

## Toward Ubiquitous Learning Application of Digital Libraries with Multimedia Content

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**Abstract:** *A promising direction in the current e-Learning strategies and activities points to contemporary ubiquitous learning through the involvement of large-scale repositories of digitized knowledge in the learning processes. This paper aims to present a possible implementation of ubiquitous learning by using digital libraries and different knowledge delivery channels (Web, digital television and mobile technologies) – idea popularized by the project “Knowledge-on-Demand for Ubiquitous Learning” (LOGOS). The paper considers the basic concepts, functional characteristics and main architectures of digital libraries oriented to ubiquitous learning applications. It also includes a set of principles that have to be met by the digital libraries so they can be utilized efficiently by the e-Learning systems. The LOGOS project goals and overall architecture are included. The paper outlines the content, architecture and technical specifications of one involved in the project digital library “Virtual Encyclopaedia of the Bulgarian Iconography”. The last part of the paper presents two scenarios. The first scenario “Access-on-demand for studying of East-Christian culture and art” describes the execution of the learning process in the LOGOS environment. The second scenario explains the courseware creation trying to capture the main functionalities of the LOGOS authoring studio.*

**Keywords:** *Digital libraries, digital library architectures, e-Learning systems, scenarios for ubiquitous learning .*

### 1. Introduction

One of the most important features of the digital library of the future will be that it is accessible from anywhere, by anyone and at any time. Ubiquitous learning through digital libraries is a promising direction for the advanced e-Learning. Digital library could provide powerful and efficient functionalities for content management (acquisition, storage, indexing, access, and maintenance), manifold metadata for

content enrichment, and structuring, as well as services for effective content search, access, annotation, filtering, and dissemination. The content and services a digital library offers are determined by acquisition (collection development), organization, and access policies tailored to the users the digital library is intended to serve.

On the other hand, learning environments delivering knowledge through integrated channels (for example, integrated web and mobile technologies, etc.) are not often occurred solutions. However, they would be accessible by many users wishing to follow lifelong learning programs, vocational e-Training, non-formal learning or learning-by-doing programs and will offer them flexible curriculum, on-demand knowledge, learning any time and anywhere that is conformable to circumstances, etc.

This paper aims to presents the implementation of ubiquitous learning by use of large-scale repositories (vr. digital archives, digital libraries) and different delivery channels (integrated web-, digital television and mobile technologies), the main idea of the project “Knowledge-on-Demand for Ubiquitous Learning” (LOGOS) [1].

The first section outlines the basic concepts, functional characteristics and three main architectures of digital libraries (service-oriented architecture, peer-to-peer architecture and grid-based architecture) and one common infrastructure combining concepts and techniques from these three architectures. After that the paper formulates some special features and principles that are and have to be met by the digital libraries so that they can be used efficiently by the e-Learning systems. The next section presents goals, architecture and expected results of the LOGOS project. There is a short description of the multimedia digital library “Virtual Encyclopaedia of the Bulgarian Iconography” that is one of the digital repositories involved in the project. The scenario “Access-on-demand for studying of East-Christian culture and art” describes how could be executed the learning process in the LOGOS environment. The scenario for the creation of courseware by a teacher for the students of his class is considered in the last part. It tries to capture the main functionalities of the LOGOS authoring studio.

## 2. Basic concepts of digital libraries

Digital libraries are a contemporary conceptual solution for access to information archives. According to an informal definition of digital libraries, they are managed collections of information, with associated services, where the information is stored in digital formats and accessible over a network. Digital libraries contain diverse hypertext-organized collections of information (digital objects such as text, images, and media objects) for use by many different users. The collected information is organized thematically and uses hyperlinks that allow the connection between any piece of data and additional data on the same topic. As an addition to the digital objects collection, there are many levels of metadata, indexes, hierarchical links, etc. [2].

The main characteristics of digital libraries [3] are the following:

- ability to share information;
- new forms and formats for information presentation;
- easy information update;
- accessibility from anywhere, at any time;

- services available for searching, selecting, grouping and presenting digital information, extracted from a number of locations; using these services depends on the user preferences, needs and wishes of the users, i.e. there is personalization available;

- contemporary methods and tools for digital information protection and preservation;

- ability to use different types of computer equipment and software;

- no limitations related to the size of content to be presented.

In the past digital libraries were isolated and monolithic systems limited to access to content of a single provider. The development of the technologies during the last years provides new functionalities and advanced services to contemporary digital libraries such as specialized services for:

- multi-layer and personalized search, context-based search, relevance feedback, etc.

- resource and collection management;

- metadata management;

- indexing;

- semantic annotation of digital resources and collection, etc.

The new digital libraries will provide and manage complex services, processes and workflows on the basis of existing services. It is expected that these services be heterogeneous, autonomous and distributed. The flexibility, the automatic adaptation, the access anywhere and anytime, the decentralization, the wide variety of digital objects and collections, the information security, etc. will be of the some requirements.

### Digital library architectures

**Service-oriented architecture.** The digital library is currently undergoing a transition from a statically integrated system to a dynamic federation of services. This transition is inspired by new trends in technology which include developments in technologies like web services and grid infrastructures as well as by the success of new paradigms like peer-to-peer networking and service-oriented architectures. The transition is driven by digital library “market” needs. This includes a requirement for a better and adaptive tailoring of the content and service offer of a digital library to the needs of the relevant community as well as to the current service and content offer, and a more systematic exploitation of existing resources like information collections, metadata collections, services, and computational resources. Such new decentralized and service-oriented architectures [4] for digital libraries make the library functionality available in a more cost-effective and tailored way and thus open up new application areas for digital libraries. Innovative view for service-oriented architecture is that the services will have strong semantic descriptions allowing self-choreography (composition with flexibility and dynamism).

A simplified variant of service-oriented architecture, named *hypermedia digital library* (HDL), is developed for the needs of the project “Digital libraries with multimedia content and its applications in Bulgarian Cultural Heritage” [9]. The project aims to develop a demonstrator of multimedia digital library that contains digital objects from Bulgarian Iconography. A more detailed description of the content, structure, architecture and tools for development of the digital library “Virtual Encyclopaedia of the Bulgarian Iconography” is presented below.

The HDL can be considered as a database, storing data of different type (text, raster, vector, static and moving images, animation, audio or other media), which is structured in a way to allow easy manipulation and use. Data is stored in the database in the form of objects, usually annotated to facilitate running search queries services. To make these procedures automatic, the HDL includes techniques for descriptive presentation of the data semantics as well as services for its management.

Web technologies help organizing hypermedia digital libraries by providing a means to structure and present them in a hypermedia manner. Hypermedia represents hypertext media; therefore it adheres to the hypertext information organization rules. Users are allowed to quickly move across subject-related topics in a non-linear way. These topics may include sets of objects, such as text, images, audio and other media, which relate to one another via hyperlinks. The HDL includes services for semantic annotation of digital objects, metadata management, indexing, multi-criteria search, personalized search, etc.

**Grid-oriented architecture.** A grid is defined as a network or collection of distributed computer resources, which are accessible through local or global networks and are presented to the end user via an enormous virtual computer system, i.e. it is a virtual, dynamically changing organization of structured resources, which are shared among individuals, institutions and systems. Grid architecture can be conceptually decomposed into two layers: the data grid and the computational grid. The data grid presents a massive, interconnected storage infrastructure, connected to the computational grid via a high-speed network connection. The computational grid is the virtual single machine created by bringing together a large collection of independent hosts. Various ways of collaboration can be implemented on top of the virtual machine. The interconnection network at the computational grid level allows for communication across hosts, while the high-speed data connection to the data grid layer allows for data availability and fast exchange of information.

In essence, the creation of virtual digital libraries on the basis of grid-based infrastructures, support for the integration of metadata, personalization services, semantic annotation and the on-demand availability of information collections and extraction services will make digital libraries more useful and attractive to a wider clientele [4]. Such a test-bed digital library infrastructure has been created for the DILIGENT project [6] (integrated project funded in part by the European Commission

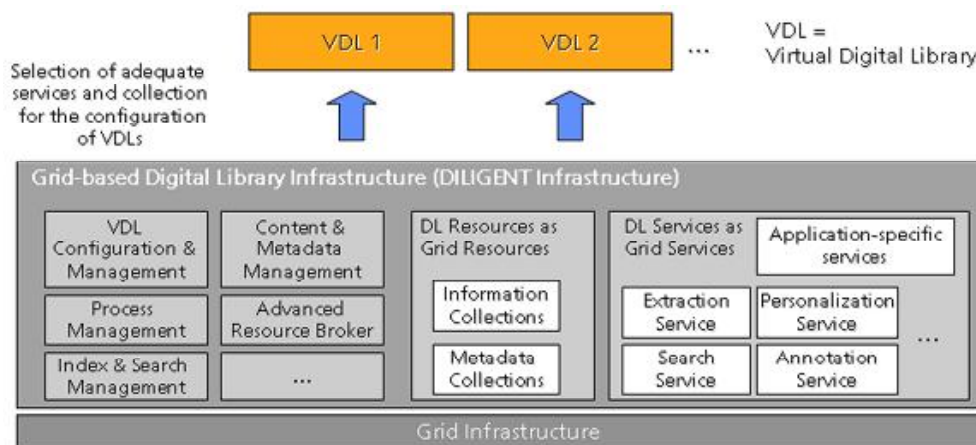


Fig. 1. Grid-based infrastructure

FP6 IST Programme [5]), based on the grid technology. Fig. 1 depicts DILIGENT infrastructure.

**Peer-to-peer (P2P) architectures.** P2P systems are the token distributed system architecture, focussing mainly on exploiting the huge storage infrastructure provided by a collection of interconnected machines. The P2P premise is collaborative sharing: everything is available to everyone, so long as there are ways of accessing the information. P2P data management allows for loosely coupled integration of information services and sharing of information such as recommendations and annotations. Different aspects of peer-to-peer systems (e.g. indexes, and P2P application platforms) can be combined [4].

Future digital libraries should enable any citizen to access human knowledge any time and anywhere, in a friendly, multi-modal, efficient, and effective way. A core requirement for such digital libraries is a common infrastructure which is highly scalable, customizable and adaptive. Ideally, the infrastructure combines concepts and techniques from peer-to-peer data management, grid computing middleware, and service-oriented architectures. That infrastructure is offered in the project DELOS „A Network of Excellence on Digital Libraries” [7] funded by the EU’s Sixth Framework Programme. Peer-to-peer networks allow for loosely coupled integration of digital library services and the sharing of information such as recommendations and annotations. Grid computing middleware supports the dynamic allocation and deployment of complex and computationally intensive digital library services such as the extraction of features from multimedia documents to support content-based similarity search. A service-oriented architecture provides common mechanisms to describe the semantics and usage of digital library services. Furthermore, it supports mechanisms to combine services into workflow processes for sophisticated search

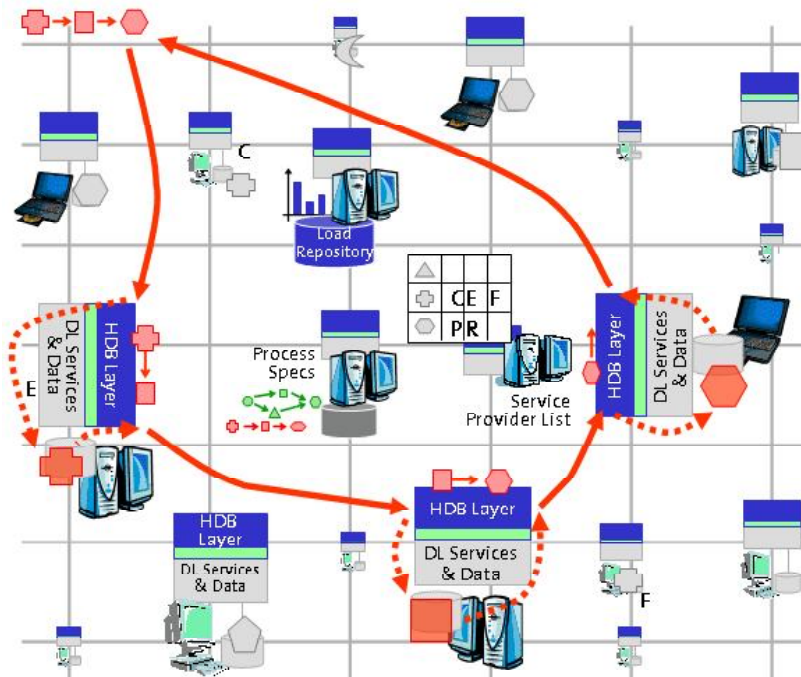


Fig. 2. Conceptual schema of digital library based on a hyperdatabase infrastructure

and maintenance of dependencies. As depicted in Fig. 2, the digital library architecture envisaged consists of a grid of peers which provide various kinds of digital library services such as storage, extraction or retrieval services. These digital library services can be combined with processes. High scalability is achieved by executing the processes in a completely distributed, peer-to-peer fashion. For that, metadata about processes, services, and load of the peers is distributed and replicated over the grid. This is performed by a small hyperdatabase layer atop each peer. This layer also takes care of peer-to-peer navigation and execution of processes.

### 3. Digital libraries and e-Learning systems VIS-A-VIS

The involvement of digital libraries in the e-Learning processes requires the formulation of special features and principles that are to be met by the digital libraries so that the latter can be used efficiently by the e-Learning systems. The last-years' trends of e-Learning for optimising and advancement put additional requirements to the learning process and construction of work scenarios. In that sense, the following special features and principles can be laid down:

*Resources-on-demand* – digital libraries have to provide resources and materials on-demand to the end-user. Tools and technologies to support indexing, cataloguing, retrieving, aggregating, and creatively exploiting of different textual, non-textual and complex objects /resources have to be developed in them. New e-Learning trends dictate the implementation of tools for personalised preference-based access to digital libraries in which the user's preferences will be used for filtering, extraction and aggregation of digital objects in order to reduce the volume of data presented to the user.

*Resource description* – the objects in digital libraries have to be segmented (i.e. partitioned into logical units), annotated and semantically indexed so that metadata are attached to them and describe their content including semantic descriptions based on appropriate domain ontologies. The metadata are written with standard description languages and are stored in an appropriate metadata repository that provides management services including efficient retrieval based on Boolean and similarity queries so that it is possible to search for content satisfying various search parameters.

*Interoperability* – establish protocols, standards and formats to facilitate the use and assembly of distributed digital libraries and their resources.

*Intellectual property rights* – a key element for digital libraries is appropriate recognition and protection of legal rights such as copyright, publicity, privacy, matters of obscenity, defamation, intellectual property protection. The vision for digital libraries includes fluid, easy access to a wide variety of materials. This is often in conflict with the duties of libraries and archives entrusted with care and management of materials that may be subject to privacy rights or other needs for security. Efforts to formulate digital libraries will be delayed or frustrated in the absence of a common, responsible framework of rights, permissions, and restrictions that acknowledges the mutual needs of rights-holders and users of materials in digital libraries. The challenge here is, in part, to develop mechanisms, perhaps social expectations independently or in combination with technical means, regarding acceptable levels of access (for example where privacy rights are at issue) and use (such as the extent or permissible copying and dissemination).

*Heterogeneous resources in a coherent way* – a digital library that provides diverse content will be characterized by heterogeneity in original format, in digital format and resolution, and in the level of detail and format of descriptive information that is available to support access. In the face of great diversity of content and description, special problems attend to the development of a coherent approach to indexing and presenting retrieval results. It is important that any approach allows all the information available to be used to aid the retrieval rather than force the user who wants to search across the entire resource to rely on some lowest common denominator of descriptive information.

*Sustaining the resource* – the creation and maintenance of digital libraries is very expensive. Costs are incurred for production, for ongoing provision of access, and for preservation of the digital information. The cost to develop and operate a distributed architecture for long-term archiving, migration, and backup of digital materials are high, too. Libraries would benefit from better estimate of costs and trends in cost for production and maintenance of a corpus of digital information *i.e.* it is important to develop economic models for the support of digital libraries.

*Provide more efficient and more flexible tools for transforming digital content to suit the needs of end-users* – today, each content item in most digital libraries is represented in multiple forms or versions. The multiple forms exist to serve varieties of users, function as archival masters, and reduce download time and transmission loads on networks. A content provider may produce large and small versions of images; compressed and uncompressed versions of images, texts, audio, and video; texts formatted for browser software and also formatted for preservation or publication; and materials both in proprietary formats and in public or “open” formats. This burden of plural production and maintenance results from the fact that today many digital objects are hard to transform on the fly. Similar capabilities are also needed to ensure the preserving of digital content for posterity.

*Services* – digital libraries offer lots of services to the visitors for example, search, indexing, content management, metadata annotation of digital objects and collections, etc. Search services (such as multi-feature search, multi-object search, personalized search, context-based search, etc.) aid the users in finding a certain objects, but when we use digital library for e-Learning search services provide additional functionalities and effectiveness to the e-Learning processes.

#### 4. Knowledge-on-demand for ubiquitous learning

The project “Knowledge-on-Demand for Ubiquitous Learning” (LOGOS) [1] contributes to the openness for ubiquitous learning of the large-scale repositories of digitised text, graphics, audio, video objects and to the process of their transformation into learning content, adequately enhancing and facilitating the knowledge building. The project addresses innovative development of the main components of the learning processes – resources, services, communication spaces. New functionality of the learning communication spaces will be achieved by integrated web-, digital television and mobile technologies, supporting cross-media learning content. New e-Learning management systems based on this integration will improve and extend the learning services within new consistent pedagogical scenarios. The use of annotated and

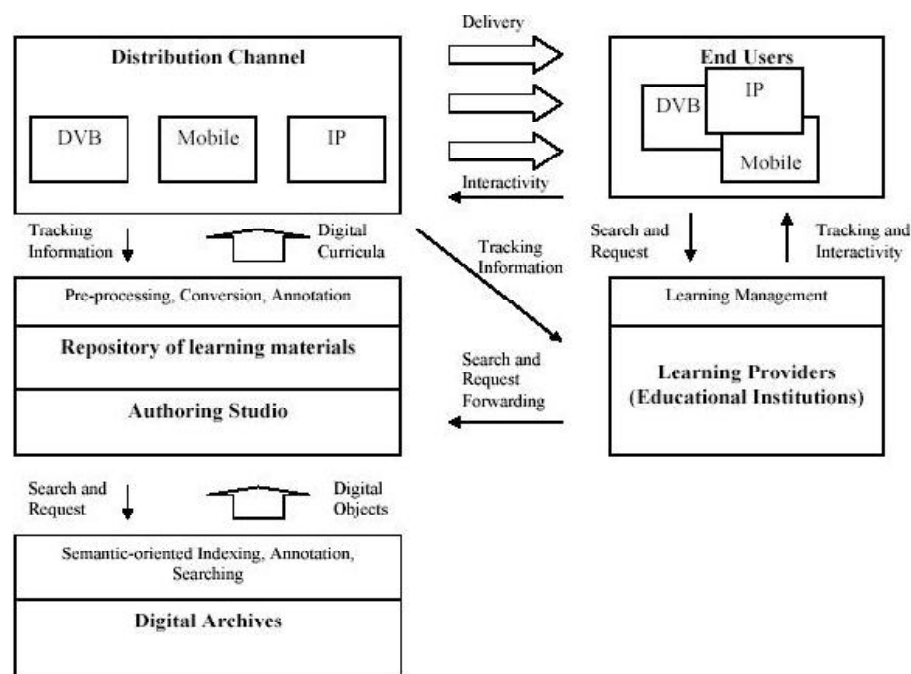


Fig. 3. Conceptual scheme of LOGOS platform

adequately structured knowledge from digital archives will enable lecturers/authors to participate in “open source” content development from massive, dynamically growing learning resources. Figure 3 depicts a conceptual scheme of LOGOS platform.

The project is targeted at the following results: 1) development of learning scenarios for ubiquitous learning in different learning contexts, modelling learning process and learning materials by considering different ways and phases of cross-media authoring, access, delivery, study and assessments through different modes and levels of integrated web-based, DVB and mobile technologies; 2) development of authoring studio for generation of learning resources from existing digital archives; 3) development and implementation of knowledge-on-demand ubiquitous learning platform, integrating learning resources and communication spaces through knowledge-on-demand learning services; 4) extended experimentation of the functionality and usability of the platform implementation by authors/lecturers and learners in multiple national contexts. The project meets the challenges of Europe enlargement by its research and development to provide highly customizable knowledge-on-demand learning services for the broad public in ubiquitous manner.

The LOGOS project involves several digital archives, such as NAVA (National Audiovisual Archive) of Hungary (<http://nava.hu/>), the French audiovisual web portal “Archives audiovisuelles de la Recherche” (AAR) (<http://semioweb.msh-paris.fr/AAR/FR/>), Regency Town House archive (<http://www.rth.org.uk/onlinearchive/>) and Geffrye Museum archive (<http://www.geffrye-museum.org.uk/>) (United Kingdom), multimedia digital libraries “Virtual Encyclopaedia of the Bulgarian Iconography” (<http://mdl.cc.bas.bg/icons/>), etc.



### **Multimedia digital library “Virtual Encyclopaedia of the Bulgarian Iconography”**

Multimedia digital library “Virtual Encyclopaedia of the Bulgarian Iconography” will be used for the implementation of the learning scenario “Access-on-demand for studying of East-Christian culture and art”. This multimedia digital library is developed during the second stage of the project “Digital libraries with multimedia content and its applications in Bulgarian Cultural Heritage” by contract between the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences (Mathematical Linguistic Department) and the State Agency for Information Technologies and Communications. It includes:

- several hundred specimens of Bulgarian icons from different artists, historical periods, and schools, and their detailed description;
- techniques of the iconography;
- description of significant iconographic schools of the renaissance –introduction of works and authors;
- biographies of known iconographic artists;
- a glossary of 95 terms.

The icons presented originate from the end of the twelfth to the beginning of the twentieth centuries and the majority of them belong to the Bansko-Razlog iconographic art (around 80 icons, XVIII, XIX, XX century). DL also presents icons from the following schools and regions of Bulgaria: Triavna iconographic school, Samokov iconographic school, icons from Veliko Tarnovo, Sozopol, Rila Monastery, Arbanasi, etc. This group includes painted icons and icons built with mosaics that are located in European museums, churches, monasteries, and private collections.

The digital objects are grouped into thematic collections according to their topics. For each object and collection, special meta-descriptions are created. They include data about the title, the artist, the period (in years and centuries), the school, the dimensions (width/height/thickness), the technique, the base material (type of wood, ground coat, etc.), the category, the location, the author (biographic data), comments (features of the icon such as state, founder’s and other signatures, previous restorations), etc. Also, they contain links to other digital objects and collections, keywords, and so on. That information is used for the semantic annotation and indexing of the digital objects, which facilitate their locating during search requests, and their web-based representation.

DL has been developed following the principles of service-oriented architecture and their subtype hypermedia digital library, described above. It has been implemented using the following technologies: PHP/MySQL, CSS, HTML (dynamic and static pages) and Javascript. The program works in a client-server architecture which requires:

- *Server*: A web server with PHP 4.0 installed, access to a MySQL 4.1 relational database with permissions for creating tables, inserting, selecting and updating data in them, permissions for writing in the main demonstrator directory, etc.
- *Client*: A DOM-compatible web browser and a TCP/IP connection to the web server.

The source code of the digital library is separated into several scripts, written in PHP and using MySQL for storing the library data, which are executed through the Web. There are various library files, containing functions used throughout the code,

grouped by their purpose, a global CSS file containing the HTML styles defining the user interface, a global JS file containing various JavaScript functions used for enhancing the user interface, and static HTML pages.

A more detailed description of the content, structure, architecture and tools for development of the digital library “Virtual Encyclopaedia of the Bulgarian Iconography” is presented in [3, 8, 9].

### **Learning scenario “Access-on-demand for studying of East-Christian culture and art”**

The scenario “Access-on-demand for studying of East-Christian culture and art” is developed in four variants according to the learning situations and communication channels. For every variant are specified:

- *learning background* (for example, East-Christian culture, Bulgarian traditional culture, cultural heritage, etc.);
- *learning situation* – formal/informal;
- *link to curriculum* – yes/no;
- *learning setting* (support, place, time);
- *devices* (for example, PC connected to Internet, PDA);
- *learner background* (learner age range, learner role and occupation, learner motivation type, etc.);
- *learning activities* (for example, preparation of project, etc.);
- *types of material accessed*;
- *specific objectives* (for example, to explore information in line with personal interests, to make specific inquiry, to store information for further use, etc.);
- *learning approach* (for example, constructivist learning approach and constructionist learning approach);
- *interactive functions needed/used by learner* (for example, access-on-demand to a multimedia digital library and display individually designed learning materials on PC via Web-based digital library, browse and read text and graphical materials, uploading or otherwise acquiring links to relevant learning material, etc.);
- *glossary*, etc.

Most generally speaking the four learning scenario situations can be summarized by the following scenario: Some users need to access certain learning objects to satisfy their knowledge needs. They connect to the LOGOS knowledge-on-demand ubiquitous learning platform (by use of PDA device or PC, connected to Internet) and request the learning materials. This platform is connected to the multimedia digital library that provides access to large volumes of digitised knowledge in different raw forms and formats. Special knowledge-on-demand learning services find the relevant materials across the digital library and deliver them to an environment for transforming digitised knowledge in courseware objects. This environment pre-processes digital objects and its authoring studio builds courseware objects for cross-media delivery. The LOGOS knowledge-on-demand ubiquitous learning platform integrates the learning resources and delivers them to the users in suitable learning form through the platform communication spaces.

## LOGOS authoring studio functionality and courseware creation scenario

The overall scenario for the creation of courseware by a teacher for the students of his class is proposed by Polixeni Arapi and Nectarios Moumoutzis<sup>1</sup>. The scheme of this scenario is depicted in Fig. 4. It tries to capture the functionality of the authoring studio, described below.

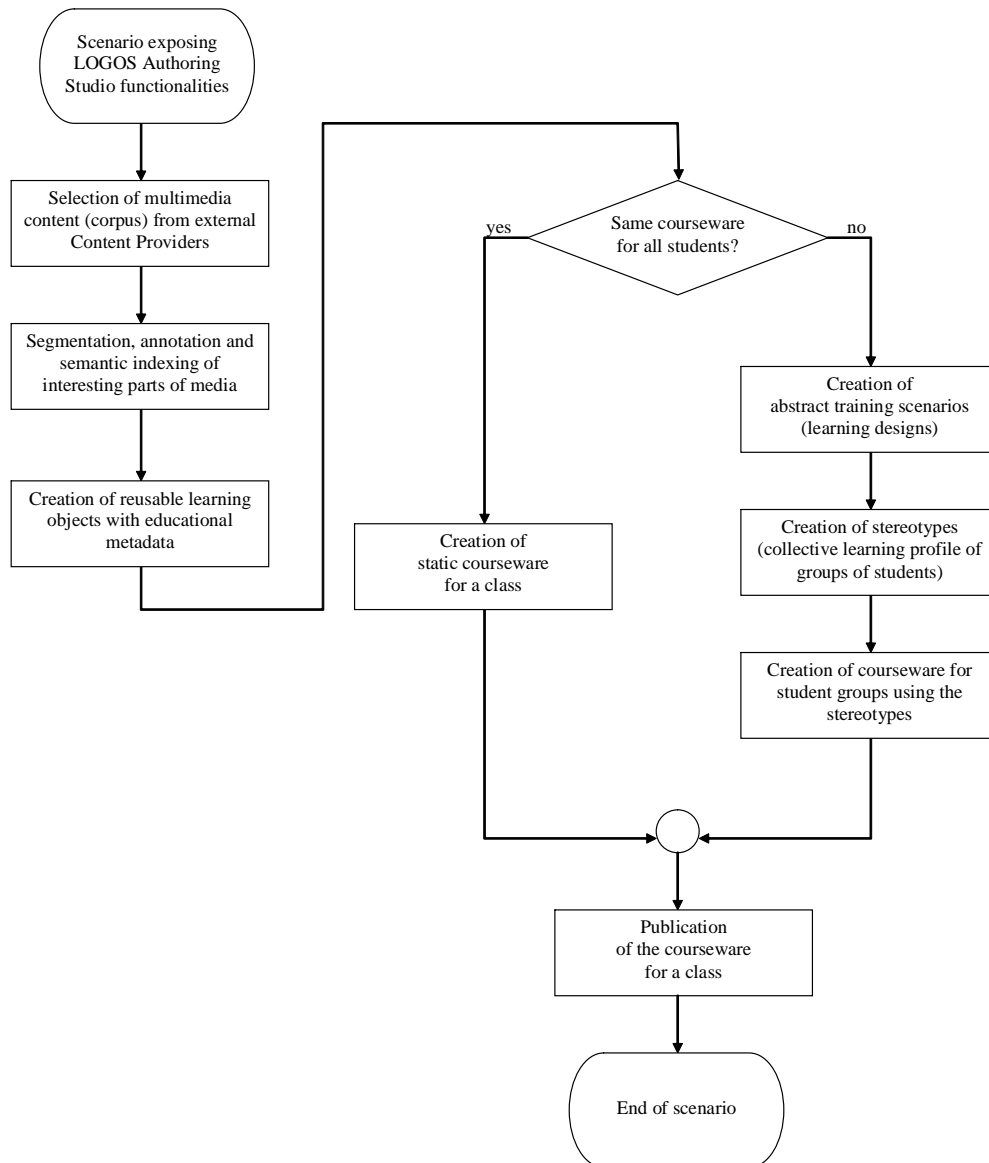


Fig. 4. Steps of a usage scenario for the creation of courseware by a teacher for the students of his class using LOGOS authoring studio

<sup>1</sup> Laboratory of Distributed Multimedia Information Systems & Applications, Technical University of Crete.

LOGOS authoring studio is a suite of tools providing all the necessary functionality to:

- Create multilingual domain ontologies for the semantic annotation of multimedia content.
- Segment multimedia content from external content providers and annotate and semantically index these segments to create digital objects.
- Create reusable learning objects consisting of digital objects (appropriately segmented, annotated and semantically indexed). Reusable learning objects contain (among other) educational metadata that facilitate their retrieval and integration in courseware objects.
- Create (statically or dynamically) courseware objects to be used by learners using the LOGOS delivery services.
- Create abstract training scenarios (learning designs) in order to describe courseware object “templates” (without references to actual reusable learning objects). These abstract training scenarios will be used together with learner profiles (describing e.g. learning requirements, selection of preferred delivery channels and end-user devices) in order to create dynamically courseware objects to meet the preferences of individual users or groups of users.

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