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The IMCOP System for Data Enrichment and Content Discovery and Delivery

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***Abstract*—This paper presents an overview of the IMCOP system dedicated to data enrichment and content discovery and delivery. A representative client application – the DEEP platform – for which the IMCOP system can serve is also depicted. Foremost categories of IMCOP web services are described in detail and their goals are clarified. A concept of Complex Multimedia Objects derived from the MPEG-7 standard and standing, in parallel, for its extension, is also introduced. Finally, advantages of the IMCOP system, as well as IMCOP's current drawbacks, with an insight into proposals for their future improvement, are discussed.**

Keywords—feature extraction; multimedia indexing; data enrichment and content discovery platform; complex multimedia objects; cloud computing; content delivery;

I. Introduction

The purpose of this paper is to present the system which has been put forward as an outcome of the IMCOP project. The IMCOP project - "Intelligent Multimedia System for Web and IPTV Archiving. Digital Analysis and Documentation of Multimedia Content", is an effect of the second call for joint Polish-Israeli R&D projects and is managed within the framework of the Eureka innovation platform (http://www.eurekanetwork.org/project/id/7635). The IMCOP project proposal was aimed at the general modern idea of intelligent discovery and sharing of multimedia content. According to IMCOP's initial assumptions, the capabilities of the system provided as its final result should in general include multimedia data aggregation and analysis, as well as finding connections between them in order to build content-related collections of data. In line with these initial assumptions, miscellaneous types of aggregated data, comprising text, images and video sequences, have been taken into consideration. Similarly, mechanisms for extensive analysis of all the above mentioned forms of aggregated data, covering detection and extraction of various features on one side and different classification approaches on the other, have also been applied. Features and additional information discovered by these mechanisms are then used to enrich the data by enhancing the list of their original (e.g. user) metadata. Rich metadata, in turn, set the scene for building the aforementioned content related collections of multimedia data. There would be, however, no collections of data

if connections (relations) between their metadata had not already been found. Some simple methods, oriented around selected descriptive metadata (e.g. time-based and text-based metadata) have been developed so far to find and create direct relations. More sophisticated algorithms involving semantic analysis as well as similarity checking are, however, also being planned. A number of multifarious and multivariate connections between multimedia data are expected as a result of the algorithms mentioned above. A significant increase in the number of potential content-related multimedia data collections should follow these connections. These – the aforementioned ones as well as the other functionalities (not reported here) of the IMCOP system - make it capable of collecting, discovering and recommending an appropriate multimedia content (represented by different data types) to end-users of various kinds, e.g. other platforms, mobile and desktop apps, etc.

The DEEP's Magazine Modeler - a component of the DEEP platform [1], is just one good example of such a potential end-user of the IMCOP system. DEEP, which stands for Data Enrichment and Engagement Platform, is a product of IMCOP's Israeli partner. The DEEP platform has been developed in part (referring mainly to multimedia analysis and data enrichment) within the scope of the IMCOP project. As a whole, the DEEP platform is not unlike the IMCOP system, with similar capabilities. The difference is, however, that the DEEP platform is strictly limited (at the moment) to actors, their life stories and movies. The content related to the above is presented in the form of digital magazines [2], where each magazine is created (assembled) automatically by the DEEP's Magazine Modeler on the basis of multimedia data aggregated, enriched and delivered by the DEEP platform.

IMCOP's capabilities are much wider within this scope, and can be addressed to subject matters (topics) of any kind. It can serve as a content delivery platform, e.g. for e-learning courses (for selected areas of study, for instance), museums (for guided tour apps), etc. It can also serve, however, as a content discovery and data enrichment platform similar to Outbrain (http://www.outbrain.com/) and DataSift (http://datasift.com/platform/data-enrichments/), respectively, as well as multimedia indexing (labeling) tools like Orbeus (https://orbe.us/).

In general, the IMCOP system is a framework for services oriented around data aggregation and content discovery and delivery. A more detailed report on IMCOP organization is given in remaining sections of the paper. Its overall

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architecture, as well as the main categories of IMCOP's services, are presented in Section 2. The idea and definition of objects, known as Complex Multimedia Objects (CMO), which are used in the IMCOP system to represent single multimedia data as their collections, are presented, in turn, in Section 3. Conclusions, with an insight into potential future improvements, are drawn in Section 4.

II. IMCOP Architecture

IMCOP is a distributed system based on Service-Oriented Architecture (SOA). IMCOP services are RESTful web services, implemented according to the Representational State Transfer (REST) architectural style. As such, IMCOP services are self-contained applications with their own REST-based interface. In addition, they are fully independent from operating systems and platforms on which they are implemented and run. Thanks to the above, they are also scalable, fast and modifiable.

All IMCOP services have been developed in Java according to the MESCore library, which provides API, programming specifications, and code examples within SDK for developers. As the MESCore library is open, IMCOP services can be implemented by developers outside the IMCOP project. Thanks to such an approach, IMCOP's capabilities can also be extended by external entities, e.g. companies or institutions interested in cooperation with the IMCOP system. The two main categories of IMCOP services are as follows:

- Data Aggregation Services (DAS), which stand for web crawlers designated to extract and collect data from the Web,
- Metadata Enhancement Services (MES), which are specialized multimedia data analysis and enrichment applications.

According to the MESCore library, IMCOP services are wrapper functions which call other, specialized applications or processes, as illustrated in Fig. 1. In the case of MES services, these are, for example, implementations of transforms dedicated to extracting local features from images, classification schemes addressing face, monuments, buildings or other types of objects recognition, smile, red-eye or unshaved faces detectors, nudity and profile/enface identifiers, dominant color counter, etc.

A. DAS Services

There are, in general, different data sources to which particular DAS services can be addressed. Their selection has to meet end-user requirements as well in terms of multimedia forms as data content relevance. The DEEP-like end-users, for example, need to aggregate and process text, images and videos related to movie and actor themes. Thus, sources selected for data crawling in this case should include, for example, multimedia data hosting websites (e.g. AlloCiné: http://www.allocine.fr/ - a service organization providing information on French cinema mainly) and collaborative knowledge bases (e.g. Freebase: https://www.freebase.com/ – "a community-curated database of well-known people, places and things").

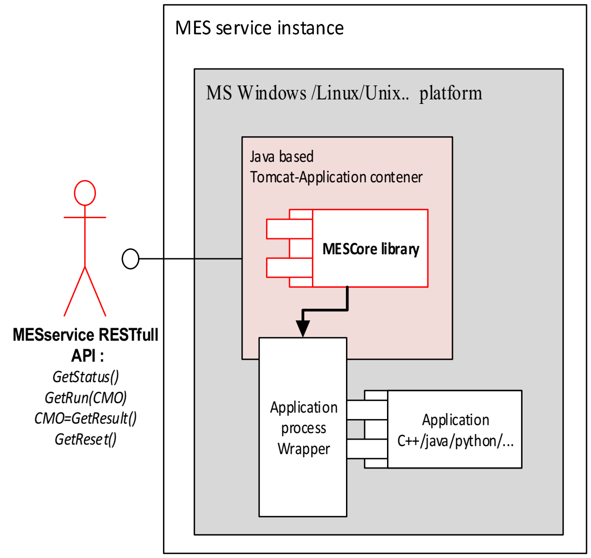

Fig. 1. Activity diagram of IMCOP services.

In addition to the above mentioned sources, at the moment the IMCOP system incorporates DAS services to Wikipedia (Wikimedia), Flickr, Foursquare (https://foursquare.com/), BBC World Service (one of the world's largest international broadcasters) and Twitter. Taking into account that DAS services are developed with regard to APIs, which differ from data source to data source, there is no one common model for implementing them. They also have to be implemented (as well as configured) separately because of the data sources' various authorization requirements, data-interchange protocols and formats (e.g. XML-REST, JSON, PHP), license conditions, etc. Taking into account all the above, we can sum up that DAS services are highly specialized and strongly end-user oriented components of the IMCOP system.

B. MES Services

MES services process the data and enrich them by expanding their metadata. We can imagine many different, more or less specialized, MES services in the IMCOP system. Some of them are general purpose services. Others, such as DAS services, are specialized to meet selected end-users' requirements. Applications wrapped by general purpose MES services implement, for instance:

- transforms dedicated to detect, extract and return descriptors for various types of local image features, including Scale Invariant Feature Transform (SIFT), Shape Context histogram, Maximally Stable External Regions (MSER), coefficients of Piecewise-linear transforms [3], etc.,
- algorithms designated e.g. to crop, resize, compress [4], scale, denoise, apply an affine transformation, trace the contour, etc.,
- scripts addressed to return selected image, audio and video quality metrics, acquired, e.g., from [5].

Specialized MES services and their wrapped applications, in turn, are dedicated, for example, to:

- detect and recognize (e.g. using local feature descriptors) text, human faces and bodies, interesting objects (e.g. characteristic monuments or specific buildings), makes and models of cars [6] as well as to identify landmarks, nudity, speakers, etc.,
- estimate similarity between images or their selected regions of interest [7],
- classify faces according to various face quality traits, e.g. profile, presence of red eye, smile or facial hair (to identify unshaved faces for instance), etc.

As well as the above mentioned attributes, at the moment the IMCOP system also incorporates other categories of highly specialized MES services. Some of them, known as Management Services (MS) are dedicated to controlling the activities of other services, and to managing data-interchange inside the system – including Data Repository (DR). There is also a group of Connection Services (CS) designated to identifying relations between processed data. Watermark Retrieval and Embedding Services (WRES) are activated, in turn, to protect the data against forbidden use, manipulation, and sharing with unauthorized end-users.

III. Complex Multimedia Objects

Web services of the IMCOP system use XML documents to exchange data. The structure of these documents meets all IMCOP's requirements, as well as those regarding multimedia data representation (given generally by their descriptive metadata) as storage of connections between the data. Such an IMCOP consistent form of XML documents is known as Complex Multimedia Objects (CMO). Thus, as depicted in Fig. 2, CMO objects are those which are subject to exchange between IMCOP services, including MS, DR, DAS, and MES services (along with CS and WRES ones), during data processing. CMO objects are created by DAS services as representatives of aggregated data, which in IMCOP terminology are defined in turn as Multimedia Objects or MOs. MOs, in general, can stand for images, video and audio sequences, documents containing only text, or other forms where all the above mentioned simple multimedia types are mixed.

The definition of Complex Multimedia Objects derives from the MPEG-7 multimedia content description standard. Therefore, descriptive metadata such as topic, name, age, date of birth (e.g. of an actor), keywords, brief texts, etc., are registered according to the MPEG-7 Description Schemes [8]. SIFT, Shape Context, MSER, Piecewise-linear or any other feature descriptors, extracted by dedicated MES services, are in turn stored with regard to MPEG-7 Descriptor's specification.

The CMO definition extends, however, the MPEG-7 standard in some respects. The most significant extension refers to connections between data and the way in which pointers to these connections are stored in CMO objects. As illustrated in Fig. 3, each CMO object present in the IMCOP system has its own Universally Unique Identifier (UUID). The purpose of using UUID identifiers in the IMCOP system is to distinguish between particular CMO objects, regardless of IMCOP's distributed architecture, and despite the lack of central coordination. After instantiation, CMO objects are passed to MES services, where they are analyzed and processed. As a result, MES driven metadata are added to their properties. Next (or in the meantime – these processes can take place simultaneously) UUID identifiers of objects recognized as related are appended to the list which stands for the list of connected objects.

IV. Conclusion and Summary

An overview of the IMCOP system, which is an example of service-oriented architecture, with many specialized, REST-compliant Web services. From its end-users' perspective, the IMCOP system can be seen, in turn, as a provider of services in the cloud. However, unlike standard cloud computing models, IMCOP does not run the client's

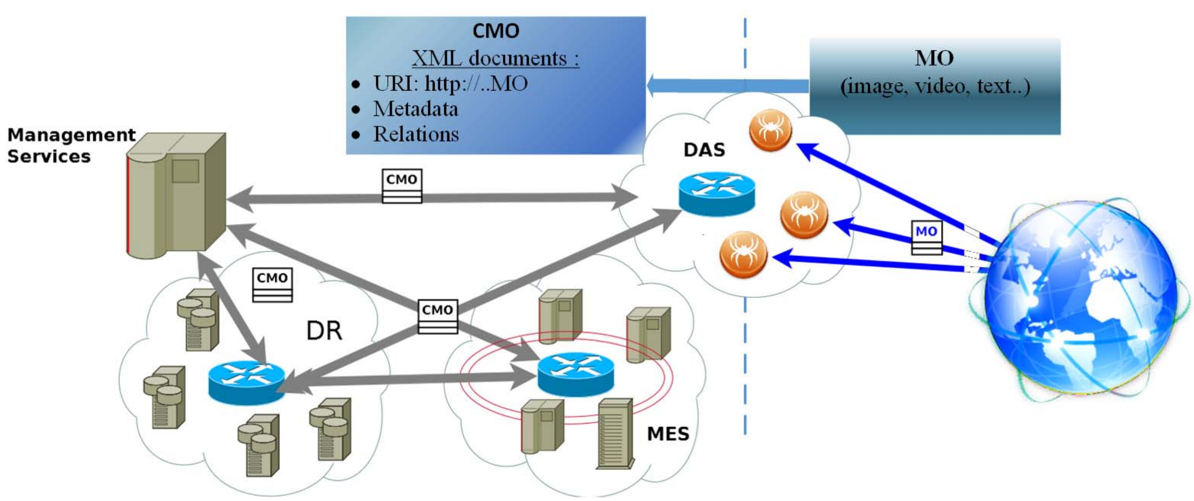

Fig. 2. Activity diagram of IMCOP services.

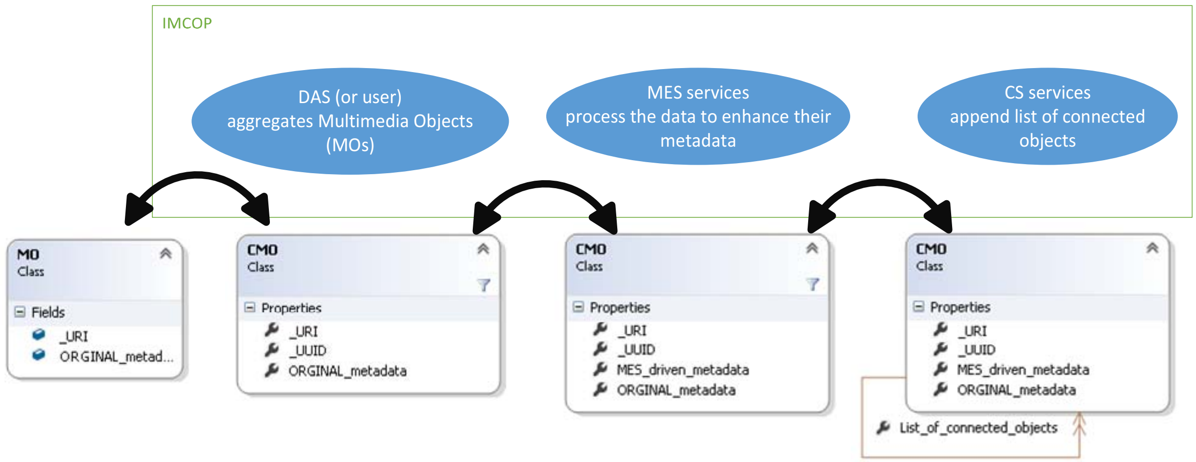

Fig. 3 Scheme of CMO objects instantiation and processing.

applications. Despite this, IMCOP activates its services to meet the end-user's demands (requests) for desired multimedia content. Taking this into account, the IMCOP system can also be regarded as a content delivery platform. However, with regard to the capabilities of its Web services within the scope of multimedia data analysis and metadata enhancement, the IMCOP system can in addition be considered as a data enrichment and content discovery platform.

The main advantages of the IMCOP system are as follows:

- versatility – due to the unlimited capabilities of its services, IMCOP can serve to various types of end-user, including DEEP magazines as museums and academic e-learning courses,
- openness – with its open API, third-party developers can enhance IMCOP's functionalities as well as adapting the IMCOP system to their requirements,
- flexibility – each of the IMCOP MES and DAS services can be activated, deactivated and replicated at any moment; thus, IMCOP can easily and quickly be reconfigured to meet the needs of a given task.

In addition to the above, like other distributed systems, IMCOP is scalable (inter alia thanks to replicability of its components), transparent, resource sharing and concurrent. Other assets of the IMCOP system refer to the concept of Complex Multimedia Objects. Metadata related to given multimedia data can easily be preserved as well as shared using the CMO structure.

There are, however, also drawbacks. At present, the most significant disadvantage of the IMCOP system refers to the possibility of instantiation of many CMO objects which represent the same multimedia data. An additional independent service dedicated to cleaning the system of redundant objects is a current idea for eliminating this defect. Other serious drawbacks are related in turn to efficiencies of IMCOP's MES services, which, in some cases, are not as high as expected. Classification errors or detection fails are sources of wrong connections which lead sometimes to incoherent collections of served multimedia data. Therefore, our current efforts are also aimed to improve these services. In addition, to extend and diversify IMCOP's capabilities, other, not implemented yet types of MES and DAS services are strongly required. Thanks, however, to above mentioned openness of the IMCOP system, we expect to incorporate new services through cooperation with interested partners.

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