Provision of Multimedia Content Search and Retrieval Services to Users on the Move

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Abstract. In this paper we present a mobile application for the seamless and effective provision of networked multimedia content search and delivery services to users on the move. The VICTORY project had as an outcome a framework enabling users to search and retrieve multimedia objects over a distributed Peer to Peer - based network. Building upon the VICTORY framework, a mobile user agent was developed, which by the use of appropriate Web Services has the ability to connect to different P2P communities in order to search for and retrieve multimedia content. The content delivered follows the notion of the "MultiPedia" object, defined for the purpose of seamless and effective content search and delivery within the VICTORY Framework.

Keywords: 3D Content Search and Retrieval, PDA Application, Web Services, Multipedia Content.

1 Introduction

Mobile devices play a key role in our everyday life. Their advanced networking and processing capabilities offer us the opportunity to use them at "any-place and any-time", in a wide application spectrum. Search and retrieval of networked multimedia content is an application area of great importance and is expected to be of even greater in the years to come. However, for each different network or infrastructure offering this kind of functionality, usually a different client application is needed from the end users in order to effectively utilize the offered capabilities.

Focusing on 3D content, one easily may identify that only a few 3D search engines are currently available worldwide, most of them providing their functionality through a dedicated web site: The "Princeton 3D Model Search Engine" [1], developed in the Princeton University, supports 2D-sketch-based search, 3D-based search and combination of them with text-based search. The "3DTrue Search Engine" [2] is a commercial tool that supports only text-based search over huge repositories. The "ITI Search Engine" [3] allows for searching with existing model as a query only. The "MeshNose" [4] search engine supports only text-based search, however it has indexed many 3D repositories. Finally, the "Geolus" search engine, a product of the

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UGS Corporation, is an integrated 3D search component of the commercial software Partfinder [5], product of the Solid Edge Company. Searches for similar parts are based on geometrical descriptors, extracted from the 3D objects.

Even though users currently have the ability to search for multimedia content within various different repositories, in order to do so, they have to use different user agents to access each of them. The proper integration of content repositories like the above would significantly benefit the quality of the search and retrieval procedure, since it would allow for the seamless search of multimedia content within different sources. In order for the different infrastructures that offer 3D content search and delivery capabilities to converge in the future, three pre-requisites can be identified:

- Definition of common generic data formats and standards allowing for the seamless search and delivery of multimedia content.
- Deployment of architectures allowing for diverse end user agents to utilize the networks.
- Development of innovative and adaptive client applications, which will finally provide the required functionality to end users.

Towards this direction, we built upon the VICTORY framework described in Section 2, which provides the two first pre-requisites. In this context, a mobile application was developed, capable to connect to different networks and communities in order to seamlessly search for and retrieve multimedia content. Our developed client application can be considered to be a very helpful tool for a wide range of user groups dealing with multimedia and especially 3D content, like 3D game designers, engineers working in design departments of the automotive industry etc, since the demanding task of 3D and multimedia content search and retrieval, often necessary for their daily tasks is simplified and furthermore, has become "mobile".

In the following, a description of the VICTORY MultiPedia object concept, used within our mobile application is initially provided, followed by an overview of the VICTORY service-oriented framework's architecture that allowed for the development of our mobile user agent. Finally, we describe our developed mobile application which delivers all the required functionality to the end users.

2 An Overview of the VICTORY Framework

The VICTORY project [6] has developed a framework enabling users to search and retrieve multimedia objects over a distributed P2P-based network [7][8]. By defining the notion of the "MultiPedia" object and a three-layer, service oriented architecture; it provided the means for the deployment of diverse and adaptive user agents.

2.1 The VICTORY "MultiPedia Object" Concept

In order to effectively utilize the VICTORY P2P-based infrastructure's capabilities, our developed PDA application operates on the basis of the VICTORY framework's "MultiPedia object" concept, where visual information is described as a 3D object along with its accompanied information (2D views, text, audio, and video).

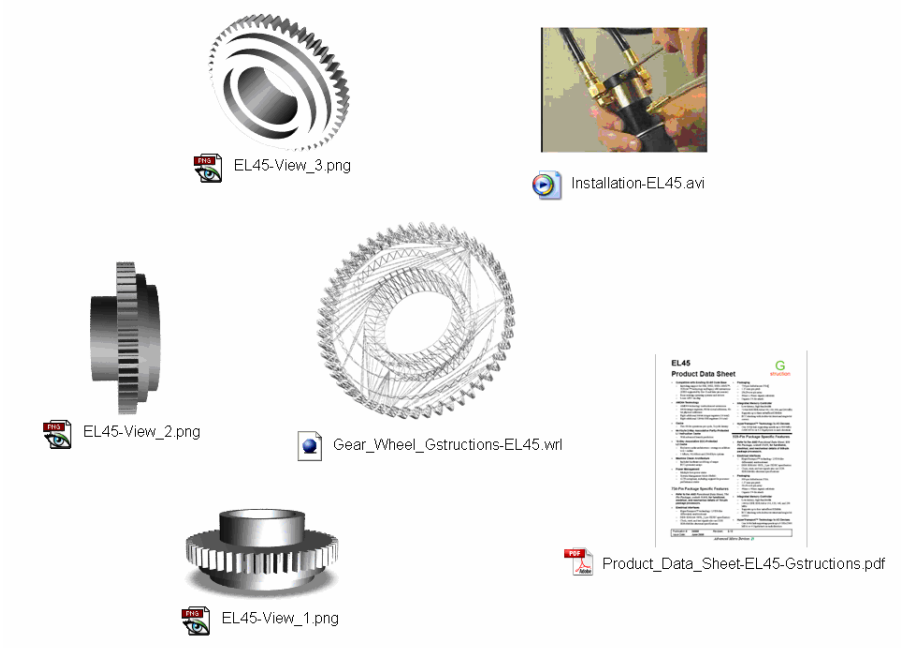

Fig. 1. An example of MultiPedia content

An example of MultiPedia content is given in Fig. 1, where the following content types are identified:

- A 3D object: it is available in VRML format (.wrl file). However, multiple other 3D file formats can be supported such as X3D, OFF, OBJ, 3DS, and so on.
- Multiple views of the 3D object: these are 2D images in any of the common image file formats.
- Textual information: it is available in several text file formats (.pdf, .doc, .txt, etc.) and it may include product information (data sheet), installation instructions, description of the 3D object or any other type of information that can be provided in text.
- Video: it is available in several common video file formats (.avi, .wmv, etc.) and may include additional information, such as demos, installation instructions, etc.

2.2 VICTORY Service-Oriented Architecture

VICTORY developed a framework for P2P-based search and retrieval of multimedia objects. The P2P middleware that was developed for VICTORY allows for generic content sharing among peers in the network. However, mobile peers, due to their limited resources, are not capable of running a fully featured P2P communication platform, neither are they capable of performing other resources consuming tasks

locally. Therefore, it was decided that mobile devices would access the Internet-based segments of the VICTORY network through a dedicated Gateway. The services running on the Gateway perform various resource consuming tasks on behalf of the mobile clients, and provide the means for device and application-independent access to the overall functionality offered by the network.

The concept of the VICTORY framework's service-oriented approach is depicted in Fig. 2. VICTORY has proposed an architecture that consists of three layers. The "Backend Service Layer" provides all the required core functionality for the search and retrieval of MultiPedia objects. It consists of: a P2P Service module, providing a Networking Stack for seamless and efficient content delivery, a Search Engine (SE) Service module that provides the desired Indexing and Search functionality, a Low Level (LL) Feature Extraction Service providing the system with advanced descriptor extraction capabilities, and Remote Rendering Servers that offer the means for a "Remote Rendering Visualization" service [9] when remote rendering visualization is applicable.

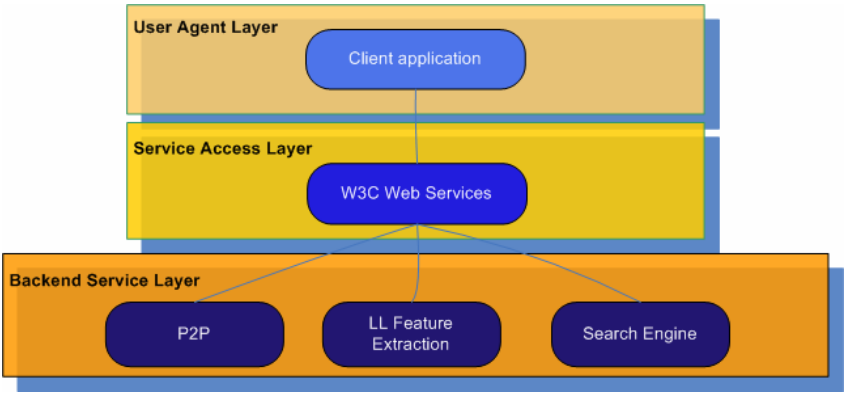

Fig. 2. The VICTORY service-oriented architecture

The "Service Access Layer" plays the key role in our case, by providing all the required functionality offered by the "Backend Service Layer" to the mobile client application in a device and application-independent form. The basic services offered by the VICTORY Mobile Gateway are the following:

- Extraction of low-level features from sketch, 2D and/or 3D objects. For the extraction the file needs to be uploaded to the mobile gateway first. The low level features are then extracted and returned to the mobile device.
- MultiPedia content search. This service is used in the combination with low-level features extraction service. Once the client compiles a search query (including low-level features), this query is sent to the search service which then propagates it to the P2P search engine.
- Retrieval of MultiPedia content from the P2P network. The content that is retrieved from the P2P network on behalf of a mobile device is stored on the gateway and can be retrieved by the mobile device using ordinary HTTP based file transfer.

The Service Access Layer was implemented on the basis of the WS-I Basic Profile Version 1.1 [10] and the Apache Axis2 Framework [11]. All this "wrapped" functionality is finally provided to end users through the "User Agent Layer", which can be implemented as any mobile client application that conforms to the standards defined within the Service Access Layer. Our developed VICTORY PDA application is such a mobile end user agent application.

3 The "VICTORY PDA" Mobile Application

In order to deliver all the functionality derived from the service-oriented approach described above to end users on the move, we developed "VICTORY PDA", a mobile user agent application for PDA devices, based on the .NET Compact Framework [12] v3.5. This application is the result of the integration of several modules, each of them dedicated to provide a specific functionality. These modules have the ability to communicate with each other, in order to provide seamless interaction to the end users. The main building blocks of the VICTORY PDA end user application are:

- A module allowing users to select 2D images or 3D models as input for the search of 3D objects.
- A module enabling users to draw their own sketches and use them as input for the search of 3D models.
- A module enabling the search for 3D models and the retrieval of the results.
- A module enabling users to form queries by using high and low-level features
- A 3D-Visualization module.
- A module enabling the invocation of the appropriate Web Services.

The VICTORY PDA application enables users to connect to any of the VICTORY framework's communities and: select the desired inputs in order to form a search query, submit it to the search engine, retrieve any of the search results and visualize it.

3.1 A "VICTORY PDA" Use Case

Prior to the submission of a search query, the user has the ability to form it, through the User Interface depicted in Fig. 3 (a) and (b). The User Interfaces shown in these figures have the same functionality, however, due to the fact that in these two cases the user has connected the application to different communities, their graphics differ in order to inform the user about the community s/he is connected.

The user can form the query by defining various high-level attributes like a keyword, the maximum allowed file size of the results retrieved, categories, and so on. Furthermore, the user has also the ability to "use a file in search", which means that s/he can either select a 3D model that already exists within the device's storage memory, a 2D image, or a new sketch drawn, get the selected file's low-level descriptors and use them as input for the search query. Fig. 3 (c) shows the UI enabling the user to select an existing 2D image, which can be a photo taken from the PDA device, or in general, any image file stored in it. The user draws the contour of the object depicted that s/he wants to search for (Fig. 3 (c)), and by selecting to "use it

in search", the application contacts the Gateway's Web Service responsible for the extraction of Low Level Features, by providing as input the user's selection. When the service finishes the feature extraction procedure, VICTORY PDA retrieves the extracted features and populates the user's query with them. As a result, the user is shown again the UI depicted in Fig. 3 (a) or (b), with the difference that it now also shows the user's selection that will be used for the query (Fig. 3 (d)).

Fig. 3. Forming a search query

The sketch drawing functionality offered to the users is similar to the functionality described above, except from the fact that in this case the user draws on a "blank" (white) background. Regarding the 3D model selection procedure, the user is initially shown a list with the 3D model-files stored in the device. After the selection of a model, the Feature Extraction Gateway Web Service is invoked with the specific model as input; its low level features are retrieved and they finally populate the user's search query in a similar procedure like the one described above.

After the user finishes with the forming of a query, s/he can search for MultiPedia content within the VICTORY network. For this purpose, the PDA application invokes the "MultiPedia content search" Web Service provided by the VICTORY Mobile Gateway, responsible to forward the search request to the VICTORY P2P-network's search engine. As a result, the search engine searches within the network and if

appropriate results are found, a list with details over them is returned back to the search web service. Finally, the service responds to the VICTORY PDA application with the list of the results found.

Fig. 4. MultiPedia content retrieval

This list is then presented to the end user by the means of the User Interface depicted in Fig. 4 (a). As a next step, the user can select to view the details of each MultiPedia object found (Fig. 4 (b)), and if desired, s/he can initialize the downloading procedure (Fig. 4 (c)). This involves the invocation of the "retrieval of MultiPedia content from the P2P network" Gateway Web Service. The file is retrieved from the network and stored in the device's storage memory. The user is now able to "visualize" the retrieved model. This functionality involves either the use of a 3D remote rendering-based visualization module, or the use of a "local 3D rendering" application for PDA devices.

A beta version of the system was initially tested on a PDA device with a 400 Mhz processor and 128 MB RAM, connected to VICTORY through a typical 8Mbps ADSL Internet connection. The response time for the feature extraction procedure was found in average around 6 seconds for 2D images, while for 3D models was higher, depending on the size of the 3D model file uploaded to the Gateway. For a relatively small file (22 kB), this response time was around 8 seconds in average. For the search process, the system's response time was found to be about 6 seconds in average.

4 Conclusions

Search and retrieval of networked multimedia content in a seamless fashion is one great challenge for the years to come. Even though internet-based search engines of multimedia content already exist, appropriate frameworks and client applications that will provide seamless search capabilities among different communities and networks have to be further research and developed. The advanced networking and processing capabilities of mobile devices offer them the possibility to be used in a wide area of applications. Focusing on the above two dimensions, our developed mobile user agent provides users the ability to connect to the different communities of a P2P network and utilize its search and retrieval capabilities among diverse repositories. Furthermore, it has the ability to connect to any network that follows the service oriented approach proposed by the VICTORY framework. By utilizing the capabilities offered by the technology of Web Services and by using the concept of the "MultiPedia" object defined within the VICTORY framework, our mobile user agent manages to provide an effective adaptive solution towards seamless multimedia content search and delivery.

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