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ARCHAEOLOGICAL DOCUMENTATION AS A SERVICE. ARCHAEOLOGICAL INFORMATION SYSTEMS IN THE CLOUD ERA: THE BRADYPUS CASE-STUDY

After finding things the first consideration is to record and preserve all the information about them. […] Recording is the absolute dividing line between plundering and scientific work, between a dealer and a scholar. The most blue-blooded dilettante *collector who digs to possess fine things, but records no facts about them, is below the level of the dealer who will publish an illustrated priced catalogue, and state what was found together, and the details of the discovery. The unpardonable crime in archaeology is destroying evidence which can never be recovered; and every discovery does destroy evidence unless it is intelligently recorded* (Petrie 1904, 48).

1. Introduction

In the almost mid-Twenties of the 21th century we can definitely confirm that archaeology is slowly entering into the domain of the so-called Web 3.0, even in a relatively peripheric area of the technological development, such as the Italian peninsula. Linked Open Data (LOD), Semantic Web technologies and big data are now trending topics of international conference programmes and of journal articles about IT applications to archaeological research. The Web of data yearned since the 1990s by Tim Berners-Lee (Berners-Lee *et al.* 2009) is probably going to flank the 'old' Web of documents in the archaeological domain as well, but this is not going to actualise until specialised structured data sets will be accessible in mass and data streams will be available to the community as fully documented web services.

It is not a matter of experimentation, or founding new ways to structure data and publish them online; it is not a matter of finding meaningful techniques to link data sets together. The table has already been set and plates, glasses and cutlery have already been put in place. What is currently missing for the feast to be celebrated is the food and drinks, i.e. publicly available, structured, and documented data sets. Important cloud-based projects like the UK Archaeology Data Service by the York University (https://archaeologydataservice.ac.uk/; http://dx.doi.org/10.17616/R3MW23) or Open Context by the Alexandria Archive Institute (https://www.opencontext.org/; Kansa 2016; Kansa, Kansa 2018) do provide infrastructure and means to make archaeological research data findable, accessible, interoperable and re-usable (i.e. FAIR as defined in Wilkinson *et al.* 2016) in the long term, but such projects do have start-up fees that might discourage younger researchers willing to contribute and provide larger public to their research. Yet, cost alone cannot explain the scarce participation of Italian projects to these open repositories, for example, and both copyright and broader cultural barriers against open culture are probably still playing a very active role. These arguments are probably behind the lack of great success of important Italian community-sourced endeavours like the MOD by the Pisa University, a project trying to provide infrastructure and technology for open-access archaeological data repositories and listing by the middle of 2022 no more than 145 archives, each of them being structured following the research needs and not obeying to a fixed schema (http://www.mappaproject.org/mod).

Copyright- and data property-related issues do play an important role in preventing the online publication of open-access archaeological data sets (Anichini, Gattiglia 2021), and limited literacy about standards and publishing formats and generalised limited access to web technologies are also critical points, especially for medium to low (or none) budget projects, like doctoral projects. Their exclusion from the general scenario is by far the most important point of failure of the current system. In particular, doctoral projects deserve a much higher attention, since most of them have at their basis the design and implementation of structured and highly specialised original data sets, that in most cases simply disappear from the research landscape after the discussion and in more fortunate cases get published in a re-arranged, not-structured format, i.e. a printed monograph.

While the open-access publication is not on the top of the agendas of ongoing projects (in fact the opposite is true), the employment of tools and technologies capable of providing unique identifiers (i.e. means for inbound citation) and linkage tools (i.e. means for outbound citation) is the very core of scientific research. Furthermore, decentralised access to data (i.e. the possibility to access data sets through more than one software/device/location), automated access (i.e. the possibility to access data sets by software other than the database managing system, e.g. GIS platforms, statistical analysis software, data analysis and visualization tools, etc.), and finally some degree of data-sharing between colleagues or other specialists is nowadays paramount even for small-scale/single-researcher projects.

This paper tries to address the general problem of the accessibility of archaeological data by focusing on its very premises, i.e. the actual possibility for small-to-medium scale archaeological research projects to access web technologies capable on the one hand of enhancing their research by providing more flexible access to structured data and, on the other, by creating well-documented structured data sets that are ready to be published online, hopefully in a rich variety of formats, once the research project has come to an end and no legal impediment exists for data to be shared with the broader community[1].

BraDypUS, a web-based database managing system, specifically designed to address the archaeological domain, will be the main focus of this brief paper and few not exhaustive case-studies will be presented as examples of the possible usage of the tool. Some final remarks will close the presentation, drafting a possible collaborative road-map of future developments.

2. BraDypUS: a brief history

BraDypUS is an open-source project aimed at providing an easy to implement and very easy to use database managing system for archaeology, and more in general for the Cultural Heritage domain. Its development started in 2006 at the Department of Archaeology of the University of Bologna, in the context of the digitisation process of paper-based excavation records of the Roman site of *Suasa*, in the municipality of Ancona, Italy. At this early step it was conceived as a series of web forms persisting data to a server database with loose user access control and almost no data validation policy. The most important problem that the software was trying to address was the synchronous work on the same data set by about fifteen students. ACID-ity (i.e. Atomicity, Consistency, Isolation and Durability, Haerder, Reuter 1983) of transactions was granted by MySQL, the highly reliable, open source database engine. Few months after, the software evolved to a more generalized tool, by losing any reference to a specific project or to a fixed database schema and by developing more consistent user-access control based on roles, tools for data management (import, export, backup, bulk editing, etc.), and powerful querying graphical interfaces.

While PostgreSQL was by then a widely adopted database engine by archaeologists, mainly because of its well-known and highly-performant spatial extension PostGIS, MySQL was adopted because of a more widespread (and much cheaper) availability of commercial hosting plans. This was determined by its adoption as the default database engine by important and popular web Content Managing Systems, such as Joomla, Drupal and the new-born at that time Wordpress. The reason behind this choice might appear prosaic – and so it is – but it wide-opened the door to a long-lasting sustainable development

[1] Larger international projects, such as ARIADNEplus, a paramount data infrastructure targeted at archaeological research funded by the European Commission, are intentionally left outside the focus of the current work, since they provide integration between institutions rather than single scholars willing to share and publish their research. Regarding single projects for archaeological data management – such as OpenArchaeo (http://openarchaeo.huma-num.fr/) or ResearchSpace (https://researchspace.org/) platforms, to cite just two examples – a huge range of them are available and a comprehensive list is out of the reach of this paper.

process that could not have afforded at that time the expensive fees for (virtual) private servers of highly customised hosting plans.

The Geographical Information System of Chaonia, Epirus (SITARC: Sistema Informativo Territoriale Archeologico della Caonia) was the first project to use exclusively the new information system in 2007 (Bogdani, Giorgi, Lepore 2007; Bogdani, Giorgi 2012, 147-162). Since then, more than 30 Italian and international projects are using the hosted version of the system (see below) and there is no way to count independently maintained instances, both for testing purposes or in production. A notable effort towards a standardization of the archaeological documentation among different excavation projects mainly in the Middle East area (Iran, Iraq, Afghanistan, and Pakistan) was started since 2008, in collaboration with many field research projects, by defining a complex schema able to address multi-scale projects (Cereti *et al*. 2012, 2014; Bogdani, Colliva 2017). The scheme is still being used, with minor adaptions, in several archaeological projects leaded mainly by the University of Bologna and Sapienza University of Rome.

Finally, since 2016 BraDypUS is the core database system for the ERC-Advanced project PAThs. Tracking Papyrus and Parchment Paths. An Archaeological Atlas of Coptic Literature, directed by P. Buzi and based in Sapienza University of Rome (Buzi 2017; Bogdani 2017). Before that date, the development of the software was carried out by a start-up company, specially born to foster research, coding and provide technical support. Since 2016 the main development is leaded by Sapienza University of Rome and, since 2021, the LAD: Laboratorio di Archeologia Digitale (http://purl.org/lad) is in charge of actively maintaining the project and further developing the software.

It is most important to underline that each research project that has adopted BraDypUS for the management or publication of their data, has very actively contributed to the enhancement of its core functionality and usability. Therefore, it is not rhetorical to assert that BraDypUS is the holistic sum of experiences, theoretical and methodological considerations, requirements and research outputs of the several projects that have used and/or are using it. Source code is perfectible and is being refactored and enhanced on each major version release, but the long discussions at the basis of each instance is ultimately the most precious output of this project.

3. Technical overview: technology, concept and license

As already mentioned, BraDypUS is a web-based relational database managing system (RDBMS) built using widespread web technologies, and following the client-server paradigm. The ‘heavy’ work is handled by the server, and the client requires only a web browser to interact with the database.

The server-side application has been built on a typical LAMP stack (Linux/Apache/MySQL/PHP). PHP is the only mandatory requirement. Linux is by far the most secure, efficient and easy to set-up target operating system, but indeed any environment capable of running a PHP instance, such as Windows, Unix or MacOS, can be used. The same is true for Apache: it is the most widespread HTTP server on the Internet, although any web server that can work with PHP can be used to run BraDypUS.

MySQL was the default database engine of the first versions and in the following years SQLite was added to the list, as well. Progressively, support for MySQL was dropped over time and currently most of the instances run on SQLite. In 2021, the release of version 4 (a major rewrite of the entire project) restored full support for MySQL (and MariaDB) and added for the first time support for PostgreSQL. This was, after many years, a very important milestone that has open new scenarios to the possible adoption of the project by the community. At present, new users are free to choose the database engine that better fits their needs without impacting their overall experience with the software.

BraDypUS is a generalized software for the management of archaeological data. It means that it does not provide in advance a fixed schema to which data must adapt, as does for example pyArchInit a well-known Italian project for the documentation of archaeological contexts, designed on data-schemata provided by ICCD (Italian Central Catalogue and Documentation Institute) or developed by the project itself (Mandolesi 2009). On the one hand this means that deep knowledge of the data that are being collected as well as a clear view on the research questions that are raised by the project are a mandatory prerequisite. On the other hand, a great flexibility is made available to the project leaders to fully customize from the beginning the information system to better fit the research goals.

BraDypUS relies on a set of project-based configuration files thoroughly describing the database schema, along with data validation policy, vocabulary definition and other constraints that highly ease the data-entry process and grant a high degree of data consistency. These files, encoded in JSON, do provide a complete description of the structure of the application, and act as fundamental metadata for the information system.

This flexibility comes at the cost of manually building the database schema, data validation policy, etc., but since version 4, the overall configuration can be dynamically handled though fully graphical user interfaces (Fig. 1). Furthermore, the schema definition can be changed over time: new tables and columns can be added, tables and columns can be renamed or dropped, data validation policies updated, etc. The possibility to continuously adapt the database schema to new needs has been by far one of the most challenging and interesting features of the entire project. The system does not support

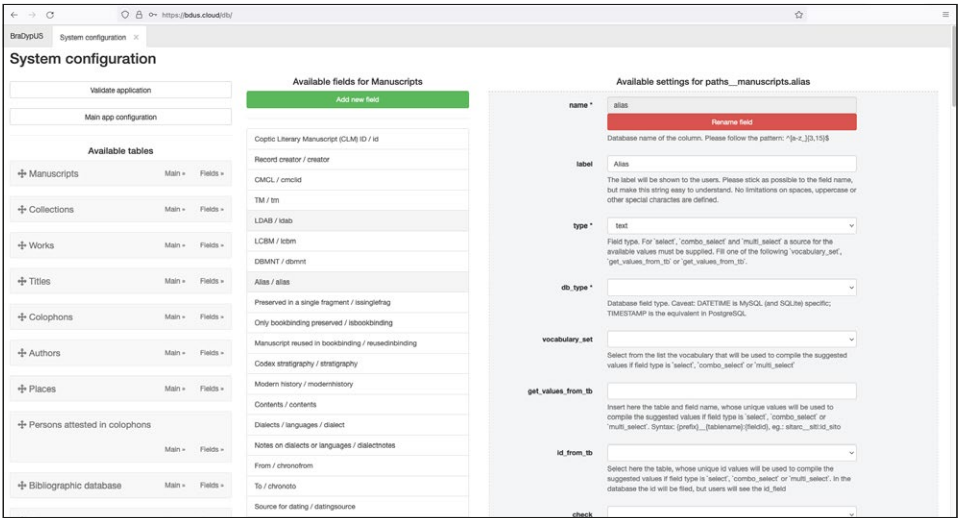

Fig. 1 – Screenshot of the graphical user interface dedicated to the BraDypUS database schema definition and data validation.

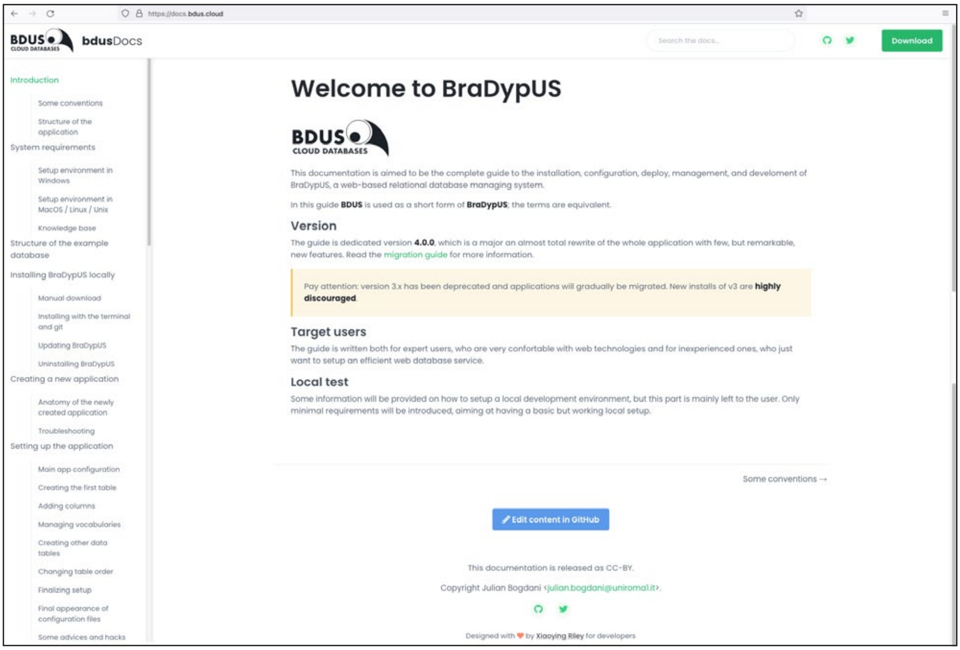

Fig. 2 – Screenshot of the welcome page of documentation portal. Readers and users are invited to collaborate by improving the contents maintained in GitHub.

the automatic creation of Entity-Relationship Diagrams, since many external tools provide this feature for each of the supported database engines. The manual creation and maintenance of ERDs is nevertheless a very instructive and beneficial practice for digital archaeologists.

Version 4 introduced an important change to the license as well. Traditionally BraDypUS has been shipped with the open-source and highly permissive MIT license (also known as Expat License: https://opensource.org/licenses/MIT). Version 4 was relicensed with the libre and open-source GNU AGPL v3 license (https://www.gnu.org/licenses/agpl-3.0.en.html), an adapted version of the most famous GNU GPL which addresses the particular case of software running on computer networks. It requires that modified versions of the original software running as a service on a (web-) server should be made available to the community as well. The intention behind this change is to provide legal ground to a free and libre development of the project in the long term.

The source code is maintained in a Git-based repository hosted on GitHub (https://github.com/lab-archeologia-digitale/BraDypUS) and Zenodo (https://dx.doi.org/10.5281/zenodo.5577979). In order to facilitate collaboration in the development process and to provide useful technical and practical information on the installation and setup, a detailed guide in English language has been published and maintained as a collaborative effort on GitHub (https://docs.bdus.cloud/), released as a Free Cultural Work (CC BY). The documentation portal has been conceived as a step-by-step guide presuming not very extensive technical skills on web technologies and coding and thus oriented mainly towards archaeologist and researchers looking to provide an easy-to-build and modern house for their data (Fig. 2).

4. Main features

BraDypUS is a web-based software, meaning that only a (modern) web browser is needed to run it, both on desktop computers and on mobile devices. The software provides graphical user interfaces for CRUD (Create, Read, Update, Delete) operations on database records. It allows the uploading of images and other types of attached files and their linking to database records; it is able to perform several types of database queries (simple string-based to highly advanced) using fully graphical interfaces; to manage geographical data through an integrated graphical webGIS tool (Fig. 3); to import and export bulk data in several formats (Fig. 4); to create, save and share queries with other users; backup and backup recovery; visual quantitative data analysis (charts); centralised vocabulary management; custom templating; custom UI language (Italian and English are supported out of the box, other translations can be easily added); fully automated Harris

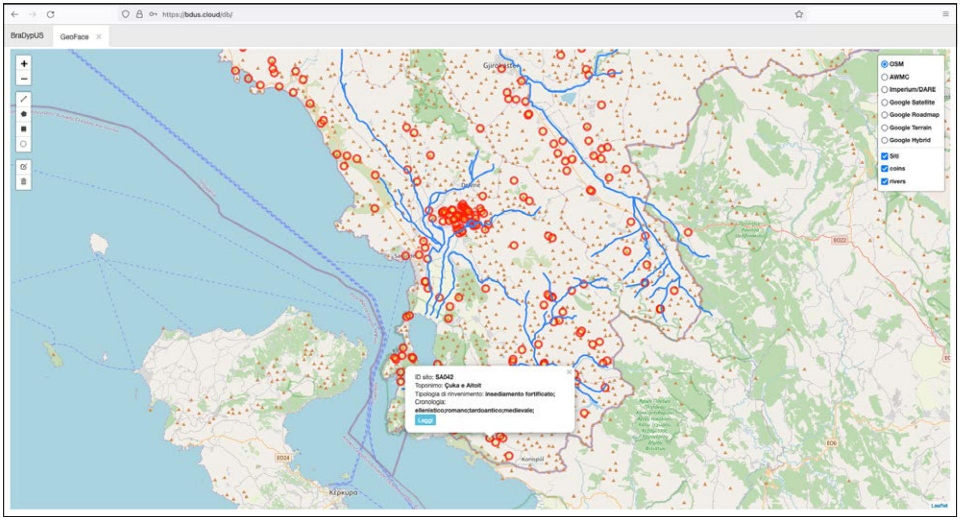

Fig. 3 – GeoFace, BraDypUS geographical interface showing point-features representing database records (archaeological sites) overlayed with GeoJSON encoded vectors representing historical hydrography and different options of out-of-the-box XYZ base maps (SITARC database).

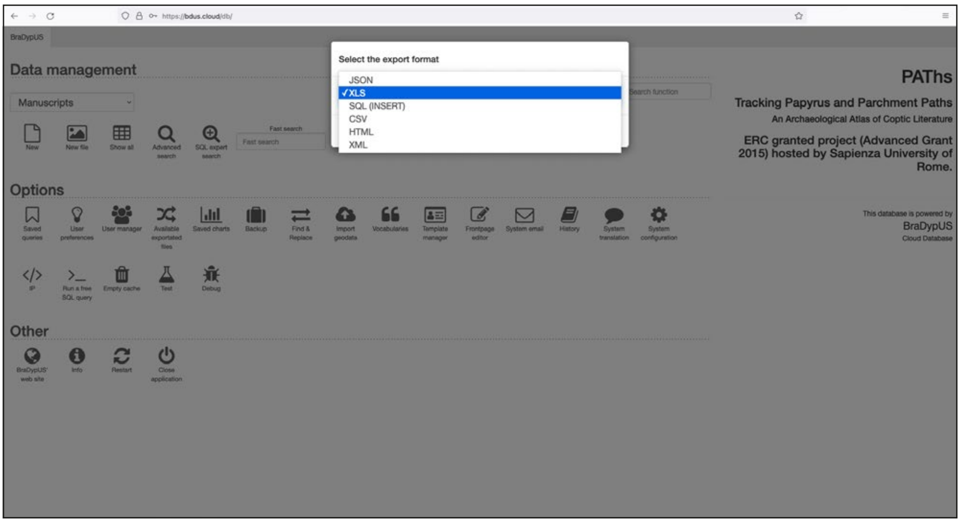

Fig. 4 – Whole data set or query results (subsets) are easily exported in different formats, such as JSON, Microsoft Excel, SQL, CSV, HTML and XML.

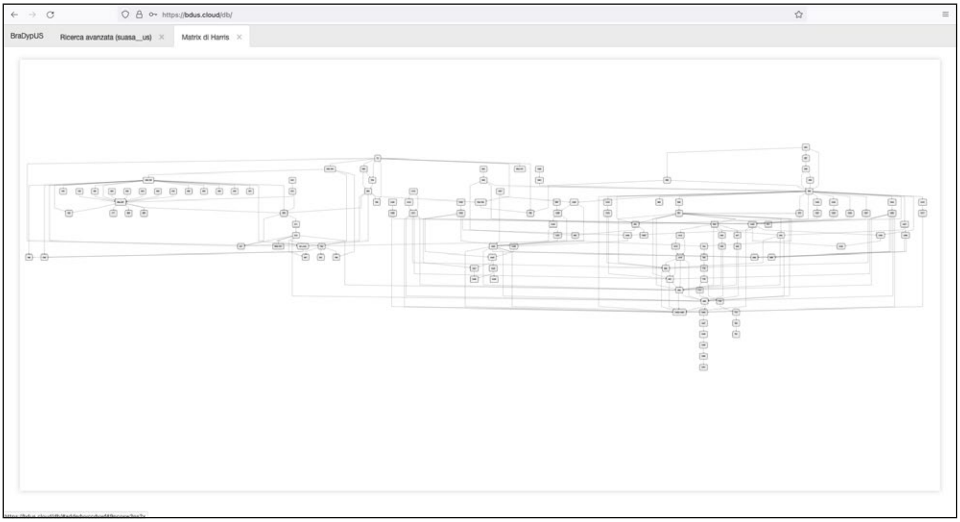

Fig. 5 – Automatically created stratigraphic Harris Matrix from an advanced query on textual data (Suasa database). The graph is built using a Dagre layout, a D3.js-based javascript library for directed graphs (https://github.com/dagrejs/dagre).

Matrix for archaeological contexts (Fig. 5), etc. As already mentioned, it is possible to build from scratch and fully configure a new application with a custom schema using graphical interfaces, obtaining full control on the database schema. User- and role-based permissions allow a very granular control over data editing and reading. Further control on data quality over time is granted by keeping trace of each edit operation, by maintaining a very detailed log of database interactions.

Finally, since archaeological excavations occur not rarely in areas not covered by broadband Internet connection, it has been necessary to develop a dual online/offline use of the software with a specific synchronizing mechanism. It is possible to install the software on a personal computer and create e local network within the scope of a laboratory or excavation area. While the local server is running the main application on the web is put on a "frozen" status, where data are accessible in read-only mode. After the excavation is finished, it is possible to synchronize back to the main server.

Up to 3-4 years ago the offline mode was a very requested feature, not only in remote extra-European areas but also in several parts of Italy. More recently, nevertheless, the substantial diffusion of 4G and 5G mobile network coverage even in remote geographical areas has rapidly changed the needs of the archaeological teams who do not require any longer a local ('offline') version of their databases.

5. Software as a service: new patterns for the archaeological documentation

For long years the only way to build a new instance of a BraDypUS database was to hire an IT specialist who was aware of the specific details of the software, a fact that has deeply determined the development and diffusion of the software itself. Only bigger and structured projects could afford the initial costs, and single researchers where in most cases discouraged by the rather high technical threshold. This was not determined only by economical reasons, but also by the fact that bigger projects had a greater urgency for a multi-user database. Things has changed in recent years, since the cloud paradigm is becoming progressively part of our daily life, and multi-device/location access to data has become a paramount requisite.

In order to facilitate participation, full support for database creation and schema editing has been introduced since 2021 and detailed documentation

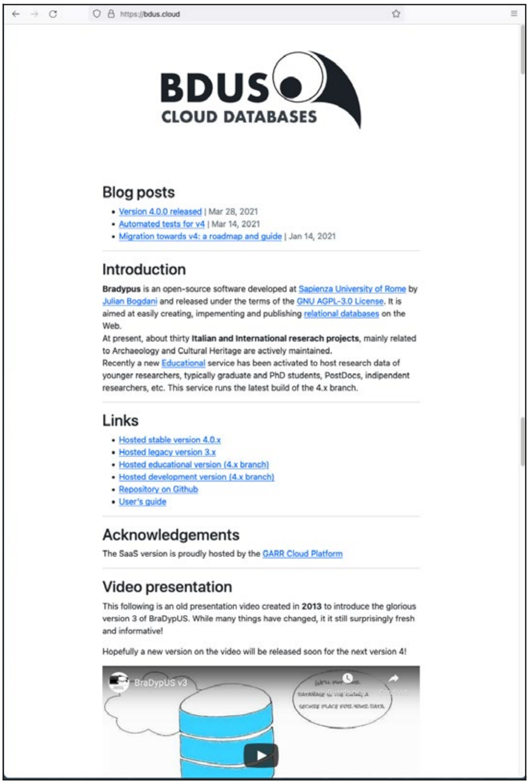

Fig. 6 – BraDypUS hosted version at https://bdus.cloud/.

has been published online in the BraDypUS Official Guide aiming at facilitating the creation of a database also by archaeologists non particularly accustomed to IT applications.

In the context of an institutional collaboration between Sapienza University of Rome and the GARR Consortium (https://www.garr.it/), a cloud service has been made available, distributing BraDypUS as a fully-managed service (Fig. 6). This is a freely available service for institutional participants and is paired with an 'educational' version, a free to use virtual space for experimenting and creating research. While the creation of a new hosted instance under the main branch is subject to authorization, the educational space is absolutely free to experiment with. Anyone can create new projects, develop them further and make them production-ready. The education branch is therefore the best place to start with for new users; once an application is ready for production and is actively maintained, it is eligible to be moved to the main branch.

This is a very concrete way to promote independent research and to offer a sustainable digital house for research data to small-scale projects, a house that they are free to adapt to their specific needs. Data sets remain in the exclusive availability of their owners, who freely decide on the degree of openness of their archive.

6. Data as a service: new patterns for the archaeological publication

Even if BraDypUS is a self-contained multi-featured software package, it has been developed with the firm intention of not building a silos. The most important investment in terms of code developing has been focused in obtaining a fluid user experience, aiming at progressively lowering barriers for non IT specialist. The most important goal was developing a system that did not required any specific training for end-users. Security and performance where also paramount targets and in the last years many improvements have been introduced.

Yet, data availability beyond the software itself has become one of the most important key features. Data availability through application programming interfaces (APIs) using open and well documented web standards has made possible on the one hand the creation of other digital products based on the published data sets and, on the other, it has made possible a richer set of customized and parallel alternative data formats, a most useful feature to programmatically (i.e. automatically) align data through different projects. From the technical point of view, outbound communication is available through a REST (Fielding 2000) API that outputs JSON, a text-based widespread standard for information interchange (https://www.ecma-international.org/publications-and-standards/standards/ecma-404/) or GeoJSON, a JSON-based

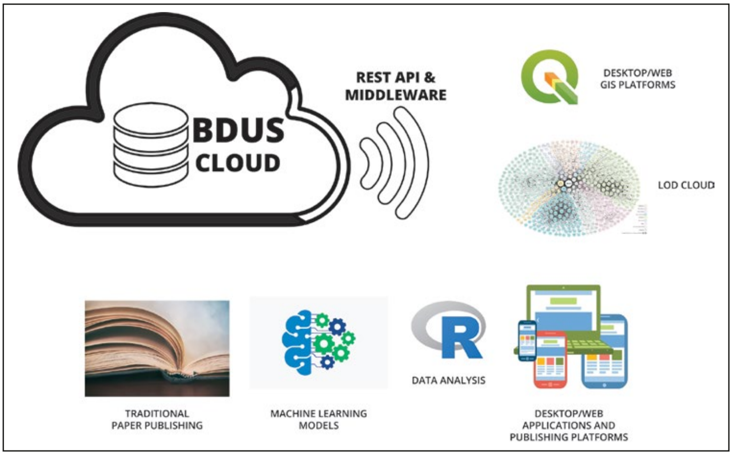

Fig. 7 – Diagram of possible archaeological data usage beyond the specific RDBMS.

standard for geographic data representation (https://datatracker.ietf.org/doc/html/rfc7946). The custom design of middleware makes it possible to output custom data-structures and data-formats, as well.

Three examples can clearly demonstrate the flexibility and the potentiality of opening databases to a broader public and sharing data with other projects (Fig. 7).

6.1 *Ghazni: a multidisciplinary digital archive for the managing and preservation of an endangered cultural heritage (https://ghazni.bdus.cloud)*

The first example regards the creation of a web portal curated by Orientale University of Naples aiming at providing a digital open-access publication of archaeological objects and contexts related to the Italian Archaeological Mission in Ghazni, Afghanistan (Fig. 8). This important crossroads of Central Asia represents an evocative synthesis of the developments of cultural phenomena that occurred in the region from the 2nd to the 19th Century. The Italian field research has recovered in Ghazni highly important and suggestive traces of the Buddhist and Islamic culture, a heritage constantly endangered by 20th and 21th Century continued crisis. The reasoned organization and online publication of the archaeological data aimed at securing their preservation, at facilitating their circulation among the scientific community, and at promoting new research inside and outside Afghanistan. An active contribute to the training of the new generations of Afghan cultural heritage professionals was also a paramount goal.

The first version of the web portal (Bogdani 2016) has been recently updated, enlarging the quantity of information published online. The cataloguing

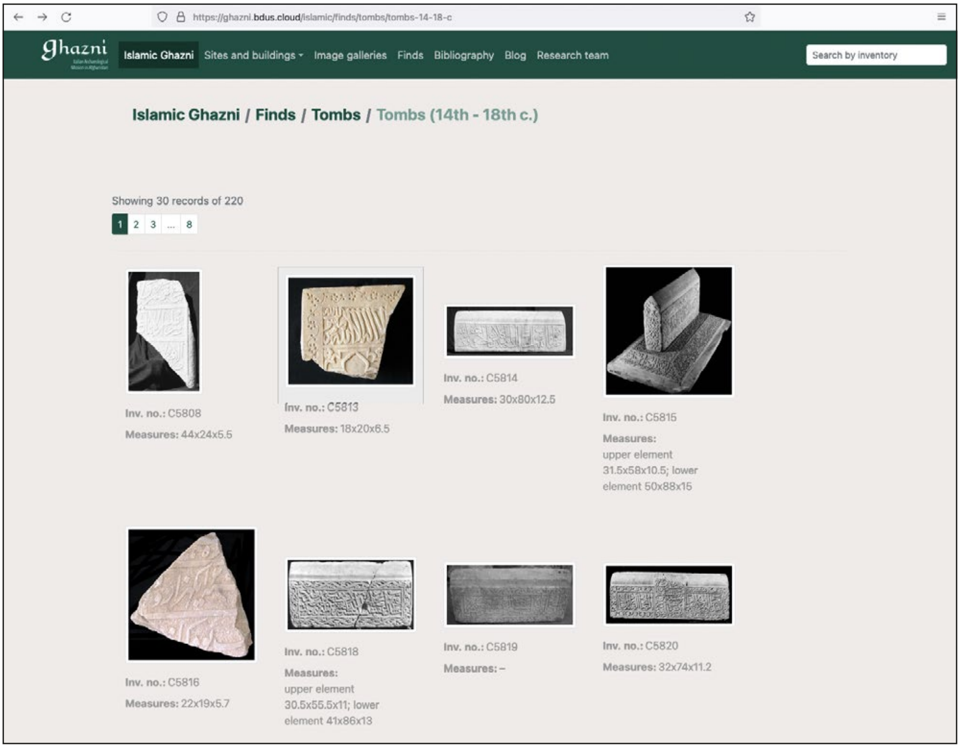

Fig. 8 – Screenshot of one of the newly added sections of the Ghazni website, dedicated to the tombs and the architectonic elements pertaining to them.

of objects and contexts has been (and still is) a hard and meticulous work conducted by researches that have transferred to the digital domain paper-based archives and new original research. The main data-container is a BraDypUS instance that exposes the entire dataset via the REST API. The web portal pulls data from the database and publishes them online, wrapping data with an interpretative narrative, context and taxonomy. The web portal can thus be considered as a context-aware and higher-level version of the main database, automatically updating each time changes are applied to the main repository. By building custom filters, various ways of organizing and presenting the information are available, based on contexts of discovery, typology of the objects, material, function, iconography, chronology, etc., providing new and original ways of exploring and studying the archaeological record.

From the technical point of view the Ghazni website is coded in PHP. For this project a high-level PHP class to connect and retrieve data from the database API, using Object Oriented Programming (OOP) paradigm has been expressly developed. The library can be used also by thirds willing to develop new PHP applications consuming data from a BraDypUS database. It is available for download with the MIT license on GitHub (https://github.com/lab-archeologia-digitale/BdusApiPhpClient: https://dx.doi.org/10.5281/zenodo.5744345).

6.2 *PAThs: Archaeological Atlas of Coptic Literature (https://atlas.paths-erc.eu/)*

Similar premises, but of a completely different scale, have led to the development of the Archaeological Atlas of the Coptic Literature, a Rich Internet Application (RIA) coded in JavaScript, a client-side programming language. The online Atlas has been designed to be an open-access read-only public version of the PAThs database, counting, on November 2021, ca. 9,200 unique digital objects, organized in Manuscript, Places, Works, Authors, Persons, Titles, Colophons and Collection entities. The PAThs database is actively updated on a daily basis, since the research project directed by Paola Buzi and located at Sapienza University of Rome is still ongoing.

The text-based data presentation is paired by a map-based (WebGIS) interface acting as a connection hub for the various georeferenced entities and connecting the archaeological dimension to the textual one, i.e. the Coptic literary manuscripts, a paramount characteristic of this ERC funded project

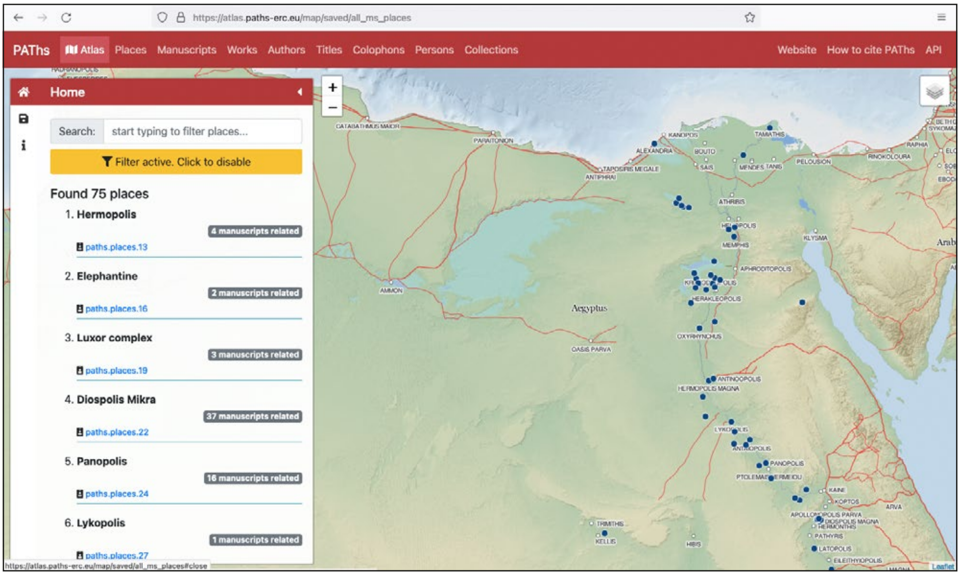

Fig. 9 – Screenshot of the geographical interface of the PAThs: Archaeological Atlas of the Coptic Literature, showing places (i.e. archaeological sites) connected to Coptic manuscript production or discovery.

(Fig. 9). Once more, the live connection between the web database and the data presentation portal is the very premise of creating a living web-based application, continuously and automatically updating as the work of the researches advances. This is not only a technical detail about developing modern applications for the humanities domain, but a radical change of perspective toward a data-centric vision. The database in the sense of the data-container tool or the data-portal in the sense of the presentation interface software are put in a second plane, offering a most eminent and central place to the structured data set. In a data-centric view, applications and interfaces are fundamental tools necessary to implement and interact with data, yet they must be interchangeable and as such not indispensable to the actual use of data. The separation of data from software can be therefore considered as a prerequisite of breaking silos.

6.3 *Connecting PAThs to Pelagios: Linked Open Data on-the-fly transformation from online RDBMS (https://atlas.paths-erc.eu/api/)*

A final example regards a not yet documented feature of BraDypUS database, that is the possibility of coding custom data transformation algorithms in the form of middleware software, able to transform on-the-fly the API-served data streams. Using this functionality it is possible, for example, to output data in formats other than JSON, and also to transform the data structure to fit different usage needs. There is a variety of possible scenarios where custom schema or custom output formats are required; typically this is a fundamental feature when the programmatic collaboration between research projects comes into account. Data-alignment between databases is a requisite for data-exchange and actual collaboration, for data linkage and further data enhancement.

The example of the PAThs data-transformation pipeline to meet the Pelagios Gazetteer Interconnection Format (https://github.com/pelagios/pelagios-cookbook/wiki/Pelagios-Gazetteer-Interconnection-Format), a custom ontology that can be serialized in different LOD standards (Turtle, JSON, N-Triples, RDF/XML, Graphviz Dot, N3) can be enlightening. In this specific case the API is wrapped in custom code that on-the-fly transforms data regarding PAThs places to meet the specific structure of the Pelagios Interconnection Format. It is also able to express (serialize) this conceptual scheme to different formats, based on JSON, XML or completely different encoding schemes (Fig. 10).

The most important point that must be stressed out is that with BraDypUS a researcher does not need to adapt the way he collects, analyzes and stores data to the needs of compliancy with parallel projects. He only has to focus on his own research questions. In a second step, it is possible to build custom tools on top of the already available API function to expose one or more custom data-schemes expressed in one or more custom data-formats to meet the needs of connection to other data sets, in the context of a desirable increasingly connected research and/or interoperability.

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▾ http://paths.uniroma1.it/data/places#agents/me:
  ▾ http://www.w3.org/1999/02/22-rdf-syntax-ns#type:
    ▾ 0:
        type:                "uri"
        value:               "http://xmlns.com/foaf/0.1/Person"
  ▾ http://xmlns.com/foaf/0.1/name:
    ▾ 0:
        type:                "literal"
        value:               "Julian Bogdani"
  ▾ http://xmlns.com/foaf/0.1/mbox:
    ▾ 0:
        type:                "literal"
        value:               "julian.bogdani@uniroma1.it"
  ▾ http://xmlns.com/foaf/0.1/homepage:
    ▾ 0:
        type:                "literal"
      ▾ value:               "http://www.lettere.uniroma1.it/users/julian-bogdani"
  ▾ http://xmlns.com/foaf/0.1/depiction:
    ▾ 0:
        type:                "literal"
      ▾ value:               "http://www.lettere.uniroma1.it/sites/default/files/pictures/picture-1844-1508316765.jpg"
▾ http://paths.uniroma1.it/atlas/places/1:
  ▾ http://www.w3.org/1999/02/22-rdf-syntax-ns#type:
    ▾ 0:
        type:                "uri"
        value:               "http://lawd.info/ontology/Place"
  ▾ http://www.w3.org/2004/02/skos/core#exactMatch:
    ▾ 0:
        type:                "uri"
        value:               "http://pleiades.stoa.org/places/736963"
    ▾ 1:
        type:                "uri"
        value:               "https://www.trismegistos.org/place/1344"
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Fig. 10 – Excerpt of different serialisations of data about the PATHs places modelled to follow the Pelagios Gazetteer Interconnection Format for Linked Open Data. From left to right: JSON, Turtle and RDF/XML. Available options are published at: https://atlas.paths-erc.eu/api/ *(follows on the next page)*.

7. Alternatives

It is important to remark that in the international stage different efforts aimed at providing digital tools for the documentation of the archaeological record have been put in place, developing software to address the on-field or in-laboratory data collection. In the next paragraphs follows a very short and not exhaustive list, hopefully significative of the trending topics of this research area.

The *iDAI.field* is a set of applications developed by the Deutsches Archäologisches Institut in Berlin, covering the desktop usage (iDAI.field Desktop), the on-field data collection using mobile devices (iDAI.field Mobile), a web publication platform (iDAI.field Web) and a central server for the data management (iDAI.field Server). These applications are used internally by the German Archaeological Institutes teams operating all over the world and are made available as open-source projects (*de facto* only iDAI.field Desktop is clearly licensed with Apache v.2 license and the other projects are lacking any clear indication) to the community of archaeologists on GitHub (https://github.com/dainst/idai-field).

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix lawd: <http://lawd.info/ontology/> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .
@prefix geosparql: <http://www.opengis.net/ont/geosparql#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dc: <http://purl.org/dc/terms/> .
@prefix time: <http://www.w3.org/2006/time#> .
@prefix periodo: <http://n2t.net/ark:/99152/p0v#> .

<http://paths.uniroma1.it/data/places#agents/me>
  a foaf:Person ;
  foaf:name "Julian Bogdani" ;
  foaf:mbox "julian.bogdani@uniroma1.it" ;
  foaf:homepage "http://www.lettere.uniroma1.it/users/julian-bogdani" ;
  foaf:depiction "http://www.lettere.uniroma1.it/sites/default/files/pictures/picture-1844-1508316765.jpg" .

<http://paths.uniroma1.it/atlas/places/1>
  a lawd:Place ;
  skos:exactMatch <http://pleiades.stoa.org/places/736963>, <https://www.trismegistos.org/place/1344> ;
  geosparql:hasGeometry [ geosparql:asWKT "POINT (31.255061 29.849491)" ] ;
  rdfs:label "Memphis"@en ;
  lawd:primaryForm "Memphis"@en ;
  lawd:hasName [ lawd:variantForm "Ineb-Ḥedjet"@egy ], [ lawd:variantForm "Men-nefer"@egy ], [ lawd:variantForm "İnb-ḥḏ"@egy ], [ lawd:variantForm
"İnb-ḥt"@egy ], [ lawd:variantForm "Ḥw.t-kȝ-Ptḥ"@egy ], [ lawd:variantForm "Mḫȝ.t-tȝ.wy"@egy ], [ lawd:variantForm "Ms-ṯḥny"@egy ], [
lawd:variantForm "Μέμφις"@grc ], [ lawd:variantForm "Μέμφη"@grc ], [ lawd:variantForm "ⲙⲛϥⲉ"@cop ], [ lawd:variantForm "ⲉⲕⲉⲡⲧⲁ"@cop ], [
lawd:variantForm "ⲙⲉⲃⲉ"@cop ], [ lawd:variantForm "ⲙⲉⲙⲃⲉ"@cop ], [ lawd:variantForm "ⲙⲉⲛⲃⲉ"@cop ], [ lawd:variantForm "ⲙⲉⲛϥ"@cop ], [
lawd:variantForm "ⲙⲉⲛϥⲓ"@cop ], [ lawd:variantForm "ⲙⲉϥⲉ"@cop ], [ lawd:variantForm "ⲙⲉϥⲓ"@cop ], [ lawd:variantForm "ⲙⲏⲃⲉ"@cop ], [ lawd:variantForm
"منف"@arz ], [ lawd:variantForm "Manf"@eng ], [ lawd:variantForm "Memphis"@eng ] .

<http://paths.uniroma1.it/atlas/places/2>
  a lawd:Place ;
  skos:exactMatch <http://pleiades.stoa.org/places/727149>, <https://www.trismegistos.org/place/1245> ;
  dc:temporal "750/750" ;
  time:hasDateTimeDescription [
    periodo:earliestYear "325" ;
    periodo:latestYear "750"
  ] ;
  geosparql:hasGeometry [ geosparql:asWKT "POINT(31.1339825 30.1223455)" ] ;
  rdfs:label "Letopolis"@en ;
  lawd:primaryForm "Letopolis"@en ;
  lawd:hasName [ lawd:variantForm "Sḫm"@egy ], [ lawd:variantForm "Pr-Ḥr-nb-Sḫm"@egy ], [ lawd:variantForm "Sšm"@egy ], [ lawd:variantForm "Šm"@egy
], [ lawd:variantForm "Ḫm"@egy ], [ lawd:variantForm "Ḥs"@egy ], [ lawd:variantForm "ȝy"@egy ], [ lawd:variantForm " Λητοῦς Πόλις"@grc ], [
lawd:variantForm "Λέτους"@grc ], [ lawd:variantForm "Λητοῦ"@grc ], [ lawd:variantForm "Λιτούς"@grc ], [ lawd:variantForm "ⲃⲟⲩϣⲏⲙ"@cop ], [
lawd:variantForm "ⲉⲅⲥⲓⲙ"@cop ], [ lawd:variantForm "اوسيم"@arz ], [ lawd:variantForm "Letopolis"@eng ] .

<http://paths.uniroma1.it/atlas/places/3>
  a lawd:Place ;
  skos:exactMatch <http://pleiades.stoa.org/places/727217>, <https://www.trismegistos.org/place/2072> ;
```

```
<?xml version="1.0" encoding="utf-8" ?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/"
         xmlns:lawd="http://lawd.info/ontology/"
         xmlns:skos="http://www.w3.org/2004/02/skos/core#"
         xmlns:geosparql="http://www.opengis.net/ont/geosparql#"
         xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
         xmlns:dc="http://purl.org/dc/terms/"
         xmlns:time="http://www.w3.org/2006/time#"
         xmlns:periodo="http://n2t.net/ark:/99152/p0v#">

  <foaf:Person rdf:about="http://paths.uniroma1.it/data/places#agents/me">
    <foaf:name>Julian Bogdani</foaf:name>
    <foaf:mbox>julian.bogdani@uniroma1.it</foaf:mbox>
    <foaf:homepage>http://www.lettere.uniroma1.it/users/julian-bogdani</foaf:homepage>
    <foaf:depiction>http://www.lettere.uniroma1.it/sites/default/files/pictures/picture-1844-1508316765.jpg</foaf:depiction>
  </foaf:Person>

  <lawd:Place rdf:about="http://paths.uniroma1.it/atlas/places/1">
    <skos:exactMatch rdf:resource="http://pleiades.stoa.org/places/736963"/>
    <skos:exactMatch rdf:resource="https://www.trismegistos.org/place/1344"/>
    <geosparql:hasGeometry>
      <rdf:Description>
        <geosparql:asWKT>POINT (31.255061 29.849491)</geosparql:asWKT>
      </rdf:Description>
    </geosparql:hasGeometry>

    <rdfs:label xml:lang="en">Memphis</rdfs:label>
    <lawd:primaryForm xml:lang="en">Memphis</lawd:primaryForm>
    <lawd:hasName>
      <rdf:Description>
        <lawd:variantForm xml:lang="egy">Ineb-Ḥedjet</lawd:variantForm>
      </rdf:Description>
    </lawd:hasName>

    <lawd:hasName>
      <rdf:Description>
        <lawd:variantForm xml:lang="egy">Men-nefer</lawd:variantForm>
      </rdf:Description>
    </lawd:hasName>

    <lawd:hasName>
      <rdf:Description>
        <lawd:variantForm xml:lang="egy">İnb-ḥḏ</lawd:variantForm>
      </rdf:Description>
    </lawd:hasName>

    <lawd:hasName>
      <rdf:Description>
```

Heurist network has a starting point very similar to BraDypUS, since it pretends to be a low threshold, adaptable and incremental database managing system for Humanities researchers, able to ingest existing data sets, provided with advanced search tools, data analysis functionalities and simple web publishing interfaces. It was originally designed by Ian Johnson, based in Sydney, Australia. Heurist is an open-source project licensed with GNU General Public License v3.0 whose source-code is currently available on GitHub (https://github.com/HeuristNetwork/heurist).

Specifically addressing the issue of remote and not connected areas where archaeologist often operate, *FAIMS* (Field Acquired Information Management Systems) is conceived as a mobile application for Android-based devices. It is designed to collect data from a number of not connected mobile devices that synchronize when a connection to a network is available towards a central data repository. The latest version (3) is still under active development (pre-alpha). It is also developed as an open-source project (Apache v.2 license) with its code being hosted on GitHub (https://github.com/FAIMS/FAIMS3). Other than archaeology, FAIMS is used by projects focused on Geoscience and more in general on the Humanities domain (Sobotkova *et al.* 2016, 2021).

Finally, the Archaeological Recording Kit (ARK) is another open-source (GNU GPL v.2.0), web-based 'toolkit' for the collection, storage and dissemination of archaeological data, including data-editing, data-creation, data-viewing and data-sharing tools, all of which are delivered using a web-based front-end (https://ark.lparchaeology.com/; Eve, Hunt 2008). It uses a stack similar to the one used by BraDypUS, relying on Apache/MySQL/PHP. Its code is hosted in SourceForge but it seems not to be actively updated, the latest release dating in 2018 (https://sourceforge.net/projects/arkdb/). One of the most important projects adopting ARK is Fasti Online (http://www.fastionline.org/).

8. Conclusions

While a much opener archaeological record production and analysis and in general a more participated research process remains a desirable but still remote goal, it is much important to offer to the community of scholars digital tools able to foster their research, capable of building bridges and fit to serve as a stable basement for this common objective.

BraDypUS, as other parallel projects, does provide an agile and flexible tool able to bring the archaeological research to the cloud era. While user and role based restrictions provide a secure data protection layer, still necessary and fundamental in most use-cases, a versatile use of the API can permit the external use of data towards publishing platforms, data analysis software, desktop GIS platforms and other desktop or mobile applications that can be built on archaeological data sets. This is probably one of the most effective ways to avoid isolation and promote collaboration, in the hope that legislation and copyright regimentation will permit in the near future a much more dynamic and collaborative research process. It is not only a matter of the most efficient tools to be adopted or of the most recent technological trends to be followed. Real-time collaboration and data-sharing beyond the borders defined by a single software do provide a new methodological point of view in the archaeological data recording, analyzing and publishing. The possibility of transforming, with none or little effort and investment, each isolated data set into a well-documented data access point might provide new means toward a more concrete Web of data also for the archaeological domain.

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ABSTRACT

The paper discusses new trends in the archaeological documentation practice, heavily conditioned by the capillary diffusion of web-based technologies and cloud-based services. In this context, a close examination of BraDypUS, a libre and open source project both available for download, self-hosting and as a cloud service, is presented. The online availability of archaeological data sets and the possibility of building new original research on them, by adapting original schemas and formats to new requirements, is considered a very promising initial step towards a more collaborative research. Reducing IT barriers and setting the stage for web-based data management and publication to small-scale (single-researcher and/or highly specialized) projects, will lead to a new era for archaeological data analysis and dissemination.