

A New Web, Multi-service Tool for Regional Management of Allergies, Asthma and Rhinitis

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Summary: In this paper, a new web solution for administering allergies, asthma and rhinitis in a pan-European level is described. The proposed system was designed to provide: professionals with easy workload and access educational and informational material; sufferers with personalised management tools and educational sources; and citizens with rich informational material. The IREMMA system architecture embeds the existing information networks and data sources on allergy by offering high data integration and multi-modal access to its users, through a multi-service tool and high-distributed architecture. Hence, IREMMA sets the ground for establishing a wide integrated network for environmental monitoring and diffusion of health information. User feedback was collected through extensive pilot trials with real users and the results were used to improve the IREMMA services and the designing and the content specification.

Keywords: telematic services, allergies, environmental monitoring, web applications

1. Introduction

Nowadays, in the area of health care two interlinked states dominate. From the one side, health informatics has faced a great number of critical issues, providing continuous, effective and qualified medical care, through advanced telematic services and novel technologies' use. From the other side, the requirements of health professionals and citizens grow rapidly for more such services, as IT attainments support their mobility with useful tools. These demands become more imperative for a special domain in health care, this of allergies, asthma and rhinitis. Considering the mass of people that are involved in that domain in the worldwide level, and the fact that the treatment and monitoring of sufferers are dependent on a huge number of non-medical factors – basically environmental – that domain becomes very critical.

From the technical point of view, there are three basic approaches that have been established for solutions in the area of health care: a) patient-oriented, b) professional-oriented and c) knowledge-oriented. Each of them is easily applied for solutions regarding applications limited in the environment of a hospital. But in the case of administering allergies, asthma and rhinitis these become hard to use and a hybrid solution is required for managing a number of fundamental issues. These issues are mentioned with the following statements:

- There is a lot of spatially and regionally distributed information,
- sufferers are characterized by intense mobility that may influence their health,
- there is a great demand for citizens' information about environmental conditions of the area that they live or visit,
- the continuous provision of medical care and monitoring of sufferers is needed, even far from their doctor,
- citizens need to be updated for news and novel products regarding allergies and asthma,
- citizens should be educated to perform self-monitoring with the use of easy tools, and
- professionals need to exchange their knowledge about special issues in allergies and asthma and access information of novel researching and technological attainments.

There have been a lot of proposed solutions for administering these issues, especially applied in the national level, and cover partially a number of the above issues. IREMMA is a new, integrated multi-service tool that provides the environmental monitoring and management of allergies, asthma and rhinitis in a pan-European perspective. IREMMA manages the citizens' and professionals' needs described above, through a number of basic services. IREMMA provides its services with an integrated way, establishing an electronic workspace that enables the users to access it according to their profile, while sharing the same distributed information sources. The related work was done within the project "Integration of Regional Environment Monitoring and Management for Asthma (IREMMA)", which is partly funded by the EU eTen program.

In the first part of this paper, the design method and considerations of IREMMA are presented, through the analysis of users' profiles, the basic IREMMA services and the distributed information sources. In the second and third parts, the basic and special implementation issues are presented, respectively, describing the general architecture of IREMMA and the individual components of it. In the last parts of the paper, the results and discussion issues are included.

II. DESIGN METHOD AND CONSIDERATIONS

Citizens, sufferers and health professionals are considered as the main types of users of the IREMMA system. Each user may alter his type according to his needs and requirements. IREMMA's basic concept is the integrated administration of the multiple users' roles, establishing a number of distinct profiles and providing a number of basic services using the available distributed information sources, as shown in the tree-level design diagram of Figure 1.

A. Users' Profiles

IREMMA defines three different user profiles, which are available to all types of users (citizens, sufferers and professionals), the 'Citizens Profile', the 'Sufferers Profile' and the 'Professionals Profile'. Users are enabled to choose one or more profiles, in accordance with their requirements and the type(s). Each profile specifies a number of services that are accessible to the corresponding type user, applying special management, control, authentication and authorization mechanisms. Among the services that each profile provides, each user is enabled to select these that he is willing to have access to. The 'Citizens Profile' is the only one that every user can utilize, independent of his type, without posing any limitation.

B. Basic Services

IREMMA distinguishes five basic services: *Informing, Communication and Advising, Education and Training, Personal Data Management and Monitoring*. These basic services are provided differently to each user profile through specialized services that are presented in the following paragraphs, based on the user profile that they are available to.

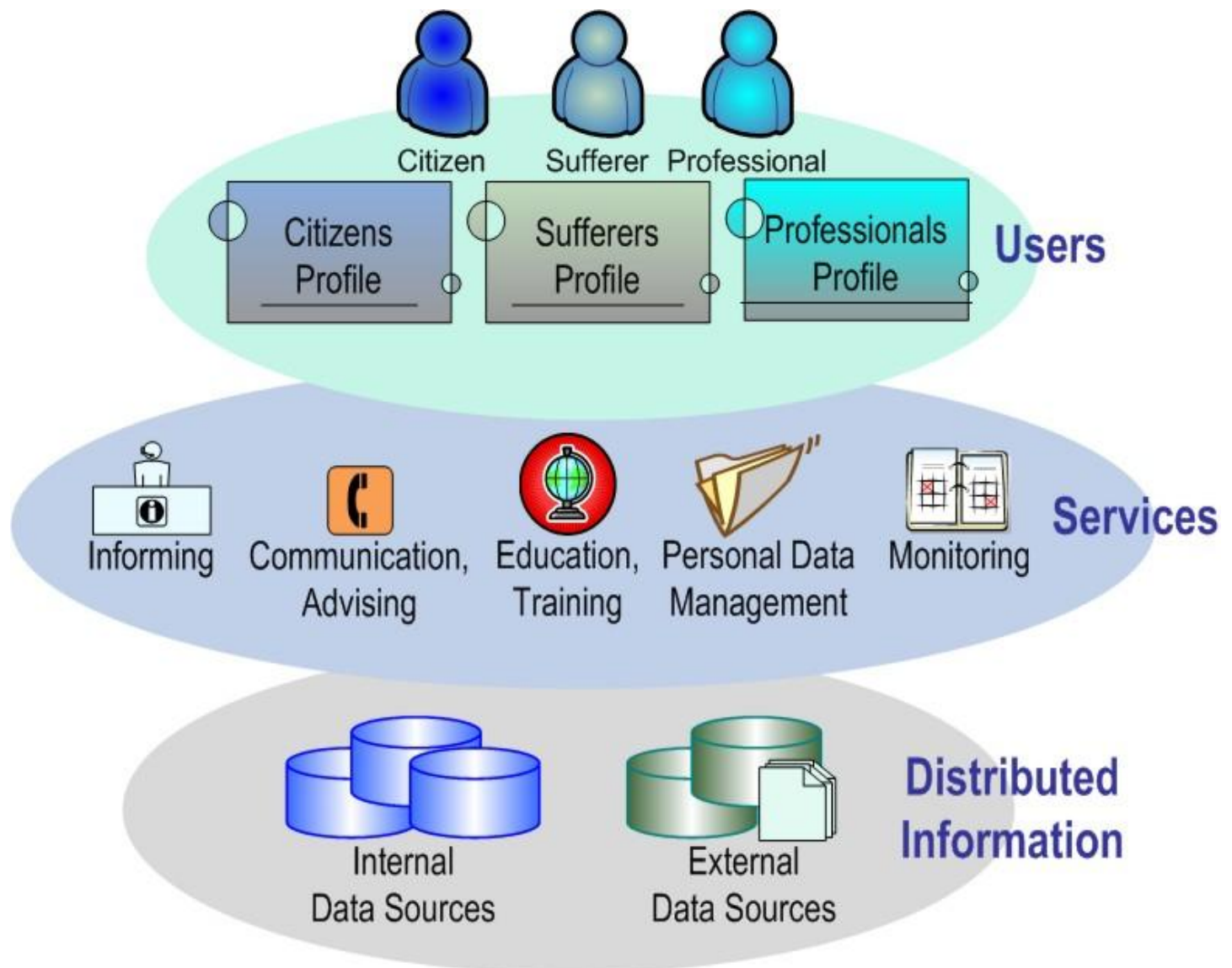


Fig. 1. IREMMA three-level design.

Specialized Services for 'Citizens Profile'

All the specialised services those are available for 'Citizens Profile', come under the 'Informing' basic service.

Allergy Maps: The use of IREMMA Pan-European Pollen Trap Network data from the IREMMA web site provides mapping of allergens concentration in each European country. Following collection of data from pollen traps across Europe, aero-allergen data from each country are stored. Collection of historical data, according to the area and the season, is used for forecasting purposes. The user, through a web-based application has the ability to search for all or a specific allergen existing in a geographical area.

The service provides pollen measurements for selected aeroallergens and for selected location and time. The result can refer to the latest actual measurements, the prediction for next week or to a specific date around the year. In the latest case, estimation based on statistical data is used. A high-medium-low indication per aeroallergen is displayed and in the case of actual measurements, also the precise pollen count is available. It is also possible to display the yearly distribution of aeroallergens for a specific location, according to statistical data.

Information Library: The purpose of IREMMA information library is to provide to each user, Internet based information on allergies and asthma on demand like:

- Reference medical information in the form of a Medical Encyclopaedia.
- New advancements/developments in Rhinitis and Asthma.
- Description of most common allergens.
- List of precautions and useful tips for sufferers.
- Specialised medical centres across Europe.
- Information on medicinal products in collaboration with pharmaceutical companies.

Latest News: The user can access scientific news on allergies, rhinitis and asthma in the form of short articles that are updated on a daily basis.

Frequently Asked Questions: The Frequently Asked Questions (FAQ) screen displays a set of questions and their corresponding answers. It is accessible by all users and intended as a basic reference of information. It is frequently updated as new questions and information arise.

Useful Links: A set of frequently updated links to relevant sites is offered, such as allergiological societies and organizations, medical sites, pharmaceutical companies, health organizations, etc.

For Travelers (includes the visitors of the Olympic Games in Athens): The services to travelers and in particular to the visitors of the Olympic Games are in principle the same as those for all other allergy sufferers. However, in order to address in a better way the needs of this special user group, additional designing features are added to the IREMMA website. More specifically, a link has been added in the home page with the symbol of Olympic Games, which links directly to special information about the Olympic sites and the health system in Greece.

Specialized Services for 'Sufferers Profile'

SMS and e-Mail Alerts: This is a 'Monitoring' service and enables sufferers to receive SMS or email alerts when increased pollen levels are expected in the atmosphere. Each such user defines the corresponding preferences in his personal profile, including allergens of interest, email address, mobile phone, location, etc. The user can also activate or deactivate the alarms and he is able to view the messages he has received and the corresponding charging.

Personal Allergy Map: This is a 'Monitoring' service and provides the user with aeroallergen levels for the area where he lives and only for the allergens that he has chosen, as selected in his personal profile. The displayed data are the latest live measurement or the forecast for the following week, and are provided in the form of a report, depicting graphically the aeroallergen levels.

e-Learning: This is an 'Education and Training' service and offers information that is useful for the sufferers in order to increase their knowledge on specific issues related to their health problem, through a number of specific themes. The sufferers are enabled to search the available information of IREMMA internal and external data sources using special criteria.

Self-management Tool for Asthma: This is a 'Monitoring' service and facilitates sufferers with a special tool for monitoring their asthma by measuring their peak flow. The measurement of their breathing flow helps in assessing their current breathing status. A common Peak Flow Meter is used to measure the peak flow and the user records the obtained measurement to IREMMA system, in his personal account, in order to monitor his condition. The Self-Management Tool uses a personal best value (calculated according to the sufferer's age, sex and body measures) and peak flow history in order to:

- Inform the user immediately for his status and whether he needs his doctor help or not, and
- present him a chart which figures his progress. This chart shows in graphical form the history of the patient's measured values. The graph can be either 15-day, or 6-month. There are 3 color zones, the Green zone which means that everything is going well, the Yellow zone which suggests to take additional measures to control his asthma and the Red zone which is an emergency situation and urges the patient to ask for medical help.

Travel planning: This is an 'Informing' service and allows sufferers-travellers to view the pollen levels for a specific location in Europe. Pollen levels can be displayed as follows: the latest live measurement, the forecast for next week, the yearly distribution or the expected levels at a specific date. The yearly graph allows the user to view the occurrence of specific allergens in the specific area around the year and plan for the best period to visit the specific location. The user can also view pollen levels on the specific date of interest, based on statistical. In case he is interested for an immediate trip, he has access to live measurements and forecasting for the following week. The user can view pollen levels at the location of interest according to his personal allergy profile. After selecting the location, the user can also access local information, such as a presentation of the allergy profile of the area and information on the local health system.

Personal profile: This is a 'Personal Data Management' service and enables the registered user can to view and update his personal allergy profile and preferences. The information contained includes:

- the allergens in which the patient is sensitive,
- the area for which he wants to be informed,
- the presentation of his personal allergy maps,
- information necessary for the self management tool,
- preferences about SMS or email alerts,
- info about his subscription and chargeable services.

Discussion List: This is a 'Communication and Advising' service and provides to the users an electronic discussion room in order to either read comments and contributions on issues that may interest them or to participate actively in posing questions and commenting on ongoing discussions. An expert assigned by IREMMA enters the discussion list on a frequent basis and adds comments to ongoing discussions. In this way, certain posed questions are also answered by an expert and the attention of the users is drawn to opinions that have been expressed and are not acceptable by the medical expert.

Specialized Services for 'Professionals Profile'

Medical Education: This is an 'Education and Training' service and is offered to health professionals through recorded training sessions, ground rounds and recorded telemedicine sessions. Participants are able to attend in teleconferencing rooms close to the area where they live and work. The event is organised by IREMMA with the collaboration of local organisers who provide the room and specialised canters in Europe, who provide the training sessions. Special announces in IREMMA web interface make the scheduled sessions known to the users and they are able to register their participation. Tele-education sessions are eligible for CME credits and have a specific cost. Users can be informed about the cost, summary, provider and place/date of each session through the site. Users are also informed about the sessions for which they applied for participation.

e-Learning: This is an 'Education and Training' service and offers information that is useful to the health professionals in order to increase their knowledge on specific issues related to their specialization.

Personal profile: This is a 'Personal Data Management' service and through of it health professionals are able to define, view and update their profile information and preferences. The data screen is accessible only by the corresponding professional after successful authentication procedure. The displayed data are derived from the record of the specific doctor who enters the screen. The displayed items are:

- Personal information, address, medical specialization, contact information, username & password.
- Information about the professional's account, such as charging info for medical education & e-learning (date downloaded, title, price and total).

Discussion List: This is a 'Communication and Advising' service and enables the professionals to take enter the discussion list, either to read comments and contributions on issues that may interest them or to participate actively in posing questions and commenting on ongoing discussions. The discussion list for health professionals is separate from the discussion list for sufferers and the discussions are on a professional level.

C. Distributed Information Sources

As shown in Figure 1, the distributed information is distinguished in two categories, the Internal and the External Data Sources.

The Internal Data Sources consist all the special inputs of data into the IREMMA system, containing allergens' measurements and informational material. The allergens' measurements are introduced to the IREMMA system using a data acquisition mechanism from assessed pollen traps (such as University Clinics, Local Health Units, Hospitals and Botany Institutes). These pollen traps are positioned in the geographical areas covered by the specific project and follow a standard procedure for the collection and archiving of pollen data in IREMMA system. The internal informational source is enriched by the users of IREMMA and relative organizations, enterprises and local initiatives, which provide their informational material, in order to enable the rest of the users to access them, through the IREMMA system.

The External Data Sources consists of external databases and informational sources. IREMMA places connections with other databases that are used to provide environmental data, allergy information, weather reports and other information relevant with the IREMMA services. These databases belong to collaborating institutions, weather agencies and independent networks. The external informational sources are independent web-sites, libraries and databases of informational material, that provide to IREMMA with their content through special links.

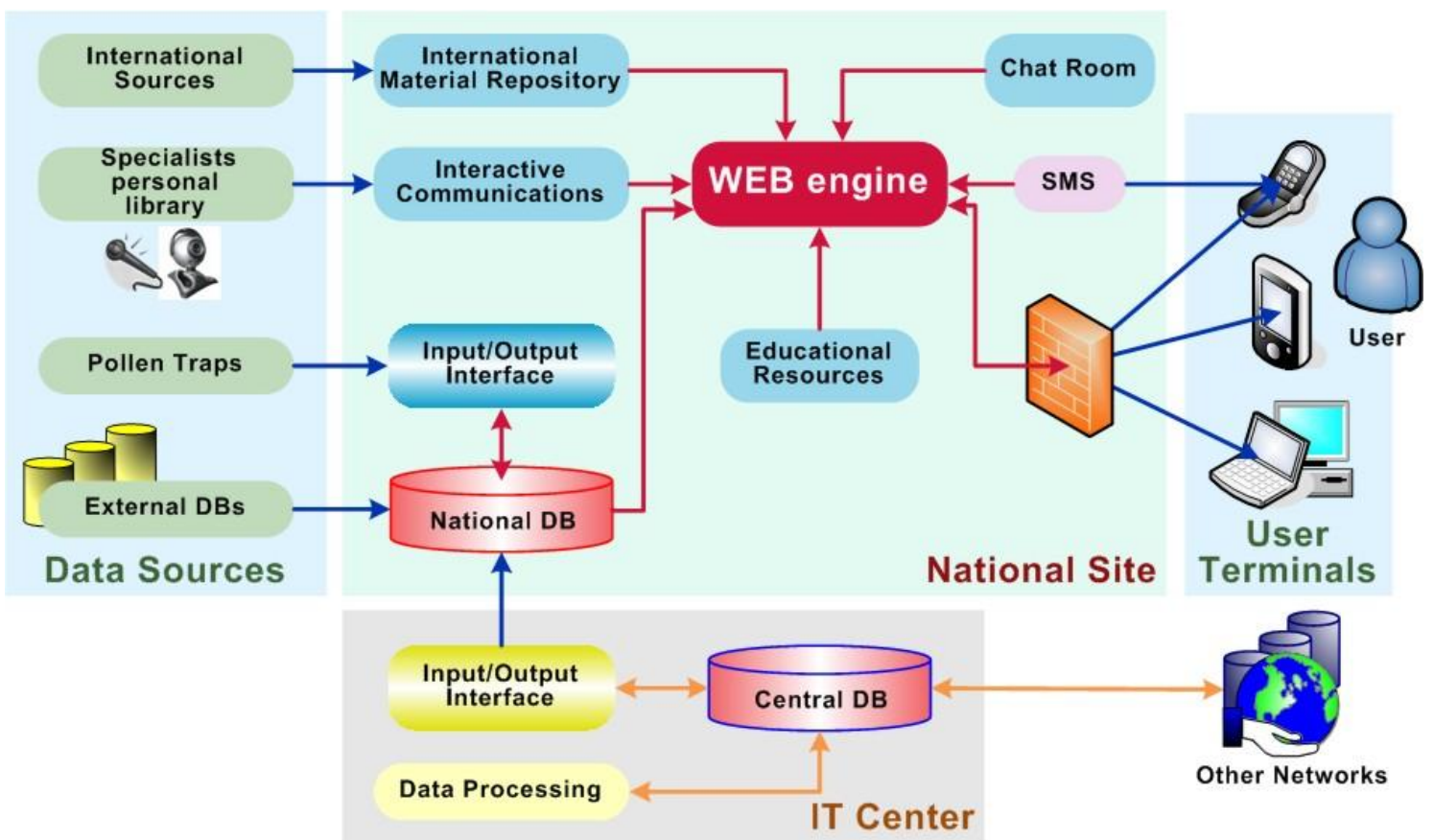


Fig. 2. IREMMA general system architecture.

III. IMPLEMENTATION

A. The General Architecture

The IREMMA system architecture, as depicted in Figure 2, is basically comprised of the IT Centre and a network of National Sites. The structural components and functions of IREMMA system are distributed in these two parts. The National Sites act as interface between the local Data Sources, the IT Centre and the IREMMA users. The communication between the National Sites and the IT Centre are standardised in order to every National Site can be easily connected to IT Centre. The communication between the National Sites and the local Data Sources are specified conditionally, according to the data source, not only technically, but also organisationally.

From the functionality point of view, in each National Site the procedures of data collection and presentation are executed as the service provision and user management are performed too, while information integration and processing are performed in the IT Centre, setting it as the heart of IREMMA information network. This concept of integration of all data from many information sources, internal and external, into a single point, centralising the processing procedures, is the basic advantage of IREMMA architecture.

IREMMA users access the provided services through their terminals, establishing the communication with a special access point of National Site, which they come under, according to their geographical position. The user terminals may be mobile phones, PDAs, personal computers or laptops, in respect with the type of service they use.

B. Implementation Structure of National Sites

The National Sites, while playing multiple roles in IREMMA system, are the most complex part of the general architecture and their development platform is based on a three-level approach. The lower level is the Allergy Warehouse which comprises the infrastructure for information collection and management, user administration, inbound data management and security issues. The second level is the Multi-Service Tool Provider, which acts as the service implementation level. This is an intermediate level which accesses internal procedures of the Allergy Warehouse and provides processed data to support the provision of all specialised services. The third level is the End-User Applications, through of which the IREMMA users are enabled to access the IREMMA services, be choosing the willing profile.

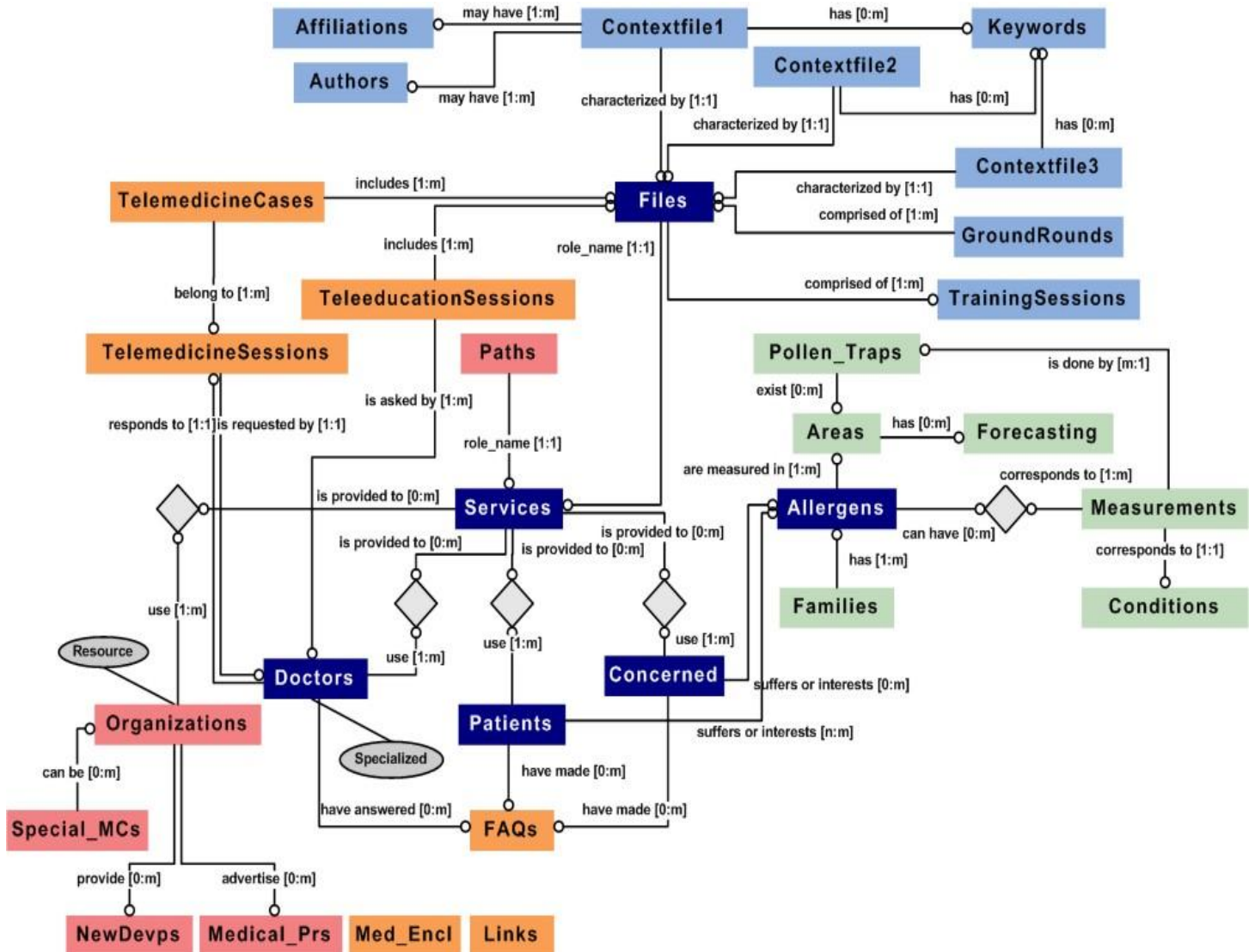


Fig. 3. Entities relationship diagram of Allergy Warehouse.

Allergy Warehouse

Allergy Warehouse is the central internal information source of IREMMA system and its entities relationship diagram is depicted in Figure 3. Its main scope is hosting all the native allergy data, derived from measurements that come from specific pollen networks, and are introduced after special processing in a standard format, for supporting the environmental monitoring services. Furthermore, includes distinct entities for supporting the specialised services that are based on the informational material of IREMMA and real-time services.

The data that are hosted by Allergy Warehouse are of different types. Apart from these of allergy measurements that are native text in a special format, multimedia content is also registered. This special content is basically binary files, including images, videos and document

files of various formats. The management of this content becomes a critical issue, considering the mass of the data they include. Thus, a special protocol has been applied, in order to achieve efficient storage, browsing, indexing and retrieval [1]. This protocol is based on the distinction between the content and the context data of these files. A special indicator object is used as an encrypted alias name of the physical path, where the content is located and it is registered to the corresponding entity in conjunction with the rest features of the specific file, combining the context of it. This information is used for the indexing and retrieval of IREMMA multimedia data. For the retrieval of images an approach of knowledge-based method is implemented. The users who attempt to collect the available files follow an assessed set of steps. The users undergo the constraints of the authentication data; (1) call an already fixed special query for the context and indicator; and (2) the host's operation system restrictions are enforced to them. It is recommended that these steps must be passed successfully as to obtain the target information [2], [3].

Regarding the security issues, a number of special mechanisms have been established. First of all, Allergy Warehouse includes an upper level, above native data, for communicating with the user application programs, as shown in Figure 4. This level is an interface that serves the inbound Data Manipulation Language (DML) calls, after identifying and committing the validation of them. Extra access control is performed by authentication mechanisms. For data protection issues a special management protocol is employed to certify the secure and correct transaction when registering the inbound data. Cases of incorrect registration, unfinished or incompatible records are handled via different control mechanisms in a number of different levels. Therefore, the registered data are accurate, complete and up to date so as to fulfil data integration and compatibility and are used only for the declared purposes. Finally, for tracing of users' actions a real-time tracing model has been applied. This is activated after every successful action that effects a change to the status of data and when a user accesses any kind of the stored information. For each such action the elements that concern the kind of access or modification, the user who caused it, the exact time of the actions performance and the features of the user's domain are transcribed [1]. Special attention is given to facilitate administration (for instance data upload), which is done by the data providers (no system administrator or other technical personnel is involved) and consists of preparing a data file and clicking on a button.

Finally, for the maintenance of the system the Allergy Warehouse includes procedures for backup and restoring of the application data, the application programs and the exact structure of the repository entities in case of a failure. More frequently the backup will be applied for information related with users' attributes and allergy data, imported from the pollen networks. Also automated are system auto-diagnostics and auto-recovery, for instance backup systems automated notification to the relevant personnel in cases of, for instance SMS gateway failure-even though the backup system takes over transparently to the user.

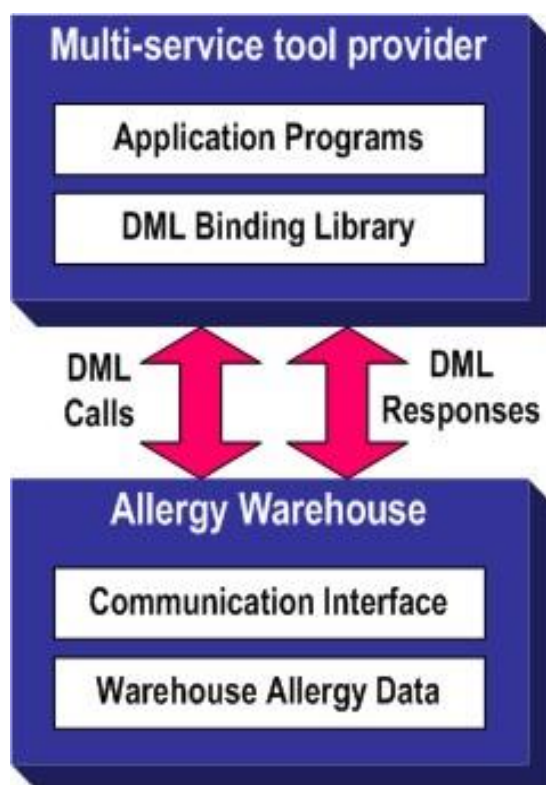


Fig. 4. Multi-service tool provider secure the communication between the users and the Allergy Warehouse.

Middleware multi-Service tool Provider

The Multi-service Tool Provider is the middle level in the proposed development platform of National Sites. It is the core of the Application Layer and implements the functionality and application logic of the supported services. It performs a number of tasks in order to manage the users' data and transactions, routing the application data and translate the users' requests to understandable statements for the

functional interface of the Allergy Warehouse. In Figure 4 the structure of the Multi-service Tool Provider and the communication with the Allergy Warehouse is depicted.

The basic consideration is the users' identification and management of their profiles, ensuring their rights of access and the personalized nature of the provided specialized services. This enables the proper mode of usage, depending on the user identification. End-users are provided with an enriched presentation mode while professional-users may exploit the intranet application benefits (intranet mode). Secondly, it channels the information to and from the users according to their preferences and needs and finally their location and access mode.

For the routing and transfer of application data, apart from the above mechanism, the definition of the participating entities for each communicating session is required. The conversion of information to the appropriate mode according to the participants' access modalities is being performed based on a logic table, which implements the correspondence between the supported transactions and the array of services.

The lower layer of the Multi-service Tool Provider performs the translation of the application user requests to sets of multiple statements, defined using a high level Data Manipulation Language (DML) [4]. This mechanism makes a search for the appropriate already fixed functions and addresses their specified interfaces as calls to the communication interface of Allergy Warehouse.

User Applications

The End -User Application level, including the user interface is web based. The users of the services are mainly using PCs to access the information needed and mobile phones to receive SMS alerts. The use of devices such as PDAs with mobile access is foreseen, which are also web based. The user access for all types of users is through an Internet browser window, which contains all the information, navigation capabilities and functionality. Three different levels of service provision are identified, each one being targeted to a different end user group, namely general information services –for 'Citizens Profile'–, services to patients –for 'Sufferers Profile'– and services to health professionals –for 'Professionals Profile'–. An access control component, gives access to the functionality corresponding to the specific user group. Differences also exist in the informational content, presentation of data and level of information depth. An additional set of applications is offered to experts who maintain the content and to the administrator. These comprise a set of tools for information and user management and they are accessed through a similar web-based interface, which however has slightly different designing than the end-user interface. The screenshots of IREMMA user applications in Figure 5 depict the homepage (a) and the user interface of self-management tool service page (b).



Fig. 5. (a) Homepage for registered sufferers, giving access to personalized services; (b) the progress chart presented by the self-management tool for asthma.

IV. SPECIAL IMPLEMENTATION ISSUES

In this part, a number of special implementation issues are presented, analysing the methods that were followed for the structure of IREMMA data and the integration of the information sources.

A. IREMMA Data Structure

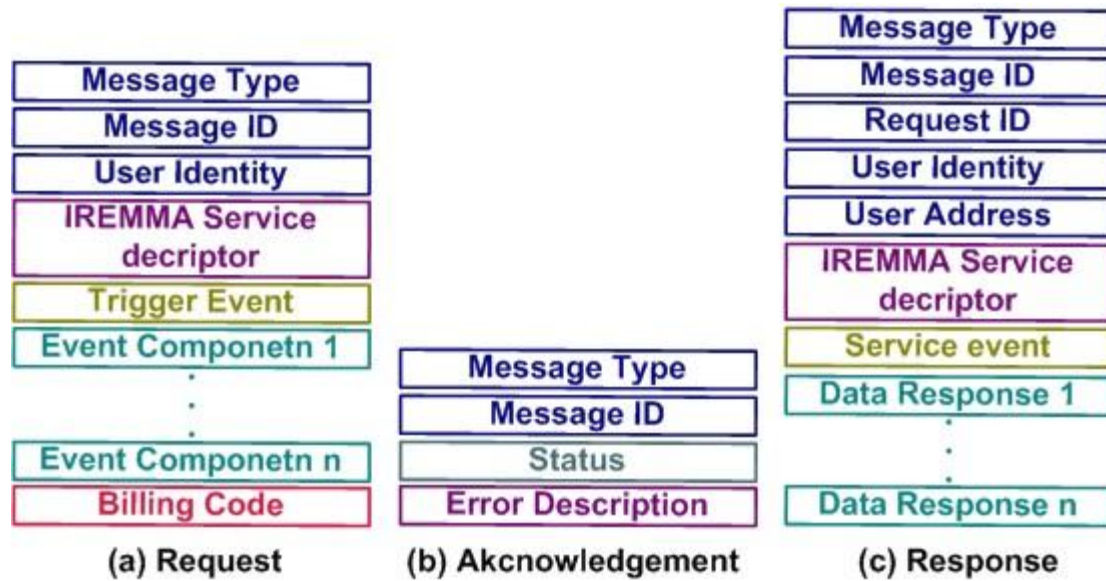


Fig. 6. Structure of IREMMA application data.

Transferred data structure

The structure of data that are transferred between the various components of IREMMA architecture and especially between the users and the National Sites is formed in messages of three different types: the user requests, the acknowledgements and the response (application data). In the following paragraphs these types are described.

User Requests: Each time a user accesses an IREMMA specialised service, a special request is sent through his application interface to the National Site, including specific information in predefined data fields. Such a request structure is pictured in Figure 6.(a). The exact data fields of message are presented in Table 1.

Table 1. 'Request' message's data fields

| | |
|----------------------------------|---|
| Message Type | This field defines the type of the transferred message. For the described case its value is always 'Request'. |
| Message ID | It contains the identification ID number of the exact message. |
| User Identity | The value of this field is the identification parameter of the user if registered, or the user domain access features if not registered. |
| IREMMA service descriptor | It contains the descriptor parameter of the service for which the user makes the request. Its value can correspond to these services that the exact user can have access. This and the previous fields are the two criterions according to which the provider will decide if the requested service can be served for the user or not. |
| Trigger Event | For each IREMMA service a number of actions can be done. In this field the exact requested action is defined. |
| Event Components | To serve the requested action the provider needs a number of parameters that are specified in these fields. |
| Billing Code | For services that is charged the Billing Code of the user is required in order to administer the related procedures. |

Acknowledgments: These are ancillary messages that are addressed from National Site to IREMMA users with an unsolicited way, as confirmations or error messages in response of the requests. The data fields of these messages are presented in Table 2 and graphically depicted in Figure 6.(b).

Table 2. 'Acknowledgement' data fields.

| | |
|--------------------------|--|
| Message Type | This field defines the type of the transferred message. For the described case its value is always 'Acknowledgement'. |
| Message ID | It contains the identification number of the message whose confirmation receipt is performed. |
| Status | This field can have the value 'Confirmation' or 'Error'. In the first case no errors have been arisen. In the second case a reason produces an error and the response of user request has not been arrived to the user-domain. |
| Error description | In the case of error this field specifies exact the error that took place. |

Application Data: The messages that are addresses form the National Site to the users and include the data that correspond to a specialised service, as responses to a user request are of different structure. Their data fields are shown in Figure 6.(c) and presented in Table 3.

Table 3. 'Application data' data fields.

| | |
|----------------------------------|--|
| Message Type | This field defines the type of the transferred message. For the described case its value is always 'Response'. |
| Message ID | It contains the identification number of the message. |
| Request ID | Its value is the identification number of the message request whose response is. |
| User identity | The value of this field is the identification parameter of the user to who the message is sent. |
| User address | The user-domain features to who the response is addressed comprise the value of this field. |
| IREMMA service descriptor | It contains the descriptor parameter of the service that is provided. |
| Service event | Each service includes a number of actions that can provide to the users. This field define exactly the event that the user has been requested for. |
| Response data | In each such message these fields include the appropriate data elements, which are the real response to the user request. These data has been arisen as a result, after processing the message request internally to the provider's domain a. These, according to the service and the 'Trigger Event' of the message request, can be: Informational data Maps Statistics E-learning data |

Regarding the conferencing data for Telemedicine and Tele-Education services, these include the audiovisual conversational data, which are transferred during the online sessions and are in accordance with the ITU H320 video-conferencing standards.

Pollen data structure

A special class of information of IREMMA internal data source is the pollen data, which are gathered from specific pollen traps. The transfer of these data follows the previous structure; independently of the final presentation format from the user application programs (maps, statistics, simple text, etc). It is important to notice the structure of organization of this information.

For each group of measurements the following attributes are defined and recorded:

- percentage of grains in the atmosphere,
- frequency of data acquisition,
- dates of acquisition,
- frequency of database update,
- dates of database update,

- pollen trap,
- country,
- covered area,
- statistics.

B. Integration with data sources

During pilot trial of IREMMA, all data and informational material were collected by a number of providers and made available to the users. During real operation of IREMMA, a number of independent national sites collect all the data (pollen and informational) and send them to the IT Centre, which act as a controller of data flows. The transfer of information between the different components of IREMMA architecture and the special nature of aeroallergen data that are exchanged pose a critical number of issues, regarding the integration of these data among the different components. These issues focus on the following communications:

- Pollen data collected and owned by national site are sent to the IT Centre.
- Pollen data collected by IT Centre from each European national site are provided to all national sites.
- Informational material collected and owned by national sites are sent to IT Centre.
- Informational material collected by IT Centre is provided to national sites on demand.

In order to manage these issues, a number of special mechanisms have been applied and are described in a following way.

A standardized codification of aeroallergens has been defined, which includes all the types of aeroallergens that may appear throughout Europe. The produced codification is usable and possible causes of confusion regarding the naming or categorization of individual species have been clarified. Using this codification, it is possible to exchange and integrate data on aero-allergen levels at pan-European level.

A template file in Ms-Excel and a definition of XML message have been produced allowing the easy transfer of measurement data through Internet-based communication.

It has been decided that aeroallergen levels are recorded and communicated as actual levels measured as spores/m³ and not as danger levels. Because of the danger levels involve a degree of subjectivity according to other environmental conditions, each national site estimates them individually. Additionally, recorded measurements are stamped with the time period and the location to which they correspond. More specifically, the location of each pollen trap is numbered and named uniquely so that there is no overlap of measurements coming from different sources. Measurements can also be daily or weekly.

The collection of pollen data is performed by TCP/IP based communication between pollen networks, pollen traps and national sites. Aeroallergen data is received either by pollen traps through the hospital or institute which operates them or by existing networks which act as providers. A survey was performed in pollen trap technology and it was found that in most of them the measurement is acquired after manual processing and cannot be automatically transmitted (usually sent by fax or e-mail). The result is expressed in standard units (spores/m³) and the only subjectivity lies in the categorization and naming of the aeroallergens. There are also different types of pollen traps, according to the measurement period (e.g. one day, one week, etc.). Pollen networks collect data from many pollen traps and keep them in their own format.

The solution given in order to integrate existing and new pollen data sources into a unique allergy data repository as:

- to standardize the coding of aero-allergens,
- to develop a web interface for manual insertion of the measurement by the pollen trap operator directly in IREMMA database,
- to propose a file template which can be used by the data provider in order to insert the data and upload it to IREMMA, where it is automatically imported in the database,
- to propose an XML schema to allow pollen data exchange through http connection,
- to develop filters that import data provided by pollen networks, according to the format used by the providers.

The scientific partners within the IREMMA project consortium concluded to a specific codification of allergens and technical partners have implemented a message format for data transmission. The operators of pollen traps (hospital clinic or allergiological institute) send the live pollen measurements and forecasting to the National Sites, which are in agreement for data provision. This can be done either by sending a message in an agreed format (defined in XML and alternatively in EXCEL file) or by using the provided web interface, which allows the manual insertion of the pollen data directly by the experts to the database. In addition to live measurements and forecasts sent on a regular basis, there is provision for the exchange of statistical data covering the pollen levels at specific locations during past years. Such data has been successfully exchanged within the pilot phase by developing a configurable importing component which has been adjusted to the format of origin. Since the format of pre-existing data can not be controlled, such interfacing components are necessary in order to import external data. A standard coding of aeroallergen types is also used, such as the one proposed within this project.

Informational material can be inserted, edited and revised directly on the National Sites by authorized experts through a web interface dedicated to information management. The "Administration" tool of IREMMA, which is addressed to information providers, experts and the IREMMA administrator, offers the corresponding functionality. The implemented tool offers the required functionality to experts in order to insert and manage News articles, Frequently Asked Questions, eLearning items, Useful Links, description and schedule of Medical Education sessions. It also allows them to edit or upload content for the Information Library. The tool offers the ability to the administrator to define new languages, areas and locations of pollen traps, providers of Medical Education sessions and a user management window for viewing and managing user accounts. Finally, a usable web interface is offered to experts acting as providers of pollen data to insert manually live measurements and forecasts and to upload already prepared files with measurements.

C. Development tools

The IREMMA services are offered through a telematic platform that is designed, implemented using mature technologies and operated in pilot form within this project. This platform is the basis for future expansion to fully blown commercial services. Information delivery and supporting transactions are offered over both wire line and wireless links to a set of end devices, such as desktop PC, laptop PC, mobile phone and PDA. Modular design allows future expansion to additional user devices, such as Digital TV, MMS and others. The telecommunication infrastructure is based on public switched digital networks and data networks. Internet-based communications ensure universal user access and high expandability of the services.

The databases of IREMMA were developed using the Oracle8i Database Management System. The web user interfaces were built with HTML and the access to databases was based on ADO technology and SQL data manipulation language.

The hardware and communications infrastructure of OTE were used in order to run the services for pilot trials. The platform used is UNIX-based which was considered as the most appropriate for future expansion to wide scale service provision. The database has been implemented in Oracle 9i and the implementation language of the web application is php. An Apache webserver was used [6].

V. RESULTS

The proposed system was implemented by OTE - the national Greek PPT, Pouliadis Associates Corp. and the University of Patras within the activities of IREMMA project. The platform is currently operational in pilot form and services are offered to groups of trial users in Greece and Spain. Data is collected by aeroallergen networks with the participation of Corporacio Sanitaria Clinic – Spain, Royal Brompton Hospital – UK, Venizeleio hospital – GR, Sotiria hospital – GR, Laiko hospital – GR, Municipal Institute of Medical Research – Spain and the Italian National Research Council, who also provide the medical expertise and informational content.

The system has been evaluated by expert users regarding usability and functionality and by developers regarding technical issues (correctness, efficiency, reliability). The focus of the work presented in this paper was to establish the technical feasibility of collecting, processing and redistributing information within a highly diverse set of providers and recipients. The exchanged information is health related and intended to support the management of aeroallergen-initiated diseases. In this respect, the obtained results were encouraging regarding the successful addressing of a number of challenges.

Aeroallergen information is successfully collected and integrated by a non-uniform and expandable set of pollen trap networks. The defined standard for information exchange, expressed as an XML schema, was based on international allergen coding. Issues, such as spatial overlap and sampling, were compatibility managed with by coding locations and stamping samples with time period and method.

A Distributed Allergy Data warehouse was developed, in order to allow the exchange of information at a professional level, including measurement data and scientific informational/educational content. These services enabled health professionals, health administrations and the scientific community to handle medical issues regarding allergens, asthma and rhinitis, in a more effective way.

Information is delivered to patients and health professional users in a highly usable, personalised and multi-modal fashion. Designing was performed in close collaboration with users and preliminary feedback indicated the effectiveness of the approach.

Finally, the adopted architecture and technologies allow for future expansion to large geographic coverage, large scale of users and additional services, which set the ground for commercial exploitation.

VI. CONCLUSIONS

IREMMA has set the ground for establishing a pan-European network to support groups concerned with common environment-related allergic diseases. Based on this network, it supplies health, environmental and informational data to citizens, sufferers and professionals, through a number of basic services, while managing distributed internal and external data sources. During IREMMA implementation and pilot operation the standards and European legislation issues were covered by written contracts and license agreements between the

IREMMA consortium and the data providers. The efficiency and functionality of the whole solution were confirmed through the evaluation of the system, in pilot and real conditions operation. The implemented IREMMA services were proved useful and efficient for the users and set the proposed IREMMA architecture a promising solution for creating sustainable integrated network of data sources throughout Europe. The future work on IREMMA is focused on expanding its network of data sources throughout Europe and to collect credible informational content. In this way, it can be transformed realistically into a fully blown high-quality service of considerable value to an extremely high number of users.

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