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Web Service Workflows for Distributed Visual Media Retrieval Framework

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ABSTRACT

The need for content-based retrieval from visual media, such as image and video data, is ever increasing rapidly in many applications, such as electronic art museums, internet shopping malls, internet search engines, and medical information systems. In our previous research, we proposed an architecture, called the HERMES, which is a Web Service-enabled visual media retrieval framework. In this paper, we propose the Web Service workflows that are employed in the HERMES. We describe how we designed the workflows for service registration and query processing in the framework. We especially explain how metadata and ontology can be utilized to realize more intelligent content-based retrieval on visual media data.

Keywords: Visual media Retrieval, Workflow, Web Service, Service Ontology, HERMES

1. INTRODUCTION

Searching visual data is one of the essential functions for multimedia database systems, which take important role in majority of emerging information technology applications, such as electronic art museums, GIS(Geographical Information Systems), digital library, internet e-commerce, EDMS(Electronic Document Management Systems), and medical information systems. The need for content-based image retrieval(CBIR) from visual media databases is ever increasing rapidly in these applications.

The pioneering work has been done by IBM's QBIC(Query By Image Content) system, which supports queries using color, shape, sketch, and texture features on images, such as post stamps, art pictures, and trademark drawings[1]. The Chabot system was another interesting CBIR system, with high level concepts, such as "light yellow" and "sunset," as well as low level features based on color[2]. One of the most recent research work has been done by the SIMPLIcity system which supports CBIR based on the color, texture,

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shape features, while increasing matching correctness by utilizing local features on regions[3]. In the medical domain, the KMeD(Knowledge-Based Medical Database) system utilizes semantic modeling focusing on object shapes and spatial relationships between them[4,5].

Web Services are a standardized way of integrating Web-based applications using open standards including XML, the SOAP(Simple Object Access Protocol), the WSDL(Web Service Description Language), and the UDDI(Universal Description, Discovery, and Integration) specification. XML structures the message, SOAP transfers the message, WSDL describes the available services, and UDDI list them. XML describes both the nature of each self-contained function and the data that flows among systems[6]. The SOTA is an ontology-mediated Web Service system for smart office task automation[7]. The previously developed visual media databases, such as QBIC, Chabot, NERD-IDB, etc, can be considered as visual media service providers from the viewpoint of Web Services. The main idea of this paper is to exploit the Web Service-based approach to support intelligent retrieval on large volumes of visual media resources, widely distributed over the web.

This paper is an effort to make visual media, such as image and video data, better utilized by visual media consumers. The major purpose of this paper is to show how visual data, widely spread over the internet, can be effectively searched using Web Service technology and to present how semantic metadata and ontology can be utilized to realize more practical and intelligent content-based retrieval on visual data. In our previous research, we proposed an architecture, called the *HERMES (tHE Retrieval framework for visual MEdia Service)*, which is a Web Service-enabled visual media retrieval framework[8].

The remainder of this paper is organized as follows. Section 2 describes overview of the visual media service architecture. Section 3 proposes Web Service workflows for service registration and query processing. Comparison with related works is described in section 4. Finally, section 5 concludes the paper.

2. HERMES ARCHITECTURE

In this section, we briefly review the overall architecture of the visual media service framework and the Service ontology for the visual media service finding.

2.1 Web Service Architecture

The architecture named the *HERMES* is a Web Service-enabled visual media retrieval framework architecture which consists of HERMES/B node (Web Service broker) and multiple HERMES/P nodes (Web Service providers), each servicing visual media resources using their own metadata standard format or customized metadata format. The overall HERMES architecture is depicted in Figure 1. There are other entities that provide local and/or global feature extraction services, called F.E.S (Feature Extraction Service) Providers.

The HERMES/B consists of modules, such as Query Handler, Query Processor, Query Result Integrator, Matchmaker, Service Inference Engine, Metadata Mapping Manager, Service Registration Handler, and Feature Handler, as shown in Figure 2. The Query Handler of HERMES/B receives user

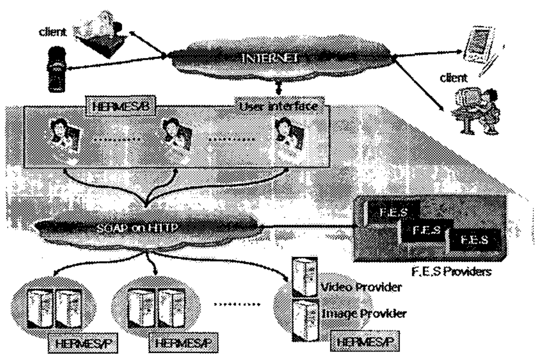


Fig. 1. HERMES Architecture.

queries, reformulates queries using metadata and service ontology, and sends the reformulated queries to HERMES/Ps. The Query Processor transforms query string into provider-specific XML queries. The Query Result Integrator combines query results and sends them back to users. The Matchmaker finds best service provider list for the given query. The Service Inference Engine determines service provider list by using Service Ontology and Service Registry. The Metadata Mapping Manager transforms query string into provider-specific format by using Metadata Registry. The Service Registration Handler registers services provided by HERMES/Ps. Provider-specific service and metadata information are stored in Service Registry and Metadata Registry. The Feature Handler selects suitable F.E.S. Providers and/or obtains features using them.

The HERMES/P consists of modules, such as (local) Query Processor, Visual Media Manager, Provider Inference Engine, Semantic Metadata Manager, Visual Media Search Engine, Provider Registration Handler, and Semantic Annotator. The Query Processor of HERMES/P receives and extends reformulated queries from HERMES/B. The Visual Media Manager coordinates image searching processes. The Provider Inference Engine reformulates user queries by using Provider Specific Ontology. The Semantic Metadata Manager manages semantic metadata for each image using Semantic Annotator. Semantic

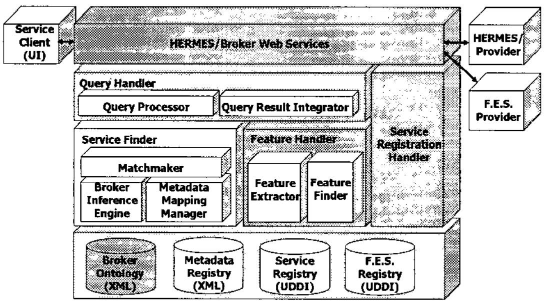


Fig. 2. HERMES/B architecture(adapted from[8])

metadata consists of description metadata, global feature, local feature and semantic contents metadata. Concepts in query term are transformed into corresponding color values. The Visual Media Search Engine searches provider images by utilizing description metadata, global feature, local feature and semantic contents metadata. This module performs similarity-based retrieval using multi-dimensional index structures, such as B-trees and R-trees. The Provider Registration Handler receives image category and common metadata information from HERMES/B. Reports provider service types and metadata standard types (or its own metadata schema) to HERMES/B. The Semantic Annotator is a provider-side tool to annotate metadata for each image.

2.2 Visual media service finding

The representative sample queries are as follows: find 'modern painting' images whose creator is 'Albers' (Q1), find 'passionate' images whose creator is 'Van Gogh' (Q2), find photos of 'Californian' nature (Q3) and find pictures similar with the given image (Q4). Q1-Q3 are example queries, which require ontology-based service site matchmaking and metadata mapping. For Q4, we need to extract global and local features of the sample image by using F.E.S.(Feature Extraction Service) Providers.

To find the most appropriate Services, the Broker Inference Engine extends service domains by using Broker Specific Ontology, the Matchmaker finds Web Services using the extend service domains and ranks Services using information on Service sites in Service Registry, and finally the Metadata Mapping Manager transforms the HERMES/B metadata into provider-specific metadata.

2.3 Service ontology

Figure 3 shows Service Ontology of HERMES/B. The Service Ontology can be viewed as the superset of all the provider-specific ontologies from the HERMES/P. In other words, the provider-specific ontologies of the HERMES/P take the part of the Service Ontolgy. In this paper, the ontologies are assumed to have the tree form. The Service Ontology is stored in RDF format. The RDF has the form of subject-property-object which can easily represent various relationships such as 'is-a'. This ontology and Service Registry(UDDI) are used to determine service provider list.

3. WEB SERVICE WORKFLOW

In this section, we will first describe the Web Service interfaces for HERMES/B, HERMES/P and F.E.S. Providers, and then show the basic service workflow of the system in terms of two important scenarios: service registration and query processing scenarios.

3.1 Web Service interfaces

HERMES/B provides the following Web Service interfaces: *getAllDomains* returns the list of all domains derived from the service ontology; *registerMe* registers a named service provider to HERMES/B together with information about metadata schema; *getFESInfo* returns the list of Feature Extraction Services for a specific domain images; *acceptQuery* accepts client's query and returns a set of images collected from one or more service providers. HERMES/P provides *acceptQuery* interface, which analyzes reformulated query from HERMES/B and returns appropriate images. Feature Extraction Engine provides *GetFeatureInformation* interface, which receives a list of images and returns the list of extracted features.

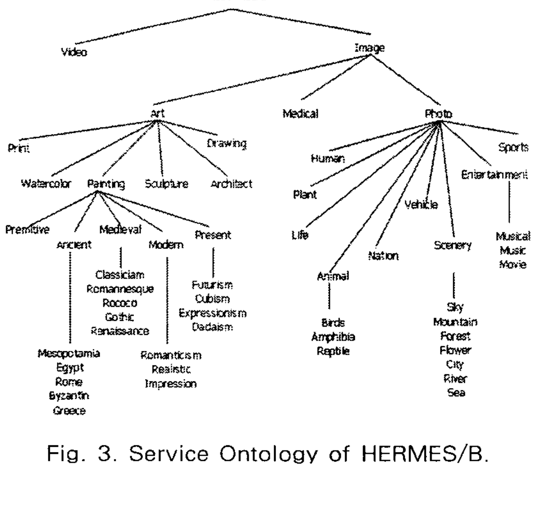


Fig. 3. Service Ontology of HERMES/B.

3.2 Service registration

In this scenario, service providers register themselves on the HERMES/B together with the information about their metadata schema. As shown in Figure 4 and Figure 5, the service registration occurs in two phases: Service domain search and Service provider registration.

In first phase, the Provider Registration Handler of HERMES/P first calls getAllDomains() service of HERMES/B and receives visual media service

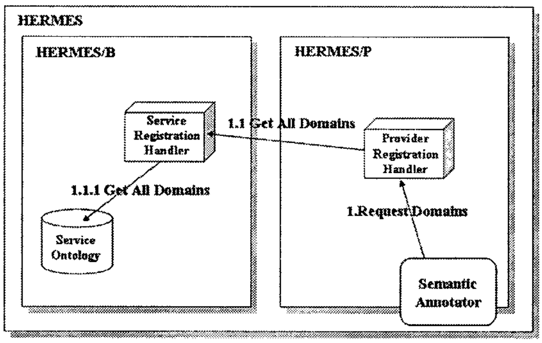


Fig. 4. Service domain search.

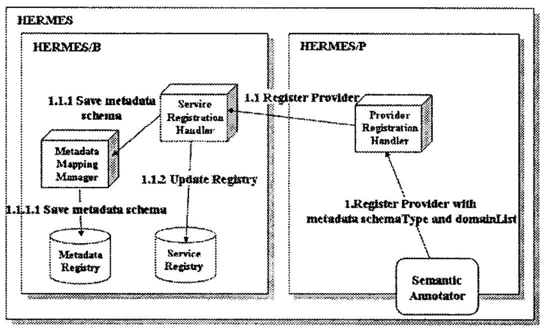


Fig. 5. Service provider registration.

domain information and service ontology from Service Registration Handler of HERMES/B. It then determines its corresponding service domain from the list.

In second phase, the Provider Registration Handler registers itself by calling registerMe() service of HERMES/B, while providing information, such as provider ID, domain list, metadata schema type, metadata schema version and metadata schema. This service call is received by the Service Registration Handler of HERMES/B. The Service Registration Handler then calls registerProvider() service of the Service Finder and stores UDDI-related information, such as ProviderID, Service Key, Service URL and tModel, into Service Registry and service domain list and metadata-related information into Metadata Registry.

The service domain list information is stored into Matchmaker Cache table of Metadtata Registry by referencing appropriate Service Ontology and Service Registry(Figure 6).

3.3 Semantic annotation

Service providers can optionally use the Semantic Annotator for their registration for convenience purpose, as shown in Figure 7(a) and 7(b). Also, the Semantic Annotator of HERMES/P provides metadata fill-in form to insert description metadata and semantic contents metadata for each image, as shown in Figure 7(c).

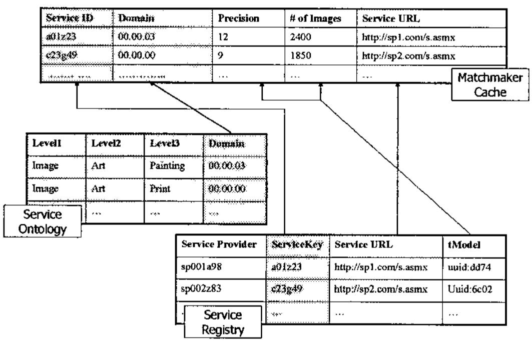
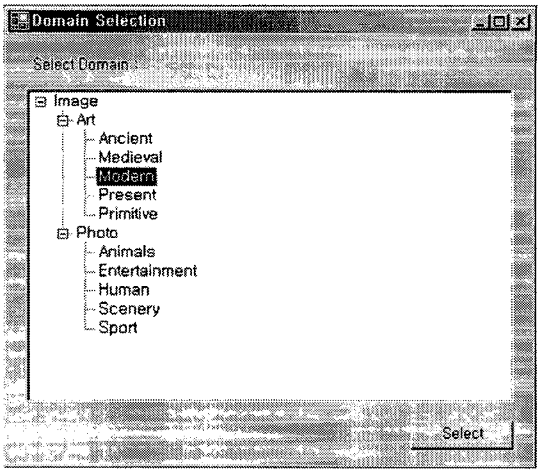
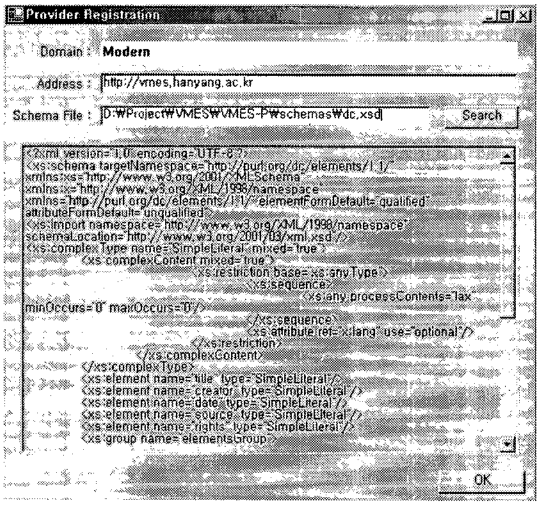


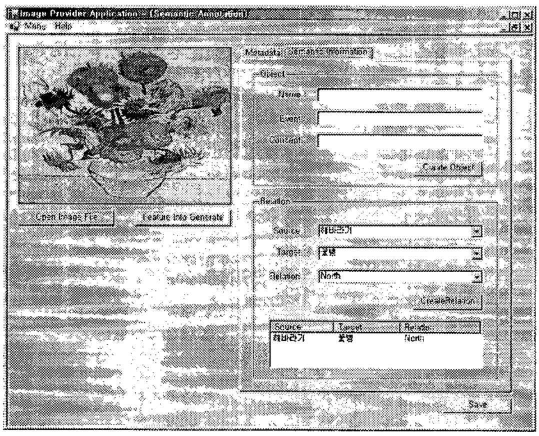
Fig. 6. Handling service domain information.



(a)



(b)



(c)

Fig. 7. Semantic annotator.

The input fields of this semantic annotation form are determined according to the metadata standard used by each HERMES/P. The 'Feature Info Generate' button is used to invoke the Feature Extractor of HERMES/P, which extracts the global and local feature metadata, such as color, shape and texture, by using external F.E.S. Providers. The whole metadata for each image, including description, global feature, local feature and semantic contents metadata, annotated manually or generated automatically, are stored as the Semantic Metadata of corresponding HERMES/P.

3.4 Query processing

When user(Service Client) fills query form, the query string is received by acceptQuery() service of the Query Handler of HERMES/B. The Query Handler then calls customizedQueryWithProviderList() service of the Service Finder. The Service Finder returns service provider list with provider-specific queries, which are reformulated by using service ontology and metadata mapping information of HERMES/B. For Q1, the appropriate service providers for 'modern painting' is determined by considering Service Ontology, Service Registry and Matchmaker Cache table of Metadata Registry. To find which providers service the 'modern painting', the Service Ontology is traversed from the root to the target node (Visual Meida - Image - Art - Painting - Modern, for Q1). All the nodes under the target node (Romanticism, Realistic, and Impression, for modern painting) are traversed too. Any provider that services any of the resulted node set should be included in the target provider list. The provider-service information is of course located in the the Service Registry and Metadata Registry. For example, a provider that services 'Art' is included in the target provider list while the provider that services 'Photo' is not. Q3 is similarly processed: 'Scenery' under 'Photo' is the target node in this case. The query like Q2 is not easy to determine the provider list since there is no provider-specific information in the query. The query is simply transferred to all the providers. Figure 8 shows the collaboration diagram for the query processing on the part of HERMES/B.

The reformulated queries by HERMES/B are transferred to HERMES/P by calling acceptQuery() service of HERMES/P wrapper interface. A query received by HERMES/P is sent to executeQuery() service of the Visual Media Manager and then reformulated again by considering provider-specific ontology and semantic metadata of HERMES/P. In case of Q1, the 'modern painting' is expanded to {'Romanticism', 'Realistic', and 'Impression'} using the provider-specific ontology in HERMES/P so that the search engine can easily match the target images. In case of Q2, the emotional term 'passionate' is changed to corresponding color values by using Semantic Metadata[9]. The final formulated query is then transferred to the Visual Media Search Engine of HERMES/P. Query results from the participating HERMES/Ps are finally combined, ranked, and returned to the Service Client by the Query Result Integrator of HERMES/B. Figure 9 shows the collaboration diagram for the query processing on the HERMES/P.

In case of Q4, the internal workflow of both HERMES/B and HERMES/P are still similar to that of previous query examples, except that interaction with external (possible internal) F.E.S.

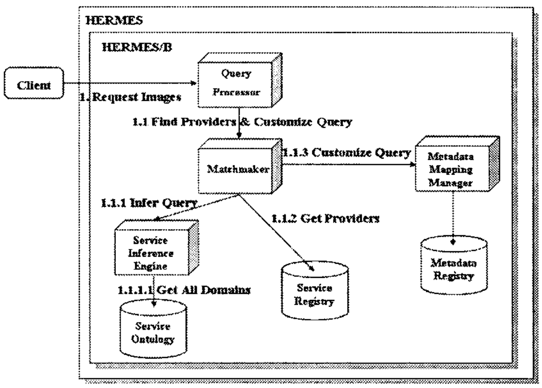


Fig. 8. Query processing on HERMES/B.

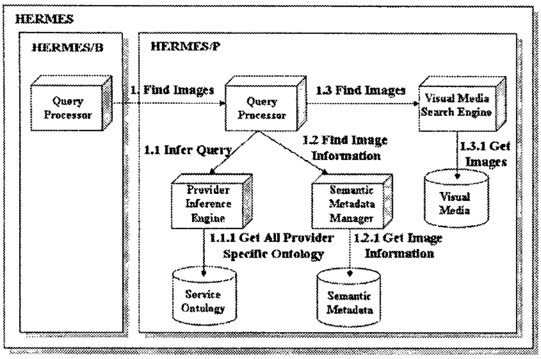


Fig. 9. Query processing on HERMES/P.

Providers are required to extract local and global features from the submitted image. Figure. 10 shows the collaboration diagram on the HERMES/B for queries of type Q4.

4. COMPARISON WITH RELATED WORKS

The visual media retrieval techniques can be divided into two categories: one is content-based image retrievals(CBIRs) which are usually based on the low-level features, such as color, texture, and shapes, and another is metadata-based retrievals, such as Photobook[10] and QBIC, which are based on high-level features, such as objects contained in image contents. But, most of these methods have inherent limitations, utilizing only keywords for image retrieval. To overcome such restrictions, Semantic Web and ontology-enabled systems have been proposed to allow inference-based image retrievals[11,12]. However, such systems only allow image searching on limited image domains. The Chariot System[13], which was proposed to overcome such limitation, allows image retrieval on images distributed over the network, while providing image providers with certain autonomy. But, Chariot still relies on keyword-based retrieval. We have developed HERMES to overcome all the limitations described earlier, while allowing visual media retrieval using metadata and ontology on images distributed over the network, while providing image providers with its own local autonomy. Table 1 compares between HERMES and other related systems from the viewpoint of processing styles, metadata support and ontology support.

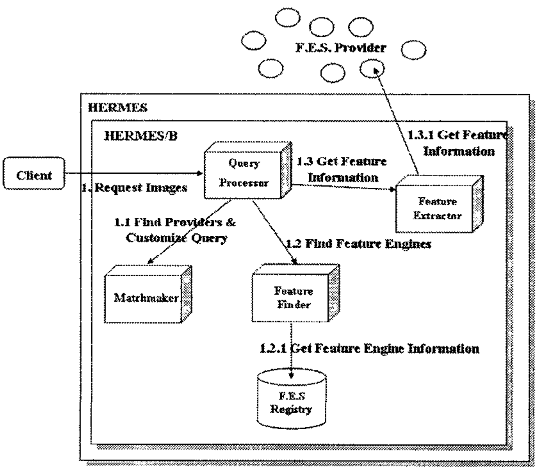


Fig. 10. Query processing for Q4 on HERMES/B.

5. CONCLUSION

In this paper, we proposed the Web Service-driven workflows for service registration and query processing on the *HERMES* architecture, which is a Web Service-enabled visual media retrieval framework architecture which consists of HERMES/B (broker) and multiple HERMES/P (provider), each servicing visual media resources using their own metadata standard format or customized metadata format. Especially, we explain

Table 1. Comparison of HERMES with other related systems

	processing style	metadata support	ontology support
Photobook	centralized	yes	no
QBIC	centralized	yes	no
Uni-Ontology	centralized	no	yes
Federate Ontology	centralized	no	yes
Chariot System	distributed	yes	no
HERMES	distributed	yes	yes

how metadata and ontology can be utilized to realize more intelligent content-based retrieval on visual media data. The proposed workflows can be utilized to effectively search visual media, which are widely spread over the internet, using leading-edge Web Service technology. We believe that experimental studies of the performance aspects are highly meaningful subjects for future research.

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