DatabencArt and EDUBBA: digital infrastructures for cataloguing and sharing cultural heritage content

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Abstract.

The paper presents DatabencArt and EDUBBA, two strictly integrated digital infrastructures designed and developed to cope with the increasing demand of a smart use of cutting-edge technologies in the Cultural Heritage (CH) realm. DatabencArt has been primarily designed to facilitate the cataloguing of CH objects while EDUBBA is focused on educational purposes. These platforms are the results of a long-term research effort made in the last five years by DATABENC Consortium (Distretto ad Alta Tecnologia per i Beni Culturali) and treasuring the experiences gained with the exploitation of many research projects in the field of of ICT technologies for Cultural Heritage knowledge, preservation, valorization and sustainable fruition.

1. Introduction

In the last decade, we witnessed an increasing demand of technological solutions for managing the digital life cycle of tangible (e.g., monuments, artworks) and intangible (e.g., literature, music) Cultural Heritage (CH). However, such demand is still evolving. Up to a few years ago, the primary goal was to document and provide access to the cultural heritage information, which led to the creation of hundreds of different datasets and web portals.

Today, the issues of data standards and interoperability with third-party applications are becoming every day more relevant. Besides, making possible to automatically correlate cultural information coming from different experts (e.g., archaeology with literature) has proved its importance in creating and promoting knowledge. To cope with this new demand for cutting-edge technologies for the CH sector, in the year 2012 the “Distretto ad Alta Tecnologia per i Beni Culturali” DATABENC (High Technology Consortium for Cultural Heritage) was founded, a Consortium putting together the majority of the Academic and Research Institutions of Italian “Regione Campania” and a great number (more than 60) of Enterprises operating in the CH realm.

During the last five years, DATABENC designed and developed two digital infrastructures: DatabencArt and EDUBBA with the main goal to create an open platform for experimenting the use of new technologies in the CH field.

DatabencArt has been primarily designed to facilitate the cataloguing of CH. It controls the entire process of producing records of both tangible and intangible heritage by following the latest ICCD2

1 DatabencArt, available at https://databencart.com, last accessed: 22/11/2019
2 ICCD, available at https://iccd.beniculturali.it
cataloguing standard. The platform is based on a NoSQL database and includes an advanced application programming interface for sharing information through other systems, and a web interface to provide access to records and multimedia attachments. Each record, defined in DatabencArt by a file in JSON format, can also be extended to be tailored to different types of third-party applications. The platform handles the entire cataloguing procedural flow in a traceable way and provides features to create collections of records and to connect records to IoT sensors available in a cultural space.

With the main goal to foster content production by unprofessional end-users in a collaborative and social way, DATABENC also promoted the design and development of a web-based software environment focused to manage user-generated content and mainly devoted to educational activities. This platform, strictly integrated with DatabencArt, is called EDUBBA\(^3\) and is named after one of the most ancient “school” of the world (the Sumerian Scribal School, c.a. 2000 BC). The ICCD-like records produced in EDUBBA are created by people, most commonly students, with knowledge of the territory and local culture. By using serious games and interactive tools, EDUBBA facilitates the creation of knowledge paths and exploitation strategies, especially useful to promote non-mainstream cultural sites.

2. Motivations and Architectural Choices
The main mission of the DATABENC Consortium can be summarized in the application of ICT technologies to the knowledge, preservation, enhancement and sustainable fruition of Cultural Heritage.

In this scenario, the development of the digital platforms DatabencArt and Edubba has been driven by the need to pursue the quoted objectives while dialoguing with the many existing stakeholders of this realm.

For a better understanding of how challenging this can be, let us try to briefly summarize the wide complexity of the Cultural Heritage dominion.

First of all, there are the public/institutional actors (such as, the so-called Super-intendencies, Museum Institutions, Municipalities, Provinces, etc.). The adherence to and the use of “standards” is of vital importance for such actors. As already cited in the previous section, ICCD rules and communications are to be adopted when dealing with Italian CH.

Then, there are the academic and professional experts, such as Archaeologists, Art Historians, etc., who would like to be able to use and possibly extend the formalism adopted in the quoted standards for scientific purposes.

Finally, there are the End Users, such as common citizens, tourists, etc., that are very heterogeneous in the adoption of technology and purpose of use.

Given the previous no-exhaustive list of Stakeholders and having the ambition to address all of them, we designed our platforms for being able to make contents accessible according to different user profiles, and in different ways (e.g., web portal, API for mobile apps, etc.).

During the last five years, we explored on the field the complexity of the interactions with all the quoted stakeholders through the realization of some research projects funded by the Italian Ministries of University and Research (MIUR), and of Economic Development (MISE) and by Campania Region. In 2017, as a final result of the first two DATABENC Projects, we realized a prototype system named CHIS – Cultural Heritage Information System that gave us a fundamental help in identifying the requirements that have driven the design and development of DatabencArt and EDUBBA.

In the following, we will summarize such requirements while in the following section we will illustrate in more details the platforms architecture.

The main choices characterizing the design of DatabencArt are the following.

- **STANDARD ADHERENCE**: adoption of a subset of ICCD v3.0;
- **FLEXIBILITY**: availability of tools for managing extensions to ICCD, multi-language and multi-profile descriptive fields, additional attributes;

\(^3\) EDUBBA, available at https://edubba.databencart.com, last accessed: 22/11/2019
MULTIMEDIA: the platform is able to connect multimedia objects of different types (images, videos, 360 videos, etc.) to the records of the catalogue;

NOSQL TECHNOLOGIES: we adopted the use of non-relational technologies plus API (Application Programmig Interface)

REDATIONAL FLOW: editorial flow management for complex structures, explicit and traceable validation of the information content;

SMART FRONT-END: creation of a portal, usable with desktop computers, tablets and smartphones, for cataloguing and viewing data - focus on user-friendliness plus QUERY evolved, with openness to semantic queries;

MULTI-TENANT: multi-tenancy is guaranteed to promote the commitment to cataloguing by third parties, and dedicated tools of use (for example, each museum/body can offer a special view of its own segment of cultural offering)

PROFILE: the platform allows the applications services to provide specific content depending on the profile of the user; advanced tools to define profiles are available

COLLECTIONS/EVENTS: services are available to select a subset of the CH objects available on the platform, from which to create one or more events (e.g., a temporary art exhibition). There are tools to define “paths” as a selection of works that form a thematic voyage within the event, which finally combine multimedia content;

IoT: within an event it is possible to associate a single or a group of art objects to IoT sensors (e.g., Beacon), necessary for the mobile use of proximity.

While working on the development of DatabencArt, and dialoguing with the already cited different Stakeholders, we became more and more convinced that when operating in the CH dominion a key mission is to provide inclusive, participatory access to cultural heritage experiences for as many sociocultural groups as possible.

The challenge is often to improve and evolve the participation and enjoyment of experiences, adapting proposals to the ever-changing society and to models established in daily experience. In this framework, it seems effective and promising to promote tools that allow the evolution of the participatory and collaborative process of users so that they can move within a known and comfortable experiential framework.

Hence, as stated in the Introduction, we decided to complement the DatabencArt platform with an integrated software environment called Edubba. The design of Edubba focused on promoting the use of collaborative approaches to cultural activities by adopting social media tools, distributed chat, co-design and promotion of the creation and publication of original content, following the modern and widespread model of communication and collaboration represented by platforms such as Instagram, Twitter, Facebook, WhatsApp. The use of collaborative and inclusive tools allows Edubba to provide services and opportunities to different social groups and categories of users to consult, review, model and enrich information on cultural heritage through the collaboration and participation of other users. Users can contribute to enrich cultural heritage by adding new material, customizing existing content, revisiting or simplifying existing information or augmenting content through multimedia contributions, promoting digital encoding and representation of cultural heritage.

Furthermore, Edubba aims to build experiences of fruition starting from the participation "from below" of groups of users such as, for example, students, experts in local tradition and culture, tour operators, scholars of current and past customs and traditions, etc. Users belonging to these varied categories can use the platform both to contribute to the enrichment of the information heritage (participation from below) and to the fruition of experiences and contents resulting from such participation (fruition from below). Scenarios for the use of the platform include the creation of interviews, audio guides, photo books, detailed research, descriptions of stories and legends, simplified narrations for young and very young users - all content brought into growth and enrichment of pre-existing information and digital content.

The platform allows to consult in an articulated way through maps, cards and multimedia reproduction channels all the contents generated, even on mobile devices. Thanks to the availability of
these user services, the platform makes it possible to build specific vertical applications such as, for example, information atlases, mobile applications designed to accompany users in the direct discovery of the heritage through field experiences and applications that allow users to create "thematic tours" in a participatory and shared way, always adopting the collaborative tools offered by the platform.

The employment opportunities offered by the Edubba platform are, in short, aimed at helping the cultural tourism sectors, educational institutions, cultural heritage institutions, NGOs, socio-cultural organizations and other actors in enhancing the heritage by enriching the information available and the channels of use for a better understanding of cultures, history and communities.

3. Digital infrastructure

3.1. DatabencArt Components

Figure 1 shows the overall sketch of DatabencArt architecture which can be regarded as a layered structure.

At the lower level, the platform consists of a Data Layer where content is stored. All data related to the entire platform can be find at this level: user information (users, groups, roles, …), cultural assets information, multimedia contents and links to external sources, like Linked Open Data (LOD), etc.

As reported in the Figure, the Data Layer contains the following main components:
- a RDBMS (Relation Database Management System) repository of the CMS (Content Management System) used, including in particular the user access info. We adopted the use of Drupal with its dedicated accounting software.;
- a NoSQL database (ElasticSearch) devoted to managing all the contents like catalogue records, projects, content metadata, validator schema;
- an Object Storage for storing multimedia contents (audio, video, …) of the cultural assets catalogued in the system.

Immediately above the Data Layer, there is the Data Access Manager dedicated to Access Management. This layer allows the different applications and services of the platform to access their needed data depending on the scope of the access (for example, users management vs applications management). The Drupal Accounting Software module directly accesses his own database with the user info (username, group, role). On the contrary, access to other information is mediated by a REST API layer so to obtain an efficient decoupling between data and applications using them. The presence of an Access Token Manager guarantees shielding against unauthorized access.

The Application Layer hosts the “atomic” functions of the platform and specific third-party modules developed to extend DatabencArt capabilities.

In this level, we can observe the existence of three main families of application modules:
- User Management Modules (based on Drupal Accounting Software);
- DatabencArt “native” Modules (Research, Validation, Publishing, Data Entry, …);
- Third-party Modules that have to be realized using REST APIs.

Going upwards, we find a Single Sign-On Layer containing Drupal CAS. This level provides single sign-on capability for Drupal site by implementing the CAS (Central Authentication Service) protocol.

Finally, the top layer of DatabencArt contains a Web Portal to access the platform services: DatabencArt Portal is the “internal” portal that, using the core services (accounting, catalogue sheets management, …), allow the user catalogue or make use of the cultural heritage assets. In this layer, we have also web or external software platforms (like existing museum web sites) or modules (like EDUBBA vertical modules).
The design of DatabencArt is totally API-centric, in order to make possible to build, in a vertical way, an entire ecosystem of applications to fully exploit the value of CH contents. Consequently, all the accesses to data and functions are mediated and made available through the API layer making the platform easy to be integrated with third-party applications and ensuring adherence to state-of-the-art standards in terms of services consumption, security and scalability.

The **API Services Layer** guarantees the management of access to backend services, ensuring the following mechanisms:

- **Authentication**: the platform manages the entire lifecycle related to the release of application credentials for access to services
- **Authorization**: an authorization level is also guaranteed with a very fine granularity that, in some cases, reach the single resource level.
- **Api Throttling**: dedicated access and consumption policies based on the maximum number of calls are also managed on the platform.

Let us explicitly note that the Shared Repository realized in the Data Layer represents a common element used by the blocks above, up to the highest layer so allowing any application designed for DatabencArt to efficiently use the archived data.

DatabencArt’s data are organized following a **Multi-domain** approach, which in many ways recalls the Multi-tenant architecture.

DatabencArt’s **domains** are storage spaces dedicated to the end user, with distinct peculiarities. Specific users and groups belong to each domain, for which it is possible to define:

- the type of data sheets to be memorized
- the track records of each data sheet
- the level of details of the data sheets
- the validation rules

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**Figure 1.** A diagram of the general architecture of our platform
The characteristics of each domain are reflected in all the components of the system by placing rules and constraints in the memorisation phase, whether this occurs through the Web Portal or through the Api REST layer.

Thanks to this architectural approach, external applications can interact with the DatabencART platform by modelling their domain according to their own specific needs, although in compliance with the minimum cataloguing requirements given by the ICCD standards.

Let us briefly discuss some other important features of DatabencArt. 

**The first one** is related to Digital Rights Management. For the implementation of the complex regulations concerning the domain of copyright, protection and consultation of digital cultural heritage contents, DatabencArt is equipped with an additional layer that manages the level of access to catalogs, forms and materials multimedia on the basis of access rights of proprietary bodies. Such a layer is main delegated to protection, but it works also on the basis of subscriptions to "packages" of services or catalogs to be consulted. This approach extends the granularity of control of use up to the level of individual content, guaranteeing different levels of visualization for content with possible limitations (e.g., watermarking).

A second important service is constituted by the Advanced Search module where the use of No-SQL technologies allows, in addition to the basic search functions (based on fields and keywords,) advanced features such as:

- Full-text searches based on degrees of similarity and distance between strings;
- Searches with fuzzy logic and on a semantic basis;
- Geo-localized searches on single coordinates or within entire areas of interest.

This service has been developed for allowing in depth exploration of DatabencArt catalogs so to possibly individuate new relationships between contents. Such a search model makes the platform, in its interrogation mode, closer to a search engine than to a cataloguing application.

Finally, a very important function made available by the platform is the Editorial and validation workflow. Namely, DatabencArt implements a well-defined workflow for the preparation, revision, validation and certification of all contents recorded in the platform.

3.2. EDUBBA

Edubba can be considered a first example of a specialized module “built on”, “made by the use of” DatabencArt.

Edubba's design was guided by the intent of offering to educational user communities a user-friendly collaborative and social-based experience of production, management, collaboration and certification of contents, guided by a well-defined workflow. Those needs typically characterize schools and university contexts where students of a class are guided in a learning path regarding CH realm.

The design was also aimed to achieve two additional goals:

- Easily provide different user experiences for different types of projects and users based on their objectives and the skills involved;
- Achieve a complete integration with DatabencArt either for allowing the fruition of contents already stored in it or in order to transfer Edubba results onto it and therefore obtain a formal certification of crowd-sourced contents.

To this purpose, Edubba introduces the following entities: Project, Work and Task.

A **Project** can be defined as a global activity, possibly lasting several years, carried out by a community. Within each project, a set of **works** are defined which may relate to different functional areas or cultural contents on which a group of users will work. A **task** is a self-consistent activity within a work. All contents managed by Edubba present an information schema divided in two parts:

- **ICCD section**: consisting of the fields of the extended ICCD format used on DatabencArt
- **Enrichment section**: consisting in a flexible set of fields and in easy management of additional attachments to enrich the description of the CH object in a creative way.

Users will also be able to insert and integrate their work with various types of multimedia content (images, text, audio, video, documents), so to create photo books, personalized presentations, etc.

As previously stated, Edubba provides a highly collaborative experience by implementing a well-defined editorial and evaluation workflow. Each activity is assigned to an owner who will perform the work under the supervision of a tutor. Moreover, each work can be reviewed by owner’s peers, who can add opinions or comments through the following structure:

- **Social-Room**: each work has a dedicated social room in which the collaborating users and the Tutor can interact by exchanging messages, opinions and observations. There is also a hashtag logic based on the single task so as to allow the user to carry out searches within single conversations only for the tasks of his interest.

- **Punctual comments on a single field**: when reviewing the work of one of his group mates a user can insert timely comments to create interaction at the “atomic” level of information content related to a cultural object.

- **Real-Time Notifications**: the system is equipped with real-time notification functions to guarantee an interaction that is extremely engaging and responsive.

Figure 2 shows a simplified view of Edubba Environment and its integration in DatabencArt.

![Figure 2. A simplified view of the Edubba Platform and its integration with Databenc Art](image)

### 3.3. User interfaces

Today, the quality of the user interface in an application plays a fundamental role - if the user interface is poorly designed, then it lowers the chances of an application to succeed and to be adopted. This argument is even more important for the construction of applications designed for younger users, used to interacting with modern mobile applications and dynamic web applications which adopt rich and responsive interfaces. A significative design effort has been devoted to realizing a really flexible and dynamic approach to user interfaces in our platform.
In DatabencArt, the record layouts of the catalogue are defined with "descriptors" (JSON schema) which are used to dynamically model the three basic elements of the system:

- Data structure;
- User interfaces (forms);
- Validation interfaces (formal and substantial) of the incoming data.

This choice guarantees the possibility to quickly change/modify/integrate existing data structures and to add new types of records layout without heavy coding efforts.

In such a way, user interface forms dedicated to the consultation and management of catalogue elements are dynamically generated at the time of the request. Consequently, forms are able to perceive any changes to the data model, such as the modification of a record layout or the creation of a new type of CH object.

The structure of the quoted forms follows the ICCD data model and are organized with the same series of homogeneous sets of information, called paragraphs. Each paragraph contains two types of elements: simple fields or structured fields, which can contain further subsets of items called subfields.

Two storing modes are allowed:

- draft - to allow partial saving of the catalogue sheet
- complete - all mandatory requirements set by the law are verified

Our platform is natively oriented to multi-language and multi-profile use meaning that it is possible to easily adapt the fields of the recordings to manage contents if different languages and for different user profiles (e.g., child, adolescent, adult, expert, guest).

One significative example is given by the presence of an Abstract field, multi-language and multi-profile, in which it is possible to insert a descriptive content of the CH object to be used for fruition purposes.

Let us now briefly discuss the EDUBBA platform UI.

Edubba is equipped with a front-end system based on React technology. React is a JavaScript-based library for building web (and mobile) user interfaces. The library role is to support the implementation of the view layer for web applications. All React applications are based on composition principle and the building blocks of such application are components. A component is a self-contained module that renders some output. We can write interface elements like a button or an input field as a React component, then we organize these components inside higher-level components which define the structure of our application.

React approach was ideal for rich-UI collaboration-based applications due to its capabilities of dynamic data updates based on a reconciliation approach. When a component is first initialized, the library generates a lightweight representation of a view; from that representation, a string of markup is produced, and injected into the document. When data changes, the render process is called again. In order to perform updates as efficiently as possible, the approach is to differentiate the return value from the previous call to generate a minimal set of changes to be applied to the document structure. This capability is used in EDUBBA both to manage components for user collaboration and for the dynamic construction of data management forms.

4. First Experimental Results and Future Work

Since DatabencArt has been mainly devised to facilitate the cataloguing of CH, the number of records catalogued is an important evaluation parameter for the platform, also considering as a value the variety of expertise involved, in terms of areas of study and so of the typologies of records produced.

At the time being, in DatabencArt are collected 4,230 ICCD records: 2,862 artworks; 1,236 archaeological finds; 86 architectures; 38 archaeological monuments; 4 archaeological ensembles; and, 4 engraved matrices. In addition, the platform includes 11,749 multimedia attachments: 5,147 images; 3 videos; and, 6,599 audio files. Currently, thanks to a collaboration with the “Soprintendenza Archeologia, Belle Arti e Paesaggio per il Comune di Napoli”, 10,200 highly detailed records, focused
on the archaeological ensemble of Piazza Municipio, in Napoli, are being migrated to the DatabencArt platform. Once included in the catalogue, the experts will be able to test the most advanced DatabencArt features extensively, and then provide us with valuable feedback that will direct our future work in this area.

For what concerns EDUBBA, on April 2019 Databenc started a protocol with the “Ufficio Scolastico Regionale – Regione Campania”, with the aim to contribute to the general knowledge of the territory and local culture by involving students and tutors in the creation of CH content in a collaborative and social way.

The results achieved are more than promising. In three months, April-June 2019, the number of 37 schools, including 63 classes, decided to use the platform within their educational activities. A total of 509 users created 45 different projects on EDUBBA, producing 146 CH records in about 4000 collaborative work sessions. On December 2019, Databenc started a second experimental trial with schools. At the time being, 31 additional schools decided to join the project, with 62 more teachers registered on the platform.

An extensive experimental campaign of use of the two platform is already scheduled for 2020 and 2021, given that DatabencArt and Edubba are involved at the present day in three Regional and National Projects currently under development: REMIAM, PAUN and VASARI. Further information can be found on the web site of the Consortium (https://www.databenc.it).

Already planned further developments will concern two main goals:

- the integration with a complete IoT (Internet of Things) Management Module, so to allow the monitoring of CH objects through the use of sensors;
- the integration with a semantic search engine based on the introduction of an ontology layer in the architecture.

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