

into digital form. This is multidisciplinary library, that contains not only mathematical collections but also history of Law, history of the Humanities and the Sciences, travel and North American literature and other collections. Mathematical collections have about 7000 resources and also have some Russian resources. Library contains more than 15 million digitized pages.

Portal provides search in metadata and full text of resources and browse functions. Many resources are historical, not modern, main aim of the project is to digitize and preserve resources. All resources have full texts and can be viewed page by page or in structured mode. Metadata of any resource contain stable URL of resource, metadata can be downloaded in METS format.

3.7 Zentralblatt MATH

Zentralblatt MATH (zbMATH, [34]) is abstracting and reviewing service in pure and applied mathematics. It is hosted by the Berlin office of FIZ Karlsruhe – Leibniz Institute for Information Infrastructure GmbH (FIZ Karlsruhe) and distributed by Springer. The zbMATH database contains more than 3.5 million bibliographic entries with reviews or abstracts currently drawn from more than 3,000 journals and serials, and 170000 books. zbMATH is not a digital library itself, it is an indexing service and provides easy access to bibliographic data, reviews and abstracts from all areas of pure mathematics as well as applications, in particular to the natural sciences, computer science, economics and engineering.

Search functions provide search for documents, authors and journals. Search can be done in one line, or in structured form using attributes such as title, author, subject, source, keywords etc. Service also provide full-text formula search for indexed arXiv documents [35]. The zbMATH formula search uses the MathWebSearchsystem, which is a content-based search engine for MathML formula based on substitution tree indexing.

Portal offer three ways of displaying mathematical formulas – MathML, MathJax and LaTeX. The XML-based MathML is the solution recommended by W3C for displaying mathematical content on the web and is set as default within zbMATH. Mathematical Reviews and zbMATH maintain the Mathematics Subject Classification (MSC), a classification scheme for mathematics. It is used by reviewing services to categorize items in the mathematical sciences literature. The database of service contains about 2.1 million direct links to electronic versions of the indexed publications, to the publishers’ websites and/or to electronic libraries with open access to the full texts.

3.8 Bulgarian Digital Mathematics Library

Bulgarian Digital Mathematics Library, BulDML is a digital repository at Institute of Mathematics and Informatics of Bulgarian Academy of Sciences. Library has 7 mathematical journals, 4 book series and proceedings in its repository. In fact, BulDML is an institutional repository and is built on open-source DSpace software [36]. As known, DSpace preserves and enables open access to all types of digital content

including text, images, moving images, mpegs and data sets. All functionality of DSpace software is clear and we will not describe it in this paper. For example, additional information about DSpace can be found in [17, 37].

3.9 European Digital Mathematics Library

The European Digital Library (EuDML) was a project partly funded by the European Commission. EuDML [12–14, 38, 39] is an aggregation and indexing services with was established under The EuDML Initiative and promoted by European Mathematical Society. EuDML assemble as much as possible of the digital mathematical corpus in order to make it available online, with eventual open access, in the form of an authoritative and enduring digital collection, growing continuously with publisher supplied new content, augmented with sophisticated search interfaces and interoperability services, developed and curated by a network of institutions.

The system, presented in the diagram in Figure 1, conceptually consists of a metadata repository, a search engine, a metadata enhancer, an association analyser, annotation and accessibility functions and of course the interfaces [38].

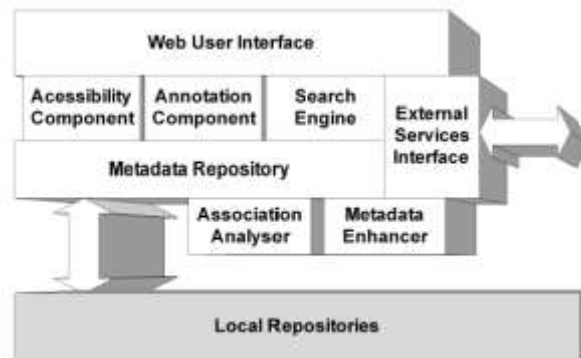


Figure 1 EuDML architecture

The metadata repository provides the central point of reference for all the managed contents. It will work with an OAI-PMH harvester to ingest repositories’ content descriptions, maps the metadata into the internal EuDML schema. The performance and the quality of responses of the search service directly influence user experience. Therefore, particularly this service has to be reliable, scalable and customized to fulfill user expectations.

The metadata enhancer function consist in a collection of tools that each contribute to expand or complete the existing items’ metadata, depending on the improvements needed. These range from applying OCR over full texts, adding key words or multilingual metadata by merging information from different databases when an item happens to have such non-redundant description, generating MathML for mathematical expressions, etc. The association analyzer detects, analyses and records relations between individual items. The annotation component provides mechanisms to attach new material to individual items in the repositories and maintain this new material. The accessibility component provides support for enhanced accessibility of items, if required, before presentation to end users. Finally, the user and system interfaces provide

access to the collected resources on different levels both to human and machine users. Now EuDML offers several service interfaces that allow other applications to connect with the service. These are OAI-PMH server, REST services, OpenSearch service, which allow to query library index in machine way and annotation retrieval services in JSON.

EuDML aims to be an open source of trusted mathematical knowledge. That is why it has some policies:

- All texts must have been scientifically validated and formally published;
- All items must be open access after a finite embargo period. Once documents contributed to the library are made open access due to this policy, they cannot revert to close access later on;
- The digital full text of each item contributed to library must be archived physically at one of the EuDML member institutions.

All DMLs, described above except All-Russian Mathematical Portal Math-Net.RU are partners of EuDML.

4 Conclusion

In order to outline all differences of observed projects we created comparison Table 1 listed below. Note that, we excluded from table two DMLs due to following. BulDML is and built on open-source DSpace software, so all functionality of it is clear, for DML-PL we could not find any working portal in order to study it more deeply.

In all the projects studied, emphasis is placed on the transfer of the resources themselves to the electronic form, rather than on the development of semantic services. Only a few portals have a mathematical formula search, and only one has a recommender service.

After the analysis done it is clear that there are only two types of repository systems: the first is actually DML, which preserve the resources themselves, the second is indexing and aggregating services that do not have their own database of electronic documents, but provide a wide range of convenient search capabilities.

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Table 1 Comparison table of DML projects

DML Criteria	Math-Net.ru	CEDRAM	NUMDAM	DML-CZ	GDZ	zbMATH	EuDML
Information space	There is an object hierarchy. Collections split into journals, issues, articles and so on. Currently contains more than 120 journals with nearly 200 thousand publications. Information about the article includes a bibliographic description, an annotation, lists of literature and a file with the full text of the article.	DML contains 9 French math journals, 1 book and 7 proceedings of seminars and conferences. All CEDRAM journals are open access. Access to the database containing the bibliographical references of all the articles of all participating journals is totally free. The full entry of articles contains abstracts and bibliographical references.	Contains more than 57000 articles in 76 periodicals, 373 books in 4 collections, 263 theses. Full texts available in PDF and DJVU formats. Each article in NUMDAM is available via a stable URL.	The digitized journal and proceedings papers are displayed with the agreement of the publisher who owns the digital data. DML-CZ presents full texts articles and book chapters in PDF format, equipped with enhanced metadata including bibliographical references. The digital born documents are being obtained from the original sources provided by publishers.	This is multidisciplinary library, that contains not only mathematical collections but also history of Law, history of the Humanities and the Sciences, travel and North American literature and other collections. Mathematical collections have about 7000 resources and also have some Russian resources. Library contains more than 15 million digitized pages.	The database contains more than 3.5 million bibliographic entries with reviews or abstracts currently drawn from more than 3,000 journals and serials, and 170,000 books. The database of service contains about 2.1 million direct links to electronic versions of the indexed publications, to the publishers' websites and/or to electronic libraries with open access to the full texts.	This is an aggregation and indexing service. EuDML assemble the digital mathematical corpus in order to make it available online.
Functionality	The portal provides the ability to search for publications and links on the bibliographic description and keywords in the title, annotation or text. As result of the search, an abstract, article IDs (DOI, resource references in abstract databases, URIs), a citation pattern, classifier values are issued. There are no recommender service, in fact all semantic services work with a bibliographic description of the resource	CEDRAM has OAI-PMH server, which can be used for systematic download of metadata in various schemas. Search functions provide search by keywords, author, title, bibliography and full text search. Quick search searches in all fields except full text. Advanced search interface offers several types of research, more or less complicated. The full entry of articles produced for CEDRAM contains abstracts and bibliographical references.	NUMDAM has an OAI-PMH server, thus allowing sharing of metadata and better visibility of collections. System provide following functions: search and navigation by title, author, references or in full text of resources. During search all statistics, related to the search topic is displayed – co-authors, journals and years of publication. Browse functions provide navigation through sorted list of resources. Metadata extraction made only for bibliography. Any additional services like formula search or recommender system are absent.	Editors of all journals are using tools and workflows that enable them to produce inputs in a semiautomatic way. The formal consistency and integrity of the data are controlled by several validating procedures that have been developed in the project. There are some automated procedures for validation of data of new journal issues but all of them are for internal use and development. DML-CZ allows to search by title, author of publications, by language or by zbMATH and MathSciNet identifiers. Browse functions provide navigation through sorted list of resources. There is search of related articles.	Portal provides search in metadata and full text of resources and browse functions. All resources have full texts and can be viewed page by page or in structured mode. Metadata of any resource contain stable URL of resource, metadata can be downloaded in METS format.	Search functions provide search for documents, authors and journals. Search can be done in one line, or in structured form using attributes. Service also provide full-text formula search for indexed arXiv documents. The zbMATH formula search uses the MathWebSearch system. zbMATH maintain a classification scheme for mathematics.	EuDML offers several service interfaces that allow other applications to connect with the service. These are OAI-PMH server, REST services, OpenSearch service, which allow to query library index in machine way and annotation retrieval services in JSON.

Users	There are role model of users, everybody can register and create own personal area. Registered users can create personal pages, manage personal collections of publications, authors get access to the full texts of their articles.	No any user registration	No any user registration	No any user registration. End-users cannot submit any resource, everything can be submitted only through editorial board of journals, also there is no any personal area for users.	No any user registration.	There is a personal area for users – for reviewers, publishers etc.	No any user registration.
Quality of service	System is available in two languages. The policy for accessing the full texts of articles is determined by the publisher of the paper. Access for any other information is free.	Portal is available in English and French. Files of the full texts are the property of the journals. All online records exist in two formats, which are only different by the way they display mathematical formulas: MathML or TeX and have stable url link.	Portal available on English and French. Formulas can be viewed in TeX source code or in compiled, graphical way. NUMDAM only disseminate resources that were already published in journals, books or theses but submission process of resources is not clear.	Project was finished in 2010 and now it is in a stable form. Portal is available only in English.	Portal is available in German and English. But main aim of the project is to digitize and preserve resources.	Portal offers three ways of displaying mathematical formulas – MathML, MathJax and LaTeX. MathML is set as default. Not all services of the system are free, some of them need to be purchased.	EuDML has some policies: all texts must be scientifically validated and formally published; all items must be open access after a finite embargo period. Once documents contributed to the library are made open access due to this policy, they cannot revert to close access later on; the digital full text of each item contributed to library must be archived physically at one of the member institutions.