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Electronic Roads: Intelligent Navigation Through Multi-Contextual Information*

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Abstract. This paper proposes a model for intelligent navigation through multi-contextual information that could form electronic roads in the information society. This paper aims to address the problem of electronic information roads, define their notion and the technical form they can take as well as present the tools developed for implementing such a system. The main objective of the proposed model is to give the traveler the capability of exploring the information space in a natural way where the information offered will remain continuously interesting. The system offers links to information in a dynamic and adaptive way. This is achieved by employing intelligent navigation techniques, which combine user profiling and meta-data. Electronic roads emphasize the presentation of multi-contextual information, i.e., information that is semantically related but of different nature at different locations and time. An electronic road is the user's navigation path through a series of information units. Information units are the building blocks of the available cultural information content.

Keywords: Electronic roads; Intelligent information navigation; Meta-data; Multi-contextual information; World Wide Web

1. Introduction

Over the last few years there has been an explosion in the importance of research and development in multimedia systems and their deployment over the Internet and World Wide Web (WWW). However, these systems usually have limited interconnections among them; they may be viewed as virtual territories with very few existing

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facilities that can help users explore and retrieve relevant information. They only apply to discrete data spaces, failing to provide users with a means of continuous exploration in the related information space that often spans multiple data spaces. As a result, users may be lost from their intended destinations since they cannot describe a desired journey explicitly. Thus, there is a strong need to address this problem and to provide information guides that would allow a coherent exploration of information – an exploration that can be viewed as a structured journey in the available information (Fakas et al., 2000).

Search engines are used to gather a list of potential interesting sites in an effort to solve this problem. Human intervention for the update of interconnections is often employed. Both approaches have major disadvantages. The required time and effort for the manual update are both overwhelming and expensive while search engines often respond with a large set of sites that are only peripherally related to the actual query. A great amount of research is being invested towards the creation of more powerful and intelligent search engines. (Boyan et al., 1996; Brin and Page, 1998; Lawrence and Giles, 1999).

Our approach proposes the concept of Electronic Roads as a meta-form in exploring information. Electronic Roads can be thought of as the underlying fabric of the information space and the information society at large. They shape this space and define a novel way of acquiring, using and exchanging information, which ultimately can result in new social links between the users of these roads. Electronic Roads create an information map with spatial, temporal and context or more generally semantic associations amongst different information elements. These electronic roads could be based on existing physical roads mirroring the information available in the physical area of the road or they could be completely thematic roads that traverse *multi-contextual* information that is semantically related but of different nature at different locations and time. Users who are interested in a specific topic would search for and take an appropriate Electronic Road. This will provide them with a traversal of a meaningful set of related information sites, with each different user selecting a journey that suits their own interests and priorities in a dynamic way as they follow the road and discover new information that they judge useful.

The primary objective of an Electronic Road is to achieve a network of information in which the traveler can explore the information space in a natural way, where the information offered will remain continuously interesting. A secondary objective is to achieve an environment where the users can adapt their exploration mode according to personal preferences both at the start and during the journey and learn new information, particularly new relevant associations of their original domain of interest with other domains.

The system employs *intelligent navigation* algorithms that combine user profiling and meta-data in order to generate Electronic Roads. A central challenging issue in the formation of these information roads is to define what indeed is the appropriate way to link, structure and organize information together. The available information needs to be structured in a way that supports flexible learners, rather than experts. For this reason, every piece of available information in the system is associated with some meta-data (semantic and system). Meta-data can be maintained according to several standards such as the Dublin Core (Weibel et al., 1997), XML[1] (Harold, 1999), and RDF (Miller, 1998).

The Electronic Roads system has been designed to be primarily an educational tool for teachers, students, and researchers. It has been shown, however, that it can also be used by tourists and explorers, or by any other individuals that like to retrieve cultural information about the three Mediterranean countries, namely Cyprus, Egypt or Jordan.

[1] XML (Extensible Markup Language), W3C. Available at http://www.w3.org/XML/

In Cyprus, there is a long-term plan to introduce the tool into a number of high schools, as an educational aid, and also into tourism as a tourist guide, since both the Cyprus Ministry of Education and Culture and the Cyprus Tourism Organization have sponsored part of the project.

A teacher who is a member of the CJIS team has already used the tool in his classes. In a first trial, the teacher asked his students to use the system in order to extract information and prepare a report with multimedia content about a Turkish-occupied area of Cyprus of their desire. In a different exercise, he gave his students a cultural journey he had prepared (the one presented in Appendix 1) and asked them to study it and then write a report about the consequences of the Arab incursions and the Turkish invasion and their similarities. Both students and teacher welcomed this novel educational tool, for many reasons: firstly, for the way of delivering continuously interesting multimedia content; secondly, for the adequate and accurate quality and quantity of content; and finally, for the convenience of editing the available digital information, as the students can easily cut/paste content into their word-processing applications.

The rest of the paper is organized as follows. In the next section we present related work. In Section 3 we describe the system concepts. In Section 4 we present the system components and it is followed by Section 5, where we describe the Electronic Roads cycle. In Section 6, we give the implementation platforms used in the project. The paper ends with conclusions.

2. Related Work

Very few of the currently available multimedia cultural systems are similar to our system in their approach of retrieving information. Below is a list of such related systems.

2.1. Aquarelle

Aquarelle (Michard, 1998) is a cultural heritage information system that offers access to the huge information repositories which are created by public bodies and, to a lesser extent, by some private organizations, and which together document the cultural heritage of four countries, i.e., Greece, Italy, France and the UK.

The overall Aquarelle architecture is designed to relieve users from the cumbersome manual task of maintaining cross-references, as well as to support the high precision required in referencing and retrieval. Aquarelle provides an information retrieval service for searching across different database systems with different data architectures. It does this by presenting the user with a common vocabulary, including a set of access points for the purpose of phrasing a query. The Aquarelle cultural content providers use over 300 fields to store the data in their respective databases (NISO, 1995).

2.2. Perseus

The Perseus project (Crane, 1998) is an evolving digital library of resources for the study of the ancient world and beyond. Collaborators initially formed the project to construct a large, heterogeneous collection of materials, textual and visual, on the Archaic and Classical Greek world. The primary goal of the project is to bring a wide range of source materials to as large an audience as possible. Perseus built and supplemented a powerful set of searching and indexing tools. These tools form the connections between the various kinds of materials within Perseus and facilitate the exploration of these materials for general readers and specialists alike.

The Perseus Digital Library has three different kinds of search tools, each of which presents its results in a different way. Two of them, the word-search tool and the Perseus Lookup Tool, allow users to request searches of the texts and the databases of the digital library. The third search tool works transparently on the user's behalf, and is tightly integrated into the text display engine (Mahoney, 2000).

2.3. Argos

The Argos project (Beavers, 1999) was funded by grants from the University of Evansville. It is the first peer-reviewed, limited area search engine (LASE) on the WWW. It has been designed to cover the ancient and medieval worlds. Quality is controlled by a system of hyperlinked Internet indices, which are managed by qualified professionals who serve as the associate editors of the project.

Argos was designed to use a two-tiered protocol to determine what to search and what not to search. This protocol serves two purposes: limiting the range of Argos and determining the overall quality of the index. Argos searches a small set of associate sites and all the pages they link to, with the exception of a few pages that Argos is told to avoid, such as personal homepages and the major search engines discussed above. This procedure, in turn, passes Argos's editorial control over to the experts that manage the associate sites. By simply linking their index to a page, these editors are also instructing Argos to include it in the search window.

3. Electronic Roads Concepts

The primary concept of the system is the Electronic Road. An *Electronic Road (ER)* is the user's navigation path through the information space, i.e., the series of *Information Units (IU)* the user chooses to visit. IUs are the building blocks of the information content of the system. The system produces a number of *dynamic links* that point the user to new IUs. These dynamic links are based on the IU semantic meta-data, *user profile* and the *Semantic Dictionary (SD)*. The semantic dictionary is a tree structure used to organize IUs. *The Presentation Unit (PU)* is what the system delivers to the user and it is a composition of dynamic links and the current IU.

3.1. Electronic Roads

An ER is the series of IUs the user selects to explore. At every stop, a new set of dynamic links and an IU are presented to the traveler. The user explores the IU content and proceeds by selecting a new dynamic link; all these stops form an ER. The primary aim of ERs is to provide electronic travelers with interesting and natural journeys that will attract their attention for as long as possible. The users can define or redefine their personal preferences or interests. The system also provides the facility to users to save interesting and educational journeys and revisit them or recommend them to others; this is very useful for educational reasons.

Table 1. Information Unit (semantic and system) meta-data

IUID	Unique Identification
Semantic Keywords	The semantic dictionary nodes the IU is associated with (see SD)
User Group	The group of users that might be interested in this IU. Users are classified by age (12–18 and older than 18) and depth of interest (low, medium, high)
Format	i.e., text, image, video
System Format	Provides information about the format of resource, which could be used to better utilize the network resources, e.g. if the resource is a video segment it could provide the bit rate
Language	The language the document is written in, e.g. English, Greek
District	The IU might be associated with a geographical position (Cyprus.Kerynia, Cyprus.Famagusta)
Historic and time period	The historic period (e.g. British period) and time period (e.g. 1950 AD) the IU is associated with
Other keywords	e.g. Museum
URL address	The URL address of the document

3.2. Information Unit

IUs are the building blocks of the system and consist of the actual content (e.g. segment of video, image, sound or text) and an attached meta-data index (*semantic* and *system meta-data*). The system contains thousands of IUs, which are collected and entered into the system by the cultural experts. The system can also support remote content, which is available over the Internet. The content of IUs is stored as an HTML document and is uniquely identified by its URL address. The available IUs need to be structured in a way that our system can easily retrieve them. For this reason, the IU content (local or remote) is associated with some meta-data, which is maintained in an Oracle database. A user-friendly tool has been developed that assists the cultural experts to enter the meta-data for each IU, i.e., the Semantic Dictionary Entry Tool (see Section 4). Table 1 shows the structure of IU meta-data.

3.3. Semantic Dictionary

The IUs' semantic meta-data is organized in a tree structure called Semantic Dictionary. The SD is created by the cultural experts of the system. Its purpose is to structure cultural information in a hierarchical manner from general to specific and also to capture the multi-contextual dimensions that a simple piece of information (i.e., an IU) can have. Every IU is uniquely associated with an SD node. In addition, the semantic meta-data of an IU might be associated with other SD nodes; this captures the multi-contextual property of an IU. An SD entry tool has been developed that assists the culture expert to easily construct the SD and also enter the meta-data of the associated IU for each SD node (see Section 4).

A universal cultural SD has been developed that could be applied to any country's culture (the one we have developed captures Cyprus, Egypt and Jordan cultures). The universal cultural SD is classified by country, historic period and a repetitive standard part that describes science, architecture, arts, folk arts/food and history. An instance of the standard part for each country/period is first specialized and then extended accordingly with specific information.

Appendix 2 presents a representative historic period of Cyprus SD, i.e., Byzantine Period. Nodes colored white belong to the standard part of the SD and nodes colored

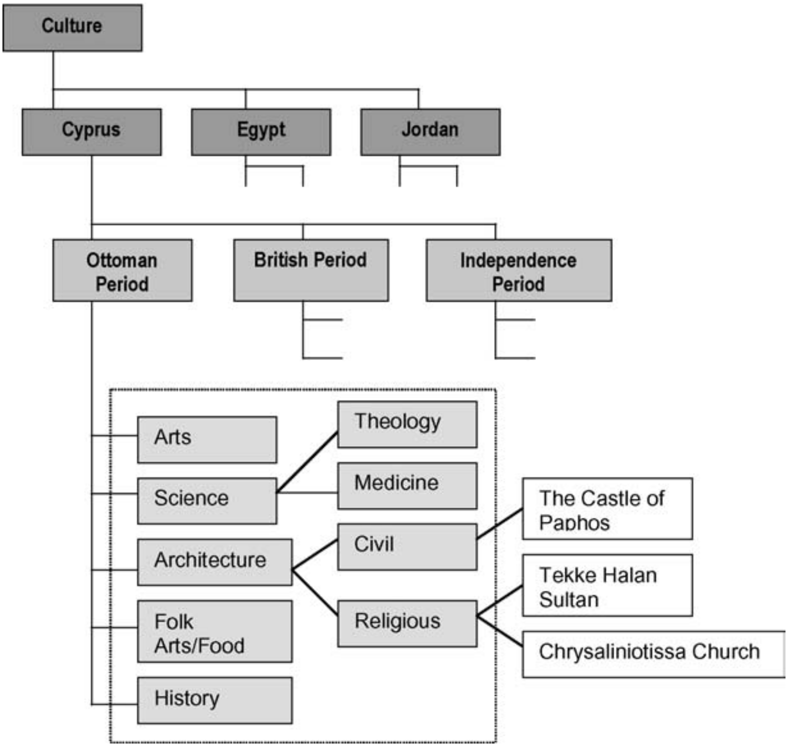

Fig. 1. A simplified part of the SD for Ottoman Period of Cyprus.

gray belong to the country/period specific part of SD. Figure 1 shows a simplified part of the SD. The SD's root is Culture and then it is specialized to Cyprus, Jordan and Egypt culture. Cyprus culture is then specialized to historic periods, e.g. Independence, British, Ottoman. The SD squared section that follows the Ottoman period is an instance of the repeated part of the universal SD for the specific period of Cyprus. The extension of this section (i.e., the castle of Paphos, Tekke Xalan Soultan etc.) is information specific to the culture of the period.

An IU is associated with each SD node. Multi-contextual IUs are associated with more than one SD node as well. For instance, Chrysaliniotissa Church is associated with Arch. Kyprianos, Tekke Halan Sultan with Halan Sultan.

3.4. Dynamic Links

The whole intelligence of the system is encapsulated in the algorithms, which generate the dynamic links. Every time the user selects an IU to visit, the system dynamically generates a new set of links. Dynamic links generated by the system should be continuously of interest to the user and capable of adapting his/her exploration mode and personal preferences. The system presents links to users in groups, i.e., Route Links (e.g. Primary and Last Primary), Exploration Links (Lateral, and Last Lateral), and Previous Stops – a detailed description of the links is given in Section 5.

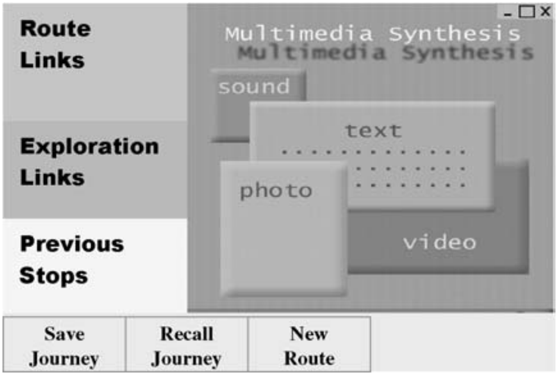

Fig. 2. The Presentation Unit.

3.5. User Profiling

Moreover, the system provides a *User Profiling* function in order to provide users with information that is closer to their interests. The users may give any information they desire about themselves (i.e., age, depth of interest) and their interests (i.e., period, geographic area, special interests etc.) in order to start an ER, i.e., the *Initial User Profile*. They may also redefine any part of this information at any time during their journey. The system also records the profile (i.e., the meta-data) of every IU (or a number of the most recent ones) the users have visited, i.e., the *Recorded User Profile*. Finally, the system tries to find the similarities between initial and recorded profile and propose what the user's profile might be (i.e., *Proposed User Profile*). However, it is not always that the system will be able to propose a profile. All these entities have a common structure which is as follows:

- Age of user (e.g., below 18)
- Depth of interest (DOI) (e.g., High)
- Time period (e.g., 1970 AD)
- Historic period (e.g., British Period)
- Geographic area (e.g., Cyprus-Nicosia)
- Special interests (e.g., Churches)
- Primary interest (i.e., a list of semantic keywords, e.g., Cyprus.British Period.Sience).

3.6. Presentation Unit

The *Presentation Unit (PU)* is what the user sees. It presents an element of information, i.e., IU, and a set of dynamic links. The button 'new route' gives the option to the user to change his/her initial profile and interests and start a new journey. The buttons 'save journey' and 'recall journey' give him/her the option to save and recall journeys. Figure 2 shows the basic components of a PU and Fig. 5 shows the PU for the *Arabic Invasions* IU.

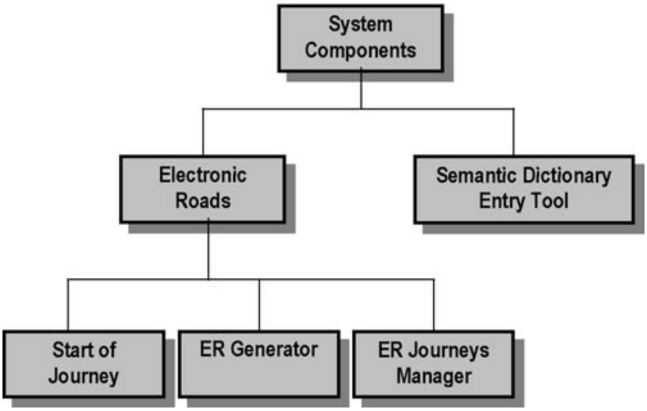

Fig. 3. System components.

4. System Components

The system consists of two main components, i.e., the SD entry tool (only accessed by the cultural experts of the system) and the ER system. Figure 3 presents these components.

4.1. Semantic Dictionary Entry Tool

This component assists the cultural experts to enter in the system and maintain the SD. The SD has a hierarchical structure and consists of nodes, i.e., SD nodes. Each SD node is associated with an IU and its meta-data. This tool is user friendly enough so the specialists could easily add and modify SD nodes and their meta-data (see Fig. 4). The meta-data associated with each IU is shown in Section 3. This tool is available over the Internet, and it could be accessed by the cultural experts of each country.

4.2. Electronic Roads System

This is the main core of the system that any user can access over the Internet (see Fig. 5). This tool gives the capability to travelers to explore the information space by offering links (ER) to information. It consists of the following components:

- *Start of journey*. The user starts a journey by defining his/her profile (i.e., age, depth of interest) and interests (i.e., period, keywords, links to SD). This information is not obligatory but it might be of vital importance to define a good starting point of the journey that will be closer to the user's destination.
- *Dynamic ER generator*. When a journey starts, the system delivers a series of PUs, which consist of dynamic links and IUs. (The functionality of this component is described in detail in the following section.)
- *ER journeys manager*. During the exploration of journeys users can save or recall journeys.
  – *Save Journey*. The user can save his/her electronic journey.
  – *Recall journey*. The user can explore existing saved journeys. Electronic journeys can be created by the user or even provided by the system.

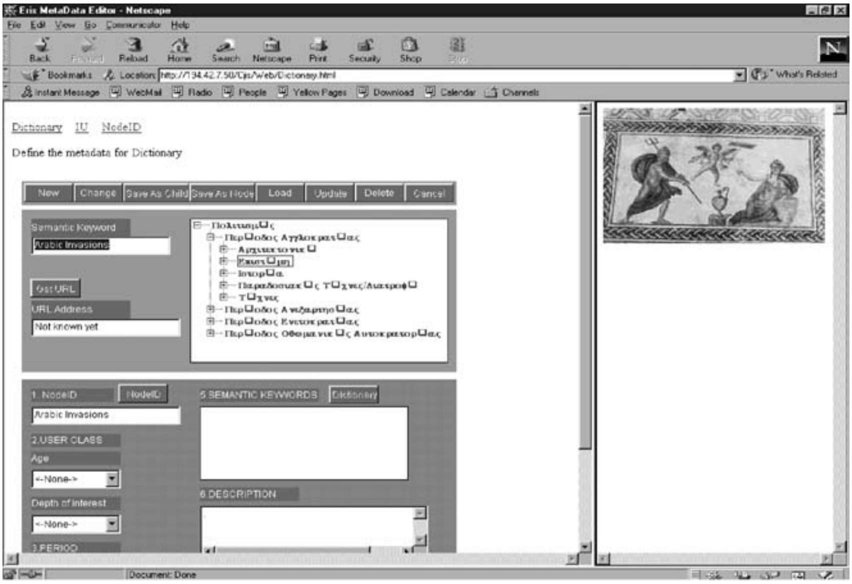

Fig. 4. Semantic Dictionary entry tool.

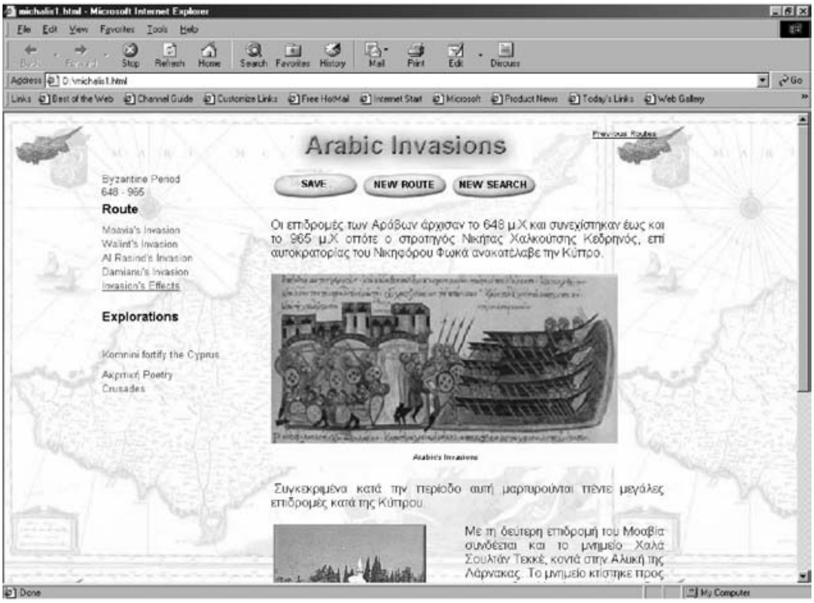

Fig. 5. The Electronic Road system.

5. The Electronic Road's Cycle

This section describes the cycle of activities the system performs every time it generates a new PU, i.e., when the user starts a new journey or selects a new dynamic link. Figure 6 presents the ER cycle.

- *User profiling*. The system generates the Proposed User Profile, which is a function of the Initial User Profile and Recorded User Profile.
- *Link generator*. This module takes as input the meta-data of the current IU and the Proposed User Profile and produces a list of related links.
- *System-based refiner*. The delivery of information via a network needs to meet certain *Quality of Service* (QoS) requirements dictated by the user application (Wang and Crowfort, 1996; Pitsilides et al., 1997). As a result of this module, some IUs might be omitted or have their rank changed. This module is not further described in this paper because it is beyond its scope.
- *IUs selector*. This module takes as input the user's next choice and returns the selected IU.
- *PU composition*. This module takes as input the outputs of the System Refiner and IU selector and produces the final Web document that the user will see.

The remainder of this section describes in detail how the user profile and dynamic links are generated, and presents a scenario of a cultural journey.

5.1. User Profiling

Many of the existing search engines support personalization with the help of predefined user profiles or a collection of customizable parameters such as suggestions about keywords to include or exclude, language choices, document location, etc. These functions can help a search engine find more relevant documents for the user. User profiles are often automatically created, or manually created by users (Bollacker et al., 1999; Chen et al., 1999; Meng and Chen, 1999; Hesley et al., 1999).

The aim of user profiling is to model user interests and predict his/her future interests. In our approach, we try to find the most common characteristics between users' last stops (i.e., Recorded User Profile) and initial profile (Initial User Profile) and propose a user profile (i.e., Proposed User Profile). This approach is inspired by Maes' learning algorithms (Stanfill and Waltz, 1986; Maes, 1994). The result of this module is the Proposed User Profile, which is used in different ways by the Link Generator module, e.g. for link filtering or for finding similar IUs.

A representative example of the results of the above algorithms is illustrated in Table 2. For instance, the user declares initial interest in the British Period (Initial Profile), but in his last stop was exploring an Independence Period IU and so he was in the stop before; thus we could propose that his/her interest is now in both Independence and British Periods.

5.2. Dynamic Links Generator

In search engines the communication between users and search engine is like a dialogue between them: the user gives a query to the engine, and the engine uses the query to search the index database and returns a list of documents. The dialogue finishes when the engine finds the desired documents for the user (Bollacker et al., 1998; Widyantoro et al., 1999).

ER gives the capability to the user to explore the information space in a natural way where the information offered will remain continuously interesting. This is achieved by

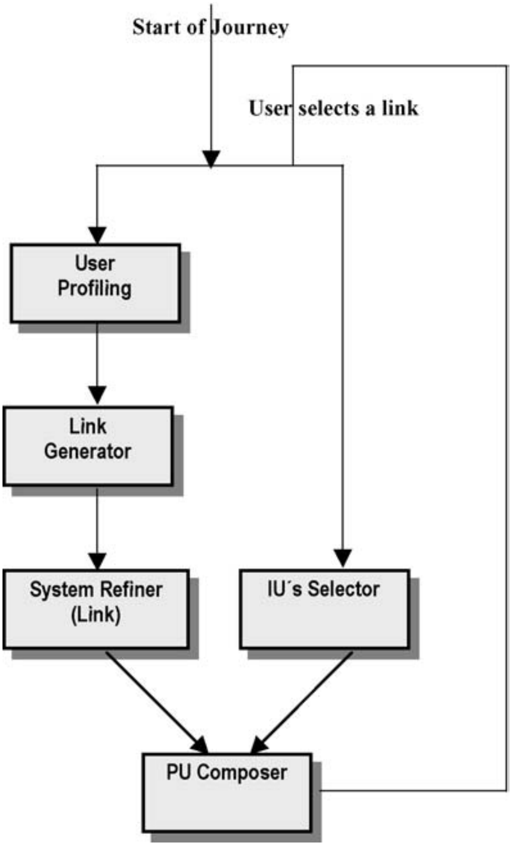

Fig. 6. The Electronic Road's cycle.

Table 2. The Initial, Recorded and Proposed User Profile

	Initial Profile	Recorded Profile (Stop 1)	Recorded Profile (Stop 2)	Recorded Profile (Stop 3 – last)		Proposed Profile
Age	> 18	> 18	> 18	> 18		> 18
DOI	High	Medium	Medium	High	User Profiling	High
Time period						
Hist. period	British	British	Independence	Independence		British, Independence
Geographic area	Nicosia	Nicosia	Limassol	Limassol		Nicosia, Limassol
Special interests	Churches					Churches
Pr. interest		Culture.British Period	Culture.British Period.Arts	Culture.British Period.Arts. Dance		Culture.British Period.Arts

employing intelligent navigation techniques that combine user profiling and meta-data. The system keeps delivering links to the user until the user reaches his/her cultural journey destination. This section describes the algorithms generating the different types of dynamic links; the journey of Appendix 1 is used as an example.

5.2.1. *Primary Links (PL) – Route*

These links give more specific information relative to the current position on the SD. These are the children SD nodes of the selected link (every link is a link to an IU, and every IU is an SD node).

In our example, in Stop 1 where the user selects *Raids Consequences* (i.e., its position on the SD is *Cyprus/Byzantine Period/History/Politics/Facts/Middle Byzantine Period/Arab Incursions/Raids Consequences*) the primary links will be *Capturing the Cypriots*, *Decline of commerce*, *Disasters*.

5.2.2. *Last Primary Links (LPL) – Route*

These are the PL of the last PU and are only generated when a primary link is selected. In any other case, no LPLs are given.

In our example, again, in Stop 1 where the user selects *Raids Consequences*, then *Moabia*, *Oualind*, *Al Risind*, and *Damianos* are becoming the LPL of Stop 2 PU. LPL belongs to the Route set of links and is presented below PL. It should be stated that the selected IU is excluded from the LPLs since it is the IU currently presented by PU.

5.2.3. *Lateral Links (LL) – Exploration*

This is a very interesting and novel way of delivering links to the user that are laterally related to the selected IU. If any of the lateral links are included in LPL or LLL then they are excluded from the LL. This lateral dimension of links is divided into the following types of links:

- *Brother IUs*. These are the brother SD nodes of the selected link. If these links are included in LPL or LLL then they are excluded from this set of links. In Stop 1, *Emperor Fokas liberates Cyprus* is a brother SD node of *Arab Incursion*. In Stop 2 although, *Moabia*, *Oualind*, *Al Risind*, and *Damianos* IUs are brothers to the current IU, they are not included in LL because they are included in LPL.
- *Parent IU*. This is the parent SD node of the selected link and is only given when the selected link is a lateral link (where LPLs are not given). This gives the capability to the user to search more abstract information regarding the current IU. For instance, in Stop 3, where the lateral link *Occupation Consequences* was selected, in Stop 4 the parent IU is given as a lateral link, i.e., *The Period after 1974*.
- *Cross-links*. Every IU has a multi-contextual dimension, i.e., cross-linked with other laterally related IUs. The cross-links of each IU are prioritized and are included in its semantic meta-data. In Stop 1 *Arab Incursion* is cross-linked with *Acreta Poetry* (with SD position *Cyprus.Byzantine Period.Arts.Literature. Poetry.Acretan*). In Stop 2 the *Raids Consequences* is cross-linked with the IU *Occupation Consequences 1974* (with SD position *Cyprus.Independence Period.History.Political.Events.Cyprus Independent State.The period after 1974. Occupation Consequences 1974*).
- *Historic period lateral links*. This is a set of links (usually two: a period before and a period after) with equivalent positions (or as close as possible) on the SD of the

selected IU. If there is not an IU in the equivalent position on the lateral period (most probably there is not) then an abstraction is done to the lateral period. In Stop 1, the selected IU's SD position is *Cyprus.Byzantine Period.History.Political.Facts.Middle Byzantine Period.Arab Incursions.* Historic period lateral IUs will be *Cyprus.Roman Period.History.Political.Facts* and *Cyprus.Frankish Period.History.Political.Facts* which are calculated based on the abstraction of the selected IU, since equivalent identical IUs do not exist in those periods.

- *Similar IUs – (use of the proposed User Profile).* These are IUs with similar content and semantic meta-data to the selected one. The parameters for defining similar IUs are the PUP Primary Interests and the selected IU semantic cross-links. We are trying to identify IUs whose position (usually the abstraction of the position) on the SD is similar to the PUP Primary Interests and also whose cross-links are similar to the selected IU's. As a first step the PUP Primary Interest is abstracted up to the boundary of the universal SD (for instance, in Stop 2 the PUP Primary Interest is *Venetian Rule.History.Politics.Events. The Ottoman Threat.The Ultimatum*, then its abstraction would be *Venetian Rule.History.Politics.Events*). Then, we search all IUs below that point of the universal SD to find IUs with exactly the same cross-links as those of the selected one. If we fail to find any, then an abstraction of their position on SD is done in order to find IUs that are similar as possible. In Stop 2, the current IU has one cross-link, i.e., *Independence Period.History.Politics.Events.The period after 1974.Occupation Consequences*. We are now searching for any other IUs in that scope that have the same or an abstraction of the above cross-link. The IU *Expedition Against Cyprus (Venetian Rule)* does, so it is added to the LL. The following pseudo-code shows the generation of such links:

```
crossLinks= getCrossLinks(selectedIU);
absPI= abstractionToUniversalSD (PUP.PrInterest);
for all childrenIU of absPI do  {
    similarTF= TRUE;
    childrenIUcrossLinks = getCrossLinks(childrenIU);
    for (int t=0; t<crossLinks.length; t++)
        IF abst(crosslink[t])<>abst(childrenIUcrossLinks[t])
             similarTF= FALSE;
        IF similarTF==TRUE
        LL=+ childrenIU;
}
```

The role of the proposed user profile in filtering LL.

In cases where the system returns a number of LL bigger than the maximum number of LL (usually the maximum number is 10), then some of the LL are omitted by filtering them using the PUP. Filtering is achieved by comparing each IU attribute to its equivalent in PUP. IU and PUP attributes are associated with a weight (the sum of weights of attributes for each PUP or IU is always 10) and the sum of weights of common attributes is a measure of similarity between IUs and the PUP. IUs are then sorted by their sums and then IUs with pour sums are excluded from LL.

Table 3 shows how the similarity between IUs and PUP is calculated. Now, IUs will be sorted ascending to their sum of weights and will have the following order: IU3, IU4, IU2, IU1. Assuming that the maximum amount of LL is 3 then IU1 will be excluded from LL. The following pseudo-code shows how the above algorithm could be implemented:

Table 3. Calculation of the similarity between IUs and PUP

PUP or IU attributes	Proposed Profile		IU 1		IU 2			IU 3		IU 4
Age	> 18	1	> 18	1	< 18	0	..	1	..	1
DOI	High	1	High	1	Medium	0	..	1	..	1
Time period		1		0	1100AD	0	..	1	..	1
Hist. period	British	2	Independence	0	British	2	..	2	..	2
Geographic area	Cyprus.Nicosia	2	Cyprus.Limassol	0	Cyprus.Nicosia	2	..	2	..	2
Special interests	Churches	1	Churches	1		0	..	0	..	0
Pr. interest	Culture.British Period.Arts	2	Culture. Independence	0	Culture.British Period.Arts	2	..	2	..	0
Weights sum		10		3		6	..	9	..	7

```
void filterLL (int maxNoLL)
{
            IU temLL=LL;
          int weightAge=1, weightDOI=1, weightTimePeriod=1,
              weightHistoricPeriod=2, weightDistrict=2,
              weightSpecialInterests=1, weightPrimInterests=2;
          int weightSum[]
          int tem=0;

          for all LL[]
          {     weightSum[tem++]=0;
                if LL[tem].Age ==PUP.Age
                      weightSum[tem]=+weightAge
                if LL[tem].DOI==PUP.DOI
                      weightSum[tem]=+weightDOI
                if LL[tem].TimePeriod ==PUP.TimePeriod
                      weightSum[tem]=+weightTimePeriod
                if LL[tem].HistoricPeriod ==PUP.HistoricPeriod
                      weightSum[tem]=+weightHistoricPeriod
                if LL[tem].District==PUP.District
                      weightSum[tem]=+weightDistrict
                if LL[tem].SpecialInterest==PUP.SpecialInterest
                      weightSum[tem]=+weightSpecialInterest
                if LL[tem].PrInterest==PUP.PrInterest
                      weightSum[tem]=+weightPrInterest
          }

     sort weightSum[];
     LL= elimimateLL (maxNoLL, weightSum);
}
```

5.2.4. Last Lateral Links (LLL) – Exploration

These are the LL of the last PU and are only generated when a primary link is selected. In any other case, no LLL are given.

5.2.5. Previous Stops Links (PS)

These are a list of links where the user changes route by selecting an exploration link. The initial value of PS is the starting point of the journey. Then any LL selected are added to this list. PS are the copies of the PUs the user has already visited; i.e., the PUs (dynamic links and content) are not regenerated.

In our example, *Arab Incursions* is the first link in PS as it is the starting point of the journey. When the LL *Occupation Consequences* is selected it is also added to PS.

5.3. A Cultural Journey

Throughout this paper a user's journey is described that starts from *Arab Incursions* (Byzantine Period) and continues until the *Turkish Invasion* (Independence Period) (Appendix 1). The journey starts when a traveler visits our system in order to make a cultural journey and he/she gives his/her personal profile (i.e., age, depth of interest) and interests (i.e., Historic or Time Period, Geographic Period, Special Interests, and Primary Interests). This information is not obligatory but it is very useful for the system in order to identify a good starting point of the journey. The user may change this initial information at any point in his/her journey.

In our scenario, the user declared that he/she was interested in *Byzantine Period* (Historic Period), *Cyprus* (Geographic Area), and *Cyprus.Byzantine Period.History.Political. Facts.Middle Byzantine Period.Arab Incursions* (Primary Interests as the starting position on the SD). The user omitted to enter values for the rest of the profile attributes. With this set of initial user interests the system will start the journey by giving a PU about *Arab Incursions*.

Appendix 1 gives the scenario of this cultural journey. It shows the dynamic links that the system produces. The underlined links are the ones that the user selects to visit. In the first stop, the user selects the primary link *Raids Consequences*. At the *Raids Consequences* stop, the user explores again a primary link (i.e., *Capturing the Cypriots*), which gives more specific information about *Raids Consequences*. At Stop 3, the user selects the lateral link *Occupation Consequences 1974*, which belongs to the Independence Period. *Occupation Consequences 1974* is an LLL and provides lateral content. In Stop 4, the user again selects a lateral link (i.e., *The Period 1964–1974*). This is a cross-link and contains more abstract content and links. In Stop 5, the user selects a primary link, i.e., *Turkish Invasion*, where he/she stops his/her journey.

6. Implementation Architecture of CJIS

A number of different technologies have been employed for the development of the project. Figure 7 predicts the implementation architecture and platforms of the system. The system has a client/server architecture.

A Web-based *user interface* is implemented; the system can be accessed through any Web browser. The system delivers a dynamic HTML document by using Java Server Pages (JSP) (Avedal et al., 2000). JSP achieves that by accessing the Java classes located on the server. JSP technology enables the rapid development of Web-based applications that are platform independent.

The *system* server hosts the server site of the ER program, and the IU content and meta-data. An Apache server and Tomcat were selected, as they inherently support JSP. The ER program was implemented as a Java application (Morrison, 1997). The ER Java classes include the functionality of the whole system, and they are responsible for the interaction with the client (i.e., responding to the JSP), and also for accessing the system's information.

The content of IUs is maintained in *HTML* documents, and the associated meta-data in an SQL *Database management system (DBMS)*. The structure of the IU meta-data is presented in Section 3. The DBMS selected is Oracle (Celko, 1995; Awai et al., 2000). The ER program accesses the DBMS by using RMI (Remote Method Invocation) and JDBC (Java Database Connectivity) drivers (Reese, 2000). Java RMI is used for invo-

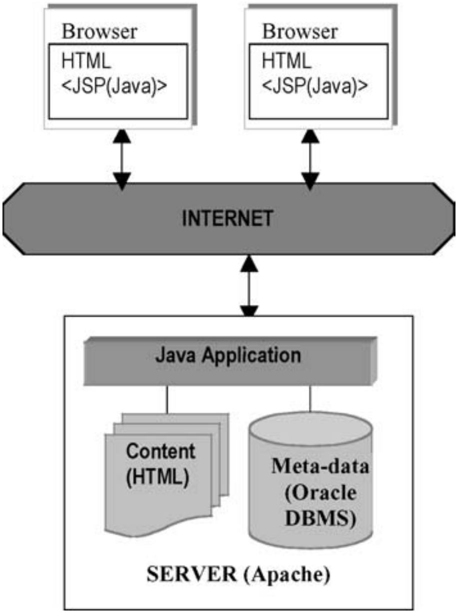

Fig. 7. The proposed system implementation architecture.

cating JDBC methods. RMI is simple and abstract but powerful enough for the communication needs of our system (RMI). JDBC is an API that enables the virtual access of any tabular data source (including Oracle DBMS) from the Java programming language. The ER program uses SQL queries to retrieve information from the DBMS. The DBMS solution was selected for maintaining the system meta-data over the alternative solution of XML technology, since with DBMS retrieving big quantities of information is faster and easier, as indexes and SQL queries may be used.

7. Conclusions

This paper describes an intelligent navigation system through multi-contextual information, which is the result of the CJIS project. The main objective of this navigation system is to give the capability to the traveler to explore the information space in a natural way where the information offered remains continuously interesting. Novel information retrieval techniques and algorithms combine user profiling and meta-data in order to generate dynamic ERs. For this purpose, an intelligent navigation tool has been developed, i.e., the ER system, which concentrates on cultural and historical information.

A central challenging issue in the formation of ERs is the way the available information is structured; every piece of available information is associated with meta-data. This information is organized in a tree structure, i.e., the Semantic Dictionary. The SD is created and entered in the system by the cultural experts. This together with the entry of meta-data for every piece of information in the system is a huge and expensive effort and methods should be found to semi-automate this task.

In the future we are studying ways to scale up the system by entering a larger amount of information, distributed to different servers. We are going to examine the performance of the scaled-up system and try to improve and adjust the retrieval algorithms. We also want to investigate the networking issues involved in such a system, by studying alternative solutions and making the appropriate modifications to our retrieval techniques.

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A. Appendix

Stop 1
Arab Incursions
(Byzantine Period, 365–1192 AD)

Previous Stops

Route
Moabia
Ouakind
Al Rasind
Damianos
Raids Consequences

Explorations
Emperor Fokas liberates Cyprus
Acreta Poetry
Events in Frankish Period
Events in Roman Period

Stop 2
Raids Consequences
(Byzantine Period, 365–1192 AD)

Previous Stops
Arab Incursions

Route
Capturing the Cypriots
Decline of commerce
Disasters

Moabia
Ouakind
Al Rasind
Damianos

Explorations
Occupation Consequences 1974
Expedition Against Cyprus (Venetian Rule)

Emperor Fokas liberate Cyprus
Acreta Poetry
Events in Frankish Period
Events in Roman Period

Stop 3
Capturing the Cypriots
(Byzantine Period, 365–1192 AD)

Previous Stops
Arab Incursions

Route
Cypriots in Artaki
Cypriots in Syria and Babylon

Decline of commerce
Disasters

Explorations
Events in Frankish Period
Events in Roman Period

Occupation Consequences 1974
Expedition Against Cyprus
(Venetian Rule)

Stop 4
Occupation Consequences 1974
(Independence Period, 1960–2000 AD)

Previous Stops
Arab Incursions

Route
Refugees
The missing Cypriots
The enclaved Cypriots
Destruction of culture heritage

Explorations
The period 1964–1974
Cyprus issue after 1974
The road to European union
Cyprus international position
The period after 1974
Events in British Period

Stop 5
The Period 1964–1974
(Independence Period, 1960–2000 AD)

Previous Stops
Arab Incursions
Occupation Consequences 1974

Route
T/Cypriots Enclaves
Greek Military Division
Cofinou Crisis
National Front
Turkish Invasion

Explorations
The period after 1974
The period 1960–1964
Cyprus Independent Country
Events in British Period

Stop 6
Turkish Invasion
(Independence Period, 1960–2000 AD)

Previous Stops
Arab Incursions
Occupation Consequences 1974
The Period 1964–1974

Route
T/Cypriots Enclaves
Greek Military Division
Cofinou Crisis
National Front
Turkish Invasion

Explorations
The period after 1974
The period 1960–1964
Cyprus Independent Country
Events in British Period

B. Appendix see figure on next page.

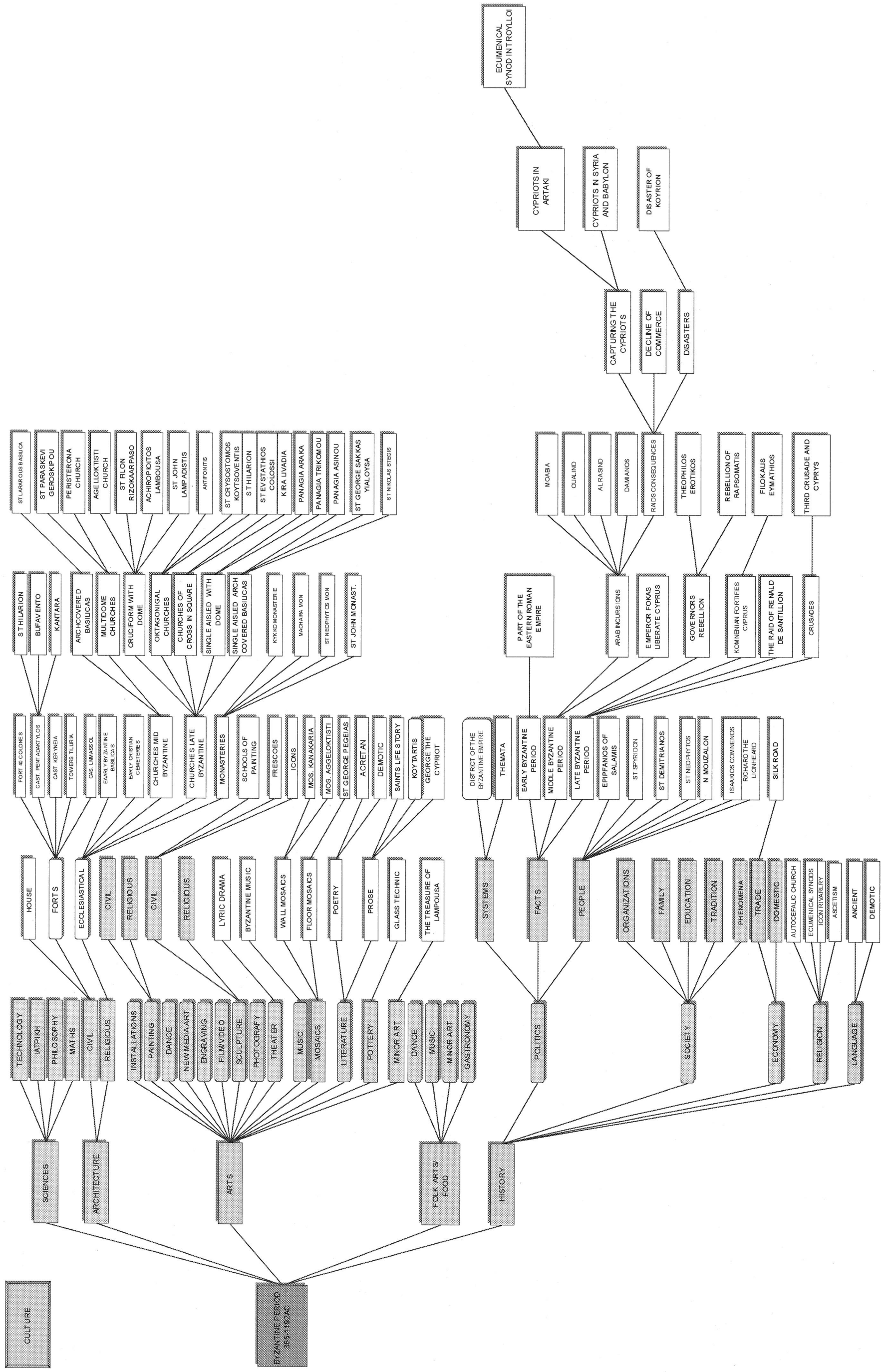

Fig. 8. The Cyprus Cultural Semantic Dictionary – Byzantine Period.

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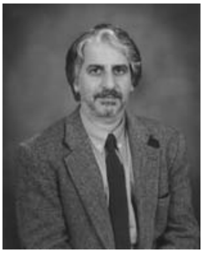

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