EMPOWERING GEOGRAPHICALLY ISOLATED COMMUNITIES WITH INSTANT ACCESS TO LEARNING AND TRAINING THROUGH SATELLITE

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1. Introduction

Enabling learning for members of geographically isolated communities such as agrarian, or maritime communities presents benefits in terms of promoting regional development and cost savings for governments and companies. We present a methodology for designing a satellite and wireless based network infrastructure and learning services to support distance learning for such isolated communities. This methodology entails (a) the involvement of community members in the development of targeted learning services from an early stage and (b) a service-oriented approach to learning solution deployment. Here this methodology is applied in the context of the European research project BASE^2 (BASE2 2006), in which the following two types of geographically isolated communities are considered: agrarian and maritime.

2. Motivation and Contribution

The empowerment of community members to engage in distance learning is an issue that becomes more acute when the objective is to kick-start the involvement of isolated user communities in formal and informal learning activities. A solution to this problem can involve many iterative cycles between the learning solution providers (pedagogical and technological experts) and the communities for the definition of e-learning services, the identification of e-learning scenarios and eventually the finalisation of e-learning platform requirements. In addition, it involves the setup and fine-tuning of communication infrastructures that can provide reach to isolated areas.

However, adherence to service oriented architecture for the definition of services, the evaluation of the appeal of each service to specific community members and the composition of service features into service scenarios to suit the needs of each community appears to be a promising approach based on the early research results presented here.

The European research project BASE^2 has started to explore the above issues by identifying, designing and deploying e-learning services over an integrated satellite and wireless broadband infrastructure for isolated agrarian communities in Greece and Cyprus as well as maritime communities on ship following the steps of the methodology outlined above. Fig. 1 presents the generic network architecture BASE^2 is building.

This paper presents the initial results of this work on empowering isolated communities to engage in distance learning by implementing a specific methodology. The service and network architecture to support services and scenarios that were elicited following this methodology and implementation experiences are discussed.

This methodology involves following phases:

1. Service Elicitation phase: isolated user communities were involved in the process of eliciting services and service scenarios that can empower communication, collaboration and learning. Initial services were identified and potential learning scenarios were outlined.
2. Evaluation phase: community members were invited to provide detailed feedback on the first compilation of services and service scenarios.

3. Scenario finalisation phase: based on the outcome of the evaluation phase, it was possible to finalise the learning scenarios that combine identified services into learning experiences for the community members.
4. Service and Network Requirements: the requirements for the performance of the terrestrial wireless and satellite network as well as the communication services for learning were compiled as part of this phase.
5. Deployment and Trial: implementing the software and network architecture and running trial sessions to examine the extent to which the service and network requirements are respected and to evaluate the community members' satisfaction with the implemented learning experience.

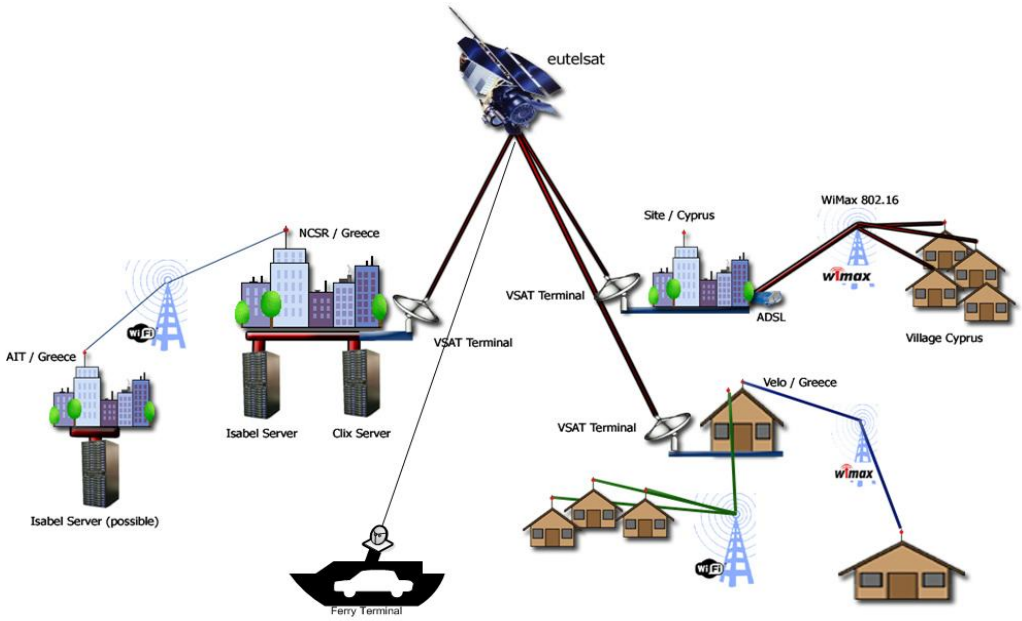

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Figure 1: Generic Satellite and Wireless Network Architecture for Education.

This paper details the experiences with the application of this methodology for provided learning solutions over satellite to isolated agrarian and maritime communities.

3. E-Learning Services for geographically isolated communities

A set of services that can be combined in different leading scenarios were first identified in the BASE[2] project in collaboration with selected members of the agrarian and maritime communities who had more experience with the training requirements of their communities.

During this phase a list of services were presented to the representatives of the two communities who were able to give initial feedback on whether they should be further considered and offered for evaluation via questionnaires to the who of the community. In addition, the representatives of the agrarian and maritime communities were able to provide some hints on the different modes of operation that could be considered for the identified services. The community representatives in both cases were community members with more advanced knowledge in ICT than the average community member. Therefore, they were able to collaborate efficiently both with the technological partners in the project and their communities. In addition, the number of users who provided evaluation feedback on the initial scenarios had a higher familiarity with ICT than the average community members; they are thus expected to become the catalysts for enabling education in isolated communities in the project.

Previous projects succeeded in providing satellite-based education in isolated areas in Greece (Sotirou et al, 2004) but the learners had a satisfactory background in ICT and there have not been as requirements on the number of services to be deployed and their features as in BASE^2.The low familiarity with ICT has been an important challenge in BASE^2.

Following this approach, the services presented in the following paragraph were considered for evaluation by the project (Serif et al, 2006).

- **Virtual Classroom (VC) Service**. A Virtual Classroom service was favoured as a candidate service for evaluation by community members. A VC is defined as a computer accessible, on-line learning environment intended to fulfil many of the learning facilitation roles of a physical classroom.
- **Learning Management System (LMS) Service**. Among the services that were also identified in BASE^2 as relevant by the community members was the deployment of a Learning Management Service (LMS) for individual access to educational material anywhere- anytime.
- **Tele-Conferencing Service**. This is a core service for the BASE^2 vision and its value was recognised by the community member representatives. It enables live sessions connecting many geographically dispersed sites, either ad-hoc or prearranged.
- **Webinar/Webcast Service**. This service consists of a unidirectional, live or pre-recorded, transmission of content from one site to other remote sites. The date and details of each session needs to be announced in advance in order for the receiving site to tune in properly.

Other services were identified as potential candidates in BASE^2 in addition to the ones above and involved the delivery of pre-recorded educational content is either broadcasted over satellite core and access networks at pre-scheduled times or by the course coordinator but were not put on the top of the priority list by the community members participating in this phase of service elicitation.

4. User-based evaluation of e-learning services in the Communities

Following the initial identification of services as candidates for further evaluation user questionnaires were authored to elicit feedback from a much larger base of the agrarian and maritime communities participating in the project (Tsekeridou et al, 2006).

A total number of 27 maritime users and 49 agrarian users, summing up to 76 users, completed the questionnaire. Maritime users have been employees of the SuperFast Ferries and the Minoan Lines companies, on ships that also undertake international routes. Agrarian users were gathered from distributed geographic locations in Greece, to measure differentiating user interests and needs per regions. 76% of the users were men and 24% were women. Half of them were in the 35-49 range of age, while the rest were mainly younger, and almost all of them were employed. The majority of those attend educational seminars or programs only a few times a year or seldom. The majority of users are accustomed to technology and electronic communication. Currently the members of both communities do not get the chance to participate in training programmes very often.

Almost 90% of the members of both communities have never participated in a teleconference. Nevertheless, 54% of the participants in this survey are very or extremely interested in participating with colleagues from remote areas in future, while a significant 32% appears to be open to this possibility. 1 in 4 of the participants consider it very or extremely important to be able to use TV-based equipment instead of a PC for participating in video conferences (as shown in Fig. 2) which is indicative that the motivation factor needs to be strengthened for participation in virtual classroom services. Almost none of the participants have had the experience of participating in a Webinar/Webcast session. However, half of them are very or extremely interested in participating in Webinars, while more than 1 in 3 say they are open to this potential. 1 in 3 of the members of the maritime community consider very or extremely important to be able to participate in Webinars using TV-based equipment, while one 1 in 4 members of the agrarian community place high importance on this feature.

For both communities 3 out of 4 have never yet used a learning management system and an educational portal to access education resources. However, around 60% of both communities is eager to use such a system. Half of the users of both communities would use the LMS system for collaboration with other colleagues and exchange of ideas. A 62% of users in average believe the communication with remote tutors and learners is of great importance. The preferred modes of remote communication and collaboration are emails (64%), chat (50%) and forums (44%).

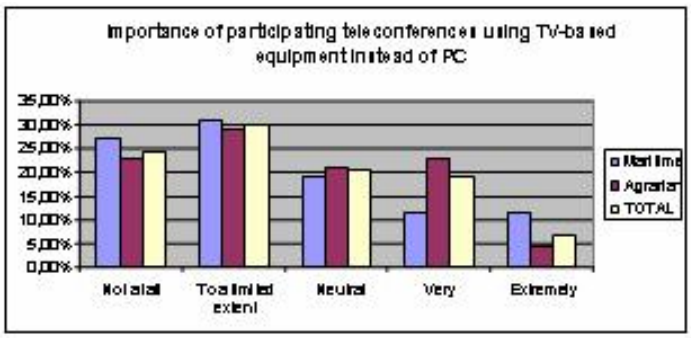

Figure 2: Preference for TV-based vs. PC-based terminal equipment for education

To the option to receive low quality video streaming of educational lectures but in timely manner rather than high quality videos but with longer delays, users from both communities are open to adapted implementations per case. Finally, both communities are in favour of the dynamic adaptation feature of the learning process, believing in its efficiency to provide enhanced learning experiences. Finally, 72% of both communities prefer synchronous services, while 28% asynchronous ones. With respect to the option of being provided with integrated services, combining both synchronous and asynchronous types of services, more than half of the users of both communities believe it very or extremely important.

5. Design of realistic Learning Scenarios

Given the feedback received via the questionnaires a number of Learning Scenarios was finalised and the functional and non functional requirements of the identified services were detailed using the Volere template (Robertson and Robertson, 1995). This is an important phase of the methodology, since, these learning scenarios will form the basis on which the service and network architecture requirements will be identified and trade-offs in terms of how these requirements can be best met will be considered.

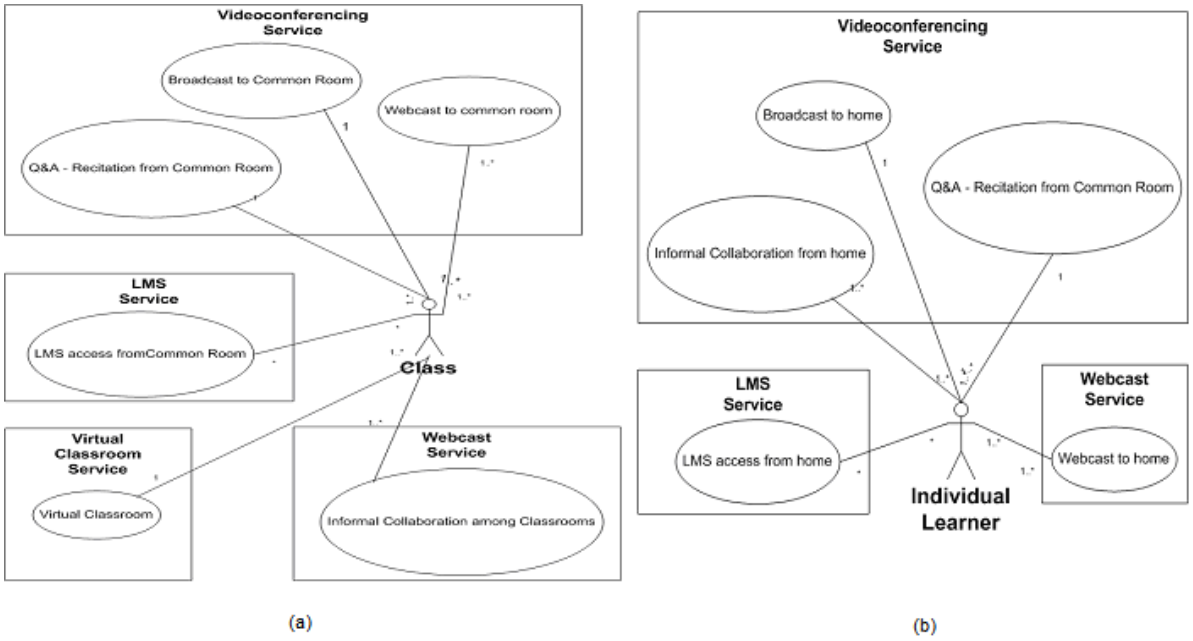

Figure 3: High level use case diagrams for (a) common room and (b) home based learning.

Thus, number of tele-education and e-learning scenarios were defined to present the direct deployment of BASE^2 services in the following sections. Each scenario may involve the deployment of part of a service, of a full service or of a combination of services based on the feedback received during the evaluation. This is the reason that services and scenarios are distinguished. Further, the specified scenarios present the basis for BASE^2 trials definition and evaluation of BASE^2 implemented services and infrastructure which is the last phase of our methodology.

The scenarios are grouped into two major categories as illustrated in Fig. 3.

- The common room oriented e-learning scenarios. These address cases where groups of learners are gathered in a common room to be educated using a BASE^2 service. The key factor here is groups of learners in a common room - that is, a tele-education room is setup with all required equipment to access the BASE^2 service and access is mainly scheduled and occurs simultaneously.
- The home oriented e-learning scenarios. These refer to cases where each learner accesses the BASE^2 services from home and from his own enabling equipment at any time of the day.

6. Satellite-based network architectures for distance learning

Our implementation considerations concentrate mainly on three distinct satellite network architectures for education applications, namely Very Small Aperture Terminal (VSAT), Digital Video Broadcast - Satellite (DVB-S/S2) and Digital Video Broadcast - Return Channel Satellite (DVB-RCS). The rationale in supporting multiple satellite communication environments stems from: (1) the variability of expected user requirements (some users have inflexible legacy communication systems, while others can be open for very innovative deployments), and (2) the existence of a number of satellite platforms with a wide range of capabilities and cost.

6.1 VSAT Solution

6.1.1 Land-to-Land VSAT Architecture

This architecture includes a number of VSAT enabled sites and further interconnection using WiFi and/or WiMax wireless infrastructure for delivering the service to more users. Different usage scenarios can involve point-to-point, point-to-multipoint interactive communication, live lectures and video on demand capabilities, as well as interconnection between the network sites in order to ensure the necessary collaboration between the learning groups, which is an essential e-learning element.

6.1.2 Land-to-Vessel VSAT Architecture

This network architecture includes one or more ship(s) connected with a VSAT station at the central node with a fully equipped studio. It facilitates live lectures and video on demand capabilities using IPv4 protocol. In order to realise the proposed e-learning services on VSAT networks, we require minimum of 500-550 ms round trip time (RTT) on a 1.8-2.4 meter antenna with 8/25/40 Watts SSPA/TWTA. The required satellite bandwidth for the network would be approximately 11.5 MHz for an 8 Mbps shared mesh carrier, with a bit-error-rate equal or less than 10^8.

6.2 DVB-S/S2 Architecture

This architecture involves DVB-S or DVB-S2 enabled sites for e-learning. It can support e-learning scenarios, such as point to point and point to multipoint interactive communication and collaboration, as well as live lectures and video on demand capabilities using IPv4 and IPv6 protocols. In a DVB-S/S2 architecture, the quality of service requirements is quite different than of VSAT's. The expected round trip time (RTT) should be in the range of 250 – 280 ms unidirectional and 300 – 2000 ms bidirectional (with terrestrial return). The dish at the hub station should be 3.7 to 9 meters with 100+ Watts TWTA output and at the receiver end 2.4 to 6 meters. Depending to the technology used, network bandwidth could reach up to 120Mbps in the range of 1.5-36 MHz. In order to achieve a smooth e-learning content transmission the overall bit-error-rate (BER) should be less than 10^9.

6.3 DVB-RCS Architecture

This architecture involves DVB-RCS enabled sites connected with the central DVB-RCS platform. Similarly to the previous architecture, this architecture can support live lectures and video on demand capabilities using IPv4 protocol. The DVB-RCS architecture follows strictly the approach of a star distribution system with one outgoing broadband satellite channel from a central hub station and multiple return channels originating from VSATs which log-in to a Network management system via the satellite link. The return channel architecture is organized in MF-TDMA time slots in which either MPEG-2 or ATM cells are utilised. In order to guarantee a quality transmission of e-learning services on such infrastructure, the expected round trip time (RTT) should be in the range of 580- 650 ms and overall bit-error-rate (BER) less than 10^{-9}. The dish at the hub station should be 3.7 to 9 meters with 100+ Watts TWTA output and at the remote station .98 - 2.4 meters with 1– 4 Watt BUC SSPAs. The bandwidth for the hub station would be 1.5 to 45 Mbps at 1.5 – 36 MHz, and for the remote stations .016 – 2048 kbps at .02 – 2.2 MHz.

7. Conclusions and Discussion

The next and last phase of the methodology followed in the BASE^2 project involves the deployment of the service and network infrastructure and a number of trials. About 10 agrarian community sites in Greece and 2 in Cyprus have been identified and works for the network and service deployment are underway. In addition 1 vessel has been identified as a maritime community site that will communicate with a fixed site on land as part of the implementation of the scenarios identified above. The objective is to try all different scenarios for both communities. Following the deployment and trials further evaluation will be carried out to establish the degree to which the expectations of the community members were met and potentially additional work to move close to that direction.

The initial feedback shows that (a) high-quality audio-visual material and (b) the opportunity for community members to interact with other community members either as groups (common-room oriented scenarios) or individuals (home-based scenarios) is expected to provide strong motivation for engaging in both formal and informal learning activities.

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