FINAL REPORT

AVANTI
AdaptiVe and Adaptable InTeractions for multimedia Telecommunications applications

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1. **EXECUTIVE SUMMARY**

The main objective of the project was to demonstrate that it is possible to develop generic multimedia telecommunications applications adaptable and adaptive to the requirements of most potential users (including e.g. disabled people, elderly people, occasional users, professionals), in terms of networks and terminals, information content and human-computer interface. Practical testing was carried out in field trials of applications of important social impact and potential commercial value (services for citizens and tourists, in terms of information support to mobility of people on a territory).

The project’s approach was to demonstrate transparent access to a variety of databases (textual and/or multimedia), using a selection of terminals (from text terminals to multimedia terminals) and network facilities (from narrowband to broadband connections). This implies real-time integration and adaptation of information to be transferred as a function of the user abilities and preferences, the available telecommunication infrastructure and terminal. The adaptation at the information content and user interface level was carried out on the basis of the concepts of adaptability and adaptivity. Adaptability focuses on the notion of the automatic provision of various presentations with different interaction characteristics, based on knowledge about user needs, abilities and preferences. Adaptivity refers to the ability of adaptive software applications to dynamically modify the dialogue characteristics during user-terminal, user-network and user-application interaction, according to the user behaviour.

Validation was considered an integral part of the project. This aimed to test in a real environment selected aspects crucial for usability of the system, as the user interface, usefulness of the service (e.g. quality of information), and impact on the real mobility capabilities of addressed end users (e.g. motor impaired people). Three main steps were identified:

- identification of user requirements and service functionalities;
- design and adaptation of communication and information applications;
- integration of the system, experimentation and validation of the application.

The project carried out two field trials, respectively located in Siena and in Finland, and a demonstration in Rome. Both field trials were realised on existing network facilities, mainly provided by the National Hosts of the two countries. The field trial in Italy mainly addressed motor disabled people with information about accessibility of the territory. The broadband access to the system was assured by sites located on the Tuscany MAN (Siena and Florence sub-networks). Both sub-networks were based on a 140 Mbps backbone, and were connected through a 34 Mbps link; the sites involved in the trial were provided with 2 and 34 Mbps accesses. Access to the system by the PSTN was tested as well in order to take into account different network capabilities. In the Finnish field trial the testing was carried out with occasional able-bodied and professional users. The application mainly regarded information about mobility, entertainment and accommodation facilities at a city level. The trials employed the sites of Kuusamo and Helsinki, where ATM connections are available to the Finnish Host; each site was connected to a 4 Mbps access. The narrowband access to the application was tested through the public N-ISDN service.

The main issues addressed by the project were the following:

- User needs elicitation, both in terms of data content and presentation;
- Selection and adaptation of telecommunications facilities and terminals;
- Development of software modules that allow for adaptability and adaptivity at the information content and at the user interface level;
- Integration and functional testing of the entire system;
- Field trials in Italy and Finland and assessment of the application;
- Dissemination and exploitation activities, particularly in the Jubilee perspective.

The expected Impact on the European society is the following:

- Improvement in the working and living conditions of disabled and elderly people by reducing barriers to information access;
- Increase in service effectiveness and integration of existing databases through the production of multimedia documents and the introduction of adaptability and adaptivity concepts;
- Increase in the quality of information; "right" information to different users in terms of information content and presentation;
- Transparent access to geographically distributed databases through a scaleable set of network facilities;
- Automatic user interface adaptability at design time and adaptivity at run-time.
The project provided a concrete step towards the long-standing objective of universal accessibility to the emerging telecommunications infrastructure and application services, by users with different requirements, abilities and preferences, including disabled and elderly people.

In particular, the economic and social impact of the project focused on the following main points:

- to provide an interactive multimedia information application, which will offer new opportunities to all users, including disabled and elderly people; such opportunities deal with both the economic aspects (possibilities of employment) and the social aspects (promotion of participation in social activities and improvement in the quality of life);
- to improve the working and living conditions of disabled people by reducing barriers to information access, and by supporting their mobility and therefore increasing their social cohesion;
- to improve access to computer systems for all users, since they adapt to the needs of the individual user;
- to reduce costs for all adaptations, in order to meet the requirements of the various user categories (the project developments ensure adaptability and adaptivity to the various user groups);
- to promote mobility and tourism in Europe; contributing to cultural, economic and social exchanges between different countries;
- to facilitate the retrieval of information about public services and institutions (e.g. museums), transportation and entertainment opportunities, thereby helping all citizens to take better advantage of these facilities.
2. Project Objectives

Developments in telecommunications and information technology and the substantial merging between the two technologies are currently causing the emergence of an information society, characterised by:

- the wide availability of information in geographically distributed heterogeneous databases;
- the deployment of networks with different bandwidths and built-in intelligence;
- the proposal of a variety of terminals with different facilities, intelligence and human-terminal interfaces.

In this scenario, generic multimedia applications are emerging which, according to a widely accepted principle, should attempt to satisfy concurrently the communication and information requirements of the greatest number of potential users, addressing usability issues of different customer categories, with the aim to increase the market of multimedia telecommunication equipment, services and applications. Users may differ in expertise (e.g. domestic versus professional use), interests (e.g. entertainment, remote working, remote shopping, remote banking) and capabilities (e.g. expert versus inexperienced), including also disabled and elderly people.

With a view to make access to the complex environment outlined above possible by all potential users, including people with disabilities, the project objectives were:

- to carefully define information needs in different application environments;
- to interconnect existing databases dealing with the same application environment, irrespective of the physical location, technology used for their implementation, representation of information (textual databases, multimedia databases);
- to integrate their contents and organise the presentation in a way that satisfies the information needs, physical and sensory abilities, type of available terminal, and telecommunication links of the individual users;
- to allow the use of different types of terminals (from text-based terminals to multimedia workstations), equipped with suitable user interfaces and receiving information compatible with their characteristics (scalability at the level of terminals);
- to allow the use of telecommunication links of different bandwidths (scalability at the level of telecommunication infrastructure).

A Content Model, that is a meta-description of the contents of the databases connected to the system, and a Multimedia Database Interface, which offers to the system the information coming from different databases in an unified and integrated way, were defined and implemented. An information system sits between the terminals and the Multimedia Database Interface and is responsible for the reorganisation of the information for presentation to the user through a suitable human-terminal interface. The concepts of adaptability of the information presentation and of human-terminal interfaces according to user capabilities, as well as adaptivity as a response to user behaviour, were used for the implementation of the AVANTI telecommunication application, concurring to facilitate access to the available information space. Adaptability focuses on the notion of the automatic provision of various presentations with different interaction characteristics, based on knowledge about user needs, abilities and preferences. Adaptivity refers to the ability of adaptive software applications to dynamically modify the dialogue characteristics during user-terminal, user-network and user-application interaction, according to user behaviour.

The concepts and the related implementations were tested in a real environment with groups of people who can particularly benefit from these new approaches (e.g. disabled and elderly people), and by using an application which could potentially have an important impact on their opportunities for socio-economic integration (access to multimedia information as support to planning their mobility, including tourism aspects). The application chosen for experiments addresses a field of paramount importance for all and, at the same time, had sufficient complexity to test significantly the technical and usability aspects of the proposed products, thus providing indications for the characteristics of a real application, possible uptake and commercial exploitation. The interoperability of different telecommunication links (narrow-band and broad-band) was concurrently tested. Information was made available by integrating transparently already existing (textual) databases and new multimedia information. Access was shown possible irrespective of the terminal and network available to the single users, with automatic adaptations of the information to both the user capabilities and the network and terminal characteristics.

From the user perspective the potential benefits from the project are:
• to improve accessibility to information by all users including disabled people, according to their requirements and preferences;
• to integrate information transparently by addressing different aspects of an application environment (in the present case information to support mobility);
• to give access to complex multimedia information through multiple terminals and network set-ups, with automatic adaptation to the available resources.

Representatives of all the foreseen user groups were continuously involved throughout the development, particularly during user requirement analysis and field tests. Experiments were carried out using broadband network facilities of two National Hosts, accessible to the consortium and integrating different network environments.

Summarising the general objectives previously outlined, the goal of the project was to develop specific software modules for the adaptation of information contents and terminals, and to integrate them into network facilities used for accessing information from existing databases which deal with mobility planning problems, in order to validate the general concepts through an appropriate set of experiments.
3. RELATIONSHIP TO PROGRAMME OBJECTIVES/CONSSENSUS MANAGEMENT ACTIVITIES

The carried out work was within the area of "Intelligence in Networks and Service Engineering" (Area 5), and covers issues also concerning the areas of "Interactive Digital Multi-media Services" (Area 1) and "High-speed Networking" (Area 3).

It contributed to the overall ACTS objectives for social integration of a wide variety of people through the provision of accessibility to the proposed system by several user categories (including elderly and disabled people) and for the cohesion of the European service provision through the utilisation/support of a variety of terminals and communication networks.

The AVANTI project directly contributed to the objectives of Task AC516: "Adaptive User Interfaces" by defining and developing application components to be utilised for easy adaptation of multimedia retrieval applications to the requirements of particular groups of users and individual users.

Additional tasks addressed by the project were the following ones:

- Task AC119 (Multimedia User Access), particularly with respect to media integration to achieve a common multimedia system interface, suitable for different network architectures, and the exploration of how users (including disabled people) would prefer to interact with advanced communication services.
- Task AC304 (Usage Experiments on Applications and Network Functionalities), with particular reference to the "Access to Multimedia Databases". This was obtained through the realisation of trials involving end users and by aiming to validate the viability of applications and the selected technical solutions.
- Task AC305 (High Performance Networking Service Provision for Citizens), through broadband infrastructures which can provide additional media for people with special needs, so that their flexibility can assure services for a broad range of citizens.

Moreover, the AVANTI project covered aspects of a variety of tasks on a limited basis, in that the project addressed some specific sub-parts of the Task, while it was not directly related to the Task as a whole. Pertinent examples of such Tasks are the following:

- Task AC20 (Applications feasibility: service demonstrator), with the particular aim to define and implement advanced communications service concepts intended for the specific sectors of "Citizen network" and "Administrative network".
- Task AC40 (Advanced Communications Experiments), with the particular aim of identifying new business opportunities, by extending the potential range of customers through the iterative analysis of user needs and testing of prototype systems.
- Task AC121 (Service Interface, User Guidance and Information Retrieval in Multimedia Distributive Systems), with particular respect to adaptive User Interfaces, user guidance, content description, the linking of content information for multimedia service components, and the tailoring of information to the user's needs.

The project's capability to provide instruments for extending the range of potential customers in the telecommunication services market is supposed to contribute to increasing the competitiveness of the European industries. In particular, the project attempted to increase European competitiveness in the field of integrated user-adapted multimedia applications on a network, as well as of adaptable and adaptive interactive systems in general. The success of the project will hopefully encourage European system developers to use this technology in more comprehensive applications, which will give these applications a significant market advantage.

Finally, the project fitted completely the European Union policies which aim to extend the accessibility of communications services to the largest number of users, including elderly and disabled people.
4. MAIN ACHIEVEMENTS OF THE PROJECT, INCLUDING REFERENCES TO THE MAIN DOCUMENTS PRODUCED

4.1 Summary
The main achievements during the AVANTI project are the following.

- Collection of information requirements of user groups of interest in order to facilitate their mobility and
definition of modalities for presentation (WP1).
- Investigations on problems in accessing terminals and consequently the presentation media (WP1).
- Identification of test sites in co-operation with user organisations (WP1).
- Development of the following software modules:
  - AVANTI Multimedia DataBase (WP1);
  - Multimedia Database Interface (WP1);
  - Content Model (WP2);
  - User Model Server (WP2);
  - HyperStructure Adaptor (WP4);
  - User Interface (WP4).
- Implementation of the network infrastructures: broadband networks connections have been provided by
  Italian (i.e. a SMDS over DQDB 2 Mbps link) and Finnish National Hosts (i.e. an ATM connection)
  (WP3).
- Integration and testing in the main laboratory of the AVANTI system (WP5).
- Implementation of the AVANTI system prototypes in Siena, Kuusamo and Rome (WP6)
- Implementation of the main experimentation scenarios including also scenarios for testing adaptability
  and adaptivity (WP6 and WP9).
- Evaluation of the systems in Siena, Kuusamo and Rome (WP6 and WP9).
- Dissemination and exploitation activities (WP7).

4.2 Detailed achievements

4.2.1 Set-up and execution of the experiments

4.2.1.1 Specifications and guidelines (WP1, WP9)
The main achievements in the specifications and guidelines part of the projects are the following.

Identification of the user groups
The groups involved in the testing were determined on the basis of the preliminary hypotheses made in the
proposal (disabled people, able bodied customers and travel agency clerks) and subsequent direct contacts
with potential user groups. In Italy, for example, people with disabilities directly contributed to the analysis
phase (i.e. the identification of information needs and information content) and participated in the evaluation
phase. On the basis of the analysis of the situation in the planned test sites the following user groups were
identified:

- users with forms of spasticity and dystrophy (Italy);
- paraplegic and tetraplegic users (Italy);
- blind and low-vision users (Italy and Greece, in a laboratory environment);
- occasional able bodied users (Finland);
- tourists (Italy and Finland);
- business travellers (Finland);
- travel agency clerks (Italy and Finland).
User needs
The investigation of the information needs were simultaneously carried out in Germany, U.K., Finland and Italy, using different methodologies to cope with the differing cultural approaches to the problem of the autonomy of disabled people. User needs for Information necessary, for example, to plan a trip, to facilitate mobility on the territory, to facilitate the administration of time and energy during his/her stay were elicited, including e.g. information about accommodations, transportation, opening hours of public services and accessibility of the different sites.

Identification of the information content
Following the identification of user needs, the information content as well as the related modality of representation of the information were identified. The term “information content” refers to the kind of data items the user requires (e.g. if the chosen hotel has accessible rooms, the size of a door, the accessibility of a specific museum for people with a wheelchair), for deciding about possibility of autonomous and/or assisted mobility.

Identification of the modality of presentation
In order to be accessible to disabled users, information must be adapted to the specific user capabilities not only at the level of content (e.g. essential information regarding accessibility for people using a wheelchair has to be provided); but also at the level of the representation (e.g. blind users cannot access videoclips of hotel rooms, and therefore an audio or a braille-text has to be provided to them).

Identification of access problems
Users with disability may experience problems of accessibility:
- at the terminal level;
- at the media level;
- during navigation in the system.

Guidelines need to be identified for accessibility by end users to the terminals and therefore to the available information, as well as for easy navigation through the information system.

Acquisition of the AVANTI knowledge and tools for the implementation of the Rome system
The available project documentation was studied and discussed with all other partners who provided strong contribution to educate a SME in the difficult task of developing an adaptable and adaptive system.

The components of the Project have been studied and tested one by one to be used in the development of the Rome Demo Prototype; specifically they are:
- The Multimedia Database Interface (MDI);
- The Content Model Editor (CME);
- The User Model Server (UMS) and its language;
- The HyperStructure Adaptor (HSA);
- The User Interface (UI).

4.2.1.2 Setting-up of the telecommunication facilities (WP3)

The AVANTI project exploited existing telecommunications facilities in providing transparent access to a variety of information systems and delivering multimedia information to different groups of users. The experimentation in AVANTI was carried out in laboratory and field trials in Italy and in Finland.

As regards the telecommunications infrastructure, one of the main aims in the project was to develop a system that could automatically adapt the service according to the bandwidth of the telecommunication channels utilised by the end user. This means that information requiring high bandwidth (for example, video) should not be offered to a user accessing the system through a low speed link. On the other hand, a user with high speed access should in principle be given the choice of retrieving any type of information.
For validating the concept of adaptability of the information content of the application to the network environment, several types of communication technologies with varying bandwidth and quality of service characteristics were selected for the trials. These include ATM, DQDB, N-ISDN, and PSTN.

Networks and National Host services

The Italian field trial in Siena exploited the existing facilities offered by the Tuscany MAN. The Tuscany MAN is a regional broadband communication network realised using the Alcatel DQDB technology (IEEE 802.6, Distributed Queue Dual Bus), where the SMDS (Switched Multimegabit Digital Service) and 802.3 services are offered by Telecom Italia. Private LANs are connected by multiprotocol routers to the main switching systems running at 140 Mbps.

The Florence and the Pisa MANs, part of the Tuscany MAN, belong to the Italian National Host (ItalHost) managed by the non-profit Consortium "Itinera". In the context of AVANTI Alcatel Siette was connected to the Tuscany MAN through a SMDS 2 Mbps link for the period April ‘97 - August ‘98 on the basis of the contract signed with the Itinera Consortium. This connection has supported the experimentation phase for the Siena test site.

The access speed in the trials could vary between 28 kbps and 34 Mbps, according to the telecommunication network employed (PSTN, leased lines or MAN access). In Finland the ATM architecture was based on 25.6 Mbps ATM network interface cards (Adaptec and ForeRunnerLE) in the client and server PCs, and work group switches (Whitetree WS 3000 and ForeRunner ASX-200WG), connected to an ATM backbone. The VTT premises at Espoo and Tampere were interconnected using the FUNET (Finnish University and Research Network) ATM service, which offers 8 Mbps connections for free for its member organisations. TCP/IP protocols were conveyed on ATM, both by using LAN Emulation as specified by ATM Forum and using Classical IP over ATM (RFC1577). N-ISDN connections from the client stations located at a residential site utilised external terminal adapters (ZyXEL Elite 2864I).

The demonstration in Rome was realised using an N-ISDN BRI modem and an ISDN router located in Alcatel Siette laboratory.

The performances of the DQDB and ATM networks were measured using FTP transfers and various benchmarking utilities, that probe the network with ICMP echo packets.

The available narrow band facilities will still be in wide use in the close future, but the broad band solutions based of DQDB-MAN as well as end-to-end ATM might be more rare in the future.

4.2.1.3 Siena experiments (WP6)

A scenario-based evaluation methodology was chosen for the experiments in Siena. The scenario-based design/evaluation methodology is a well-established procedure for representing, analysing and planning how an interactive system might impact its potential users.

Three main activity scenarios, which include instances of information needs of all user groups of interest and are representative of common situations requiring information about mobility, were adopted. The scenarios are frameworks to organise possible alternative environments in which actions might be carried out. They can also be seen as devices for facilitating communication among members of the design team.

The experimentation followed three phases; the third phase was particularly focused on adaptivity testing. A total number of 60 users were involved; some were novice in AVANTI, and others participated different sessions in order to evaluate developments and improvements in the evolving prototypes.

Both a qualitative and quantitative analysis were carried out, in accordance with the methodological strategy defined in the first years of the project, as reported in appropriate deliverables (DE027, DE030, DE033).

The tools used in the evaluation of the AVANTI system were observation, interviews, questionnaires and log files. The objectives of the experimental evaluation activity were to evaluate:

- the usability of the system (learnability, efficiency of use, memorability, rate of errors and satisfaction);
- users attitude towards the system;
- adaptivity rules.

Since contextual factors are of paramount importance in assessing usability, the following independent variables were considered:
Sites: context of use (e.g. public - private) - qualitative measure
connection speed (e.g. low - high)

Users: physical condition (e.g. motor disabled people - people without motor disabilities)
experience of the user with web service (e.g. some experience - no experience)
extpertise with the AVANTI application
expertise with computers
origin of the users (e.g. citizens of Siena - Tourists) - qualitative measure

The manipulation of these variables allowed to define the boundaries within which the developed application is usable, and possible way to overcome such boundaries.

The evaluation was carried out according to the following path:

1) Performance on the scenario;
2) Filling in of the After Scenario Questionnaire;
3) Filling in of the Post-Study System Usability Questionnaire;
4) Interview.

User's performance was evaluated on three levels: phenomenological (e.g. number and time dedicated to overcome breakdowns in the interaction), cognitive (e.g. identification of the cognitive distance involved in the breakdown) and experiential (e.g. subjective evaluation of the interaction through the filling in of a scenario-based questionnaire of usability and semi-structured interviews).

For what concern the qualitative assessment of context of use (e.g. public - private) interviews were the main tool for comparison. The private factor was considered through the involvement in the experimentation of a disable person connected at home full-time for the entire duration of the 3rd session. The contents of the interviews with disabled people in the public sites were compared with the content of the interview with the disabled person at home (content analysis).

As regards the origin of the users (e.g. citizens of Siena - Tourists), the comparison was carried out on the basis of the analysis of the cognitive distance involved in the breakdowns and in the analysis of the content of the thinking aloud protocols, since the mental model mediating the interaction with the system was considered the most relevant difference among the two groups.

The last session was focused on the assessment of adaptation features provided by the system. Both quantitative and qualitative variables were considered. The quantitative variable concerned the subjective assessment of the behaviour of the system, expressed on Lickert’s scale in the questionnaire (question n.20 of the PSSUQ).

The qualitative analysis, based on the post test interview, was centred on the following questions:

1) Does the user recognise that something is changing in the behaviour of the system, with respect to the same kind of commands?
2) Does the user succeed in figuring out the right meaning to the adaptive features of the system?
3) Does the user exploit these features?

Test results were reported presenting first the quantitative variables and then the qualitative variables.

**QUANTITATIVE ANALYSIS**

Independent variables were:

- a) Avanti expertise (novice, expert).
- b) Web expertise (low, medium, high).
- c) Computer expertise (low, high).
- d) Connection speed (high, low).
- e) Physical condition (able-bodied, disabled).

Dependent variables are:

- a) Learnability.
- b) Efficency of use.
- c) Satisfaction.
- d) Error rate.
e) User attitude.
f) Memorability.
g) Adaptivity.

From an analysis of the questionnaires, the following general results can be summarised:

AVANTI EXPERTISE
- Time to accomplish scenarios decreases with expertise in the use of the system, due to its coherent structure.
- AVANTI experts make less errors especially in the first page (access page with username and password) and in the second page (questionnaire about user’s capabilities and preferences).
- AVANTI experts better understand and use adaptation features.

WEB EXPERTISE
- The difference in performance between expert and novice users is restricted to the 1\textsuperscript{st} session. In the 2\textsuperscript{nd} and 3\textsuperscript{rd} sessions such difference is no more present.
- Web expert users are more critical about the interface of the system.

COMPUTER EXPERTISE
- Computer experts are less satisfied of the system speed than computer novice; on the contrary experts are more satisfied of the low error-rate during interaction and estimate the learning rate faster than novice users.

CONNECTION SPEED
- Users feel that time to accomplish scenarios is lower at the school of engineering than at the public information point.
- Disabled people are more satisfied at the school of engineering because they succeeded in downloading the video of the streets with small time delays.

PHYSICAL CONDITION
- Disabled people are more satisfied with the information provided by the system.
- Disabled people recovers easier from breakdowns than able-bodied people.

CONTENT AND INTERFACE
- Between sessions users found no relevant improvement in the content of the system, while the pleasantness and usability of the interface increased with the evolving prototypes.

QUALITATIVE ANALYSIS

DISABLE CITIZEN’S HOME (WHEELCHAIR-BOUND)
The Siena citizen considered the system very easy and useful. She was very satisfied with the attention paid to disabled people and assessed the information as detailed and clear, particularly the part related to accessibility. Moreover she felt that information was provided through a pleasant interface, but she considered comfortable the use of the system only in a private environment.

TRAVEL AGENCY CLERK

The travel agency clerks found easy the use of the system. On the other hand, they did not feel so attractive the presentation, especially in comparison with many other web sites. As regards the information content, they noticed different levels of details (e.g. some very detailed information for chemist’s shop, superficial information for car park, means of transport, and tourist details).

Moreover, some information they expected to find is missing, like a suggested tour of the city, information about surroundings and suburbs, links from place to place.

ADAPTIVITY
The path navigation tool was mostly used by web and computer experts. The “+” and “−” icons for selecting/deselecting alternative information should be substituted by more explicit text.

The links highlighted by the icon of a little heart, as an effect of the activation of an inferred user interest, were detected, but not properly understood. This happened especially in their relationship with the additional links (“nearest…” buttons), provided by the system when interests are activated.

Explanatory instructions are not evident, since most users were not able to detect them.

Additional links were understood and used by most users.

Adaptable tables, additional accessibility buttons, role-taking buttons and related information were detected, well interpreted and often used.

- **Adaptivity testing – Siena experiments**

  Further scenarios (built up by rearranging components of the main scenarios) constituted the benchmark for assessing the adaptivity of the application. Three new scenarios were constructed.

  The first one was designed for testing the following adaptations:

  a) users’ knowledge
     - Experience working with computers/AVANTI system
     - Domain knowledge (e.g., Siena)
  b) users’ interest
     - Disability information
     - Domain interest

  This scenario is carried out in two steps:

  - first the user browses the system in order to get familiar with it and to activate some adaptive features related to its interests and needs. After this session, the user exits and enter the system again with an updated profile (based on his/her previous interactions);
  - in this second session, adaptation rules are activated, since the stereotype has changed (e.g. now he/she is an AVANTI expert), and the system provides adapted information according to the updated stereotype.

  The second scenario was constructed to test the “role taking buttons”. These buttons are part of the AVANTI browser and provide the user with the possibility of activating different stereotypes, based on the type of disability. When one or more role buttons are selected, the system presents information that is considered relevant for the chosen user groups, matching their information requirements, as defined in the WP1 framework.

  This feature is provided for expert users and it can be particularly useful for travel agency clerks, to assist customers with different abilities and requirements. Clerks can more easily react to requirements of their customers without stopping/starting a session to modify the questionnaire that is presented when starting the AVANTI system (see figure of the questionnaire). They can for instance “take the role” of a wheelchair-bound person to prepare a journey for a wheelchair-bound customer. Obviously if a user is a wheelchair-bound person interested on that additional information he/she can indicate that in the questionnaire at log-on. The use of these buttons is not strictly needed for an ordinary use of the system.
The third scenario is designed to test a particular feature, the so-called “adaptable tables”. In fact, tables are presented to users with the possibility of selecting/deselecting the attributes to be shown to personalise the information content of the table itself.

The selection of attributes in the tables is provided by the system according to the users’ interests (i.e., disability information is only automatically provided if the user is interested). This attribute selection can be controlled manually by the user (i.e., the user can select which attributes should be presented to him/her). If the user has selected/deselected 3 attributes which are related to a certain user group (i.e., blind or wheelchair user or dystrophic) then the system assumes that the user may be interested/not interested on that kind of information and asks the user. If the user answers "yes", the system activates/deactivates the corresponding stereotype and all the special information will be further on automatically presented/not presented. If the user answers "no", then no changes concerning the stereotype activation will take place.

4.2.1.4 Kuusamo experiments (WP6)

Task-oriented evaluation was adopted as the evaluation approach for the Finnish field trial. In the beginning of the session the test persons were asked to use the system performing a single task: selecting a suitable cottage for a holiday. The users were able to set various criteria for the selection of accommodation, to browse through different alternatives, and to select a suitable cottage for their purposes.

The evaluation was based on Nielsen’s usability attributes: learnability, efficiency, memorability, errors and satisfaction. Two additional attributes were adopted to evaluate the Finnish field trial, i.e., user attitude, and adaptability and adaptivity. The tools used in the evaluation were observation, interviews, questionnaires and a log file. Qualitative data was gathered through observation, interviews and questionnaires. Log file and questionnaires brought quantitative material to the evaluation to strengthen and enrich the analysis of the data collected.

The evaluation results indicate, that users found the system pleasant and easy to use. From the traveller’s point of view the system was profitable and interesting for users arriving Kuusamo and looking for accommodation or places to see. The layout of the system and the index were easy to comprehend.

The touch screen was easy to use with the AVANTI Visual Browser and suited to its purpose.
The users had a positive attitude towards the adaptivity and adaptability features of the system. The adaptability features in the system were adaptations according to user’s interest and language as well as travelling season. The interest groups in the system were found sufficient. Possibility to choose language was appreciated, even though all the users were Finnish speaking. The system automatically selected the season of interest (current or coming). However, the users were able to change the season selection manually. The users appreciated also this feature.

4.2.1.5 Rome demonstration (WP9)

Evaluation was carefully designed by evaluators and executed in co-operation with technical partners. From statistical surveys on socio-economic data it was deducted that the population distribution of users for the next 2000 Jubilee will be:

- 50% tourists;
- 25% pilgrims;
- 25% Romans.

Blind users are estimated in a small percentage (below 1%) of the population. Given this statistics it was decided to develop the evaluation with at least 40 users distributed according to the above distribution; moreover, it was decided to test at least 10 blind users.

The material, which was prepared for the evaluation, may be summarised in the following items:

- Interviews to the users before evaluating the system. These interviews were aimed at providing the individual user profile and to set the independent variables for the quantitative analysis (age, title, experience with computer etc.).
- Guidelines for designing scenarios and some examples. University of Linz suggested to have scenarios inspired by the users. To this end it was helpful the pre-evaluation with normal and blind users to elicit realistic scenarios about interesting subjects.
- Practical suggestions on how to conduct the evaluation. Questions that should be asked to the users while evaluating, observations which should be collected.
- Guidelines for designing the questionnaires and one example.

The evaluation took place in two parts: the first devoted to blind users and the second to visual users. Initially, ten blind users evaluated the system at "Cappella di S. Silvia", Rome, under the control of ECG. Then, ECG executed the evaluation with ten other blind users and 40 normal users (20 tourists, 10 pilgrims and 10 Romans). At the end of the execution of the evaluation 60 questionnaires were available.

A comparison of samples (visual vs. blind users) has been carried out.

A statistical analysis of the questionnaire has been conducted, calculating and interpreting the frequency distribution for each question in the questionnaire. The questionnaire contained even open questions to be answered with subjective considerations.

4.2.1.6 Experimentation overall conclusions (WP6, WP9)

The results from the three experimental trials provide some preliminary evidence that through adaptability and adaptivity it is possible to make telematic services accessible to different classes of users, including people with disabilities for everyday life activities. This seems the case for what concern both the information content and the interface. However, according to our experience three main issues have to be considered more deeply in the future.

First, it is mandatory the development of sound methodologies for testing the added value of adaptation. This is of paramount importance since adaptation introduces new variables that do not fit straightforwardly with current testing since apparently they conflict with well established usability principles as user control and visibility of the interaction modalities. We maintain that user control and adaptation are not necessarily one against the other, but it is necessary to introduce innovative short-term testing that can be representative of extended interactions and is able to consider the activity for which the system is designed at a more deep level than tasks.

Second, information content and interaction modality are more interrelated than what is currently suggested by the literature on interactive system. The importance of their relationship has been recently stressed in the
field of information architectures. This demands for more attention for the semiotics of graphical and acoustic interactions, which play a very important role in understanding and exploiting the new adaptive features.

Third, to enhance the adaptation we think it will be worthwhile to include the integration of additional, non rule-based decision mechanisms, and the application of research results in the development of semantic level adaptation capabilities into the adaptation mechanism.

In the near future a growing market for adaptive techniques can be expected to provide personalised information, which is tailored to the needs of the individual user or user groups. At their March Forum “Push Your Business Beyond the Web”, this year in San Francisco the Forrester Research, Inc. asked the audience of 250 new media executives about their companies’ state of personalisation: 13% were actively using personalisation at the time, while 55% were investigating or piloting the technology and only 33% were making no effort.

The AVANTI system produced in Siena was able to support adequately the activity for which it was designed, that is tourist mobility. This seems the case for what concern both the information content and the interface. In particular, content information made the difference in testing on more dimensions (citizen vs tourist; able vs. disable; expert vs. novice). Through adaptation it seems feasible to control this difference and tailor the interaction to the user features. However, it also seems that content was considered by users the more relevant asset of the system together with a sound organisation of the content enabling an efficient exploitation of the system.

Indeed, so far, adaptivity seems to work well within the different classes of users both for what concerns content and interface. Adaptivity raised a great interest and expectation in the users but the results of the testing confirmed what is known in the literature: that is, that user control should balance the autonomous system adaptation.
4.2.2 Technical developments

Figure 2 gives an overview of the AVANTI architecture. AVANTI system components (or subsystems) are divided in three different categories:

- **Main components**: the basic active elements of the system connected with the external environment (USER), or constituting the core performing the adaptation process and the access point to the Databases of the AVANTI system;
- **Subcomponents**: internal active components of the system providing services to the other subsystems;
- **Archive/Permanent Store**: the archives that the system makes available to the end-user.

Subsystems are linked by communication links. Communication links are used to exchange data and control messages between the subsystems. Control messages are used to coordinate subsystems, whereas data messages generally deal with the retrieval of information content or with the exchange of adaptation-related information.

The USER, which is part of the external environment for the AVANTI system, interacts with the User Interface by sending commands in order to extract information from the AVANTI DBs. The User Interface accepts the user requests and provides the requested information in the form of hyper-pages. The user queries the AVANTI system by navigating the hyper-pages which, at the same time, report the information requested and show the allowed ways to reach further information. Moreover, the User Interface monitors all user interactions so as to collect knowledge about the user content interests, skills and problems in accessing the system.

The User Interface reports a selection of these events to the User Model Server, which uses this information for the elicitation of assumptions about the current user. The events reported to the User Model Server may change during the execution. The collected information is also used by the User Interface in order to perform adaptation at the User Interface level.

The User Interface interacts with the HyperStructure Adaptor, the User Model Server, the Multimedia Database Interface, and ordinary HTTP-servers. The interaction with the HyperStructure Adaptor concerns the retrieval of hypermedia pages: the User Interface requests hyper-pages to the HyperStructure Adaptor, which acts as a hypermedia server. The communication between the User Interface and the User Model Server regards the monitoring of the user interaction and the inference of situations in order to achieve the adaptivity and adaptability of the AVANTI system. The interaction between the User Interface and the Multimedia Database Interface is performed to resolve the references to Multimedia objects directly contained in the AVANTI DBs: the User Interface queries the Multimedia Database Interface Multimedia objects in order to fetch and insert them into the hyper-page that has to be presented to the user. An analogous interaction may take place between the User Interface and ordinary HTTP-servers: this is related to the retrieval of Multimedia objects to be inserted into the hyper-pages in the case that the AVANTI DBs contain only URL references to the real Multimedia objects which are located somewhere else.

The HyperStructure Adaptor retrieves the hyper-pages from the Page Archive (a file system containing the hypermedia skeleton pages of the AVANTI system), performs some adaptations on the pages, queries the Multimedia Database Interface to retrieve the references to the Multimedia information contained in the page
in order to format the hyper-page, and then report the page to the User Interface. The entire interaction process with the user is also reported to the User Model Server to acquire further knowledge about the user interests and modify the assumption used to adapt the information. Particularly, User Model Construction Rules control the acquisition of assumptions about user's knowledge and interests based on the interaction of the user with the AVANTI system. The User Model Server is asked to provide assumptions about the user in order to adapt the page to his/her needs.

The User Model Server interacts with the User Interface and the HyperStructure Adaptor in order to achieve adaptivity and adaptability on different levels of abstraction. The interaction with the User Interface deals with the lexical and syntactic levels in order to understand user problems in accessing the information through the AVANTI interface. The interaction with the HyperStructure Adaptor deals with the information content level in order to understand the information which the user is probably interested in.

The Multimedia Database Interface acts as a Multimedia DB server to the HyperStructure Adaptor and to the User Interface: in response to their queries it provides URLs to Multimedia objects and the real Multimedia objects, respectively. It should be noted that the Multimedia Database Interface returns URLs to the HyperStructure Adaptor for non-textual objects, whereas textual objects are directly returned. It should be noted that the Multimedia Database Interface acts as a standard HTTP server with respect to the User
Interface, permitting access to Multimedia objects whose URL reference is local to the Multimedia Database Interface. Moreover, the Multimedia Database Interface also provides the HyperStructure Adaptor with information about the structure of the DBs available to the AVANTI system, which constitute the Content Model of the AVANTI system.

The Content Model is a DB whose content is a description of the information structure of the DBs available through the AVANTI system. Its purpose is to decouple the HyperStructure Adaptor from the data structure of the DBs. The HyperStructure Adaptor has only to know about the Content Model general structure and how to query the Content Model to retrieve the real DB data structure. Moreover, the Content Model provides content related information needed for the adaptation process (e.g., relevant user categories).

Details about the achievements in terms of specification and first development of each system component are provided in the following paragraphs.

4.2.2.1 Database integration (WP1)

Multimedia information structuring

A multimedia database and interfaces for the multimedia database already available in Italy and Finland, were developed. The integration of existing databases in the AVANTI system through a database interface first requires the technical knowledge of these databases. The databases (one in Italy and the other in Finland) and the available data were technically described (i.e. used DBMS, data model, etc.). In parallel, technical choices concerning the new multimedia database were made.

Collection of data and data insertion

Specifications available from the study on user needs were taken into account in order to preliminary identify the experimentation scenarios and hence the data to be collected.

Collection of all data included in the scenarios for the experimentation phase was carried out. Information considered critical for the users was collected in different modalities (e.g. textual, graphical) in order to test advantages of information redundancy for different user groups.

Integration of the Rome database

The multimedia database provided for the project was thoroughly investigated. The SME in charge of developing the Rome application had to cope with a very large and undocumented database, whose structure had been re-engineered from scratch using a pure bottom up approach. Very often, it was necessary to deduce the meaning of attributes from the physical occurrences. At the end of this process the whole multimedia database structure was reviewed. This was the fundamental pre-condition to integrate the Rome multimedia database in the AVANTI system.

4.2.2.2 Adaptation of the information content (WP2, WP4.2)

One of the main objectives of the AVANTI project has been the development of approaches and instruments for the implementation of generic hypermedia applications, based on the concepts of adaptability and adaptivity. The aim of WP 2 was the integration of multimedia data to be presented to the user in hypermedia form according to his/her needs and the development of a network wide server to acquire and maintain assumptions about the user's needs. A hypermedia description language has been specified and a meta model about the multimedia data and a user model server has been developed.

Specification of the Information Resource Control Structure (IRCS)

A central representation structure, namely the Information Resource Control Structure (IRCS), has been specified to allow for the inclusion of dynamic elements. IRCS has been a reference for the three hypermedia applications developed for the field trials in Italy and Finland. Based on this, one central task was the selection of an appropriate standard in the area of multimedia/hypermedia description languages as a basis for the IRCS. Nevertheless, several extensions have been added to this chosen standard in order to allow for choices in the composition and presentation of multimedia documents. Also, links with the multimedia data in the target databases, content adaptation rules and user model construction rules have been added to this standard language.
Based on requirements coming from internal reports and documents related to WP 1.1 "Identification of information needs" and discussions during meetings of the consortium a set of evaluation criteria were identified:

- representation requirements (e.g. text, graphics, audio, video, synchronisation schemes);
- expandability with respect to necessary enhancements;
- availability of tools and products;
- degree of standardisation;
- usage and market penetration.

According the specified criteria a first information collection of relevant standards was carried out in the area of  
(a) document description, (b) multimedia/hypermedia description, (c) standards related to multimedia objects, and (d) IETF standards related to communication. The second phase of the investigation started with a consolidated set of six standards; two major document description standards, namely ODA and SGML from ISO/IEC, and the previously mentioned multimedia/hypermedia standards, namely HyperODA, HyTime, MHEG from ISO/IEC and HTML from IETF.

After presentation of the results of the language survey and discussions among the partners during several consortium meetings, it was decided to use HTML as a basis for the IRCS developments in AVANTI. HTML seemed to be appropriate since low requirements with respect to types of multimedia objects was identified (e.g. support for continuous media was not reflected). The support for synchronization schemes was also not requested. A further criterion was the expandability of HTML with respect to probably necessary enhancements (e.g., links with the multimedia objects in the target databases, content adaptation rules, user model construction rules). Furthermore the availability of tools and products that could be employed during the distributed development of the AVANTI subsystems was an advantage of HTML (e.g. commercial browsers or already existing HTTP servers during the development of the Hyperstructure Adaptor (HSA) or the AVANTI User Interface respectively). In order to implement dynamic elements the HSA, which implements and processes the author's perspective on the IRCS took advantage of the server-based development environment WebObjects from Apple Corporation.

**Modelling of information contained in multimedia databases**

The adapted presentation of multimedia data according to the users' needs is only possible if the system has a rudimentary model of the data. The Content Model (CM) is a repository which extends the ordinary concept of Data Dictionary (DD) to encompass accessory concepts such as adaptation, multilingual and multimedia information. It is logically divided into three parts:

- The Essential Content Model which is always consulted using conventional SQL and corresponds to a conventional Data Dictionary. It is aimed at storing classes, attributes and relationships of the data model. In addition, the Essential Content Model includes the Content Model itself, i.e. classes, attributes and relationships of the Data Model are stored. Descriptions in the Essential Content Model are written in a reference language, e.g. English.

- The Adaptation Content Model is optional and it is required only for databases whose classes are adaptable, i.e. the class attributes may vary depending on parameters: users, modalities and levels of detail. The Adaptation Content Model represents constraints on the class attributes. The Adaptation Content Model part may be directly manipulated with conventional SQL or it can be managed transparently using an SQL extension language such as AQL (Avanti Query Language).

- The Accidental Content Model is optional and it is required only for multimedia and multilingual databases. The Accidental Content Model is composed of classes complementary to the Essential Data Model classes to describe multilingual and multimedia versions of the essential objects, i.e. objects belonging to Essential Content Model classes.

The CM of the AVANTI system can be accessed by other AVANTI components (i.e., HSA and UI) via the the Multimedia Database Interface (MDI). The HSA and the UI may ask the MDI to get information from one of the Avanti databases. The MDI is responsible to query the database and to send back the resulting data to the issuing client. The MDI communicates with the HSA and the UI via the Http 1.0 protocol, i.e. the MDI is a Http-based server. The response from MDI to HSA/UI follows the standard HTTP 1.0 in the form of Multipart MIME.

**User Model Server**
The User Model Server (UMS) stores most of the user-related information in the AVANTI system in so-called "user models" (UM). A UM contains explicit assumptions on all aspects of the user that may be relevant for adapting the behaviour of interactive systems. In AVANTI the UM contains information about the user's knowledge, interests, and abilities.

The UMS is able to:

- incrementally construct a user model
- store, update, and delete entries in several models concurrently
- draw inferences from initial assumptions
- control the activation/deactivation of stereotypes
- maintain model consistency
- supply other components of the system (i.e., HSA and UI) with assumptions about the user

The UMS of the AVANTI system is based on the User Modeling-Shell System BGP-MS which offers various features to support the tasks mentioned above. It is surrounded by several additions which manage the requirements of a multi-user environment.

The interface to the UMS is based on KQML (Knowledge Query and Manipulation Language). This de facto standard describes a framework for exchanging knowledge between autonomous agents. Further developments of KQML in the direction of a standardised interface to user modeling systems lead to UM-KQML. The KAPI package (KQML Application Programmer's Interface) manages the communication of the UMS with other AVANTI components.

Based on monitoring information supplied by the UI the UMS is able to infer (in)ability situations (e.g., 'inability to navigate') of the current user and signals them to the UI. These inferences are carried out by employing statistical methods (i.e., beta distribution) and other information already available in the user model (e.g., the probability for the situation 'high error rate' leads to different probabilities for the situation 'disorientation', depending on the user's expertise in using the AVANTI system).

In BGP-MS, the notion of natural-language speech acts is generalised to dialog acts that may occur in human-computer interaction via any kind of interface, closely following other speech-act based approaches. The assumptions about the user that can be drawn from these dialog acts are interpreted as their presuppositions. Like speech acts, dialog acts can be categorised under dialog act types, which are normally parameterized and associated with a set of presupposition patterns that schematically describe the presuppositions of all instances of the dialog act type. After a set of such types along with their presupposition patterns has been defined, dialog act analysis can be performed: the presuppositions of an observed dialog act can be computed by suitably instantiating the presupposition patterns of its type.
The partition mechanism KN-STEROE puts an appropriate representation system and an activation/deactivation mechanism for stereotypical assumptions at the disposal of the user model developer. First of all, the user model developer must identify subgroups within the expected user population whose members are very likely to possess certain homogeneous application-relevant characteristics (e.g., blind users, tourists, travel agency clerks). The collection of all represented characteristics of a user subgroup is called a stereotype. For each stereotype, the application developer must also identify a small number of key characteristics which allow for the identification of the user as belonging to the corresponding user subgroup, or as not belonging to this subgroup. Knowledge about these key characteristics is encoded in so-called activation and retraction conditions for each stereotype.

The partition mechanism KN-PART implements the outer knowledge representation layer in BGP-MS to define different types of assumptions about the user as well as the system's domain knowledge in separate partitions. Inheritance hierarchies can be defined using subordination relations between partitions: each of the subordinated partitions will inherit the contents of the superordinate partition at the time of retrieval. Within partitions, knowledge and assumptions can be represented in a conceptual representation scheme. This two-level representation permits the representation of assumptions about the user's beliefs and interests with respect to the application domain, the system's knowledge about the application domain, and assumptions concerning application-relevant characteristics of user-subgroups (the so-called stereotypes).

SB-ONE is a knowledge representation language in the KL-ONE. Several extensions and refinements have been added to the original description. SB-ONE is mainly comprised of two levels of representation: the general level, which represents knowledge of a universal nature (including knowledge about classes of objects), and the individual level, which represents knowledge about individual facts and objects (the individuals) in the domain of discourse. At both levels, the most important means of representation are concepts and attribute descriptions. General concepts correspond to unary predicates which can be applied to individuals of the situation to be represented.

Content level adaptations

Adaptations at the content level are supported through the Hyper-Structure Adaptor (HSA) component. The HSA communicates with the other components of the AVANTI system (e.g., the User Model Server -UMS-, the Multimedia Database Interface -MDI) to adapt the hypermedia pages according to the user's needs. It is in essence a collection of hypermedia page skeletons that include some additional rules. From a user interface (web browser) point of view, the HSA behaves like a "normal" web server.

The mark-up language used within these pages is a subset of, and an extension to, HTML, named Information Resource Control Structure (IRCS). Apart from static elements, an IRCS page may contain optional and alternative hypermedia objects, and also groups of hypermedia objects with an associated layout like a page header, toolbar, etc. An example for an optional element is supplementary information on wheelchair accessibility. Examples for alternative elements are general versus more detailed descriptions, and a picture of a painting versus its textual description.

The processing of these optional and alternative elements is controlled by adaptation rules, which can take information from other system components into account, namely assumptions about user characteristics (e.g., knowledge, interests, preferences) from the User Model Server, and content-related information about multimedia objects from the Content Model (CM) via the Multimedia Database Interface. Information about the current user's session (e.g., previously requested IRCS pages, previously provided input) is available as well. A second group of rules that may be contained in the IRCS page are User Model Construction Rules. They control the formation of so-called primary assumptions about the user (i.e., assumptions which are directly derived from the user's interaction with the hypermedia page). Primary assumptions are directly reported to the UMS by the HSA.

The functioning of the HSA within the AVANTI system is illustrated in the following scenario concerning a user request for a hypermedia page:

1) The user requests a hypermedia page. The UI forwards this request to the HSA.
2) The HSA fetches the requested hypermedia page from secondary storage.
3) The HSA interprets the requested hypermedia page and the adaptation rules, generates an adapted page (which is compliant to standard HTML), and hands it over to the UI for presentation.
4) The UI interprets the hypermedia page, retrieves multimedia objects, and finally presents the requested hypermedia page to the user.

The HSA was implemented on top of the server-based development environment "WebObjects" from Apple Corporation and comprises of the following technical constituents:
- an HTTP server offering the Common Gateway Interface (CGI) or an application programmable interface (i.e., Netscape Server API (NSAPI), Microsoft Server API (ISAPI));
- a WebObjects Adaptor which acts as an interface between the HTTP server and the WebObjects-based HSA, thereby making it independent from a certain HTTP server;
- an HSA executable which acts as an interface between the WebObjects Adaptor and the scripted AVANTI application.

4.2.2.3 Hardware and software adaptation at the terminal level (WP4)

Terminal adaptations
Adaptations at the level of the actual terminal through which users gain access to the system have been concerned with the examination and selection of special I/O devices and the development of appropriate interaction techniques, in order to facilitate access to various terminal types by different user categories. The selected I/O devices were integrated into the system through a dedicated software layer, responsible for enabling bilateral communication between the system and the devices and facilitating the future integration of new, or updated devices. The related interaction techniques were subsequently built on top of this software layer and integrated into the user interface component of AVANTI, where they are conditionally activated, based on user characteristics and usage context. The combination of traditional and special devices with new interaction techniques has enabled AVANTI to cater for the interaction requirements of able bodied, blind and motor-impaired individuals with differing degrees of impairment. The special devices that have been integrated into AVANTI include:

- speech synthesisers (English, Italian and Finnish languages), to aurally present information;
- pointing devices under Windows 95/NT (e.g. joystick, mouse, touch screen, track ball, etc.), which can be used, in addition to the traditional way, as devices for providing gestural commands to the system;
- Braille display for supporting the non-visual presentation of information;
- touch tablet for supporting alternative input techniques (e.g. for Blind users);
- binary switches (1, 2 or 5 switches) for supporting scanning interaction techniques;
- speech recognition (English, Italian) for spoken command based interaction.

User Interface level adaptations
Adaptations at the user interface level are supported through the User Interface (UI) module of AVANTI. In addition to the static parts typical in user interfaces, the AVANTI UI encompasses a set of adaptation-specific components, which, driven by appropriate adaptation rules, automatically tailor the interface to provide equitable access and quality in use to all potential users, including blind and motor-impaired users. Adaptations in the AVANTI UI are applied at the lexical and syntactic levels of interaction.

The design of the UI module has followed the Unified User Interface Design methodology (UUID) that supports the design of adaptable and adaptive interfaces, based on hierarchical task decomposition, polymorphism and differentiation. Following UUID, only a single unified user interface has been designed and developed, which comprises alternative interaction components, appropriate for different target user categories. This single design artefact may have multiple instantiations during initiation of interaction (adaptability), in order to ensure accessibility for a wide range of users (i.e. the target user population in AVANTI), while each interface instance is continuously enhanced at run-time (adaptivity), in order to provide high-quality of interaction.

During the implementation of the user interface emphasis has been placed in the interactive components that are not directly related to page presentation and focus on providing an interactive shell for HTML pages, which is accessible, easy to use, and provides comprehensive support for navigation to end-users. In addition, a number of novel navigation facilities have been developed to facilitate end user interaction with the AVANTI information systems. These range from facilities that are disability-specific (e.g., interface scanning, interaction element «gravity», augmented interaction element proximity sensitivity), to ones that are disability independent and targeted towards the full range of end users of the system (e.g. link summary, page structure overview, enhanced bookmarking).

Two dimensions of adaptations are addressed within the user interface of the AVANTI system, with relation to the: (a) time that adaptations take place, i.e. whether adaptations take place during the initiation of interaction (adaptability), or at run-time (adaptivity), and (b) the level of interaction where adaptations take
place, i.e. lexical or syntactic level of adaptations. Thus, four types of adaptations can be distinguished as: lexical adaptability, syntactic adaptability, lexical adaptivity and syntactic adaptivity.

Syntactic level adaptations concern the selection of different instantiation styles or style components for each task. In particular, different styles have been defined for abstract interaction tasks, in order to meet different user requirements and preferences. These styles are differentiated with respect to several dimensions, such as sequencing/parallelism, targets (i.e. speed of use, ease of use, accuracy, error tolerance), etc. Examples of different styles are the adaptive use of confirmation dialogues, and the provision of extensive feedback.

Lexical level adaptations concern the provision of alternative physical instantiations for a style or style component, as well as the employment of special input techniques according to the particular user abilities and preferences. Adaptations are realised through the implementation of alternative presentation metaphors, and the selection of attributes (i.e. font, colour, size, speech parameters, scanning parameters) of interaction objects within a style or style component.

Lexical and syntactic adaptability and adaptivity rules have been defined for each interaction task and/or style providing a mechanism for selecting appropriate task instantiations. Syntactic adaptability and adaptivity rules assign different styles, and style components for each task, according to static user characteristics, user preferences, and dynamic user states and interaction situations that are detected and reported by the UMS module. Lexical adaptation rules, on the other hand, assign/set specific attribute values of the utilised interaction objects, within each style or style component.

The AVANTI UI component comprises six main software modules: the HTTP Communication module, the KQML Communication module, the HTML 3.2 Parser, the Interaction Monitoring module, the Adaptable and Adaptive Browser Interface module, the Page Presentation and Interaction module, and the Adaptation Mechanism.

The Adaptation Mechanism is the component responsible for retaining and applying the adaptation rules that concern syntactic and lexical adaptability and adaptivity at the level of the user interface, as well as for maintaining a knowledge space in which static user information and dynamically inferred (by the UMS) user states and interaction situations are stored.

The Adaptation Mechanism has been specifically designed to work with user interfaces that have been designed in a task- and style-aware manner, i.e. the design knowledge and alternatives of the task decomposition and dialogue design are clearly represented in the actual interface, thus allowing for syntactic level adaptations to be applied. Moreover, the interaction elements utilised for the implementation of each style have been enhanced in a way that allow for the automatic modification of their characteristics at runtime, resulting in adaptations at the lexical level.

The parsing, maintenance and evaluation of adaptation rules are undertaken by the Decision Mechanism (a sub-component of the Adaptation Mechanism) which operates in two different fashions. Firstly it is available for consultation on issues such as which style should be used for the instantiation of a specific user task, or what characteristics are appropriate for a newly created interface element; and secondly, it is capable of automatically triggering modifications both at the syntactic and lexical levels, when knowledge updates inferred by the UMS cause alterations in the decisions drawn from the rules that dictate such modifications.

4.2.2.4 System integration and testing (WP5)

A distributed system, planned and implemented by several technical teams in different locations, demands strong co-ordination from the phase of creation all the way through to distribution to the user.

The integration and testing activities allowed maintaining aligned all software development activities and made possible the smooth implementation of the overall AVANTI system through i) the iterative integration and validation of modules; ii) the test of the overall system.

Preliminary activities

The workpackage monitored the entire phase of specification and system design and contributed to the planning in such a way to obtain a system that is homogenous at a global design level.

Preliminary activities carried out for integration and testing relied on:

- Analysis of the system in order to single out each critical aspect.
- Specification of the integration methodology and identification of verification tests.
- Development of ad-hoc tools for testing each module (MDI, HSA, UMS, UI) through external stimulation of the module itself by the tool.
• Development of a System Logger, able to monitor and store all important messages between modules, as well as relevant events of each module (i.e. protocol messages, synchronism between modules, change of module status, check points for performance analysis, critical status of module).

• Set-up of the AVANTI main laboratory in terms of hardware, network connection, operating systems, and software tools for monitoring the integration phase.

System integration

The AVANTI system was composed of the following main modules:
- the User Interface;
- the HyperStructure Adaptor;
- the User Model Server;
- the Multimedia Database Interface;
- the Databases.

The integration of the different modules in the overall AVANTI system was performed testing the following aspects of each module using available testing tools.

• Modules functionality.
  a) HyperStructure Adaptor functionality (e.g. information presentation, information adaptation).
  b) Multimedia Database Interface functionality (e.g. integration of databases, querying of the Content Model).
  c) User Interface functionality (e.g. adaptivity and adaptability).
  d) User Model Server functionality (e.g. multi-user support, stereotypes management).

• Module interfaces and interaction.
  a) Interface between the User Interface and the HyperStructure.
  b) Interface between the User Interface and the User Model Server.
  c) Communication between the User Interface and the Multimedia Database Interface.
  d) Interface between the HyperStructure Adaptor and the Multimedia Database.

Problems as well as possible reasons were highlighted by the integration workpackage and corrected by developers through an iterative process.

System functional testing

Following the first integration step, the overall system was (subsequently) tested using the System Logger tool with respect to the following main aspects:

• System consistency (e.g. support of the correct information flow between modules).
• Compliance to user needs and support of user scenarios.
• Systems performance (e.g. wait time for page retrieval).
• Integration of distributed database (e.g. support of information retrieved form different databases in the same page).
• Ergonomics of the interface and accessibility of the system (e.g. for motor disabled and blind people).
• Maintenance of the system and expandability.

One of the major problems encountered in the integration of the AVANTI system was the organisation and development of the IRCS pages that relied on: i) the distributed and not completely shared knowledge of the application context of the AVANTI system and: ii) the different skill of partners using the technologies involved in the project (Usability engineering, HTML technologies, DB management, WebObjects Framework).

In order to cope with these different skills, a development methodology was defined and managed by the integration workpackage. The methodology covered the complete development cycle from the mock-up
specification to the final IRCS pages and its principal aim was the definition of a common development process, shared by all the partners, which supported the definition of the information contained in the pages and the layout of the pages.

4.2.2.5 Rome prototype (WP9)

The main purposes of the set-up of the Rome demonstration were:

- to test whether it were possible to transfer the AVANTI know-how to a small enterprise;
- to extend the evaluation to blind users, testing an information kiosk for the 2000 year Jubilee in Rome.

In other words, the structure of the WP9 was simple and straightforward: given a practical application - the information kiosk - test whether the concepts of adaptability and adaptivity as well all software components developed in AVANTI could be crafted by a small enterprise with no previous knowledge in the field of adaptive systems and user modelling.

Relevant partners of WP9 were telecommunication operators such as Alcatel Italia and Telecom Italia who contributed to the design and set up of the communication infrastructure for the experimentation.

To evaluate the experimentation results University of Linz developed an evaluation plan, conducted the evaluation and analysed the data.

From the organisational point of view WP9 resulted in a well-balanced structure with:

- the small enterprise (Mathema);
- the users’ representative (ECG);
- the system integrators (Alcatel and Telecom Italia);
- the evaluators from academia (University of Linz).

Technical know-how acquisition and demonstration set-up

In the early phase of WP9, Mathema spent its time and effort to reach a firm understanding of the concepts, software components and tools developed in AVANTI through the close co-operation and collaboration of all industrial and scientific partners in the project.

At the same time, University of Linz prepared the evaluation plan to cover all activities and related timelines for the evaluation.

Alcatel and Telecom analysed several communication infrastructures and proposed the best suited for the workpackage.

ECG contributed with its existing information system providing access to its information multimedia database. At the of 1997 the first version of the so called Demo prototype was released by Mathema therefore showing that the knowledge and expertise within the project had been successfully transferred. Soon after Alcatel and Telecom Italia designed and proposed the communication infrastructure to be used in WP9 and University of Linz further detailed its evaluation plan producing a cookbook to be observed during the execution of the evaluation.

Application refinements and experiments

When University of Linz reviewed the first version of the Demo prototype suggested several improvements both for the visual and non visual modules of the Demo prototype. Mathema conducted a pre-evaluation to further test the usability of the Demo. This brought to a substantial redesign of the human interface and of the adaptability and adaptivity rules.

Then, following the suggestions from ECG, a first evaluation with five blind users was conducted in Rome. New substantial improvements were added to include comments from blind users. In the meanwhile the questionnaire and the detailed steps for the evaluation were refined.

Eventually, the official demonstration took place in Rome with 20 blind users and 40 visual users distributed according to the proportions gathered from general socio-economic data about the next Jubilee. University of Linz processed the questionnaire developing rigorous statistics both descriptive and analytical.

It was found that visual users had a better acceptance of the system while blind users - even if globally satisfied - met serious problems in crossing cascades of hierarchical menus. However it should be reminded
that the hierarchy of menus was inherited from the old information kiosk from ECG and that one of the subgoal of WP9 was to test the AVANTI concepts on existing applications.

Overall WP9 may be considered fully successful. All goals were achieved: it is possible for a SME to use AVANTI and it is possible to prove this with a practical application (the information kiosk in Rome).

4.2.3 Dissemination and exploitation activities (WP7)

The main results provided by WP7 have been detailed in the three deliverables DE007, DE019 and DE031.

The work performed related to the marketing and exploitation analysis of the potential products and services developed, prototyped and demonstrated in the project as well as information dissemination relating to the projects technical content and its impact on the community.

DE007

This deliverable described the work performed to meet the project market research planning requirements.

The work performed included the definition of the scope and objectives of the research as well as the creation of a market research plan based on obtaining relevant market feedback, by way of questionnaire.

This questionnaire was circulated both within the consortium as well as to a large number of organisations in the information provision sector including organisations providing financial, tourist, regional civic service, transport and accommodation information.

DE019

Using the data gathered through the market survey of DE007 a framework was designed which provided a means of comparing strategic direction and added value processes with the necessary investment and benefits of AVANTI type information provision systems. The information was very useful to develop tactical plans looking at the consortium partners strengths and weaknesses, opportunities and threats.

Another major result was the development of a thorough cost benefit analysis which defined what are the benefits of the AVANTI system both at the technological level as well as at the level of the end user or information provider. Qualitative and quantitative information was analysed to determine the cost of developing an AVANTI system. Similarly costs were derived for similar information provision systems not relying on the AVANTI approach. From this information an overall cost benefit justification for promoting AVANTI type systems was formulated which clearly indicated the argument for adopting AVANTI methodologies in certain situations; namely large scale efficient and effective information provision.

The exploitation plans of the partners were also presented featuring two mini-consortia of industrial partners looking at the two ends of AVANTI: data gathering and system provision.

DE031

This deliverable described the work conducted in the AVANTI project to consider the dissemination activities of the partners in the project. The deliverable documented how dissemination had occurred at various levels. These included public presentations to researchers, industry and regional authorities as well as presentations in the framework of the programme's Chains and Domains in support of the consensus mechanism.

The AVANTI project also considered the need of disseminating material to a wider end user and SME audience in practical and interesting ways. A major result coming from the project were dissemination tools such as a comprehensive WEB Site (www.avanti-acts.org), a multimedia CDROM and a 6 page full colour brochure. These tools were made available free of charge to a large number of relevant organisations listed in a database created and maintained by the consortium.
5. MAIN CONCLUSIONS REACHED

From the perspective of technological development in information technology and telecommunications, the main achievements of the AVANTI project is to show that it is technically feasible and useful for end users to introduce adaptability and adaptivity both in the information contents and the human interfaces of multimedia telecommunication applications, in order to allow concurrent access of users with different characteristics, requirements and preferences. This asked for the development of the technical framework to support the above characteristics and the set up of instances of real applications to test the relevance of the approach with representative user group. The experimental systems needed to be complex enough to test the technical framework necessary to allow an efficient adaptation of the information contents and the human interface and general enough to be of interest for different user groups. The chosen application deals with tourism and its adaptations address, on the information content aspect, e.g. the transparent introduction of relevant information about accessibility of sites of interest and, on the interaction aspect, the availability of human to system interfaces accessible by different user groups.

From the user perspective AVANTI can be considered as a working demonstration of the application of a design for all approach. The AVANTI application, even if containing information relevant for people with disabilities and accessible by them, is not conceived as an application for people with disabilities. Its aim is to show that with the available technology it is possible to implement telecommunication applications that are useful and directly accessible to people with different technical expertise and different characteristics, both physical and sensorial. In particular the following user groups have been selected: able-bodied tourists both experts and inexpert in the use of computer systems, professionals users of information about tourism (tourism office clerks), people with motor disabilities, including wheelchair users who need information about accessibility of sites, blind users.

The above main aim have been accomplished within the following technical constraints:

- The AVANTI information system integrates transparently already available databases with information relevant for tourism. The system is not a special-purpose database for people with disabilities, including information about e.g. accessibility. Information about accessibility has been made available, when necessary, as an addition to the information already available for the general public, resulting from the applications of the concepts of adaptability and adaptivity of the information contents.
- The system is accessible through different telecommunication facilities, both broadband and narrow-band, adapting its characteristics to the available infrastructure. For example, multimedia presentation of information may not be convenient if the communication link is narrow-band. This may be also a necessary choice if the user is blind. In these cases a text presentation of information may be the most convenient, with automatic adaptation to satisfy the needs of the connected user.
- The same also applies to the terminal, which is adapted to the accessibility requirements of the individual user, and whose characteristics are taken into account to decide about the correct adaptation of the information contents and its presentation.

Due to the complexity of the technology framework to be set up for the adaptation of the information contents and of the human-computer interface different experiments were carried out in different places, whose rationale is explained in the following.

The Siena experiments were set-up:

- To test the integration of different telecommunication networks, both broad-band (Tuscany Man) and narrow-band (telephone line with modem);
- To test the integration of different terminal typologies including: a terminal in a public access site, a multimedia terminal in a travel agency and a terminal in the house of a disabled person;
- To test the integration of different databases (multimedia and textual), dealing with information relevant for planning a visit in Siena, and the chosen ways of representing information about accessibility;
- To test the entire system in a real distributed architecture (modules of the system in three different workstations in Siena and Florence);
- To allow co-operation on the same system of people with motor disabilities (using a browser for people with motor disabilities) and able-bodied people (including also professionals: clerks in a travel agency).

The experiments in Kuusamo were set up:

- To show the easy portability of the technology in a different technical environment;
• To test a different telecommunication infrastructure including broad-band ATM and narrow-band N-ISDN connections;
• To integrate in the system an already existing database, containing general-purpose information of interest for tourism (reservation of holiday resorts);
• To test the ideas of adaptability and adaptivity with people without disabilities and without reference to concept of accessibility of sites;
• To evaluate the system in a real tourism environment with able-bodied people.

Obviously most of these complementary experiments could in principle be carried out in a single system integrating all the above facilities and user groups. For exploitation reasons it was considered more interesting to start with different implementation addressing real application problems in the experimental sites.

In the third year of the project an additional demonstration was set up in Rome with the following purposes:

• To show that the AVANTI technology can be easily transferred to a SME to implement from scratch an information systems, based on adaptability and adaptivity concepts;
• To show that the technology can be used starting from an already running information system;
• To test the involved concept with a new user group (blind people) in addition to able-bodied tourists.

This demonstration was set up in Rome with an adaptable and adaptive information system developed by a SME, who used the AVANTI technology starting from an existing information system (multimedia database and kiosk system) dealing with cultural heritage. The kiosk versions of the browsers implemented in the AVANTI project for sighted people and blind people have been used for interaction with the system.

The AVANTI experiments have been to show experimentally that with the present technology it is possible to introduce adaptability and adaptivity in telecommunication applications. This makes them sufficiently flexible to be accessible and useful to user with different interests and characteristics. The AVANTI application is an example of implementation based on the general concepts of design-for-all or universal design. Design for all applications are meant to serve from the very beginning the maximum possible number of potential users, instead of creating tailored information systems for different user groups and adapting the interaction features to their abilities. It is important to point out that the human interfaces in the AVANTI system are also based on the design for all approach. Different interfaces (browsers) have not been implemented for the different user groups. A single interface has been implemented, which is able to adapt its characteristics to the abilities, requirements and preferences of the different user groups.
6. INPUT TO STANDARDS AND ACTS GUIDELINES

6.1 Inputs to standards
AVANTI is preparing proposals and examining the possibility of liaison activities in co-operation with European and other standardisation bodies (i.e. ETSI, ITU, CEN/CENELEC, ISO, FIPA) towards the refinement of existing standards or the preparation of new ones, contributing to the universal accessibility of the emerging Telecommunications infrastructure. More specifically and as a concrete example, AVANTI foresees to submit a proposal on agent communication and user modelling to FIPA (Foundation for Intelligent Physical Agents), thereby responding to their most recent call for standardisation proposals.

Furthermore, FORTH and CNR, through their involvement in W3C’s Web Accessibility Initiative and their participation in the TIDE-WAI project of the European Commission, are contributing to the development of accessibility guidelines for Web browsers and standards on Web Accessibility, based on the experience gained in AVANTI.

6.2 Inputs to ACTS guidelines
AVANTI basically contributed to GAD, GAT and SIA Chains with specific reference to the following guidelines.

6.2.1 GAD Chain
GAD is working on four sets of guidelines containing 10 guidelines all together. AVANTI contributed to A1, C1 and especially B3, which has its origin in AVANTI and was mainly edited by AVANTI partners.

A. Conceptual Clarifications and Transitional Scenarios for Sustainable Lifestyles
- **GAD A1 ICT, the Information Society and Sustainable Development**: presenting basic definitions, a working framework, and basic awareness recommendations.
- **GAD A2 Balancing between Information and Materials**: looking at the new equilibria required between information and materials, virtuality and reality, centrality and peripherality, etc. with recommendations for further research.
- **GAD A3 Sustainability as a Business Case**: reviewing the arguments in favour of the business community taking a leading role in promoting Sustainability, including issues such as new accounting methods which take external costs into account, standardisation of impact parameters and methods.
- **GAD A4 Socially Sustainable Best Practice of Workflow Re-engineering**: the shifting role of the information flow structure amongst SMEs and the increased viability of local communities linked to the growth of ITC-based micro-SMEs.

B. Sustainability Issues in ICT Application Sectors
- **GAD B1 Residential Broad-band Access**: the impact of symmetrical systems based on mature cable TV networks, and the potential impact of large-scale trials based on "natural communication groups".
- **GAD B2 Impact Assessment of ICT Applications in High-material Consumption Industries (e.g. construction, transport)**: balancing the assessment of the impact of ITC on manufacturing with a look at the construction and transport industries, which highlights the need for an understanding of the social factors of virtual communication.
- **GAD B3 Impact of ICT for the Empowerment of People with Special Needs**: relating the new role of information as the key to empowerment to the benefits of "investing in autonomy", in a context where the idea of handicap is defined by the socio-economic environment.

C. Sustainability Impact Assessment
- **GAD C1 Procedures for Assessing the Impact on Sustainable Development of Applications Using Teleservices**: an investigation of the need for impact assessment techniques, an overview of currently available techniques and approaches, and how their implementation in ICT trials can contribute to the development of a common practice.
• GAD C2 Assessing Sustainable ICT Application Scenarios: how scenario-building methodologies linked with simulation and decision-support tools can be used to evaluate the impact of ICT adoption and implementation decisions on local strategies for Sustainable Development.

D. Contributions to the European Sustainable Development Debate

• GAD D1 Policy Directions for ICT and Sustainability: commenting and reviewing the evolution of the policy debate and European, national and regional initiatives relating the Information Society to Sustainable Development.

Guidelines A1, A4, B3 and C1 have been endorsed in the second tranche of guidelines in the ACTS Concertation meeting in May 1998. Guidelines A2, A3, B2, B3 and C2 are prepared for the third tranche in September 1998, the status of guideline D1 is still open.

6.2.2 GAT Chain

Within the GAT chain, two guidelines have been selected for further consideration:

• Guideline GAT- G1a - First-Time Interoperability across Extranet: Developing European Competence and Confidence, which aims to highlight the need for special attention in Europe to interoperability issues relating to Extranets and to recommend actions.

• Guideline GAT- G5 - Implementation of Telework for Multi-site Software Development, which aims to describe the different solutions available for multi-site software development, either in a multi-site corporation or in multiple distributed companies collaborating in a same development effort.

The AVANTI contribution was related to Guideline G1 and concerned Interoperability at the content level. Interoperability is defined according to two aspects: technical interoperability, meaning that the connection works and data can be transferred; and purpose interoperability, meaning data is transferred in a way that satisfies the needs of both parties. Both have to be addressed for success in Extranets.

The purpose of interoperability is related to the transfer of content in a communication process. To sustain such a kind of interoperability the 'other user' should use the contents readily in the context of the relationship s/he is trying to create or sustain. To such an aim it is important to have communication protocol that are able to adapt to the different and evolving condition of communication (e.g. to the speed of communication, the version of the application available to process the data, the kind of display available - palmtop vs. deskscreen, the kind of commitment - informal vs. formal; etc.).

The work carried out within the AVANTI project can be relevant for suggesting what kind of adaptation is sustainable and on how to test it.

6.2.3 SIA Chain

The SIA Chain is currently in the final stages of fixing its medium term guideline work. At the moment there are five guidelines proposed:

G1: Consolidation of a common reference service architecture for global service integration - A Comparative analysis.

G2: Requirements on distributed service infrastructure - Issues for Multimedia Quality of Service.

G3: Enterprise models of Electronic Brokerage - Common Reference Model.

G4: Deployment and provision of services in an open environment distributed service - Technology Supporting Service Contracts.

G5: Service Creation Practices and Technologies.


G7: TINA concepts for multimedia - Joint SIA-GAM Guideline.

AVANTI contributed mainly to guideline G4 and proposed the (re-)introduction of the following issues:

- Study and modelling of user needs based on interests, knowledge, and abilities for the interaction with multimedia services.
- Investigation of innovative dialogues and navigation concepts that cater hypermedia information to these individual needs by adapting the content and the presentation of hypermedia information to each individual user and his usage environment.
7. OVERALL IMPACT, EXPLOITATION AND DISSEMINATION OF RESULTS

7.1 Main developments

7.1.1 Technical developments

The main objective of the AVANTI project was to demonstrate that it is feasible and useful to employ the concepts of adaptability and adaptivity in system development to cater different user needs both at the user interface and at the content level.

7.1.1.1 HyperStructure Adaptor (HSA)

One of the main components of the AVANTI system architecture is the so-called HyperStructure Adaptor (HSA) which is dealing with adaptations at the level of the information content.

The HSA is a collection of hypermedia page skeletons including some additional rules and behaves like a "normal" web server from the User Interface's (UI) point of view. The mark-up language used within this page is a subset of and an extension to HTML named Information Resource Control Structure (IRCS). Apart from static elements, an IRCS page may contain optional and alternative hypermedia objects, and also groups of hypermedia objects with an associated layout like a page header, toolbar, etc. An example for an optional element is supplementary information on wheelchair accessibility. Examples for alternative elements are general vs. more detailed descriptions, and a picture of a painting vs. its textual description. The processing of these optional and alternative elements is controlled by Adaptation Rules, which can take information from other system components into account, namely assumptions about user characteristics (e.g., knowledge, interests, preferences) from the User Model Server (UMS), and content-related information about multimedia objects from the Content Model (CM) via the Multimedia Database Interface (MDI). Information about the current user's session (e.g., previously requested IRCS pages, previously provided input) is available as well. A second group of rules that may be contained in this IRCS page are User Model Construction Rules. They control the formation of so-called primary assumptions about the user (i.e., assumptions that are directly derived from the user's interaction with the hypermedia page). Primary assumptions are directly reported to the UMS by the HSA.

The HSA interprets the requested hypermedia page and the Adaptation Rules, generates an adapted page (which is compliant to standard HTML) and hands it over to the UI for presentation.

7.1.1.2 User Model Server

Runtime-adaptations of the hypermedia document and in the UI are based on assumptions about the user's abilities, the user's knowledge, the user's interests, which are collected in a so-called user model. The user model is hosted and maintained by the UMS, a component of the AVANTI system, which was designed and developed within the work package 2 "Specification and implementation of the multimedia application".

The centralised management of user-related information in the UMS offers other AVANTI components particularly the UI and the HSA location-independent access to the most recent user-related information. The functionality offered by the UMS with respect to the user model include:

- storage, update, and deletion of entries in user models;
- incremental construction of user models based on primary assumptions and dialog acts;
- drawing inferences (so-called secondary assumptions) based on primary assumptions and their relationships;
- include/exclude sets of typical assumptions about user groups (so-called stereotypes) on the basis of activation and deactivation rules;
- consistency maintenance.

Additional features which are more related to the server functionality of the UMS are:

- access as a network-wide service through a restricted and slightly enhanced version of KQML. The chosen implementation KAPI (KQML Application Programmer's Interface) has been substantially
revised. Special emphasis has been paid to the name service contained therein, which, for example, allows a UI to dynamically locate and access the UMS that hosts the model of a particular user;

- support for hosting the models of several users at a time.

### 7.1.1.3 An Adaptable and Adaptive Web Browser

A main goal of the AVANTI project was to address the interaction requirements of disabled individuals using Web-based multimedia applications and services. Along these lines, one of the main objectives of the work undertaken within the work package 4 “Supporting adaptability and adaptivity” was the design and development of a user interface that would provide equitable access and quality in use to all potential end users.

The User Interface (UI) of the AVANTI information system is a component which provides interactive views of adaptive multimedia Web documents. The distinctive characteristic of the AVANTI UI is its capability to dynamically tailor itself to the abilities, skills, requirements and preferences of the users, to the different contexts of use, as well as to the changing characteristics of users, as they interact with the system, through the employment of adaptability and adaptivity techniques. The AVANTI UI also features integrated support for various special input and output devices, along with a number of appropriate interaction techniques that facilitate the interaction of disabled end-users with the system. The categories of disabled users supported in the current version of the system, in addition to able-bodied ones, are: people with light, or severe motor disabilities, and blind people. As the design of the UI has followed the principles of design for all (user interfaces for all), inclusion of additional target user groups is facilitated.

When functioning as part of the AVANTI system, the UI is externally conceived by the user as a specialised front-end through which access to the information in the AVANTI multimedia databases is achieved. The UI is also capable of functioning as an independent Web browser that employs adaptability and adaptivity to provide access to traditional Web documents to able-bodied, motor-impaired and blind people. For the adaptivity features, it requires the existence of a User Modelling Server component (e.g., the AVANTI UMS module, or a similar component).

### 7.1.2 Prototypes

#### 7.1.2.1 Application prototype in Italy (Siena). Main features and evaluation

**SYSTEM DESCRIPTION**

The Siena system contains information relevant for moving around the city and to describe possible sites of interest (including their accessibility).

It is supposed to be used by tourists and citizens and addressed the information needs and interface problems of motor impaired people and people without disabilities.

Users are assumed to access the system from home and using public information points.

The system can also support professionals (tourist office clerks) to help people with disabilities in programming their visit to Siena.

The scenario based evaluation has been organised in three scenarios, involving, respectively 24 users (14 able-bodied and 10 disabled), 24 users (again 14 able bodied and 10 disabled) and 12 users (8 able bodied and 4 disabled). The third session has been mainly devoted to adaptivity testing.

**ADAPTABILITY AND ADAPTIVITY FEATURES**

Different versions of the same unified browser for people without disabilities, people with minor motor disabilities, people with major motor disabilities using scanning have been made available to adapt the system to be accessed by the different users groups involved in the trial.

Adaptability of the information (type and quantity of information, modality) is controlled by different parameters like users capabilities, interest, preferences, expertise and preferences.

Adaptivity is introduced at the level of the User Interface, where e.g. special help functions are activated when the user is unable to proceed in the interaction. Rules controlling page adaptation are then modified according to the user behaviour.
7.1.2.2 Application prototype in Finland (Kuusamo). Main features and evaluation

**SYSTEM DESCRIPTION**

The AVANTI Kuusamo System contains information on travelling and accommodation in Kuusamo and its surroundings. The occasional traveller is able to search for general tourist information, to set various criteria for the selection of accommodation and to browse different accommodation alternatives. Another user category, travel agency clerks, use the system while providing travel information and reservation services for the customers.

Experimental evaluation of the Finnish field trial system was carried out in two phases, and a total of 51 users participated in the evaluation. The first phase trials of the system were carried out in late November 1997 on actual trial site in Kuusamo with 11 users. The second phase of the field trial was carried out on two locations, Kuusamo and Espoo, in April - May 1998. Altogether 40 users participated the second phase trials.

**ADAPTABILITY AND ADAPTIVITY FEATURES**

**Adaptation according to interest and language**

An adaptability feature that was designed to increase the personalisation of the system for the specific user is the possibility to select one’s own interest group in the beginning of the usage session. This selection could also be changed during the usage session.

**Adaptation according to season**

Adaptation according to the season of the year makes it possible for the user to automatically get information on the season to come when he/she enters the system (adaptability feature).

**Adaptation according to most visited pages**

The system gives shortcuts to the most frequently visited pages.

7.1.2.3 Application prototype in Italy (Rome). Main features and evaluation

**SYSTEM DESCRIPTION**

The Rome system contains information about cultural heritage in Rome and allows access to tourism services about mobility in the city.

It is supposed to be used by tourists and citizens and addresses the need of blind people and people without disabilities.

More precisely the following user groups have been involved:

- Blind users experts in computer (n. 20).
- Users without disabilities (n. 40).

Users without disabilities are further subdivided in:

- Tourists (n. 20).
- Pilgrims (n. 20).
- Romans (n. 10).

**ADAPTABILITY AND ADAPTIVITY FEATURES**

Two versions of the same Kiosk browser, one for blind persons and one for sighted persons are available to adapt the information system to be accessed by the two user groups considered in the demonstration in Rome.

Information adaptation is based on the user groups, interests of the users and knowledge about the city.

7.2 Dissemination

The parts of AVANTI which are dealing with content-related adaptations namely the HSA and the UMS has been presented at several international conferences, workshops, and fairs including: CeBit '96 & '97,
Hannover, Germany; Flexible Hypertext Workshop, Eighth ACM International Hypertext Conference (Hypertext ’97), Southampton, UK; Sixth International Conference on User Modeling UM’97, Chia Laguna, Sardinia, Italy; and MUST’98 Multimedia & Standardisation, Paris, France. Influenced by discussions we had during that events and based on our experience setting up the different information systems for the AVANTI field trials the necessity of a sophisticated authoring environment became obvious to bring the techniques developed in AVANTI into the market and trigger the commercial exploitation of adaptive systems in general.

The AVANTI UI component has been demonstrated in several International and European conferences, tradeshows and scientific fora including: the HCI International ’97 conference in San Francisco, USA; the IS&N ’98 conference in Antwerp, Belgium; and, the 2nd meeting of the International Scientific Forum "Towards an Information Society for All" (1998) in Heraklion, Greece, where academics, researchers, European policy makers and mainstream computer industry expressed particular interest in the demonstrated features.

The use of the prototypes of the multimedia application in public trials has constituted a way of dissemination of the results of the project outside the communities of actors in information technology and telecommunications and users involved in the project.

7.3 Market potentiality for AVANTI like applications

The AVANTI consortium is well placed to exploit the results of the project. This derives from the ability to configure key skills in such a way so as to implement the AVANTI solution in a large system. The consortium has realised that exploitation can only realistically occur if partners continue to exploit AVANTI within consortia due to the heavy requirement of mixed skills. For this reason two smaller consortia are envisaged, each addressing different aspects of AVANTI and their realisation. The SIENA consortium will concentrate on the data identification, organisation issues required by AVANTI, while the ALCATEL consortium will direct their activities at providing systems and services which integrate AVANTI technologies at the software and hardware level. This solution allows the two consortia to act in different ways which have different purposes; the SIENA consortium promotes and exploits its “soft” skills, while the ALCATEL consortium promotes “hard” skills.

TELECOM Italia, being a large tele-comms company has identified its own approach to exploiting AVANTI particularly by addressing the needs of people with disabilities.

Alcatel plays one of the major roles inside the AVANTI project being the co-ordinator, and being also involved in the main phases of system development. The systemic aspect is to be envisaged as the main interest of Alcatel in the exploitation of the project results. Alcatel is as a matter of fact operating on the telecoms market as a system integrator, aiming at offering integrated systems “ready to be run” by the users.

The company’s exploitation strategy is therefore addressed towards pointing out which are the main actors which could be interested in building up the whole system (or just a subpart), which could be interested in operating the service offered (or offering the service themselves), and which could be interested in using the service itself. In this scenario the commercial exploitation of the AVANTI system has to be broken down into three different levels, each of them representing a different group of actors involved in the system development, deployment and utilisation for different purposes. These levels are:

- System Offering level where system integration expertises and integrated systems are offered;
- Service Operation level offered to Local government/administrative entities such as “Regions” (counties), “Provinces” and “Communes”
- Service Offering level targeting companies/institutions to which the results of AVANTI, in terms of possible exploitable services, should be proposed to. They are Tourist operators and public tourist agencies, Public entities working in the field of Art&Culture (Museums, Libraries, etc.), entities working in the field of Health-care and assistance for people with disabilities, entities working in the field of Education.

ALCATEL will be assisted by the smaller partners such as MA who performed many of the terminal adaptations and used key technologies such as Speech recognition, Tactile Displays, Electronic Refreshable Braille Displays and Speech Output Devices to interface the PC. MA will ally with ALCATEL and MATHEMA so as to provide a set of solutions wherever an AVANTI system requires terminal adaptation and will involve CNR to assist on issues relating to access to computers by people with disabilities. CNR will support as well the product developments of MA and their exploitation plans in the Italian region.

The SIENA Consortium (UNISI, TECO, ADR) has identified that people with special needs, irrespective of their geographic location, expect to be contactable through, and interact with, a ubiquitous and transparent
information infrastructure. This is a new challenge for people with disabilities. In the AVANTI context people with special needs were addressed in order to give guidelines for the presentation of the information about mobility. Teleworking initiatives, in which people with disabilities can fully contribute, are foreseen. In this perspective, a strong need for new equipment, systems and applications which enable greater mobility and interfaces for disabled people, is arising as a crucial factor in easing the transformation of industry and society to the information society.

People with special needs, which cannot leave their houses, have the challenge to be integrated in the life of their city, made of cultural events, and social and political discussions. Moreover they need to be allowed to interact and to cooperate with teleworking activities.

For people with light disabilities it is possible to develop applications of important social value and commercial relevance (distribution of information related to mobility and social services), which provide users with the needed information about mobility features and are adapted to the requirements of most potential users, from the perspective of the information content and the human-machine interface.

<table>
<thead>
<tr>
<th>Arrivals</th>
<th>Pilgrims</th>
<th>Tourists and others</th>
<th>General Total</th>
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<tr>
<td>24,700</td>
<td>24,300</td>
<td>49,000</td>
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<td>Normal %</td>
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<td></td>
<td></td>
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<tr>
<td>Motor %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>3</td>
<td>7</td>
<td>92</td>
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</table>

Number of persons arriving to Rome for one day (remaining for a night or leaving during the same day)

<table>
<thead>
<tr>
<th>Presence and staying</th>
<th>Pilgrims</th>
<th>Tourists and others</th>
<th>General Total</th>
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<tr>
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<td>50,900</td>
<td>84,000</td>
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<td>Motor %</td>
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</tr>
<tr>
<td>90</td>
<td>3</td>
<td>7</td>
<td>92</td>
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</table>

Number of beds occupied during a night. The above representation can be particularly useful for the evaluation of the reception obligations.

<table>
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<th>Daily Presence</th>
<th>Pilgrims</th>
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<td>Motor %</td>
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</tr>
<tr>
<td>90</td>
<td>3</td>
<td>7</td>
<td>92</td>
</tr>
</tbody>
</table>

The representation can be useful to evaluate the accessibility planning and the daily offering of services.

Public administrations, as Siena Municipality, Siena Provincial Administration, Regione Toscana have already followed the development and testing phases of the AVANTI system and are deeply interested to real applications They plan to improve their civic networks (web interface) and information sites (kiosks) for the tourist and the citizen, following the AVANTI guidelines and products.

Municipalities and provincial administrations in Italy are responsible for the management of social infrastructures and services (culture, sport, educational etc.), concerning the local and provincial area. They can thus be regarded as one of the first and main targets of the AVANTI product. They are a potentially large market (267 municipalities in Toscana only) even if a short terms economical evaluation indicates high initial costs of investments for the presentation of the product, because it will be necessary to contact each single administration adapt the application according to the requirements of each single local situation.
Another major customer would be A.N.C.I. (National Association of Italian Municipalities), an organisation of which all Italian Municipalities are members and which makes a big effort to (re)launch political, economical and cultural initiatives.

Telecom Italia, as Public Network Operator in a country where the tourism is one of the most important market sectors, is interested to exploit the available results of the project in a larger environment. The participation to the AVANTI project of the department of “Telecomunicazioni per il Sociale”, which is a non profit mission, is fully justified to demonstrate the accessibility to the multimedia data-base services by the elderly and disabled people. The positive results of the project relating to enhanced terminal adaptation and better user interfaces for all, certainly are of interest in the access to multimedia applications by all the citizens, particularly throughout the availability of a facilitated user interface tested on the less skilled part of the population as elderly and disabled people.

The extension of the AVANTI project with a pilot site in Rome, in view of the next Jubilee 2000 event, aimed to demonstrate and validate the accessibility to some art/historical/cultural databases offering tourist telematic services (information, booking, telebanking, teleshopping, etc.). According to the previsions, there will be an affluence of about 40 million visitors, which means an average of over 100,000 extra people every day.

From these figures it is clear that the demand for telematic services related to multimedia databases will be high and will justify the implementation of a Call Centre that will support any tourist request (information, assistance, booking, health, emergency, etc.) made by phone, information-points or telematics system (Internet or dedicated tour-operators’ networks).

Telecom Italia is involved in the planning and organisation of the Jubilee 2000 services and made big investments to support the cabling of Rome using broadband networks and the realisation of new advanced telematic services to improve the accessibility and the quality of the distributed multimedia information.
8. Self Assessment

A complete identification of information relevant for mobility and its possible structuring according to the available/perceivable media for the different users and telecommunications environments has been carried out in co-operation with end users. This has then been refined during the initial collection of multimedia data for the experimentation in Siena and Kuusamo, the additional investigation on users needs related to the demonstration in Rome and the experiments in the trial sites. A compromise between completeness of information and usability by the different user groups has been reached.

Due to the increasing diffusion of the World Wide Web, the approach of developing the foreseen application in this environment appears particularly successful. The project took advantage of the new developments and products in the field and could concentrate on the technical issues of adaptability and adaptivity of the application and its human factor aspects. The information is organised using dynamic schemata of Web pages that are filled with information according to the information and presentation needs of the individual users. The development of the module that is processing these hypermedia pages has been enhanced according to the results of trials. The need of specific authoring systems has been identified and specifications have been written. The strategy and the technical support for incorporating user information in the system have been chosen. A user model server, available to the different instances of the modules active in the AVANTI information system, has been developed as a network wide service.

According to the hypermedia interaction paradigm chosen, information in the system has to be accessed using browsers that are adapted to the physical, sensorial and cognitive abilities of the user groups of interest and adaptive to their behaviour. An approach to the development of adaptable user interfaces (developed in the TIDE Project ACCESS) has been used to develop two adapted browsers, one for motor disabled and the other for blind people. It has also been enhanced in order to offer adaptivity-features during run-time in co-operation with the user model server. Versions to be used in a workstation environment and in a kiosk environment have been produced. The kiosk version has been particularly important for the trial in Finland and the demonstration in Rome.

The telecommunication infrastructure for the trials has been set up in the test sites, integrating broadband facilities made available by the National Hosts and narrow band links, to show scalability of the applications at the level of the telecommunication infrastructure. After integration and testing in laboratory, different versions of the trial system have been successfully delivered and refined on the basis of requirements identified in the experiments.

The transferability of the developed technology to a small industry has been shown possible and easy leading to the production of a new application that has been used in the demonstration in Rome. The application integrates already existing information about cultural heritage in Rome and integrates additional user groups (blind).

Trials have been carried out in Siena with motor disabled people, in Kuusamo with tourists without disabilities and professionals and in Rome with blind people and tourists and citizens without disabilities. A thorough user test of the browser for blind people has been carried out in the CNR laboratories in Florence. Test sites have been adapted to be accessible in co-operation with end users. Adaptive and adaptable WWW-based (World Wide Web) test scenarios for the use of information systems supporting mobility have been developed in order to stimulate the technical developments with feedback from the process of heuristic evaluation and cognitive walkthrough. A methodological scenario-based evaluation framework for the experiments in Siena and Kuusamo has been applied. Results from trials show interest for the offered information and appreciation of the system. Usability appears good with only some problems with blind people in Rome, due probably to the insufficient adaptation of the already existing information in an experiment that was essentially set up for testing the easy transferability of the AVANTI technology. It has been shown that adaptability and adaptivity can be used as means to aim to “design for all” implementation of telecommunication applications.

Dissemination of information has been successfully performed in the field of assistive technologies, where the approach of integrating available databases into the WWW paradigm has been particularly appreciated. In technical conferences interest has been particularly elicited by the approach of augmenting accessibility with concepts of adaptability and adaptivity of page information and user interfaces. The basic concepts have been discussed in several conferences and workshops, while the entire system has been shown in expositions and during conferences. A brochure describing the main features of the activity in AVANTI has been produced. A Web site and a CD-ROM have been developed. A market study for the potential products of the project has been carried out. Particularly the industrial partners have developed exploitation plans.
The three information systems set-up for the trials have been successfully demonstrated in Siena during the final on-site audit, using both broadband and narrowband connections and all the different browsers instantiations developed in the project, to cope with the different abilities and disabilities and the various context of use (e.g. at home, in controlled public places, in open public spaces-kiosks).
### 9. ANNEXES

#### 9.1 List of deliverables produced

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<thead>
<tr>
<th>Deliv. Code</th>
<th>WP Code</th>
<th>Deliverable Title</th>
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### 9.2 List of published papers

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<th>Author</th>
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<th>Vol / Page etc</th>
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<tr>
<td>L. Fantini</td>
<td>Quelle vacanze ad ostacoli (part A)</td>
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<td>March 96</td>
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<td>L. Fantini</td>
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<td>J. Fink, A. Kobsa, A. Nill</td>
<td>Benutzerorientierte Adapтивität und Adapterbarkeit im Projekt AVANTI</td>
<td>Software-Ergonomie '97</td>
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<td>March '97</td>
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<td>A. Nill</td>
<td>Providing Usable and Useful Information by Adaptivity and Adaptability</td>
<td>Flexible Hypertext Workshop at Hypertext '97</td>
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<td>L. Fantini</td>
<td>ACTS - AVANTI Project presentation</td>
<td>Living and walking in cities</td>
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<td>Fink, J., A. Kobsa, and A. Nill</td>
<td>Adaptable and Adaptive Information Access for All Users, Including the Disabled and the Elderly</td>
<td>The Sixth International Conference on User Modeling, Chia Laguna/Sardinia/Italy</td>
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<td>1997</td>
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<td>Embedding Scanning Techniques Accessible to Motor-Impaired Users in the WINDOWS Object Library</td>
<td>HCI International '97</td>
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<td>24-29 August 1997</td>
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<td>G. Vernardos</td>
<td>C. Stephanidis</td>
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<td>24-29 August 1997</td>
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<td>A.Bini</td>
<td>Adaptability and adaptivity in the WWW</td>
<td>Information Didactic and Disability 5th National Congress, Bologna (Italy)</td>
<td>Nov. '97</td>
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<td>C. Stephanidis</td>
<td>Supporting Interface Adaptation: The AVANTI Web-Browser</td>
<td>3rd ERCIM Workshop on &quot;User Interfaces for All&quot;</td>
<td>3-4 Nov. 1997</td>
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<td>A. Paramythis</td>
<td>C. Karagianidis</td>
<td>A. Savidis (FORTH)</td>
<td></td>
<td>3rd ERCIM Workshop on &quot;User Interfaces for All&quot;</td>
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<td>A.Andreadis, A.Rizzo</td>
<td>AVANTI: progettazione di un servizio Web per sostenere la mobilità dei disabili</td>
<td>III Workshop on Intelligent Interfaces, Rome, Italy</td>
<td>Nov. 21 1997</td>
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<td>L.Fantini</td>
<td>User groups’ needs and requirements (DE001)</td>
<td>Yes Travelling … tourism for all</td>
<td>Dec. '97</td>
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<td>IDD, 97</td>
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<td>Author</td>
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<td>C. Stary, A. Totter</td>
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<td>User Interfaces for All, ed.: C. Stephanidis, Lawrence Erlbaum, New Jersey.</td>
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</table>

9.3 List of patents/registered designs/other IPR
No patent has been registered during the lifetime of the project.

9.4 Others
None.