in space and time may be enjoyed both, on the virtual guide or on nearly-immersive fruition stations.

Stand alone units, whether portable or stationary are not adequate to meet all of the above requirements.

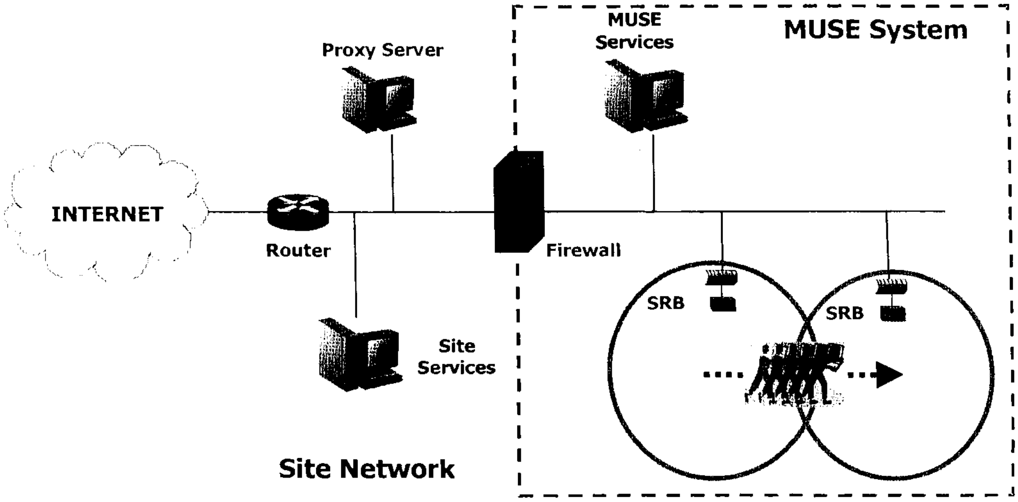

Figure 1: Integration of the MUSE system within the site

On the contrary, an on-site distributed system consisting of a variety of interconnected mobile and stationary units, a comprehensive database, an effective management and publishing system and a connection to the web can open the way to most of the services envisaged, leading in this way to a new integrated fruition and management model.

MUSE aims to interpret this scenario with an experimental and pre-competitive solution to be demonstrated in primary Italian museums and archaeological sites. The MUSE system consists of a set of cooperating devices linked by wire or by air [6]. As shown in Fig. 1, the MUSE backbone is an autonomous, self-contained local area network separated by the main site LAN through a protected router (a firewall). The hosting network may offer its services to the MUSE users including, for example, web access.

The MUSE network includes a multicell IEEE 802.11 Wireless LAN. This IEEE standard is used world-wide in indoor and outdoor applications. The radio power transmitted by both the ground and the mobile units is many times lower than the power of a mobile phone.[2]

The visitors can roam with their personal tour assistant within the WLAN wherein other appropriate devices may be accommodated as long as their environmental impact is compatible with the site requirements.

Fig. 2 details the servers and the appliances integrated within the system. The servers may be located on one or more physical stations depending on their site-specific workload.

The Administration System is finalised to system configuration, surveillance, access management, accounting, and mobile user assistance. It provides facilities to enter site relevant information that becomes instantly

[2] The WLAN operates in the 2.4 GHz ISM Band at a maximum ERP (Effective Radiated Power) of 100 mW, as specified by the relevant European directive ETSI 300-328.

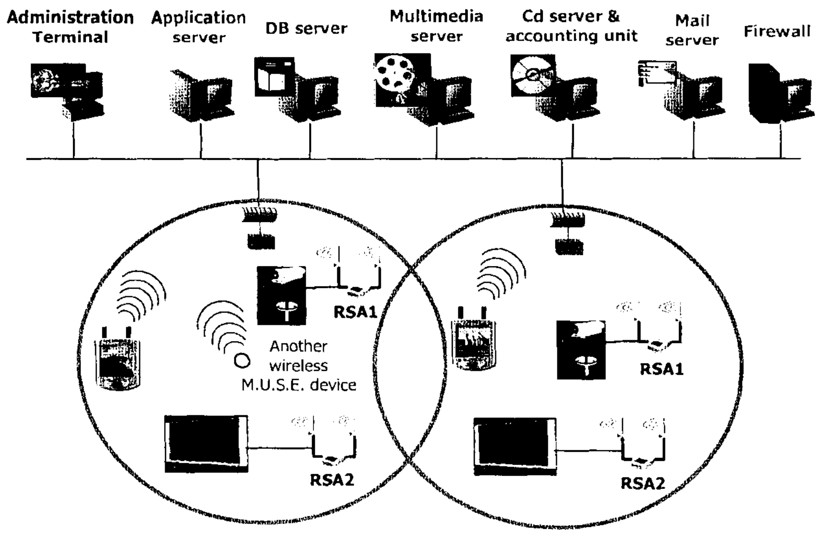

Figure 2: The MUSE system

available to the mobile users. Furthermore the Application Server supports server-side publishing and updating of fruition contents. Fruition contents originate from catalogues, iconographic archives or research and the related format can range from virtual models to movies, audio clips and hypertexts. These cultural assets are stored on the appropriate MUSE server (DB server and Multimedia server in Fig. 2).

The database supports site virtualisation by providing access to the digital representation of both on-site and off-site resources thematically related to the site. In order to structure CH information effectively, the data base relies on a data model that is becoming widely accepted among cultural institutions: the Dublin Core. The implied interoperability is a key feature for a configurable system such as MUSE.

Additional services can be integrated within the MUSE system thanks to its modular architecture. For example a call centre could be added in order to provide the user with audio/video assistance from skilled personnel whenever needed.

With reference to Fig. 2 let's consider now the stationary and the mobile devices connected to the servers through the MUSE network. Small wireless cameras may be strategically placed around the site and they represent a remote eye available both to the personal tour assistants and to the site management personnel. They support site monitoring, real-time evaluation of congestion conditions, and at the same time, they allow the visitor to take personal pictures. These personalised memories are charged to the visitor and can be either e_mailed or saved on a CD (Fig. 2) to be collected at the end of the visit. They can have a significant impact on the site revenue.

As shown in Fig. 2, fruition services are available at different resolution level on the mobile personal tour assistant and on large graphics displays located in strategically appropriate spots.

The "personal tour assistant" is the intermediary between the visitor and all of the MUSE services. It consists of a hand-held interactive, multimedia terminal providing a communication metaphor described in the next section.

THE PERSONAL TOUR ASSISTANT AND ITS COMMUNICATIVE METAPHOR

The user interacts with his/her personal tour assistant and retrieves its cultural assets through a metaphor.

The metaphor constitutes the relationship between conscious and unconscious, and between the physical reality which surrounds the user and his/her cultural background. It must therefore be able to create a friendly environment around which the visitor is able to move. The MUSE communicative metaphor is the "ancient library" representing a memory warehouse where the visitor aims at knowledge and emotions.

The entry page of the terminal, an ancient library, immediately brings to mind knowledge, organised and explained by authors, through the medium of books (Fig 3). The terminal, being the mediator between the expert and the visitor, will guide the user in their cognitive discoveries by means of a menu represented as the spine of an old book located on one side of the screen.

The communication metaphor has to be mapped onto the site structure. For example Fig.4 shows how the visit proceeds along with the navigation within the communication metaphor when the site is a museum.

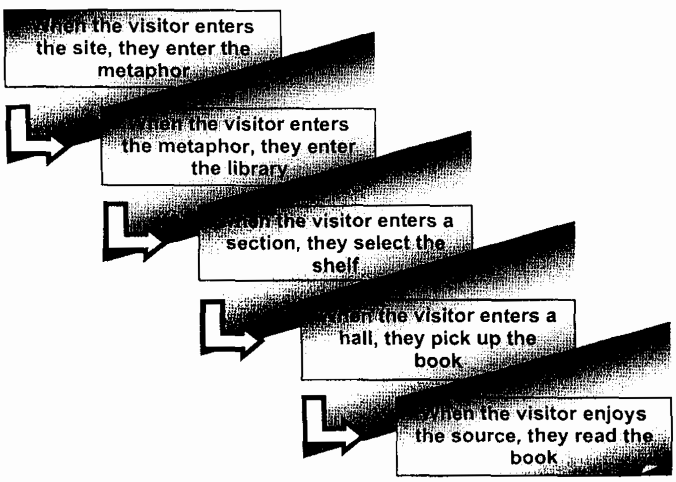

Figure 4: Navigation within the metaphor

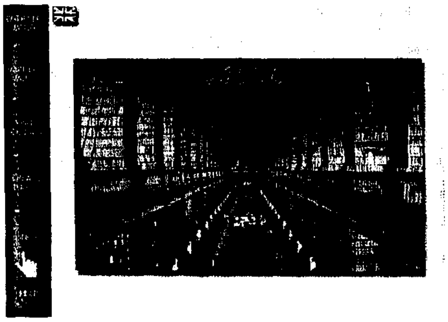

Figure3: The terminal home page

The mobile terminal must guarantee a user friendly navigation and must therefore have enough computing power to ensure good responsiveness in the reproduction of the complex multimedia contents and in the interaction with 3D models. The display size must be of at least 6.4", with 800 x 600 pixels resolution and thousands of colours for convincing graphics quality. Navigation must be available by means of context sensitive keys. Essentially the personal tour assistant will consist of a battery powered webpad based on 32 Intel architecture (IA32) with the full functionality of a notebook PC, comprising stereo sound and a PCMCIA interface for wireless communication.

Currently there is no commercial device meeting the power, weight and performance requirements of the MUSE personal tour assistant. MUSE design concepts shall be verified thanks to "Barracuda", the prototype of an advanced low power high performance hand-held tablet computer kindly made available by Intel Corporation. Based on MUSE extended testing in a variety of demonstration sites a final terminal specification including its ergonomy shall be devised and developed.

FRUITION ON STATIONARY HIGH PERFORMANCE MULTIMEDIA STATIONS

The MUSE architecture is modular and the fruition system may optionally be enhanced by large (42" or more) high resolution displays providing the realism of 3D nearly immersive visualization. For example, in an archaeological site, it will be possible to simulate the reconstruction of the surrounding environment taking the user back to the site original period.

Thanks to the integration of the display stations within the system LAN, it will be possible for the visitor to open this vision of the past directly by means of the mobile terminal.

The requests of the user will be gathered by the relevant server. The corresponding multimedia contents, whether high resolution animation or complex 3D scenes, will then be sent to the display station which, thanks to its high computing power and graphics quality, will provide for a richer visualization. The interactivity provided by the personal tour assistant will lead to the best subjective involvement in the represented scene.

In this way, as shown in Fig. 5, the MUSE system will support fruition both locally on the personal tour assistant in standalone form or, if available, on the high performance graphics panel at a much higher resolution level.

THE APPLICATION DEVELOPMENT SCENARIO

Fig. 6 outlines the application development process of the MUSE system. At the beginning digital multimedia contents are created to be stored on the system servers. Fruition can occur on-site, as shown in par. 3 and 4, on the web or on high quality graphics platforms.

In this framework it is crucial to define an appropriate data model for the historical and artistic database. Specifically two basic issues were considered: the data model interoperability and the definition of the data description metaphor. Indeed it is believed that at the top abstraction level one should look for a metaphor capable of describing the elements which in itself constitutes a cultural settlement, leaving the particular site type out of consideration. The obtained result is shown in Fig. 7. The graph points out the relationship which physically connects all the significant elements of an archaeological or a museum site. In this way the tangible reality of the site is exhaustively represented: either the architectural structures (starting from, for example, the building hosting the museum), or the individual items can be given their own description. The digital counterpart of each physical node is also a node and it provides access to the objects actually stored in the data repository (images, multimedia files or 3D reconstructions). The names assigned to each node can be considered as symbols of a contingent reality of the site. This structure is expandable as the "site" node can be recurrent. Furthermore it may be mapped on many site types and it may be expanded on more levels to describe more complex targets. For example, to adapt our descriptive metaphor to a city and its cultural buildings it is enough to expand the "site" node into the chain city -> urban elements -> (museums|buildings|churches) keeping the underlying structure unchanged.

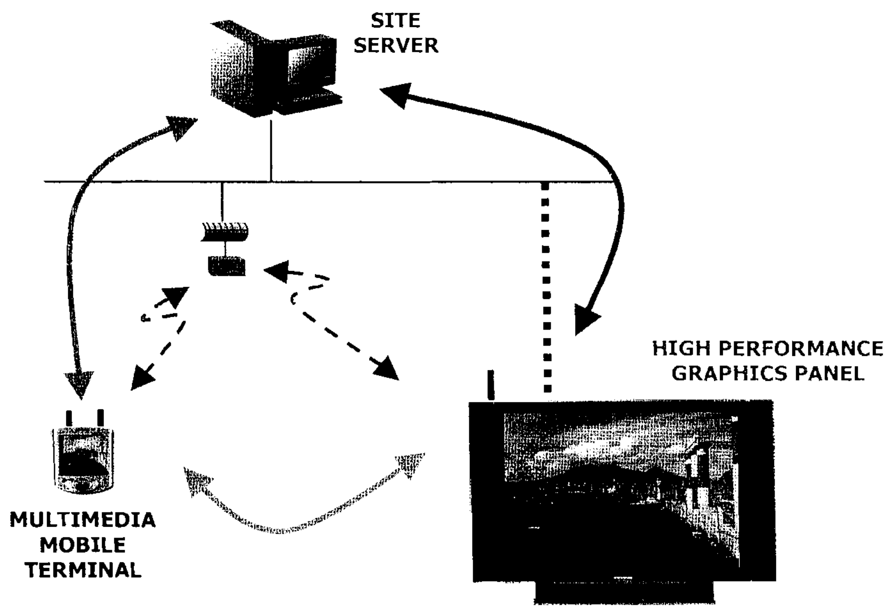

Figure 5: Wireless interactions among system components

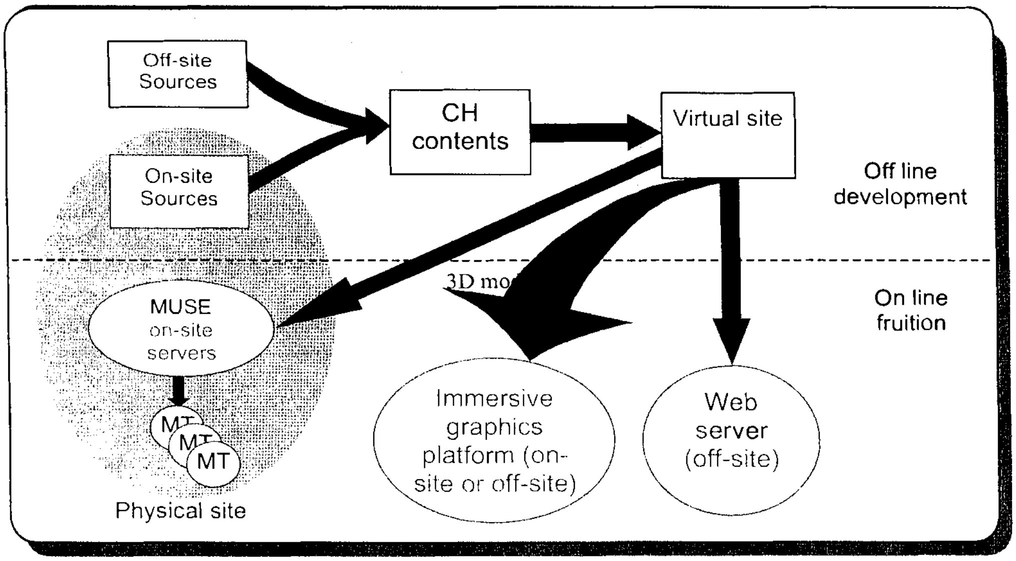

Figure 6: The application development scenario

This general metaphor is expected to be reused without requiring modifications to the logical data model: any personalisation should be deferred to the constructive details of the database reducing the stress of planning new applications.

The data model was selected having in mind interoperability. The standard XML/RDF with the Dublin Core model (Dublin Core '99) has been adopted as a

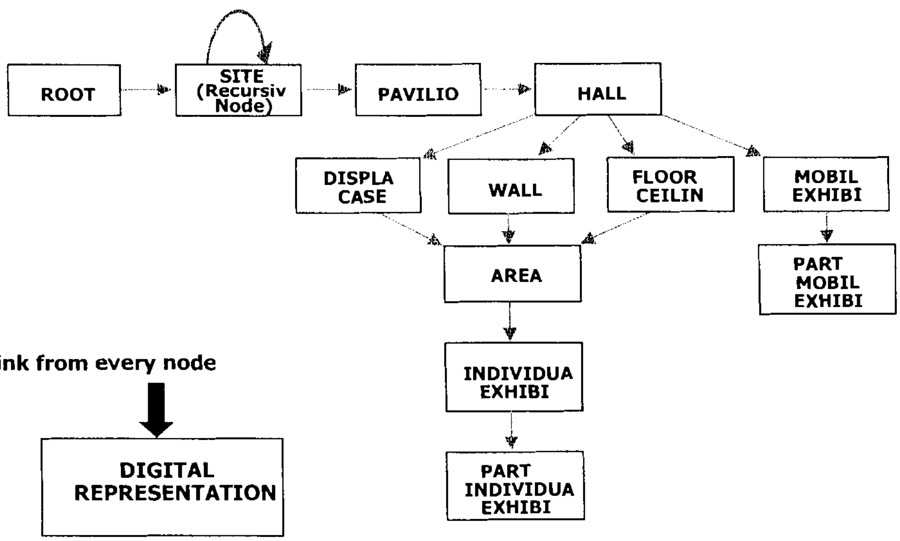

Figure 7: The data metaphor

model to catalogue the nodes previously described. In particular this allows the use of a model of homogeneous metadata for both physical and digital items.

Of course the visitor is not interested in, and should not be permitted to see, the structure of the database; rather they are interested in being able to navigate its contents as if in a virtual exhibition. The abstraction happens for the user by means of the navigation interface visualized by the mobile terminal in accordance with the communicative metaphor previously described. The contents requested by the user are retrieved from the DB and dynamically formatted at the server end by the publishing system tuned according to the personalized profile of the visitor. Similarly the structural details of the database should be hidden from the people responsible for the application site data. Therefore they will be given a simple data entry system suitable to enter both fruition data and navigation routes. In this way both visitors and site managers can take advantage of the system data structures without having to face its complexity.

THE PROJECT FRAMEWORK AND ITS ECONOMIC VIABILITY

MUSE is an industrial research project partially funded by the Italian Government within the framework of "Parnaso", a National Research Program addressed to companies operating or intending to operate in the Cultural Heritage market[3]. One of the program chapters promotes the conception and development of Cultural Heritage fruition systems based on Information Technology. The idea is to build on the invaluable Italian CH asset and stimulate the cooperation among industrial and research establishments in a market oriented environment.

Fig. 8 shows the project management model: the Government grants a contribution to a selected SME. In order to carry out the project, the SME sets up a network of complementary partners, including end-users and technological entities to carry out the project.

The presence within the project team of the end-users assures the correct definition of the target requirements. The technological partners assure the quality of the technology selection process. The verification of an industrial partner assures the consistency of the project with the market needs.

As already pointed out a project like MUSE requires the convergence of a wide mix of technologies, including historical documents processing, virtual archaeology, communication, photography, cartography, augmented reality, multimedia databases, real time publishing, interactivity, networking, industrial design, system management. To co-ordinate all of these technologies many interdisciplinary research partners converged under the MUSE umbrella including IT and humanities departments, a Bologna-based supercomputing center (Cineca) and several SMEs. In this " virtuoso scenario " new professional skills covering both science and humanities are created and every partner has an opportunity to develop culturally and businesswise.

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3 PNR Parnaso, MURST project n. 4946 (October 2000); main contractor is Boconsult I.d.S. S.p.A., a Bologna based IT company

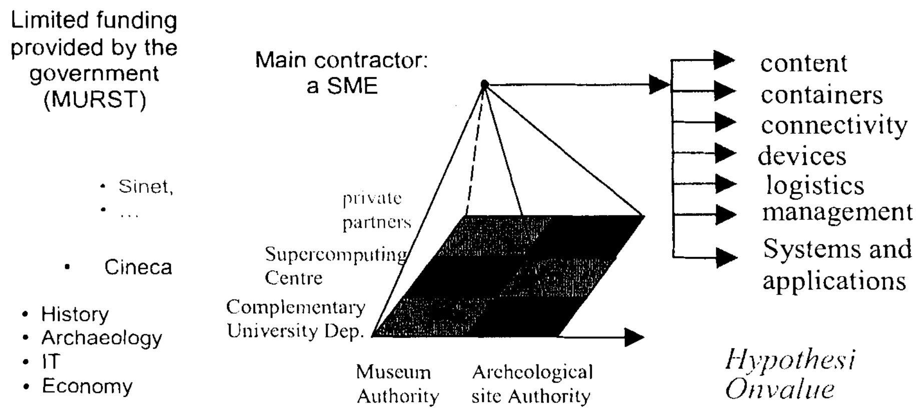

Figure 8: MUSE industrial research framework

On the right-hand side of Fig. 8 a tentative chain of values, i.e. of business opportunities originating from a project like MUSE is shown. It must be pointed out that this business potential is not limited to CH but it may be extended to most activities concerning cultural development. The rationale enabling an SME to afford an experience like MUSE is that resources and technologies to sustain this development framework (bandwidth, connectivity, tools, devices) are becoming cheaper and cheaper everyday and the development of skills covering both science and humanities is the key to turn the above mentioned business potential into reality.

But is the MUSE project economically sustainable by itself? The market size estimate (limited to the Italian public museums and archaeological sites) was based on the figure of paying visitors per annum, on their average growth rate, on the current rate of people hiring an audioguide and on the expected hire rate. The resulting market potential estimate is in the range of 7000 units, corresponding to 1750 units/year for a product life cycle of 4 years (starting in early 2003). This figure should be considered conservative since the private Italian market and the international market are not included in the projection; nonetheless it is not very big. Can therefore this product be appealing to its customers? And, who really are "the customers"? According to the Italian law, fruition aids are included among the "additional services" available at public CH establishments (other additional services are, for example, the bookshop and the cafeteria). In Italy, therefore, all "Additional services providers" are potential customers for the MUSE system, and to these companies the MUSE system must be profitable if we do not want to limit the MUSE to a pure research exercise. What is the expected revenue that a service company can make out of an interactive mobile unit? Every unit can generate revenues from the cost of hire and from its ability to generate a personalized memory of the visit (a personal CD-ROM). Considering that today approximately 6% of the paying visitors hire an audioguide (hire price is less than $ 5),the potential income originated by a unit was split according to Tab. 1 where it is shown that an income of less than $ 6000 per unit over a four year life cycle may be expected.

	Item	Price per unit (US $)	Hit rate	Annual revenue hiring each unit 180 times/year (US $)	Revenue over the unit life cycle (US $)
1	Hiring an interactive multimedia terminal	5	8%	900	3600
2	Getting a personalized memory of the visit (a CD)	12	2%	540	2160

Table 1: Revenue per unit over its life cycle

This figure must be compatible with all of the costs incurred by the partners involved in the business, i.e. the manufacturer, the service provider, the site authority and the rights owners.

Without going through a detailed and tedious cost analysis, it may be concluded that the economic viability of a system like this strongly relies on its ability to provide a cost effective after sale costs structure: system maintenance and management and content provision will dramatically affect the profitability of this system, whereby success shall therefore be influenced by the tools and the skills developed rather than from the technology and equipment costs.

CONCLUSIONS

In this paper an innovative system addressing mobile fruition and site management in cultural settings was presented. The system shall be based on a handheld multimedia terminal with high graphics performance and a wireless connection to a ground server. The proposed architecture provides a user-centric, open and multiresolution fruition model accommodating learning, entertainment and logistic facilities.

The system is expected to be demonstrated in primary Italian archaeological sites and museums,

including the "Istituto e Museo di Storia della Scienza" in Firenze, a major fine arts museum in Napoli, and, last but not least, the Pompeii archaeological area, in cooperation with the "Progetto Insula del Centenario (IX 8)" of the University of Bologna.

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