The Way Forward to Digital Archaeology in Europe

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Contents

Introduction

Franco Niccolucci
PIN

The anonymous reviewer of a paper describing ARIADNE, published at the very beginning of the project, pointed out that there were perils as well as benefits in harmonizing archaeological data, and that providing homogenous and consistent access to data might hide the diversity of interpretation that data inherently support. In other words, blindly re-using somebody else's data could lead researchers to disregard the implicit assumptions embedded in those data and make a bad use of the additional information provided in this way.

This is of course a reasonable concern, and would be worrisome if ARIADNE's plans were to make all archaeological datasets uniform in an overarching Big Brother of digital archaeology. As is well known, this is not our case. Like other European Research Infrastructures, ARIADNE consists of facilities, resources and services. The focus is on improved services to access existing data and expertise, provided to the wider research community, based on an assembly of techniques, methodologies and know-how: partners' servers are our facilities, data our resources, improved access, tools and expertise our services. Thus, we will not only provide better access to information that is already available but is difficult to find, access and retrieve. We will support transparent integration by means of an advanced metadata schema that will describe data, their relationships and their meaning, adapted to the needs of archaeology. This background may possibly include, in the future, authorship, so that basing interpretation on data provided by others will rely on the same basis as reading the conclusion of a paper written, and signed, by an author whose bias may be known to the reader.

Actually, the first step of the ARIADNE archaeological dataset integration will consist of enabling resource discovery, i.e. in providing mechanisms to detect if data about a certain topic exist; where they are located; and what they describe. Integration will enable to access data in a straightforward and homogenous way. This service will rely on the ARIADNE Registry, which will catalogue all archaeological data resources willing to be enlisted there. We will start from the partners, which altogether provide about 4,600,000 items. This figure will increase with the datasets provided by other European institutions that have asked to join this effort, reaching by the end of the project 5,000,000 items. This target will probably be surpassed by the first half of the project with the additional contributions already on way.

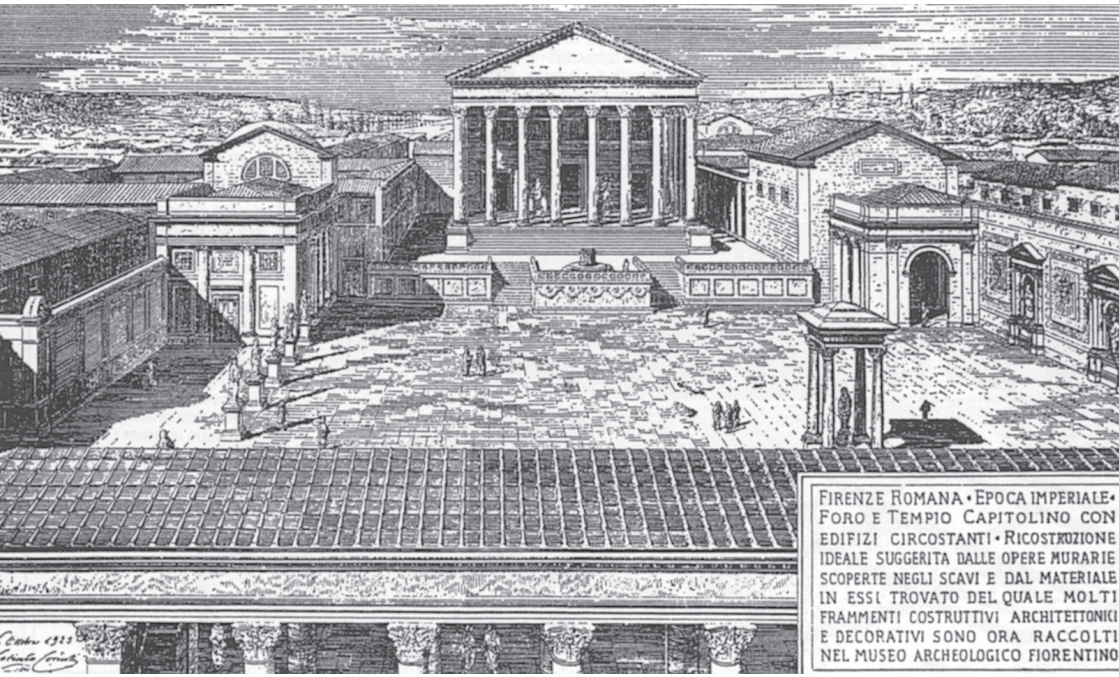
The construction of the Registry and how this will be usable are described in this publication. As stated, this is just the first step of the planned integration, a valuable service available for the whole research community. Further progress will rely on semantics. This includes a standardized and exhaustive way of describing data based on the CIDOC CRM. This is currently being extended to cover the specific needs of archaeological investigation, including information coming from archaeological sciences as well as from digital methodologies used to capture the appearance of artefacts, monuments and sites and enable remote study of objects, standing structures and landscapes. Of course, we are not going to propose, let alone enforce, the conversion of the million items already stored in archaeological datasets to this new knowledge framework. Instead, we will develop ways to make old systems compatible ("mapped" is the technical term) to this new approach.

Implementation could possibly take longer than the project life, but we aim at making it feasible by setting up all the necessary IT machinery and implementing it in a number of cases. This approach will also guide the creation of new datasets or the update of existing ones, when planned for other reasons. Semantics play an important role when aiming at integration through the so-called Linked Data approach, i.e. the recognition of common content that bridges separate data collections through the reference to an established, and shared, authority list. Here language plays a substantial role. So far we have identified 23 different languages used to describe the archaeological information in our scope, and we expect this number to increase when expanding ARIADNE's coverage to other European countries: if there are already data in Ukrainian, Macedonian and Arabic, there is still nothing in Finnish, Estonian or Polish, which we expect sooner or later to enter the ARIADNE data panorama. Our work on (multilingual) thesauri and on Natural Language Processing for languages other than English is paramount to deal with the so-called "grey literature", the excavation reports, which are already present with some 100.000 text documents. A measure of researchers' interest for online access to data is provided by the number of online access to available repositories.

All this activity would be elitist and reserved to a small circle if not accompanied by the support of the overall archaeological research community. ARIADNE is not just the interest of the small group of researchers, some 100, involved by the partners to carry out the above-mentioned activities. ARIADNE is involving a much larger community, as demonstrated by recent activities. The project intended to prioritize tasks and achievements according to the urgency of results as perceived by users, and started an online survey to collect this information. Some 100 invitations were sent around, expecting that, as usual, only 20-30% of the addressees would reply filling the online questionnaire. To our surprise, more than 700 answers were received. This means that those who were invited forwarded the invitation to many other colleagues, who believed the matter was worth their attention and invested their time in letting us know: evidence not only of the perceived importance of the topic but also of the credibility of the survey organizer. We do hope, and will do our best, to be up to the expectation of so many colleagues.

Other researchers are participating to our activities, bringing the number of scholars in the wider ARIADNE community over a thousand. Without much pressure or advertising we have also received requests for collaboration by five major national or regional heritage institutions, based in countries not represented in the ARIADNE partnership. Also under this regard, geographic coverage, our final targets have already been achieved or are progressing very fast. Moreover, ARIADNE has excellent collaboration with archaeological associations and bodies, such as EAA (European Association of Archaeologists), CAA (Computer Applications in Archaeology) and EAC (European Archaeological Council), an advisory body supported by the Council of Europe. Excellent contacts have finally been established with related initiatives, such as the memorandums of understanding in force with related European projects and the participation to DARIAH (Digital Research Infrastructure for the Arts and Humanities), the reference ERIC (European Research Infrastructure Consortium) for the domain, of which ARIADNE is one of the affiliated projects.

In sum, we believe we have grown strong and deep roots in the archaeological community. At this moment in time, we have more than half of the project duration to go. We will need to consolidate the results and implement what is currently in design. There may be difficulties and delays, but we are confident in succeeding. What we aim in a mid-term perspective is outlined in one of the papers of this booklet. In a nutshell, it consists in fostering a culture of open sharing and re-use of data; mobilizing data resources for re-use; setting up a knowledge organization and data interoperability framework; and providing services and applications to make the best out of the broader data availability: in a word, setting the scene for new paradigms of research in archaeology that bring the study of the past in the research ecosystem of the future.


FIRENZE ROMANA • EPOCA IMPERIALE •
FORO E TEMPIO CAPITOLINO CON
EDIFIZI CIRCOSTANTI • RICOSTRUZIONE
IDEALE SUGGERITA DALLE OPERE MURARIE
SCOPERTE NEGLI SCAVI E DAL MATERIALE
IN ESSI TROVATO DEL QUALE MOLTI
FRAMMENTI COSTRUTTIVI ARCHITETTONICI
E DECORATIVI SONO ORA RACCOLTI
NEL MUSEO ARCHEOLOGICO FIORENTINO

From User Needs to the Innovation Plan

Guntram Geser
SRFG

The ARIADNE project addresses the fragmentation of archaeological datasets throughout Europe and fosters the use and re-use of data through the interoperability of digital archives. Thereby it aims to promote and support a culture of sharing and collaborative use of archaeological data across disciplinary, organizational and national boundaries.

In 2013-14 ARIADNE carried out a first wave of research to understand users' requirements with regard to archaeological data and the e-infrastructure and services being developed. The research comprised an extensive literature review, 26 interviews with members of the ARIADNE partners and other stakeholders, two online questionnaire surveys with participation of 692 archaeological researchers and 52 repository managers, and contributions by ARIADNE Special Interest Groups.

The objective of this and planned further work is to help ensure that the development of the ARIADNE e-infrastructure, services and data resources will meet the existing and emerging needs of the archaeological research community in Europe and beyond.

Users Framework

The first step was the elaboration of the ARIADNE Users Framework, which distinguishes four levels of data management activity: 1) research projects, 2) institutional repositories and databases, 3) community archives (data centres, subject/domain-based repositories), and 4) the e-infrastructure and services of ARIADNE and related initiatives. Furthermore it describes the different actors, tasks and workflows at the four levels and relations between them.

The framework informed the structuring of the user needs research, which involved members of the level 1-3 data management communities. Importantly, ARIADNE will not replace any of their existing infrastructures (e.g. institutional or community data archives) but provide integrating functionality and services on top of them. Thereby ARIADNE will help making currently isolated archaeological data more accessible and useable for the research community and other groups, e.g. heritage management agencies and citizens.

But ARIADNE will have to do more than providing novel functionality and services. As the researchers in most other disciplines, many archaeologists are not prepared yet to make data openly available to others outside a research project or organisation. Therefore it is necessary that ARIADNE contributes also to the emergence of a culture of open sharing of archaeological data.

Selected findings of the User Needs Research

The ARIADNE First Report on Users' Needs, issued in April 2014, presents all results and recommendations of the first wave of user needs research (the report is available on the project website). Below some identified challenges, needs and expectations of the archaeological research and data management communities in e-infrastructure and services are highlighted.

Researchers

The selection of needs focuses on results of the online survey, with between 470 and 590 responses per result:

- *Finding available but scattered data*: 87% of the researchers agreed fully or partially that they often do not know what is available, because research data are stored in so many different places and databases. Consequently 95% considered as very or rather important having a good overview of available data(sets).
- *Improved online access to data:* 94% considered as very or rather important that data(sets) are available online in an uncomplicated way. Among the barriers were that access is often "limited to specific persons/communities" or that the data are "kept in private collections of other researchers".
- *Data and metadata quality:* 91% considered as very or rather important that available data(sets) are complete and well organised (metadata quality was the main concern of the data managers, see below).
- *Access to international data*: 74% thought that it is very or rather important having easy access to international data(sets), of which 45% considered international data as very important. This is an encouraging result for ARIADNE as most archaeological researchers arguably work in a national or regional context. It signals high interest in data that allows for comparative research, meta-analysis or broad synthesis.

- *Language requirements for (meta)data*: 25% thought that different language is a barrier in the access to data, but only 11% of which a very important one. 58% felt that metadata in English would be sufficient, while 36% thought that it should be available in 3-4 major European languages, and 6% wanted it to be in the local language.

- *Costs of online resources*: 71% considered high costs as a very or rather important access barrier; examples included journal subscriptions or digital collection items (e.g. "It's frustrating when a museum asks for 50€ for each photo of an object").

- *Barriers for sharing data with other researchers through a repository*: The two main barriers were the required additional effort for preparing the data (formatting, metadata, etc.) with 80% very or rather important, and a perceived lack of professional recognition and reward for sharing data with 72%.

- *Availability of appropriate repositories*: 60% of the respondents said that their organisation does not have an institutional repository that is managed by dedicated staff. A lack of international repositories where archaeological data sets would fit into was perceived by 66% as a very or rather important barrier to sharing data with colleagues. Consequently data was made available through an institutional repository only in a few projects or not at all by 67% of the researchers. The figures for national and international repositories were 76% and 83% respectively.

Repository managers

The survey results for repository managers summarised below are based on a much smaller number of 32 to 40 responses per identified challenge. However interviews with three experienced repository managers confirmed the general trend of the results.

- *Ensuring metadata quality* was the major challenge repository managers see themselves confronted with in their daily work. On the second place was managing a rising number of datasets.
- The major challenges posed by user needs were rising expectations with regard to *convenience* in the use of repositories and *individual service and guidance*.
- Technology was not perceived as a major issue. Among the recent technical developments of the managers were improved database functionality, implementation of new data standards and exchange protocols, and provision of Digital Object Identifiers (DOIs) for linking deposited data to publications.
- Comments suggest that the sustainability of project-based repositories and costs for operation and further development might be another key issue.
- The interviewed data managers also noted that repositories must make clear their specific role and added value (in comparison to digital libraries, for instance), demonstrate their trustworthiness, and become embedded in research practice.

User expectations for ARIADNE services

Most of the respondents expected from ARIADNE to establish a portal that provides an improved overview of existing archaeological data resources, offers capability for cross-searching repositories, and innovative mechanisms for discovering and selecting relevant data.

When asked from which services they would benefit most, 79% of the researchers considered as very helpful a portal that makes it more convenient to search for archaeological data stored in different databases. 63% thought of a portal enabling innovative and more powerful search mechanisms, 58% a directory of European archaeological databases and repositories, and 52% services for geo-integrated data.

With 29% much less relevant were data recommendations based on collaborative filtering, rating and similar mechanisms, i.e. typical features of so called Web 2.0 platforms. But this does not mean that effective filtering of search results is unimportant. On the contrary we assume that powerful mechanisms which help researchers save time in identifying relevant data would be highly appreciated.

The data managers were not as decisive as the researchers about which are the most helpful services and the ranking was different. On top were guides and recommendations for data management and for depositing data in databases, followed by services for geo-integrated data. Moreover the data managers appreciated much more than the researchers improvements in linking data and data/metadata extraction and indexing services. But Web 2.0 features also ranked last.

General requirements for developing e-infrastructure and services

In addition to the user needs and expectations identified in the surveys, there are some important findings of the literature review with regard to the development of e-infrastructure and services:

- *"Common ground"*: Mutual understanding and close cooperation of researchers, data managers and technology experts is crucial for successful development of e-infrastructure and services. The criteria for fit and usefulness should come from the research community, not technologists.

- *Focus on immediate needs:* What researchers expect from a novel service is that it should in some way simplify or accelerate a task essential to their work. But it must be easy to adopt and use, affordable and sustainable. In any case, facilitation, simplification, etc. of existing practices of the users must come before suggesting new ones. Consequently user-centered design and improvement on current services and interfaces are key requirements for success.

- *"Embedding"*: Research e-infrastructures are not primarily about technology but research practices supported by relevant ICT and services. The use of the e-infrastructure and services must become embedded in the research culture to ensure wide uptake.

- *Human resources:* Beside acceptance and sustained funding, e-infrastructures, repositories, interoperability and other services need skilled data managers at all levels. This requires capacity building, training and career paths for such professionals.

Preliminary Innovation Plan

E-infrastructure and novel services for the research and data management communities can help drive progress and innovation in archaeological and cross-domain research. In the development of the e-infrastructure and services results of user needs surveys and studies must be taken account of thoroughly. But there are also requirements which usually are not among the challenges perceived by the end-users, for example, required work on knowledge organisation systems (e.g. thesauri) and semantic interoperability.

The tables on the followin pages present a summary of the preliminary ARIADNE Innovation Plan. The plan comprises four areas of actions which build on each other. The actions should allow for providing enhanced access to a rich and growing stock of shared and interoperable archaeological data. Most of the suggestions are for ARIADNE and digital archives, but the research community and funding agencies will also have to play their part.

Focus area 1

Culture of open sharing and re-use of data

1-1: Open data policies and practices

E-infrastructures and services will flourish only within a research culture that values open sharing and re-use of data. ARIADNE can help foster this culture in archaeological research in several ways.

- Support open data policies of funding bodies and institutions and suggest appropriate guidelines for archaeological data.
- Request that the extra effort to prepare data and metadata for open access resources is covered in project grants.
- Suggest data licenses that do not impede re-use, i.e. the most open of the Creative Commons or Open Data Commons licenses.
- Promote data re-use and citation, and highlight benefits and inspiring cases of data re-use.
- Help to ensure that data sharers are recognised and rewarded by academic institutions and funding agencies, e.g. data sharing as a criterion for academic promotion and awarding research grants.
- Support the development of appropriate metrics and means for the tracking of data re-use.

1-2: Institutional and community data archives

- Archives for data deposit, long-term preservation and access provide core services underlying research e-infrastructure. They should be stable and reliable (e.g. sustained funding), and promote trust and capacity building in open sharing of research data.
- Work closely with the research community so that proper management and sharing of data are considered already in the project planning phase.
- Provide unique persistent identifiers (e.g. DOIs) for data citation and linking of publications and data; demand proper data citation (e.g. DataCite) as part of the user agreement.
- Demonstrate reliability of the data archive services, e.g. Data Seal of Approval, ISO 16363:2012 Audit and Certification of Trustworthy Digital Repositories.
- Aim at becoming embedded in the research culture and practices.
- Encourage initiatives for state-of-the-art data centres in countries where archaeologists currently lack reliable digital archives.

Focus area 2

Mobilization of fit for re-use data resources

2-1: Capacity development for shareable data and metadata

The path towards shareable data begins at the level of data management within research projects and institutions. Good practice guides and training in required skills can help that fit for re-use data and metadata emerge from the research process. This is part of the broader vision of open science that aims at making the whole research lifecycle as transparent and accessible as possible.

- Foster skills development of institutional and project-level data managers in the creation of fit for re-use data, e.g. data management plans and workflows towards data publication.
- Promote the preparation of shareable data through dissemination of good practice guides, including specific issues of sensitive data and intellectual copyrights in the domain of archaeology.
- Emphasise the need for appropriate description of the methods used to collect, analyse and present the data, including technical and other requirements for data re-use (e.g. software).
- Suggest using established open data formats, common metadata standards as well as terminology and controlled vocabulary.

2-2: Mobilization of more high-quality data and metadata

Providers of research e-infrastructure and services must aim at mobilizing more high-quality data and metadata from all relevant sources. Some sources and types of data will require targeted actions with regard to standards and tools or filling gaps in availability. Suggestions for such actions will be given by ARIADNE Special Interest Groups.

General considerations:

- Consider actual demand, technical readiness and open licensing as important data mobilization and selection criteria.
- Obviously priority will be given to large, freely available and easy to incorporate national and international data resources. Such resources may also be targeted by other data infrastructures hence there is a need for coordination in order to avoid duplication of efforts.
- Some providers of small amounts of data may need tools to manage and provide their data effectively (e.g. allowing for metadata harvesting).

Examples of specific cases:

- Grey literature of archaeological investigations: Information extraction techniques employing controlled vocabulary (e.g. thesauri) can help making such literature more accessible. Available knowledge in effective methods and tools should be disseminated to archives that hold a considerable stock of archaeological grey literature.
- Scientific data produced with various methods: Metadata is often not readily available because of lack of common standards or supportive tools. Initiatives in this field can learn a lot from exemplary work in the domain of biological data, e.g. BioSharing.

Focus area 3

Knowledge organization and data interoperability based on Linked Open Data

3-1: Availability of state-of-the-art Knowledge Organization Systems (KOS)

Knowledge Organization Systems (ontologies, thesauri, classification system and others) are among the most valuable resources of any domain of knowledge. They provide the conceptual and terminological "glue" for consistent integration of data resources. Therefore they should be openly available and easy to use, especially also for automatic, machine-based processing.

- Foster the availability of existing KOS for free and effective usage, i.e. openly licensed instead of copyright protected, machine readable instead of manuals or simple online lookup pages.
- Promote the development of KOS according to standards (e.g. ISO 25964 - Thesauri and interoperability with other vocabularies) and in machine-processable Linked Data formats (URIs, SKOS, OWL).
- Provide practical guidelines and suggest effective methods and tools for creating or transforming existing KOS in the required formats, especially simple term lists and taxonomies as used by many organizations.
- Provide mappings between thesauri and other KOS in different languages, and between major KOS and ontologies, especially the CIDOC-CRM extended for archaeology (CRMarchaeo).

3-2: Linked Open Data based interoperability

Linked Open Data (LOD) based on standards of the World Wide Web Consortium (RDF, SKOS, OWL, SPARQL and others) allow for semantic interoperability of distributed and heterogeneous data resources. ARIADNE can provide a large-scale LOD showcase of effective interoperability of knowledge (KOS) and data of archaeological research.

- Create a semantic web infrastructure for archaeological data through publishing and linking metadata schemas, ontologies (e.g. CRMarchaeo), thesauri and other KOS of the sector as Linked Open Data resources.
- Provide web services, application programming interfaces (APIs) and end-user tools (e.g. widgets) for building on these semantic resources.
- Encourage data managers to create and publish the metadata and KOS (e.g. term lists) used for their data sets as Linked Open Data, i.e. demonstrate advantages of such data and recommend effective methods and tools.
- Build and manage a Linked Open Data Cloud of archaeological knowledge and data, including semantic resources of humanities as well as natural sciences.

Focus area 4

Providing services and applications

4-1: Develop and promote a core set of required services

ARIADNE will provide a core set of services through a state-of-the-art portal for the archaeological research community, including registry, search, visualization, access, alert and other services.

- Implement a facility for registering available data sets, and motivate many providers to register their data.
- Include in the registry also metadata schemas and KOS, and mappings between them.
- Provide search & browse and data access functionality across distributed repositories.
- Enable discovery and visualization of data resources based on geo-spatial information and according to chronologies (i.e. cultural periods).
- Provide mechanisms that enable users identifying potentially relevant data quickly (e.g. "look inside" functionality); also offer alerting if similar data is becoming available.
- Allow users to manage selected data and related bibliography in a dedicated workspace, enabling e.g. to link and annotate data, and share results with colleagues.
- Offer services also for websites of data archives and research communities in particular subjects or geographic regions, e.g. RSS feeds on relevant new data.
- Cluster and present groups of related data, highlight data that are accessed frequently, and enable tracking of data re-use based on data citation in publications.
- Provide resources for developers (i.e. well-documented APIs, SPARQL endpoint) to promote the use of Linked Data for building special applications for the user community.
- Integrate the service portfolio in a state-of-the-art data portal; promote its usage and seek feedback of users for improving the interfaces and services

4-2: Enable the creation of novel applications

Based on the available data and use cases suggested by the research community various novel and experimental applications may be developed.

General considerations:

- Applications that promote cross-domain use of data and interdisciplinary research (involving e.g. cultural and natural sciences domains) might be particularly beneficial.
- Collaborative Virtual Research Environments (VREs) can be users as well as providers of enriched data, e.g. annotated and interlinked data sets.
- Advanced processing and analysis of data will require a high level of dataset integration fit for data mining and other technologies.

Examples of specific cases:

- Modelling and analysis of spatial features based on data of different datasets (e.g. data of artefacts and other finds in several regions).
- Processing and visualization tools for various types of sampled data, media and models (images, 3D, video), e.g. shape comparison, annotation, measuring or production of computer animations.
- Visualization and analysis of patterns or networks of archaeological research activity based on data in the Linked Open Data Cloud.

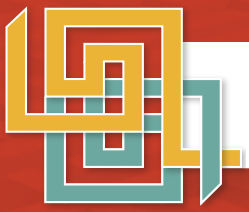
Conclusions and Next Steps

The archaeological research and data management communities are facing several challenges of e-infrastructure based research: Implementation of policies and incentives for open sharing of data, wider uptake of common data standards and semantics, mobilization of more high-quality data from all relevant sources, and use of advanced models, tools and services to drive progress and innovation. A major part of the challenges is that archaeology is an extensive and multi-disciplinary field of research that spans several domains of the humanities and the natural sciences.

How can ARIADNE help tackling the challenges? Possibly the best way to address this question is to consider different roles ARIADNE can play in helping others to make a difference:

- "Energizer" - take the challenges as opportunities to innovate, suggest new approaches to archaeological data, invite organizations large and small to participate and contribute;
- "Enabler" - establish a platform for community building, foster close cooperation of researchers, data managers and technology experts, offer guides to good practices and support in capacity development;
- "Opener" - promote open access data, help open up 'data silos', and make shared data part of the scholarly record – persistent, available, citable and rewarded;
- "Integrator" - align currently dispersed initiatives, provide interoperability services, help embedding the use of e-infrastructure in the research culture.

Following ARIADNE's Preliminary Innovation Agenda and Action Plan (which will become available this year), further work on road mapping for innovation will be carried out. This will include developing a better understanding of innovation potentials and development paths of the sector in a 5/10 years horizon, and providing recommendations for prioritised actions of the different stakeholders, i.e. research institutions, associations and funding agencies.



Online Access

Julian Richards
UOY-ADS

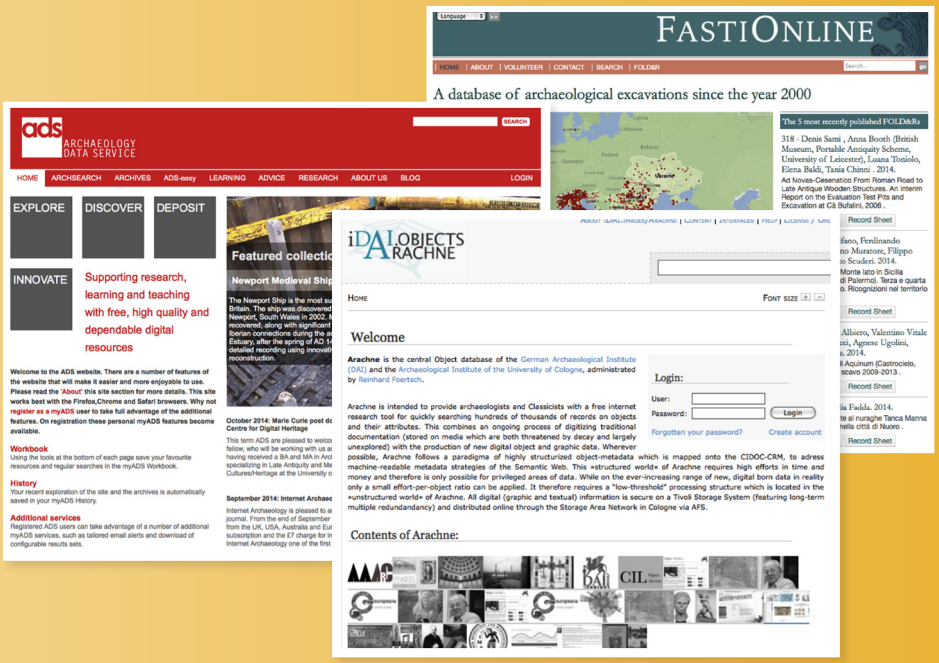
Online Services

From the outset the ARIADNE Infrastructure has provided access to online services managed by three of the partners.

The **Archaeology Data Service** (ADS) is based in the UK and supports research, learning and teaching with freely available, high quality and dependable digital resources in English, derived from UK archaeology, or UK-based (or funded) archaeology abroad. The ADS provides online open access to various services, including over 1 million metadata records cataloguing the Archaeology of the British Isles, 28,000 archaeological unpublished fieldwork reports (the "grey literature"), over 5000 journal articles, and over 700 research archives. The interface and content are in English.

The **International Association for Classical Archaeology** (AIAC) published the Fasti Archaeologici between 1946 and 1987. It contained very useful summary notices of excavations throughout the area of the Roman Empire. However, spiralling costs and publication delays combined to render it less and less useful. AIACs board of directors thus decided in 1998 to discontinue the publication and to seek a new way of recording and diffusing new results. **Fasti Online** is the result of this effort. It is an online database of archaeological excavations undertaken across the Classical World since the year 2000, including some 12,000 excavation reports and site summaries across the Mediterranean. The interface and records are in English and the content is in the local language.

The **Deutsches Archäologisches Institut** (DAI) and the Institute of Classical Archaeology in Cologne provide **ARACHNE**, which is a free object database of more than one million images of finds, architecture and excavations with meta information as well as digitised historical literature. The ARACHNE interface is in English (some of the context help is available in German as well) and the record Metadata may be in either one of these two languages, or both. The DAI has also given access to ZENON, the basic online card index of all institutions of DAI. It provides central information about all books available in the DAI libraries worldwide and access to several digitized and digital monographs and journals.



Towards an ARIADNE Portal

Since June 2014 a portal page on the ARIADNE website (http://www.ariadne-infrastructure.eu/Services/Online-Services) has provided links and descriptions to the partners' onlinee services, along with training materials for each one. Specific events have been held to promote these services to a wider archaeological audience by ARIADNE, including workshops at the international CHNT, EAA and CAA conferences.

Impact of ARIADNE

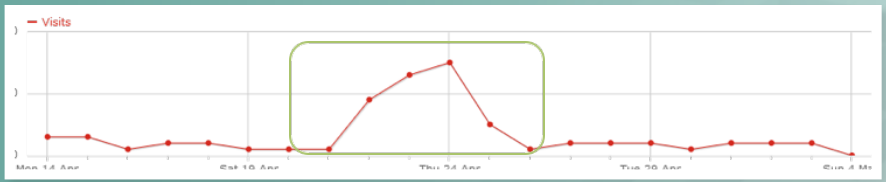
The impact of ARIADNE on the use of these online services can be assessed in a number of ways. Statistics such as the visitor rates on and just after key events, referrers and page download numbers for the ARIADNE website can provide an indication of the project's impact. Similar statistics from the individual service web services can also contribute to the overall picture.

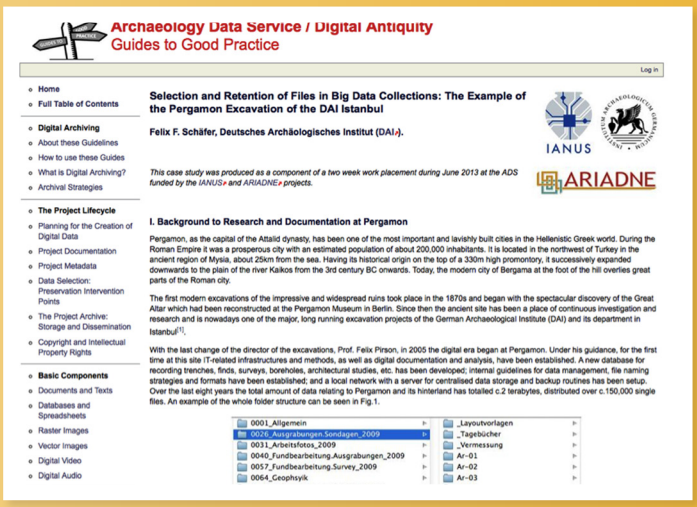
Visitors to the ARIADNE website

Between 1st February 2013 and 31st July 2014, there were 15,066 sessions by 9,346 unique visitors. English is the first language for 42% of ARIADNE website visitors, 13% German and 14% Italian, 5% French, 3% Greek and 2% each for Dutch, Spanish and Russian. Despite the languages of the partners dominating (82%), there are small numbers of visitors from the newer member states (e.g. Bulgaria, Poland, Romania, and Slovenia) as well as other countries. Europe is the main location of ARIADNE website users at 84% with a further 6% from North America.

Visitors to ADS Services

The ADS web service was launched in 1996 and has seen a gradual increase in user's year on year. During the 17 month period from 1st February 2013 to 31st July 2014 ADS had **393,964** unique visitors who carried out a total of **3,306,823** actions including **234,607** downloads and **3,030,646** page views. Close analysis of the ADS website metrics on and around the ARIADNE workshops shows a notable impact on the use of the ADS website. For example the impact of CAA2014 held in Paris (22nd–-25th April) can be seen in the increased traffic to the ADS website during the weekend of the conference. The average number of visits to the ADS website calculated across the three weekends in April prior to the conference is 2125, the weekend following the conference the number of visits to the ADS website increased by over 25% to 2755. The impact of CAA2014 is also seen clearly in the increase of visits to the ADS website from Paris during the week of the conference as shown in **Figure 1** below.



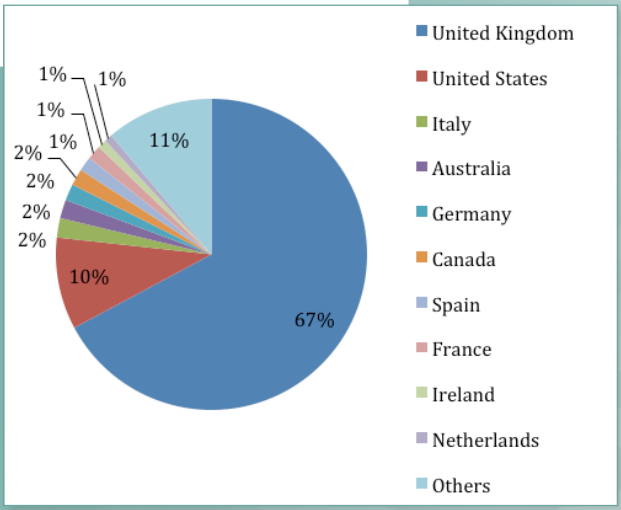


ADS also provides online Guides to Good Practice which are being enhanced and extended as a result of the ARIADNE infrastructure. The ARIADNE case study for the Guides to Good Practice; 'Selection and Retention of Files in Big Data Collections: The Example of the Pergamon Excavation of the DAI Istanbul' was the first case study to be published and has had 114 unique visitors. A new ARIADNE Guide to Good Practice on Dendronchronology is being prepared by Dutch partner, DANS.

82.9% of all ADS visitors are located in Europe with 67% of all visitors being located in the UK. Italy is the third highest location of ADS visitors. The high percentage of visitors located in Italy is probably a reflection of the four Italian partners in the ARIADNE project. Germany, Spain, France, Ireland and Netherlands all feature in the list of the top ten locations for ADS visitors. All other ARIADNE partner countries in ARIANDE make the list of top 20 locations for visitors; therefore it is likely that publicity by partner institutions is playing a part in the percentage of ADS services used by European users.

English is the browser language used by 86% of unique visitors to the ADS website this is reflected by English speaking countries being high in the top ten of unique visitor locations. The prominence of Italian as the browser language for ADS visitors further confirms the influence of Italian partners in ARIADNE on ADS usage. Prior to the ARIADNE project Italy only made up 1% of the location of visitors to the ADS site in 2012 and 0.1% of the visitors in 2011.

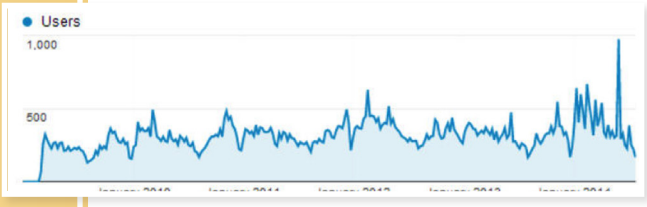
Country	Unique Visitors	Percentage of Unique Visitors
United Kingdom	258107	67%
United States	36701	10%
Italy	7754	2%
Australia	7416	2%
Germany	6585	2%
Canada	6655	2%
Spain	5772	1%
France	5639	1%
Ireland	3637	1%
Netherlands	3051	1%
Others	49797	11%



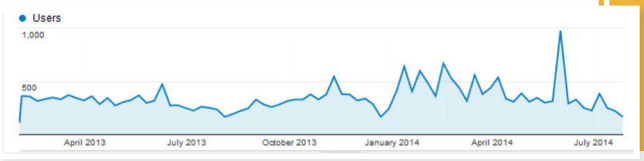
Location of unique visitors by country, 1st February 2013 to 31st July 2014

Visitors to FASTI Online

FASTI Online was launched in early 2009. The user rates have been fairly static- the average number of users last year was 1,343 per month. However, it is evident that there has been an increase in activity since the start of this year when the rate rose to over 1,500 users per month.



There have been some significant usage peaks, the first being during the week 10th -16th November, the same week as the CHNT Conference in Vienna. There are several more peaks on a monthly basis from January to April 2014 with a high of 974 users for the first week in June.



The main referrals for FASTI Online are Wikipedia (Pompeii, GIS in Archaeology, Fasti…) 16%, AIAC, the hosting organisation 14%, Facebook (10%) and Spanish Wikipedia (3%). ARIADNE partner ICCU (Istituto Centrale per il Catalogo Unico delle biblioteche italiane e per le informazioni bibliografiche) provides over 2% of the referrals. ARIADNE Infrastructure has provided 0.39% of referrals of which is 99 are new users.

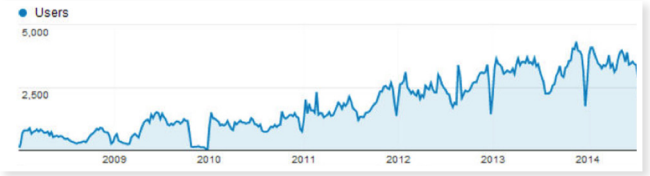
First Language of Users			
Language	01/02/11 – 31/01/12	01/02/12 – 31/01/13	M 1 - M18
Italian	58%	59%	53%
English	28%	25%	26%
Spanish	3%	3%	8%
German	3%	3%	3%
French	3%	3%	3%
Other	5%	7%	7%

The proportion of Italian and English based users dropped slightly in favour of a 5% increase in Spanish-language users. The proportion of German-language based users remains constant at 3%.

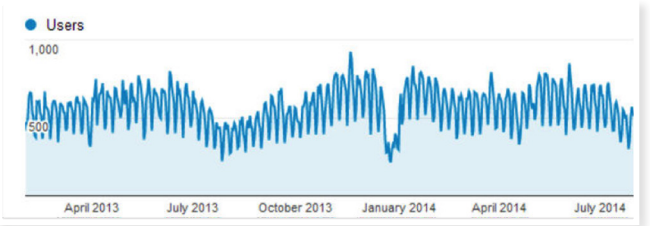
Europe is the source of 84% of users with a further 10% coming from North America.

Visitors to ARACHNE

The ARACHNE Online service was first available from late December 2007. The following graphic of users shows the steady increase in the numbers of users. By 2014, the average number of users per month is just under 12,000. Consequently, it isn't possible to tell if ARIADNE has made a significant contribution to the numbers as a few extra 100 users or so has little impact on the overall numbers.



For the 18 month period 1 February 2013 – 31 July 2014, the visitor rate to the ARACHNE website has been fairly stable. Repeat visitors and new visitors are around 50% each. During this period, there were 387,390 sessions by 198,876 users who generated 2,966,813 page views. The average number of pages per session was 7.66 and the average session duration was 6 minutes and 5 seconds. Around 3% of the site users (76,423) have visited the ARACHNE website more than 15 times.



The peak in late 2013 that can be seen in the Users profile was around the 18th-20th November, shortly after the ARIADNE session at the CHNT Conference in Vienna.

Like Fasti, (German) Wikipedia is the number one source of referrals (ARACHNE_Bilddatenbank) of 1,851 different sources at over 16%. Google.de accounts for 11% and there are several German academic institutions in the top 10 referrers as well as Facebook (3%). The ARIADNE website is responsible for 94 new users (0.11%).

Looking at previous years, the proportion of German speakers has dropped as an increasing number of other users across Europe have started to use the service. One notable increase is the proportion of Italian speakers which grew by 3% - ARIADNE has four partners from Italy which include the Co-ordinator, PIN, who have been very active in promoting the project.

Europe accounts for around 89% of users with a further 6% from North America.

First Language of Users

Language	01/02/11 – 31/01/12	01/02/12 – 31/01/13	M 1 - M18
German	70%	60%	57%
English	11%	15%	14%
French	3%	3%	4%
Italian	8%	8%	11%
Turkish	1%	1%	1%
Greek	1%	1%	<1%
Russian	1%	1%	1%
Spanish	<1%	<1%	2%
Other	0%	11%	10%

Impact of ARIADNE Activities on Online Services

The ARIADNE project events such as the workshops at CHNT 2013, EAA 2013 and CAA 2014 have a noticeable impact on website visitor rates and social media which brings in visitors who then visit the services. ADS can show that their visitor rates increased during key events and although this cannot be shown so easily for FAstiOnline and ARACHNE there are similar observable trends.

The online Stakeholder Survey was widely promoted on Twitter and other social media channels and this also had a very positive effect for the project website. Likewise, traffic from the online services can be traced back to ARIADNE. The increased involvement of Italian users is particularly noticeable for the German-hosted ARACHNE service.

Training for Innovation: Data and Multimedia Visualization

Matteo Dellepiane and Roberto Scopigno
CNR-ISTI

Two interrelated objectives of the ARIADNE project, are the design of new services (or the integration of existing ones) and the implementation of a programme of training & hands-on access. Especially in the case of visual media (which are evolving at an impressive pace) new services should be accompanied by user consultation and training, to consolidate knowledge on the potential of the new media and the impact these could have in the selected discipline. The latter is the main objective of the programme of Transnational Access and training, and user consultation events that have been organized in the first 18 months of the ARIADNE project. This short contribution presents the results of this activity and our plans for the design of new services.

Introduction

Training is an important component of an infrastructure project, especially when the infrastructure has to manage and support new technologies. Visual media are a clear example of the need for training due to: the many media available and used in Archaeological activities; the complexity of mastering both data creation and presentation; and the complexity of making the right choice, understanding which media fits better the specific documentation or visual analysis needs.

One major goal in ARIADNE is to help our community in building a clear view of the affordances of particular genres of representations, their documentation potential and the possible limitations with reference to storing, discovery, accessing, connecting with other data, and rendering. We see this as an important service to our community.

Visual data are nowadays a basic component of the massive amounts of data gathered in archaeology. By visual data we mean any visual representation that could be associated with an artwork, architecture or site, to describe its shape in terms of visual and geometric elements. The term visual data stands for different representations: 2D images (standard images, panoramic images, Reflection Transformation Images - RTI), 2D graphical representations such as maps or drawings (usually represented by standard digital image files), 3D models (either sampled or reconstructed with modelling systems) and videos (either captured from reality or produced with computer animations).

The ARIADNE TNA Programme

The Transnational Access (TNA) is an important activity in ARIADNE. A programme of training activities aims to provide opportunities to consolidate "next generation skills" and access to the research data services supported by the partners of the research infrastructure. Researchers will have access to innovative data centres, tools and methods for working on specific research questions and data related issues. Since we are aware that training is key to fast acceptance of new methodologies and technologies, the role of the TNA will also be to offer guidance in the use of new services.

ARIADNE has planned TNA opportunities (granting fellowships to eligible participating researchers) on the following topics:

- Legacy Data and Dataset Design Legacy Data and Dataset Design
- Scientific Datasets
- 3D Documentation of Fieldwork and Artefacts

We report below on the results of the first TNA summer school on 3D documentation.

In preparation for the TNA summer school, we hosted a workshop on Ariadne infrastructure for Multimedia data: Matching technologies and user needs", which took place in Pisa on October 7th-8th, 2013. The goal of this workshop was to bring together ARIADNE's data providers and technical partners and find a consensus on what we mean by Multimedia or Visual Data and the support we should plan to provide in the framework of ARIADNE. The capabilities of current technology (both commercial tools and resources produced in EU projects) were presented to users with the aim of understanding their needs and the potential services for production, sharing and visualization of visual media.

Summer School on 2D/3D Documentation for Archaeology

From 23rd to 27th June, 2014, CNR-ISTI hosted the ARIADNE TNA summer school on "2D/3D Documentation for Archaeology" in Pisa. The main goal of this school was to enable scholars and professionals to implement modern approaches for the visual multimedia documentation of artworks and archaeological sites (i.e. fieldworks and artefacts), including innovative approaches to digitize and document our heritage using 3D and enhanced 2D media.

The scope of the TNA school was to pair a classic programme based on lessons with practical activity: hands-on experience of the technologies being presented (both hardware and software) was a main component of the TNA experience. We invited participants to submit problems and test cases they are working with; the quality and interest of the test beds were an important criterion in the selection of the participants (as was their CV). Consequently, the programme for the school was designed to dedicate sufficient time to advising participants on both the practical hands-on experience and in developing their proposed case study with the technologies presented in the course.

The eleven participants (9 received an ARIADNE fellowship) were from several countries (Argentina, Belgium, Estonia, Germany, Greece, Italy, Netherlands and the UK) and had a mixed background (the majority had a background in the humanities , only a few held an engineering degree). The instructors were researchers of the Visual Computing Lab (http://vcg.isti.cnr.it/) at CNR-ISTI: Matteo Dellepiane, Marco Callieri, Gianpaolo Palma, Marco Potenziani and Roberto Scopigno.

The summer school started with a presentation by the students of themselves and their projects/case studies. After this introductory step the first lesson aimed to build up a common language and background in basic ICT and visual technology concepts. Then the work was organized with a day dedicated to each specific sub-topic (active 3D scanning and data processing; image-based approaches for 3D digitization; colour acquisition and mapping on 3D models; RTI images acquisition and visualization). Other topics, like the issues and technologies enabling the publication and visualization of 3D/2D models on the web, the advanced manipulation of 3D models, and the use of 3D in Cultural Heritage projects were touched on at different times throughout the five days. All the topics were firstly presented theoretically and then practically with some hands-on experience with real datasets.

The schedule was arranged to give time at the end of each day for the participants to experiment on their own data (or on test dataset we provided) on the topics presented, and for individual question-answer sessions with the instructors. On the last day, besides finishing open topics, was dedicated to the completion of the student's test cases, the presentation and evaluation of the results obtained and a final discussion and wrap up.

The course witnessed a fruitful cooperation between instructors and participants, providing benefits to all: the participants had the opportunity to be instructed on CNR tools by the authors, in a structured context that included practical hands-on experiences and the use of high-end technological devices; the instructors had the chance to witness a number of interesting test cases, which were extremely helpful to understanding the needs of the CH community and assessing the usability of the more recent tools and technologies.

The feedback received from the participants (who compiled formal evaluation forms after the end of the TNA) allows us to say that this first edition was a success. The main practical hints that came out during final discussions were related to the selection of an audience with a comparable technical background, so that the lecturing style could be more easily adapted to the participants, and to the preliminary analysis of the datasets they provided. (For more info, see at: http://www.ariadne-infrastructure.eu/News/2D-3D-Documentation-for-Archaeology-Summer-School)

TNA summer schools on archaeological datasets

Two further TNA summer schools were organized in 2014.

"Mapping existing datasets to CIDOC-CRM", hosted by PIN in Prato, on 26-30 May 2014. The main goal of this school was to enable scholars and professionals to implement conceptual mappings and data conversions of their existing datasets to the CIDOC CRM ontology. Two of the five days were dedicated to practical exercises, focused on the implementation of the mappings for case studies proposed by participants and carried out under the supervision of the specialists. (see: http://vast-lab.org/ariadne-2014-summer-school/).

"Design of archaeological datasets", held at CNR-ISTI Pisa, July 14-18, 2014. The main goal of this school was to enable scholars and professional to design archeological datasets endowed with rich semantics (by providing explicit representation of concepts and their relationships) and allow semantic interoperability (by drawing from existing standards). Semantic web knowledge representation languages were examined in detail along with the CIDOC CRM ontology. The participants were given the possibility of presenting their research problems, analyzing their data requirements, and applying the principles of knowledge representation to address their requirements. (see: http://www.ariadne-infrastructure.eu/News/Summer-school).

Towards innovation in Visual Media Management

Going beyond training and TNA, ARIADNE aims to provide tools and technologies for improving the management of visual data (images, 3D models, geo-specific data) stored in the archives of ARIADNE partners.

These functionalities will be implemented as resources/services available on the ARIADNE portal. The main goal is to move from the old approach still used in many archives of visual media being transferred to a remote user as a plain file, who then has to store it on a local PC and select/install an application to open the file). ARIADNE aims to move to a more modern, web-based approach, the presentation of the result set of a query to the archive enriched by adding an URL that will allow the user to inspect visual media in a standard web page. We are working on the implementation of services for three different types of data, described below.

Conversion and publishing of 3D models

The service is accessible as a web application that produces a multi-resolution version of a set of 3D models, together with a basic HTML visualization page of the given models.

One (or more) 3D models in one of the standard formats (ply,obj,stl,dae…) are manually uploaded by the user (either one at a time or zip-ed in a single file, in order to reduce uploading time). The service will perform some simple cleaning operations (e.g. removal of geometric artifacts), convert the models into a multi-resolution format (.nxs), and then creates and publishes a simple webpage that allows the user to visualize the models interactively in a WebGL frame (no add-ons needed, working on all the main browsers, except smartphones and tablets for now). The processing will be based on 3DHOP components (http://vcg.isti.cnr.it/3dhop/). All the operations will be performed by local scripted executables (meshlabserver.exe for model preparation, nxsbuilder.exe for nxs creation, a final script to prepare the webpage).

The output is the URL of a webpage on the ARIADNE portal or a zip file containing the multi-resolution nxs model and the html/js files of the basic webpage, or both. The zip file is available for download to the reference archive manager.

Conversion and publishing of RTI Images

The service converts relightable images into webRTI, and produces a basic html visualization page for the image, i.e. a version of the image that can be transmitted on the web and visualized efficiently on a standard web page.

One (or more) RTI images in the standard formats (ptm or hsh) will be uploaded to the service available on the ARIADNE portal or automatically collected in a batch (it will also be possible to automatically zip them, in order to reduce uploading time). The service will transform each image in a web compliant format (similar to Google maps, the image will be divided into chunks of different resolution) and create a simple webpage where it will be possible to navigate the model in a WebGL. The processing will be based on the components of WebRTI viewer (http://vcg.isti.cnr.it/~palma/dokuwiki/doku.php?id=research). All the operations will be performed by local scripted executables (WebRTIBuilder.exe for the processing of the image, a final script to prepare the webpage).

The output will be a webpage published on the ARIADNE server (the URL will be returned to the reference archive manager) and/or a zip file to download, containing the processed image and the html/js files of the basic webpage.

Conversion and publishing of high-resolution images

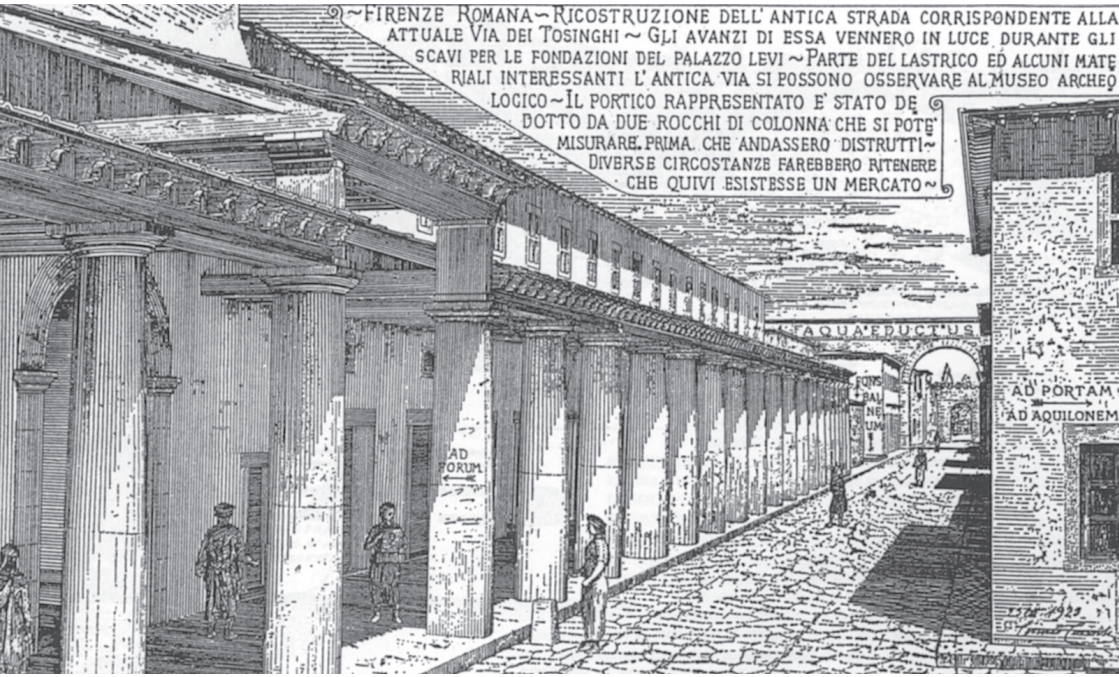
This service converts high-resolution images (uploaded using standard image formats) into multi-chunk versions, enabling progressive transmission, and produces a basic html visualization page of the converted images.

One (or more) high-res image(s) in the standard formats (such as jpg, png, tiff…). will be uploaded to the service available on the ARIADNE portal, or automatically collected in a batch (it will also be possible to automatically zip them, in order to reduce uploading time). The service will transform the image in a web compliant format (similar to Google maps, the image will be divided in chunks of different resolution) and create a simple webpage where it will be possible to navigate the image in a WebGL frame. All the operations will be performed by local scripted codes (an executable for the processing of the image, a final script to prepare the webpage).

The output will be a webpage published on the ARIADNE server and/or a zip file to download, containing the processed image and the html/js files of the basic webpage.

Conclusions

This note presents ARIADNE initiatives and activities organized so far to offer training and service opportunities to our partners and community. The new innovative services described above are now in and advanced implementation phase and will be available to partners very soon for testing and assessment.


~FIRENZE ROMANA~RICOSTRUZIONE DELL'ANTICA STRADA CORRISPONDENTE ALLA
ATTUALE VIA DEI TOSINGHI ~ GLI AVANZI DI ESSA VENNERO IN LUCE DURANTE GLI
SCAVI PER LE FONDAZIONI DEL PALAZZO LEVI ~ PARTE DEL LASTRICO ED ALCUNI MATE
RIALI INTERESSANTI L'ANTICA VIA SI POSSONO OSSERVARE AL MUSEO ARCHEO
LOGICO ~ IL PORTICO RAPPRESENTATO E' STATO DE
DOTTO DA DUE ROCCHI DI COLONNA CHE SI POTE
MISURARE PRIMA CHE ANDASSERO DISTRUTTI ~
DIVERSE CIRCOSTANZE FAREBBERO RITENERE
CHE QUIVI ESISTESSE UN MERCATO ~
AQUA·EDUCTUS
FONS BALNEUM
AD PORTAM
AD AQUILONEM
AD FORUM

Towards Interoperability: the ARIADNE Registry

Dimitris Gavrilis and Christos Papatheodorou
ATHENA

Scientific activities generate large datasets and the need for identifying, locating, re-using and exploiting data is becoming imperative. New approaches to data modelling, adaptive to the representation of the data and their contextual information are required. Data registries are a well-known data organization and management approach that provide access to and re-use of distributed data resources and services. In a data registry datasets, collections, metadata schemas, mappings and vocabularies are hosted and described by a common schema. (See a paper we co-authored at the recent ODBASE 2014 Conference.)

ARIADNE aims to step beyond accessibility and re-usability and integrate existing archaeological research data. The main goal of the project is to "to bring together and integrate the existing archaeological research data infrastructures so that researchers can use the various distributed datasets and new and powerful technologies as an integral component of the archaeological research methodology". In order to achieve this goal, it is necessary to (i) gather information about the existing data resources and services in the archaeological domain, and (ii) to implement advanced search functionalities on this information in order to support the discovery of resources that make good candidates for integration. As a necessary step towards the realization of the first objective, we designed a data model for representing archaeological resources, named the ARIADNE Catalog Data Model (ACDM), based on the W3C DCAT standard (Data Catalog Vocabulary, http://www.w3.org/TR/vocab-dcat/), as described in the above-mentioned paper and in the ARIADNE D3.1 deliverable, available on the project web site. As a necessary step towards the realization of the second objective above, we have implemented functionality for the persistence and the population of the Catalogue.

This paper presents an architecture that provides the main functionalities of the ACDM catalogue; interoperability and integration of the content of the infrastructure; interoperability with other repositories; curation functionalities of the ARIADNE infrastructure such as metadata quality and preservation; the platform on which the ARIADNE services (see the ARIADNE D13.1 deliverable) will be based and retrieve and store data.

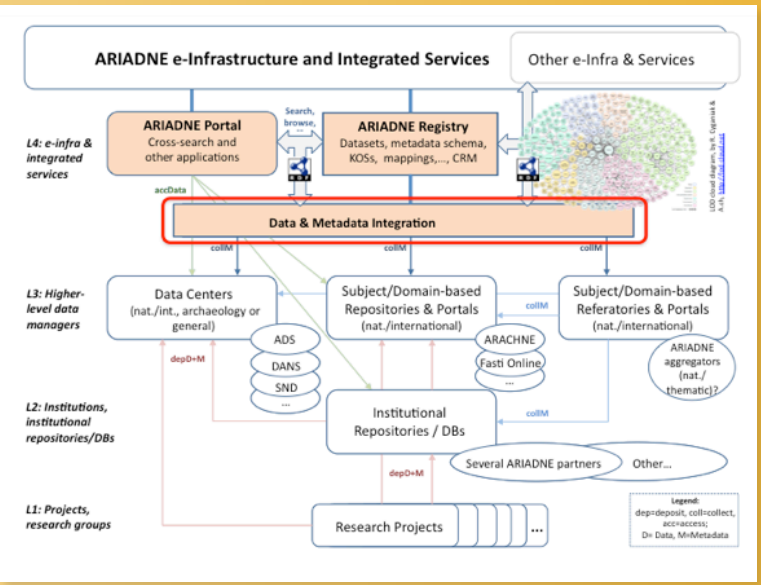


Figure 1. The ARIADNE data integration architecture

Overall Architecture

A general view of the integration functionalities, organized in four successive levels, is presented in Figure 1 (see also ARIADNE D12.1). At Level 1 data is created by research projects and groups, and is stored in Level 2 institutional repositories. Data is aggregated by higher level data managers such as data centres, portals and thematic information gates (Level 3). At Level 4, the ARIADNE infrastructure integrates all the information through the services provided by the Catalogue (named registry in Figure 1). The Catalogue provides novel, added-value information services through the ARIADNE portal.

Thus ARIADNE aims to integrate data and metadata from different providers and to provide useful and user-friendly information services for Archaeology. Services are intended to be available not only to researchers but also to a wider audience requiring access to collections and datasets.

The architecture focuses on the Data & Metadata Integration box of Figure 1 and the services presented in Figure 2. These services make use of data contained in the ARIADNE Catalogue, accessed through the Data Access service, which provides functionalities for ingestion and harvesting of data and metadata. The Deposit service allows registered users to deposit data following the ACDM schema. The provided data and metadata is managed through a Digital Assets Management service and is presented to the public through the ARIADNE portal. The Resource Discovery services (mainly indexing and retrieval) will enable access and integrated viewing of data resources through the ARIADNE Portal. The Vocabulary Management service is responsible for maintaining a list of SKOSified vocabularies and thesauri. The Metadata Enhancement service allows for automatic enhancement of metadata found in ACDM records. These enhancements include mining of relations, automatic linking with thesauri and vocabularies etc.

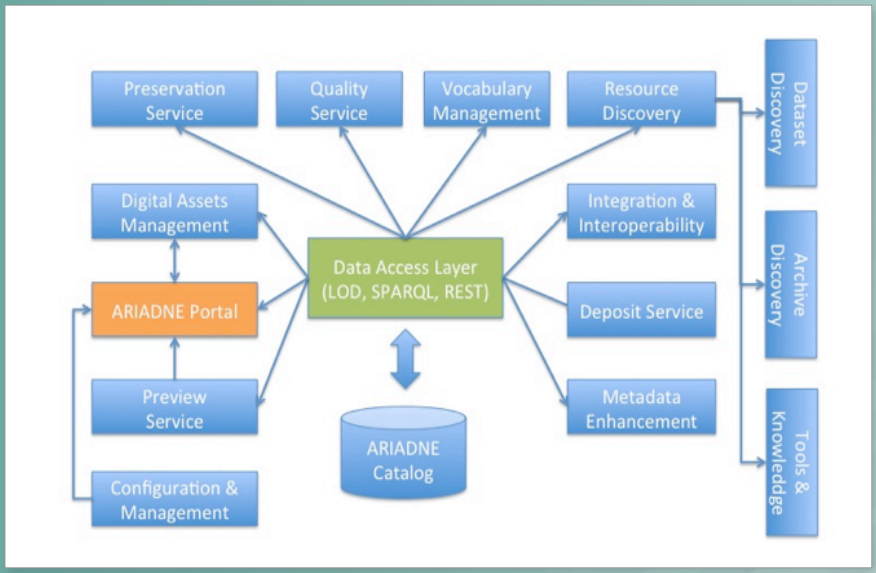


Figure 2. The ARIADNE data integration architecture

The Integration and Interoperability service relies on integration of the various resources of the ARIADNE catalogue. Heterogeneous datasets can be integrated mainly on three levels: (a) thematically, based on thematic types as explained in the next section; (b) spatially, based on spatial information which provides three levels of granularity: place name descriptions, address information, lat/long coordinates; (c) temporally, based on the temporal information which provides various levels of granularity such as: period name, BC/AD rough year periods and date ranges. For semantic interoperability and integration mapping to a core ontology, such as CIDOC-CRM, is recommended.

Moreover this service should provide functionalities for the mapping between metadata schemas, vocabularies, etc.

The architecture also provides services for the Preservation of the content. The Quality service will be responsible for measuring quality of metadata and provided information, while the preservation service will be capable of storing the full lifecycle of each entity of the ACDM model. Finally the configuration & management service will allow administrators and content owners to define certain parameters that have to do with the operation of the various services as well as the access conditions on certain records/collections that are found in the ARIADNE catalogue.

Integration Strategy

The main types of content in ARIADNE's community are: archaeological databases and spreadsheets, ethno-archaeological datasets, archaeological science databases, collections with a variety of formats, remote sensing data, map-based data, grey literature, multimedia and vocabularies including international and national terminology resources. ACDM model classifies the content to three major categories:

- *DataResource*, whose instances represent the various types of data containers owned by the ARIADNE partners and lent to the project for integration. This class is created for the sole purpose of defining the domain and the range of a number of associations. It is therefore an abstract class, whose instances are inherited from sub-classes.

- *LanguageResource*, having as instances vocabularies, metadata schemas, gazetteers and mappings (between language resources). As new resources of linguistic nature are added to the catalogue (such as subject heading systems and thesauri) the corresponding classes will be added to the model as a sub-class of this class. To describe language resources we have used ISO/IEC 11179 'Specification and Standardization of Data Elements'.

- *Services*, whose instances represent the services owned by the ARIADNE partners and lent to the project for integration.

ARIADNE deliverables D3.2 and D12.1 underline that there are six categories content with respect to the types of metadata schemas: (i) Reference models, (ii) Archaeological sites, monuments, landscape areas, (iii) Museum objects, (iv) Bibliographic materials (v) Archival material and (vi) Geospatial information.

It is estimated that the ARIADNE catalogue will gather/register thousands resources and therefore the main challenge is to develop a service that enables their integration. The objective of this service is to provide semantic discovery and allow users to identify resources relating to a specific topic, event or spatio-temporal region. We plan to develop mappings to support cross-searches of resources registered in the ARIADNE catalogue according to the following facets:

- What: resource discovery according to (i) Event Types (such as excavation, survey etc), (ii) Topic/theme (such as Monument Type) and (iii) Collections/Objects. For this integration facet mappings to thesauri and vocabularies of archaeological object types will be developed; the vocabularies will be SKOSified and available by the Vocabulary management service.

- Where: resource discovery according to spatial criteria. For this integration facet latitude/longitude conversions will be developed.
- When: resource discovery according to temporal criteria. For this integration facet vocabularies of local/national period terms are needed and their mappings to absolute date range.
- Resource type: resource discovery based on the classification of the resource types: Fieldwork databases, Event/intervention databases, Sites and monuments databases, Scientific databases, Artefacts and Collections of Artefacts and Burials. This classification is already encoded by the attribute ariadne:subject of the class ArchaeologicalResource of ACDM schema.

One of the main advantages of the ARIADNE Catalogue is that it sets the foundations for performing item level integration directly through the partners and stakeholders native repositories. This can be made possible if the native repository provides information through a machine readable interface such as OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting, http://www.openarchives.org/pmh/) or the item structure of the native repository is provided in OAI-ORE (OAI-ORE - Open Archives Initiative, Object Reuse and Exchange Specification, http://www.openarchives.org/ore/) or METS METS - Metadata Encoding and Transmission Standard, http://www.loc.gov/standards/mets/).

Finally integration with other services (such as mapping engines, portals, etc.) will be facilitated through technologies such as RDF, SPARQL, and Persistent Identifiers. ARIADNE Catalogue data is currently stored within an SQL database following the schema described in the previous sections. The SQL database will be synced to an RDF store, which will provide a SPARQL interface to the public. The RDF encoded information (will follow the schema provided in the previous sections of this document) will make use of unique and persistent identifiers.

Implementation Planning

The implementation ARIADNE infrastructure consists of a number of steps starting with the Catalogue and continuing with the interfaces of Data Access service. Table 1 presents the progress of the implementation of the infrastructure.

Service	Status	Service	Status
1. ARIADNE catalog	100%	5. ARIADNE Portal	
2. ARIADNE data access layer		6. Preview service	
2.1 RDBMS interface	100%	6.1 ACDM preview	50%
2.2 REST interface	50%	6.2 Record level preview	0%
2.3 SPARQL interface	0%	7. Digital assets management	
3. Deposit service		7.1 Human interface	100%
3.1 Human interface	100%	7.2 Machine interface	0%
3.2 Machine interface	100%	8. Preservation service	50%
4. Resource discovery		9. Quality service	
4.1 Human interface	50%	9.1 Metadata quality	50%
4.2 REST	0%	9.2 Data quality	0%
4.3 SPARQL	0%	10. Vocabulary management	

Moving Ahead: the Integration Process

Achille Felicetti
PIN

Integration in ARIADNE

The integration of data created by the archaeological research and in the Cultural Heritage domain in general, is a highly complex process. This is mainly due to the fact that the various institutions that create and use such information, although often very similar to each other, have a variety of collections that are documented in different ways, using different languages and different metadata schemas for their encoding. Very often the way the information is organized is influenced by the vision deriving from related disciplines, or by specific objectives related to the places and periods under study.

Managing this data in an interoperable way has become vital to ensure efficient use and to unlock their full potential, and to contribute to the advancement of the archaeological research. This can only take place in an integrated environment where different data are mutually interpretable and able to be consumed as if they were stored in a single archive. This will ensure the retrieval of meaningful information on both factual and space/temporal levels.

The ability to build an integrated archive and to provide uniform interfaces to access, relate, and combine data, preserving the meaning and the perspective of the different data providers, might seem an impossible task. However, such mechanisms need to be designed and implemented in order to provide uniform access to these heterogeneous and autonomous data sources.

This ambitious goal is what animates the ARIADNE project, which has identified and is currently implementing various development steps toward this ultimate goal. Each step towards interoperability is the result of a fruitful collaboration between archaeological institutions providing content and IT developers, the two souls of the project, representing the solid base on top of which the full realization of the infrastructure is built.

Integration: Preliminary Steps

The integration activities started with the analysis of information concerning data, standards, and services already in use by the archaeological partner institutions in the project. These descriptions are being collected through an online system encoded by means of a metadata standard (ACDM) that enables a detailed description of partners' datasets. This first integration phase produced the Registry, an important resource for understanding the available archaeological data in ARIADNE, together with their metadata and the related services provided with them.

The Registry also provides vital support for the planning of the subsequent data integration at the item level.

Preparing Legacy Archives

Another key step towards integration consists of operations carried out on the archives of content providers to facilitate their adaptation as part of the overall infrastructure of ARIADNE. The first and most obvious step is the assessment of existing archaeological data and their consistency in order to make them accessible via the Web. Many archives and collections already provide web access (e.g.: ADS, ARACHNE, ZENON, Fasti Online) and services for online consultation. Other archives are still "closed" existing in stand-alone databases or documents (Microsoft Excel, Microsoft, Word, PDF), some or are not available in digital format (many records were still paper-based).

Online accessibility of the archaeological information owned by the partners, once implemented, must be coupled with the ability to search the data in a standard way and gather relevant information and publish them to be used in later stages of integration. The publication of data in machine readable format is designed and implemented by means of standard protocols, like the OAI-PMH, formatted using METS, OAI-ORE, or other metadata standard schemas, and encoded in XML, RDF or in Linked Open Data format to be properly exchanged. A set of APIs makes the communication with the ARIADNE platform even more flexible and efficient. The publishing process can also be extended to the terminological resources (controlled vocabularies, taxonomies, thesauri) used in conjunction with the original data.

A more advanced step should allow data publication in a semantic format by means of mappings between the archaeological resources and the CIDOC CRM, the ontology chosen by the project for implementing archaeological interoperability at conceptual level. ARIADNE is also contributing in the development of a CIDOC CRM Global Model, which includes an archaeological extension CRMarcheo, to achieve a deep data integration.

Data Mapping and Conversion

An advanced stage of integration is being reached through extensive work on the archaeological information and the construction of a repository with semantic functionalities, able to query complex data in a scenario of advanced interoperability.

The implementation of these features is premised on the definition of mappings that allow to capture the semantic richness of the data and to express it through the classes and relations of the CIDOC CRM and its extensions (especially the CRMarcheo). Data is therefore viewed in a unified way that would make explicit the geographic and temporal scales and would allow the placement on spatial, temporal and semantic common layers so that they can actually be interpreted and queried as if they were really a single large searchable archive having a single access point.

The conceptual mapping operations (i.e. between the schema of each archaeological database and the CIDOC CRM model) are still in progress within the project, and many partners are already defining complex correspondences between the entities contained in their databases and the conceptual classes provided by the CIDOC CRM. Figure 1 shows an example taken from the data mapping of one of the MiBACT-ICCD archaeological schema (RA schema).

Metadata Repositories and Human Interfaces

The ARIADNE integration platform is conceived as a complex modular system providing advanced interfaces and functions and an architecture able to interact with the distributed repositories in a transparent way. The system is able to query and extract information from them in any format type (preferably semantic), to integrate the results into a unique semantic graph and to present them to the user in a coherent manner by providing all the tools to analyse and use them as part of the user's research. The updates of the ARIADNE repository, according to the modifications of the legacy archives, are also provided through advanced features, which always return the most updated version of the data to be queried.

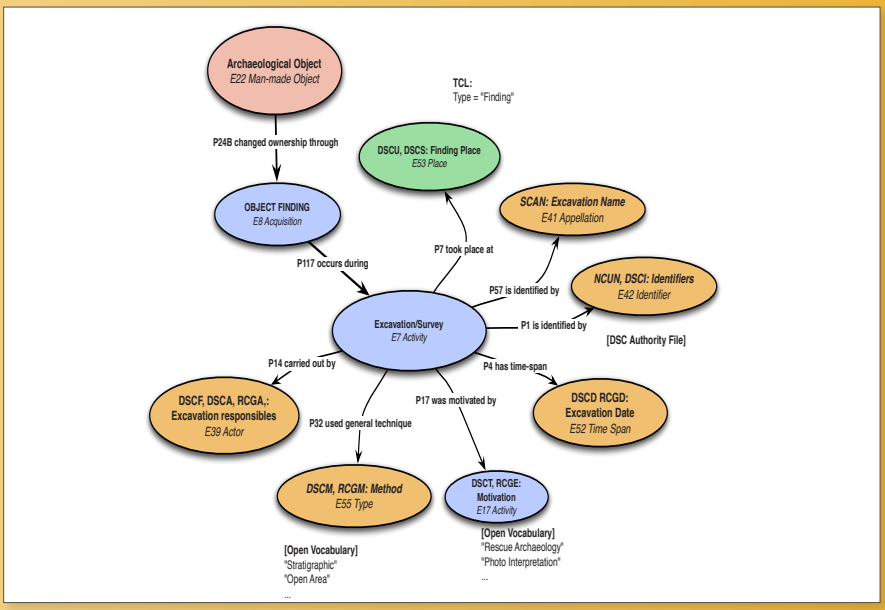


Figure 1: Example of the conceptual mapping between ICCD "RA" (Archaeological Object) Schema and CIDOC CRM entities

In particular, the user is able to query, in a semantic fashion and using advanced query mechanisms and interfaces, all the information coming from the legacy archives, shared and unified by the architecture, and to get relevant results in different views. Information concerning objects, places, events, actors and types can be retrieved and displayed in different ways, for instance on a timeline or on a map if they contain temporal or spatial relationships, or browsed and refined with facet views, issued on the most common fields.

This series of operations involve constant interaction with the Registry, which holds all the information relating to the distributed archives. The descriptive information stored in the Registry is able to drive the queries towards the most relevant archives, presumably containing information of interest to the user. Interaction with the terminological data and services is also very important for getting support at query and retrieval time.

References (i.e. URLs) to the legacy archives are always provided to allow users navigating the original information, should he requires custom searches tailored on specific needs.

The Ariadne Portal, which represents the highest layer of the system architecture, will provide the entry point for the users to the entire query mechanism. Through it, users can extract, analyse and use all the available information as well as access it through the various services provided by the system itself. A general idea of how the whole architecture may operate is illustrated in Figure 2.

This very advanced stage of development, once reached, hopefully at the end of the project, would be the best expression of the "integration of existing archaeological research data infrastructure" ("through new and powerful technologies") which is the main goal of ARIADNE.

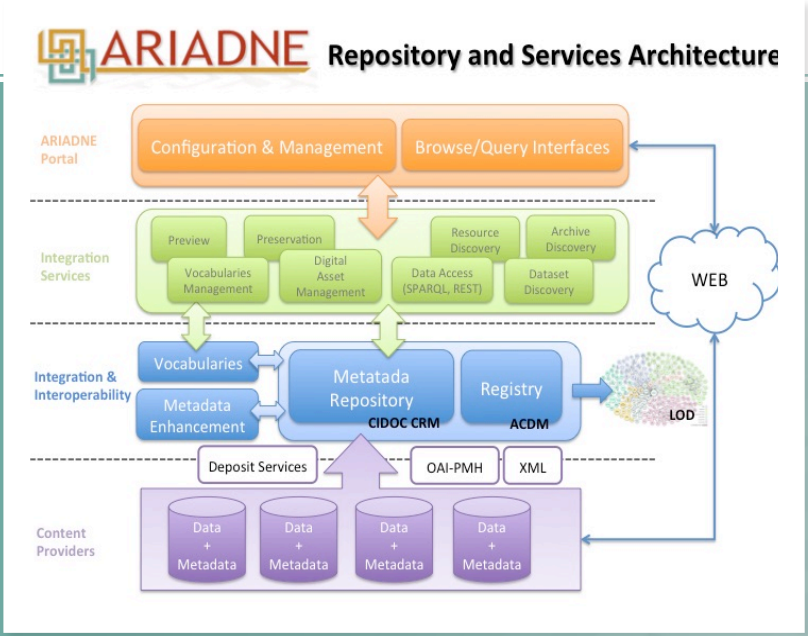


Figure 2: The ARIADNE Architecture

Providing Services: Search and Beyond

Carlo Meghini
ISTI-CNR

The ARIADNE Vision

The ARIADNE's mission statement to "bring together and integrate existing archaeological research data infrastructures so that researchers can use the various distributed datasets and new and powerful technologies as an integral component of the archaeological research methodology" poses several challenges. This is due to the high level of heterogeneity that currently exists in the archaeological research data infrastructure landscape.

Archaeological research infrastructures form a very heterogeneous and fragmented landscape. Very developed and advanced infrastructures, catering to the needs of broad research communities, coexist with much simpler infrastructures offering basic data access services to a restricted group of scholars. We must also consider the heterogeneity of the research methodologies that the ARIADNE communities follow and which inform the supporting infrastructures. Last but not least, there is heterogeneity in the information technologies that are currently in use in the ARIADNE landscape, in terms of the models and the ontologies underlying data resources, and also the algorithms, domains and architectures of the service resources. These three levels of heterogeneity are the starting point for ARIADNE.

Under these circumstances, ARIADNE has decided to pursue its mission statement by following a pragmatic approach, based on the recognition of the existing data and service resources and on the development of an infrastructure where data and services resources can be registered by their providers, and then discovered and accessed in a uniform and integrated way by the users of the infrastructure, in support of the existing research methodologies and regardless of the different architectures that support these resources in their original provision. The resources that will be discoverable and accessible through the ARIADNE infrastructure may be the one originally provided, or the results of integrations, either at the data or at the service level.

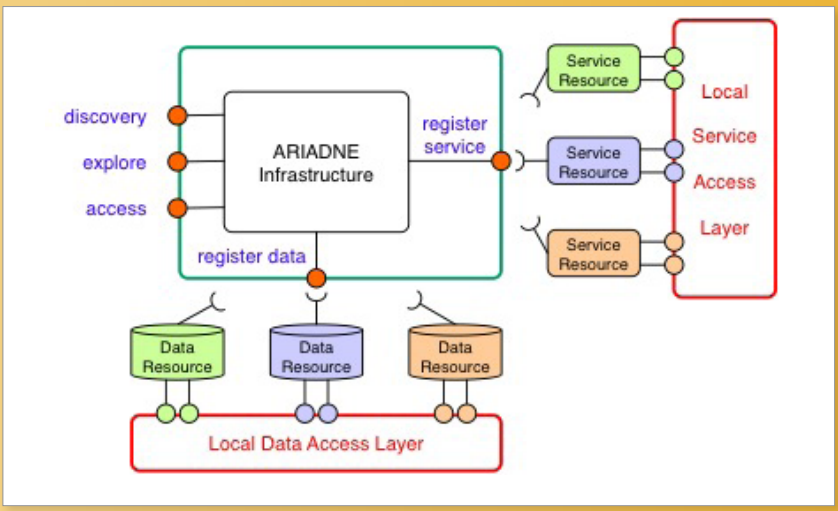


Figure 1 Initial ARIADNE Infrastructure

This infrastructure is represented in Figure 1. The general objective is therefore the creation of a single, global access point that will act as a broker between the resource providers and the resource consumers, in accordance with the intimate nature of an infrastructure. On the one hand, resource providers will be able to register their resources and supply rich descriptions of them, following the ontology established by the ARIADNE Catalog Data Model (not represented in the Figure in the interest of readability). On the other hand, resource consumers will be able to explore the ARIADNE data and service space, either in browsing or in querying mode, via simple or structured queries. Consumers will be able to access the discovered resources, consuming data or services, in the specific modality they will be offered by their providers.

The creation of such an infrastructure is already a considerable step forward in the archaeological domain, as it implies the creation of a unique space where currently dispersed resources can be uniformly described, discovered and accessed, overcoming the idiosyncrasies that currently prevent their full exploitation by the scholarly communities. At the same time, it represents a necessary step towards the more ambitious goal of creating a unique knowledge and service base for archaeology, a long-term goal that still stands as extremely challenging and desirable.

Further Ahead

The vision of a unique knowledge and service base for archaeology is the driving force towards the optimal exploitation of IT technologies for the Archaeological domain. The ideal vision is presented in Figure 3, whereas Figure 2 represents an intermediate step towards the final vision.

The distinctive character of the the intermediate step is the introduction of a cloud that offers computational resources to the organizations in the archaeological domain willing to join the infrastructure. Such cloud will allow the participating organizations to deploy their resources in the common infrastructure, laying the bases for their integration, in a common framework of sharing and re-use. The deployed resources may be identical to the locally available ones, or may just be projections that only expose a subset of the data or a limited functionality of a service. Nevertheless, this architecture already presents advantages for both producers and consumers: The producers would rely on the cloud infrastructure for computational support, being entirely free of striking the optimal balancing between local hosting and outsourcing. The consumers would be able to operate in the common resource space. As a result of this step, technical interoperability problems will be solved, allowing the underlying community to gain a deep understanding of the existing resources and of the potentialities of their integration.

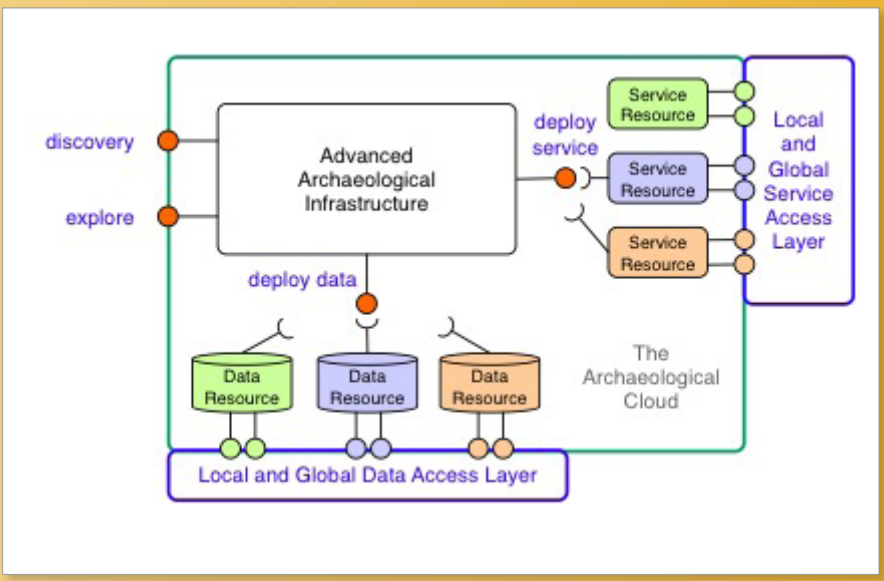


Figure 2 Towards the ideal Archaeological Infrastructure

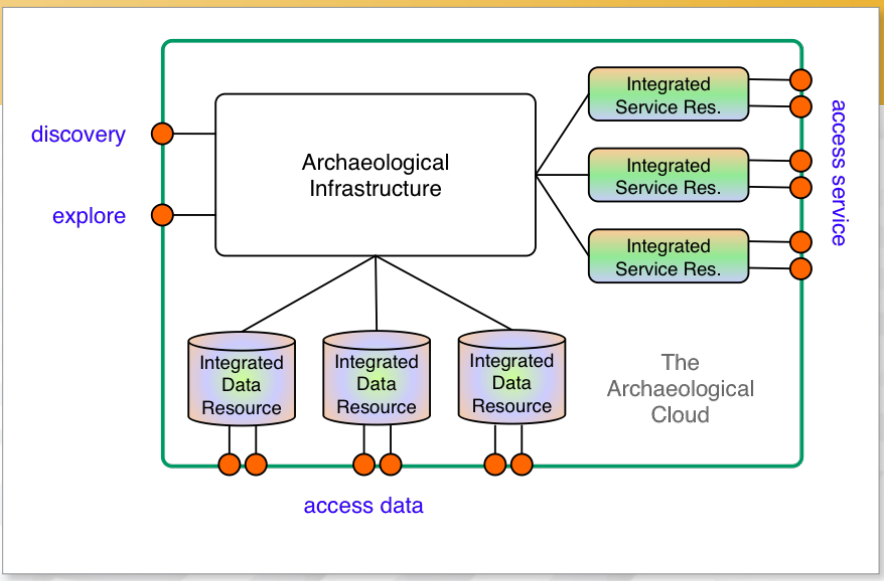


Figure 3 The ideal Archaeological Infrastructure

In the last step, the semantic interoperability problems will be attacked, leading to the creation of integrated resources that become available on the infrastructure. Figure 3 emphasizes these resources, as a way of highlighting the added value brought by this last step; but of course the original data and service resources will also be present in this infrastructure, at least those that out-stand as valuable per sé. Two examples of resources that will help clarifying the envisioned landscapes are ontologies and data visualization services. In the final infrastructure shown in Figure 3 one expects to find valuable stand-alone ontologies, such as the Dublin Core DCMI Metadata Terms, as well as newly created ontologies resulting from the integration of existing ones, such as the harmonozed CIDOC CRM and FRBR ontology. Similarly, one may find a specialized 3D-model visualization service as well as a newly created service for time- or space-based data visualization service.

Tailoring the Conceptual Model to Archaeological Requirements

Martin Doerr, FORTH

Data-driven science has emerged as a new model which enables researchers in archaeology and other fields to move to a new paradigm for scientific discovery based on large scale, distributed data aggregation environments . Hundreds of thousands of new digital objects and immense numbers of encoded facts are placed on the Web, in digital repositories and other information systems every day, supporting and enabling research processes not only in science, but also in education, culture and government. It is therefore important to build infrastructure and web-services that will allow for exploration, data-mining, semantic integration and experimentation across all these rich resources.

Archaeology as a discipline lives from the comprehensive access to an immense number of minute facts recognized by diverse methods and in different and distant contexts that may have a bearing on a particular micro-, meso- or macro-hypothesis. Therefore the ARIADNE Research Infrastructure Project for Archaeology aims at going beyond the current Digital Library paradigm with simplistic findings aids by laying the foundation for the integration of rich, structured information from all heterogeneous sources that may be relevant for answering a research question. The first aim is a common, consistent representation of data that have a potential bearing on questions beyond their local context of creation and use, so that directly and deep-indirectly related facts can be filtered out effectively from the mass in order to support further interpretation by the researcher.

Only Semantic Web technologies and formal ontologies allow for such a common representation and effective management of billions of facts. The respective technology is very rapidly advancing. Therefore the challenge of the day is not to adapt data models to the possibly still limited performance of current platforms, but to develop a global, extensible schema in the form of a formal ontology that allows for integration without loss of meaning, rather than "core fields" and "application profiles". In the end, this appears to be a more demanding task than the development of performant platforms. Also, the creation and maintenance of data in adequate form exceeds the cost of the development of platforms by some order magnitude. Therefore manually restructuring data at each technology step should be replaced by transforming data to comprehensive structures with expected long-term validity, interoperability and extensibility. This a task of highly interdisciplinary ontology engineering.

The Diversity of Archaeological Data

In order to address the complexity of archaeological data integration, ARIADNE has started with the requirement to employ and extend the CIDOC CRM (www.cidoc-crm.org) as the cultural-historical ontology which comprises most applied experience in this field. The CIDOC CRM or ISO21127 is a formal ontology intended to facilitate the integration, mediation and interchange of heterogeneous cultural heritage information. It was developed by interdisciplinary teams of experts, coming from fields such as computer science, archaeology, museum documentation, history of arts, natural history, library science, physics and philosophy, under the aegis of the International Committee for Documentation (CIDOC) of the International Council of Museums (ICOM). It started bottom up, by reengineering and integrating the semantic contents of more and more database schemata and documentation structures from all kinds of museum disciplines, archives and recently libraries as empirical base.

The development team applied strict methodological principles admitting only concepts that serve the functionality of global information integration and imposing more philosophical restrictions about the kind of discourse to be supported. The application of these principles was successful in two ways. On the one side, the model became very compact without compromising adequacy. On the other side, the more schemata from memory institutions were analyzed, the fewer changes were needed in the model. Nevertheless, archaeology is basically an empirical science – once observation of evidence is an argument – and the details of the observation and argumentation processes go beyond what is encountered in the standard documentation of memory institutions and their conservation departments that had served as empirical base for the CIDOC CRM.

In particular the large archives of excavation records and the ability to relate them to the preserved objects are a key challenge in archaeology. In order to systematically produce an empirical base of archaeological data structures for ontological analysis, we have identified the following data distinct categories that possibly require extensions of the CIDOC CRM and are collecting examples:

- Special collections: numismatic, epigraphy
- Excavation records: daily context, stratigraphy, finds, description of larger structures
- Survey records and remote sensing data
- Analytical investigation records: dating methods, materials analysis, DNA analysis
- Reference sets of analytic data:
  - ocalibration and comparison data of dating methods (dendrochronology etc.)
  - omaterial characteristics by provenance
  - archaeobotany and zooarchaeology data
  - anthropological, osteological data
- Empirical 3D Models and virtual reconstructions
- Geoinformation: GIS based find distributions and spatiotemporal culture and activity maps
- Spatiotemporal gazetteers and thesauri of periods.
- SMR record with references to protection zones and excavation licenses
- Simulation: population behavior, site prediction analysis, land use etc.

Approach

For the ARIADNE work package "Addressing Complexity", we have developed a work program of subdividing the above categories into related subdisciplines. To address all of them in detail obviously would exceed the resources of the project. Therefore we have started addressing them following an agreed-on priority, mainly based on the amount of data available, the relevance in the reasoning chain and the expectation to find concepts new to the CRM. For each field addressed, we have collected sample data structures and example data in order to map them to the CIDOC CRM, to identify missing concepts and develop the respective extensions. The team of FORTH-ICS has provided an initial analysis of the empirical data. Based on this background, we have invited experts to participate in systematic interdisciplinary workshops for related subdisciplines in order to clarify together the semantic of their data and to draft the necessary new concepts. These have later been formally elaborated by the team of FORTH-ICS, and the resulting new ontology parts have been circulated among the experts for revision.

The effort has been paralleled by other European and national projects FORTH-ICS has been participating in: Within the European project 3D-COFORM, they have developed CRMDig, a CRM extension compatible extension for describing empirical provenance of 3D and other scanning data, i.e. all steps and parameters from data capture down to the end-user 3D model. The latter can easily be adapted to remote sensing data. In the European projects iMarine about integrating marine species ecology data, the European project InGeoClouds about integrating geological observation data, such as water sampling, seismic shocks, landslides, and the national Greek project LIFEWATCH Greece about biodiversity, FORTH has been developing models for various scientific observations. Besides others, these models generalize and improve over standards such as INSPIRE, OBOE, DarwinCore, Open Provenance Model, Provenance Vocabulary, Provenir and Premise.

These models inform and support the conceptualization of the archaeological concepts, because the experience from their development allows for detecting similarities and powerful generalizations across disciplines. Besides being a proof that archaeological and other domain methods are not as idiosyncratic and incommensurable with other domains as often assumed, such generalizations allow for pooling resources from different domains to develop effective information systems, which is particularly beneficial for the cultural-historical research that has to live with a notoriously low budget.

Success Story

Coordinated research within the ARIADNE work package "Addressing Complexity" and three catalytic workshops in Crete and one working meeting at the German Archaeological Institute allowed for clarifying and modelling consistently key concepts of scientific observation for archaeology and beyond, including excavation data and key concepts of space and time used in archaeological argumentation.

In a first exploratory workshop about "Excavation Data and Applications" in Crete in May 2013, partners from the UK, Germany, Austria, Italy, Cyprus and Greece presented examples of archaeological databases comprising descriptions of sites and monuments, of cemeteries, of image collections, of coins and other find collections. Also the problem of spatiotemporal gazetteers was presented. The method of ontology development by mapping from empirical data structures was presented and discussed. In the discussion, only the concept of "issuing a coin" in the coin databases was recognized as a particular challenge among these examples that is not yet adequately covered by the CRM, as well as the question of temporality of place names.

In the sequence, the workshop engaged in a hands-on exercise to map the "dFMRÖ" database of the Austrian Academy of Sciences to the CRM. A first draft of the missing concept (corresponding to a series of production events of objects of the same type or "model") and its properties were designed. The method was recognized as effective, and two more workshops were decided, one on archaeological excavation and one on analytical measurements:

The workshop on "Context, Stratigraphic Unit, Excavated Matter and Period Thesaurus and Gazetteer Definition" has compared five of the most prominent site, excavation and find recording sheets in Europe and Israel. These comprised of the following:

- Austria: Bundesdenkmalamtes (2012) Richtlinien für archäologische Maßnahmen
- United Kingdom: Museum of London Archaeology Service (1994): Archaeological Site Manual, English Heritage (2006) English Heritage Recording Manual; Cripps, P., Grennhalgh A., Fellows D., May K., Robinson D. (2004) Ontological Modelling of the work of the Centre for Archaeology
- Germany: Bayerisches Landesamt für Denkmalpflege (2012): Vorgaben zur Dokumentation archäologischer Ausgrabungen in Bayern; LVR-Amt für Bodendenkmalpflege im Rheinland (2011); Prospektions- und Grabungsrichtlinien für drittfinanzierte archäologische Maßnahmen
- Israel: Locus Card, Wall Card (www.antiquities.org.il/about_eng.aspx?Modul_id=118)

A comprehensive, generic model could be found comprising and improving over all the compared recording sheets and related methods. For example, the notions of "positive" and "negative" stratigraphic units were generalized to stratigraphic "volumes" and "interfaces", and the subjective term "find" could be identified as a kind "documented encounter event", a particular case of observation. The full results appeared as the "CRMarcheo" model. The goal of this model is to provide the means to document excavations in such a way that the following functionality is supported:

1. Maximize interpretation capability afterexcavation. Understand goals of excavations, i.e., what was the archaeological question?
2. Possibility of knowledge revision after excavation based on existing data.
3. Comparing previous excavations on same site or space.
4. All kinds of comprehensive statistical studies

CRMarcheo is supported by the new CRMgeo model of spacetime volumes, place and time. The latter connects CIDOC CRM and OGC standards, and makes fundamental distinctions between the true (fuzzy) spatiotemporal extent of real things and events and their approximation by geometric data. It also led to an innovative revision of the representation of period thesauri and temporal gazetteers, which could be finalized in a meeting with the German Archaeological Institute in Berlin. All previously mentioned models of scientific observation were harmonized with CRMarcheo, and their generic concepts were collected into CRMSci, a new model of scientific observation generalizing over biodiversity, archaeology and geology. As a characteristic example of cross-disciplinary similarities, "encounters" in biodiversity differ from archaeological ones mostly in that the "finds" of archaeologists don't try to flee, but all basic parameters of "encounters" with objects in both disciplines are the same.

The following "Workshop on Scientific Data" focused on scientific investigation methods for archaeology, but took also into account scientific investigation in biodiversity and geology. For the first time, scientists of 6 different disciplines were brought together to directly compare the detailed protocols of their methods and to identify which metadata representation would be adequate so that later research can re-estimate precision and reevaluate results based on old and new evidence.

Six different methods were presented, analyzed, and compared:

- Geophysical Survey Workflow
- DNA analysis
- Dendrochronology
- Isotope analysis
- TL/OSL ceramics analysis
- Elemental Analysis of Archaeological Objects

The presentations focused on the methods employed, potential problems, reasoning on quality and accuracy, calibration etc. The workshop also focused on the creation and maintenance of reference data collections that allow for inferring from measured properties the provenance, kind, identity or events in the past of the analyzed objects. During the workshop, the ontologies CIDOC-CRM, CRMgeo, CRMdig, CRMsci and CRMarchaeo (for further details see www.ics.forth.gr/isl/index_main.php?l=e&c=229) which are now part of the ARIADNE Global Model, were also presented and some examples of how they could be used to model scientific data were shown. The workshop revealed an amazing analogy of the individual steps of sample selection, sample description, preparation, calibration of devices, measurement parameters and post-processing across all disciplines. It further became apparent that the models need to be slightly extended in order to cover the creation of scientific reference data collections. Partners agreed that these generic findings can inform new methodologies and guidelines of effective metadata generation, and contribute to a deeper understanding of the requirements of research infrastructures to support an actual knowledge ecosystems of scientific research interaction and to implementing more adequate IT services for such "ecosystems".

Conclusion

The work of the ARIADNE work package "Addressing Complexity" has been particularly successful to provide a new, powerful and extremely compact conceptualization for most of the archaeological data world and beyond. The CIDOC CRM itself could be improved by this research. Modifications are submitted to CIDOC. The models CRMarcheo, CRMgeo, CRMSci are now proposed for approval by CIDOC as recommended models and under revision by CIDOC working groups. The German Archaeological Institute envisages to implement the new method of temporal gazetteer definition in the next year. This method is based on the idea that a placename refers to a phenomenon in spacetime. Suitable classification, with terms such as "settlement activity" in contrast to "geopolitical unit", will allow for unambiguous definition of the meaning in spacetime. The subsequent interpretation as a particular, definite extent in space depends on the intended time of reference, and not on the phenomenon. Approximations of the spacetime extent of the phenomena by coordinates make the gazetteer more precise, but their meaning does not depend on them.

As a next step within the ARIADNE Projects, particular selected archaeological resources will automatically be transformed and integrated into the new models and the ability to answer research questions across heterogeneous resources will be demonstrated. Further, future work has to go into the analysis of reference databases for analytical methods, in the standardization efforts of the new models in collaboration with CIDOC-ICOM and their further consolidation in practical application.

We want to thank all ARIADNE partners for this pleasant and effective collaboration, in particular those who have actively participated in these productive workshops: Nicola Aloia, Chrysoula Bekiari, Agiatis Benardou, Katerina Dimitraki, Achille Felicetti, Reinhard Foertsch, Philipp Gerth, Sara Di Giorgio, Sorin Hermon, Gerald Hiebel, Dimitris Kafetzopoulos, Tuna Kalayci, Nikolaos Kazakis, Athina Kritsotaki, Niki Kyriacou, Dominik Lukas, Anja Masur, Keith May, Carlo Meghini, Franco Niccolucci, Elisabeth Pichler, Paola Ronzino, Wolfgang Schmidle, Benjamin Stular, Maria Theodoridou, Despoina Tsiafaki, Nestor Tsirliganis, Jacqueline Wilson.

Innovative Methods for Data Integration: Linked Data and NLP

Douglas Tudhope, Ceri Binding and Andreas Vlachidis
USW

Linked Data and Natural Language Processing (NLP) are seen as two key innovatory technologies that can open up new possibilities for semantic integration of archaeological datasets and the vast reservoir of fieldwork reports. New methods of cross searching and new opportunities for meta research and reinterpretation of previous work are envisioned. While the major phase of this work within ARIADNE will occur in the second half of the project, this report gives a brief overview of both technologies and finishes with some illustrative examples to give a flavour of progress and challenges to date.

Linked Data

The concept of Linked Data has been an emerging theme within the computing and digital heritage areas in recent years. It is anticipated that it will facilitate an organic and evolutionary approach to semantic technologies and semantic web ambitions. Linked Data is characterised as going beyond the linking of web documents by affording the linking of data.

> "The Web enables us to link related documents. Similarly it enables us to link related data. The term Linked Data refers to a set of best practices for publishing and connecting structured data on the Web. Key technologies that support Linked Data are URIs (a generic means to identify entities or concepts in the world), HTTP (a simple yet universal mechanism for retrieving resources, or descriptions of resources), and RDF (a generic graph-based data model with which to structure and link data that describes things in the world)." (http://linkeddata.org/faq)

Linked data rests upon layers of technological standards. Within archaeology, vocabulary standards have been envisaged as a potential solution to the current fieldwork situation where isolated silos of data impede sharing, cross search, comparison and reinterpretation of archaeological information. Interoperable standards for encoding fieldwork data and reports will afford a step change in archaeological practice with respect to digital publication and dissemination of data and also results. This will enable meta research explorations that ask new questions of existing dispersed datasets. ARIADNE promotes best practices for publishing and interlinking datasets for sharing, integration and reuse of archaeological data. Publication and reuse of linked data are seen as important innovative practices in this regard.

The first stage of work within ARIADNE has involved surveying semantic annotation and linking tools generally and archaeology related projects specifically. Reports have been drafted and are being reviewed internally. A broad overview and (non-technical) evaluation of generally available semantic annotation and linking tools (with tools identified as being current and relevant analysed in more detail) has been provided, together with applications developed within Semantic Web / Linked Data projects in the archaeological or wider cultural heritage sector. Approaches to semantic enrichment as followed by Europeana and other projects are also discussed. In the context of Linked Data, semantic enrichment mainly refers to the creation of new links between the enriched resource and other resources, which are generally knowledge organization systems, such as thesauri and ontologies.

Looking ahead, ARIADNE will support the provision, management and use of Linked Data in its Integrated Infrastructure. This work will include provision of an operational Linked Data management service (based on a triple store) working with the ARIADNE Registry and supporting tools for the linking of infrastructure, such as dictionaries, glossaries and thesauri. Technical partners will also advise interested data providers in the creation and publishing of Linked Data of their datasets according to standards that allow for the emergence of a web of richly interlinked datasets. While some specific linking by hand may be possible between individual data elements in closely associated datasets, this is not scalable on a large scale. Critical for this vision are concepts from major national vocabularies and ontological classes that can act as hubs in the evolving web of archaeological data.

Leading up and contributing to ARIADNE, major archaeological thesauri and ontologies have been published as Linked Open Data allowing them to be reused in a wide variety of applications following the standards. ARIADNE partners and associated cultural heritage organisations have published major vocabularies; in the Netherlands the RCE has published standard thesauri as XML with Linked Data forthcoming, already published as Linked Open Data are several national UK archaeological thesauri including the TMT (Thesaurus of Monument Types) and the CIDOC CRM ontology which acts as the ARIADNE umbrella framework. The Italian ICCD terminology is in progress of being made openly available in SKOS RDF format for use in ARIADNE. A multilingual archaeological dictionary has been made available by DAI and other partner vocabularies are in progress. Closely related, this year has seen the prominent Getty vocabularies, including the multilingual Art and Architecture Thesaurus, made freely available as Linked Open Data, while collaboratively sourced resources such as GeoNames have been available for some time (see ARIADNE Linked Data SIG reports for lists of other relevant Linked Data initiatives).

Much of the Linked Data development will occur in the second half of ARIADNE. In preparation, relevant vocabularies have been identified among the different partners, with some investigation of metadata for vocabulary linked data and possible linked data services. Discussions have taken place on vocabulary mapping (inter-linking) issues critical to semantic integration and some pilot experimentation is described at the end of this report.

Natural Language Processing

Archaeologists generate large quantities of text, ranging from unpublished technical fieldwork reports (the 'grey literature') to synthetic journal articles. However, the indexing and analysis of these documents can be time consuming and lacks consistency when done by hand. It is also rarely integrated with the wider archaeological information domain, and bibliographic searches have to be undertaken independently of database queries. Text mining offers a means of extracting information from large volumes of text, providing researchers with an easy way of locating relevant texts and also of identifying patterns in the literature. In recent years, techniques of Natural Language Processing and its subfield, Information Extraction, have been adopted to allow researchers to find, compare and analyse relevant documents, and to link them to other types of data.

Easy access to the information locked within texts is a significant problem for the archaeological domain throughout Europe. In particular, the inaccessibility of unpublished 'grey literature' has long been an issue of major concern. With so much work being performed and so much data being generated, it is not surprising that archaeologists working in the same region do not know of each others' work. Decisions about whether to preserve particular sites, how many sites of specific types to excavate, and how much more work needs to be done are frequently made in an informational vacuum. Furthermore new data is not fed into the research cycle and academic researchers may be dealing with information at least 10 years out-of-date. Nonetheless, the fact that such reports are not fully published should not be taken to suggest that the value of the archaeological data or interpretation is not significant enough for publication.

Information Extraction is a specific NLP technique which extracts targeted information from textual context. It is a process whereby a textual input is analysed to form a textual output capable of further manipulation. Information extraction systems fall into two distinct categories; rule-based and machine learning systems. Rule-based systems consist of a pipeline of cascaded software elements that process input in successive stages. Hand-crafted rules make use of domain knowledge and vocabularies together with domain-independent linguistic syntax, in order to negotiate semantics in context. In contrast, machine learning is seen by its proponents as capable of overcoming potential domain-dependencies of rule-based systems. The most common form is supervised machine learning, which depend on the existence of a training set.

Machine learning and rule based techniques are sometimes seen as competing NLP paradigms with different strengths and weaknesses. Which works best often depends on the specifics of the entities to be extracted and the language style of the text. However, the two methods can be combined in a complementary fashion or used sequentially in a pipeline. ARIADNE will investigate whether it is possible to compare and combine these methods for archaeological data summaries and grey literature reports. The resulting semantic enrichment will be expressed as Linked Data which will contribute to the Integrated Infrastructure.

As an illustrative example of ARIADNE NLP work to date, rule-based techniques have been employed with available archaeological vocabularies from English Heritage (EH) and Rijksdienst Cultureel Erfgoed (RCE). This builds upon previous work with the grey literature digital library from the Archaeology Data Service, which proved capable of semantic enrichment of grey literature reports conforming both to archaeological thesauri and corresponding CIDOC CRM ontology classes representing archaeological entities, such as Artefacts, Features, Monuments Types and Periods. The current pilot system has achieved some promising semantic enrichment of Dutch grey literature reports, for example artefacts such as "pottery/ aaardewerk" (via the RCE Archeologische artefacttypen vocabulary) and other concepts including time periods.

The generalisation of the previous rule based techniques to Dutch language grey literature faces the challenge of a different set of vocabularies. It also faces the issue of differences in language characteristics, for example compound noun forms. These present a challenge for the usual "whole word" matching mechanisms. Compound noun forms examples might include "beslagplaat" where both "beslag" and "plaat" are known to the vocabulary and also "aardewerkmagering" where aardewerk (pottery) is known but "magering" is not. Current work is investigating the development of gazetteers operating on part matching, in order to overcome the 'whole word' restriction.

Multilingual Mapping Experiment

A recent experiment has explored the potential of a mediating structure (a 'mapping spine') to support search in the ARIADNE Registry across metadata expressed via partner vocabularies in different languages. The mapping spine was expressed as a poly-hierarchical structure using RDF (SKOS). Experimental mappings from partner vocabulary resources (DAI, DANS/RCE, FASTI, EH, ICCD) to the concept identifiers of the central spine were expressed in RDF using standard SKOS mapping relationships. Results from an example query using a concept identifier for "cemetery" from a partner vocabulary are shown below, where the search is programmed to locate vocabulary concepts from any partner vocabulary mapped into the mapping spine at that level or below (more specific concepts). The different partner vocabularies can be seen in the prefix to each concept (eg iccd is the Italian ICCD Istituto Centrale per il Catalogo e la Documentazione archaeological site type vocabulary). For purposes of the experiment temporary concept identifiers have been generated automatically and are not presented in final Linked Data form.

The experiment is only possible because of the standards based approach that has been followed by ARIADNE and which underpins Linked Data. The results show that a query on a concept from one partner vocabulary has located (multilingual) concepts originating from five different controlled vocabularies, all related via the mapping spine structure. The query has also included semantic expansion to more specific concepts. In the next phase of the Registry development, it will be a straightforward query to find all collection items indexed using any of these multilingual, multi-vocabulary concepts.

concept	label
iccd:catacomba	catacomba
tmt:91386	catacomb (funerary)
fasti:catacomb	Catacomb
iccd:colombario	colombario
fasti:columbarium	Columbarium
dai:3736	Kolumbarium
dans:6a7482e5-2fd5-48fb-baf4	kerkhof
dai:1947	Gräberfeld
iccd:necropoli	necropoli
dai:2485	Nekropole
tmt:70053	cemetery
tmt:70053	necropolis
dans:be95a643-da30-40b9-b509	christelijk/joodse begraafplaats
dans:b935f9a9-7456-4669-91d0	vlakgrafveld
tmt:100531	walled cemetery
tmt:92672	mixed cemetery
tmt:70060	inhumation cemetery
tmt:70056	cremation cemetery
tmt:70055	cairn cemetery
tmt:70054	barrow cemetery
iccd:cimitero	cimitero
dans:abb41cf1-30dc-4d55-8c18	rijengrafveld
fasti:cemetery	Cemetery
dai:1819	Friedhof

Impressions from the ARIADNE Community

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DISC
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ZRC SAZU

Slovenia and Ireland, Two Perspectives on Archaeology Data

When tasked with describing the "Impressions from the ARIADNE community" one is faced with two possibilities. The first is to present a personal view and the other is to carry out some form of survey. The first may be too narrow in scope and the second is in danger of quickly outgrowing the initial scope of the task. We have therefore chosen a middle way by combining a fortunate coincidence of just finished survey of the state of digital assets in Ireland with the expert knowledge of the same from Slovenia. By comparing this two views from what it seems ferly typical countries with underdeveloped methodology for handling digital assets in archaeology, it seems that we have been able to encompass some of the enthusiasm on one hand and some possible pit falls that need avoiding on the other hand, that can be felt within the ARIADNE community.

IIn gathering the impressions presented in this paper the organisational scheme of the ARIADNE project proved to be a key feature. Namely, each ARIADNE partner is not acting just as a partner in the project but also as node or a hub in each country. It was in that role, i.e. ARIADNE partners acting as a node in their respective countries, that the data presented here was gathered.

The Slovenian Experience

It is not the aim of this brief text to present legislative background and "field" experience at any length or breath. Rather, a very broad brush description will be presented that is mainly based on the first hand experience and conversations with some of the key people and institutions in Slovenia over the past year.

The mayor underlying issue of everything connected to the archaeological digital data in Slovenia is the lack of formal or informal standards. The legislation does oblige everybody carrying out archaeological research to hand over all the physical finds and an archive of the research. A broad description on minimal standards for such an archive, including digital data, exists. It includes among others the spatial data in some sort of a CAD format (that is notoriously vulnerable to the ever-changing proprietary format), photographs in unspecified format (most often JPEG files of unspecified compression and with just the machine generated EXIF data), etc. The only component that is strictly enforced and reviewed is the grey literature site report. Moreover, after this archive is handed to the authorised museum the latter is left to its own devices to archive the data. Most of the museums are using the digital archive that has been endorsed by the Ministry of Culture in the past and is an unfortunate combination of an over-empowered commercial supplier of the digital services and a national interest.

In everyday practice, all digital data stemming from any archaeological research carried out prior to 2013 has been left completely in the hands of the researchers, being either public or private legal body. Therefore, the only source of data for many of the archaeological excavations carried out in the past decades are therefore printed copies of the site reports held by Ministry of Culture and brief reports published in the "Varstvo spomenikov" journal established for this reason back in 1948.

Things are looking up, though. Nowadays a digital database of what can be described as a metadata of recent archaeological research is being created and maintained by a public Institute for the Protection of Cultural Heritage of Slovenia. Funding permitting this database is planned to be available via a web service. More importantly, encouraged by the Society of Slovenian Archaeologists and supported by a good practice of the DANS there is now an undergoing initiative by the Ministry of Culture to set up a national archaeological digital data repository that will be maintained within the Ministry of Culture.

In order for this initiative to be a successful endeavour solid foundations are needed. Part of these, we are confident, can be drawn from a long tradition of sites and monuments digital databases that have been in existence since the 2000s, e.g. ARKAS maintained by ZRC SAZU. This means that there are strong foundations in existing controlled vocabularies, naming conventions etc. On the other hand we are looking beyond Slovenia for ready made solutions of standardisation or schemas for metadata, data integration of older archives etc.

In addition to integrating existing digital databases under the ARIADNE's umbrella it is for these and similar experiences that we are looking up to network of knowledge and experience network that emerged around the ARIADNE project.

The Irish Experience

During the late 1990's and the first half of the 2000's Ireland's unprecedented level of economic growth and development was accompanied by an equally prosperous time for archaeological investigations in Ireland, particularly by the commercial sector. During this period a large volume of archaeological data was collected during the course of excavations, archaeological surveys and the accompanying research carried out by a wide range of specialists. Much of this research, especially that undertaken under the management of the National Roads Authority of Ireland (NRA) was quickly synthesised and published either in the form of monographs, report or other forms of grey literature. However much of the supporting data was never made accessible or resides in any form al digital archive or repository.

Following the economic collapse of 2008, much of this archaeological data has now the potential to disappear permanently, and where the ethos of the archaeological community is the preservation by record, where the record is in endanger of extinction serious questions of the suitability of data management in archaeological activities is being raised.

The Discovery Programme is undertaking initial steps into the establishment of a Cultural Data Framework as part of the ARIADNE project. The primary step in establishing such a framework will be to identify the nature and range of archaeological datasets in existence and current practices in data management. A principal objective will also be to identify the benefits and potential challenges of incorporating archaeological datasets into an integrated infrastructure with a view to establishing measures that could facilitate this. As part of this process the Discovery Programme has documented, through the interview process, the nature and range of archaeological datasets, and the experiences and concerns of key heritage stakeholders in the area of digital data management and data sharing, including: The National Monuments Service of the Department of Arts, Heritage and the Gaeltacht, The National Roads Authority and The National Museum of Ireland

The interviews aimed to document and assess a range of data policies for the management of archaeological data, particularly focusing on:

- Metadata policy
- Digital archiving
- Data standardisation and use of standardised vocabularies
- Data access, IPR and other sharing policies
- Description of data sets in institutions

The datasets held by the organisations interviewed amount to the State record of archaeology in Ireland. For the most part they arise from the system of licensed archaeological investigation, but also from efforts to record and protect the physical archaeological record within the landscape.

Key findings within the survey include:

- Except for the submission of excavation and geophysical survey reports fulfilling license obligations, much of the data created in Ireland still resides with the commercial companies, many of which have now collapsed. Where material does exist in the national organisations much of this is in analogue form (75-90%), with resources curtailing any planned digitisation efforts.

- Within the archaeology sector there is no formal digital repository or archive for the collection of archaeological data. In addition there is no accompanying guidance or standards within the profession on the management of digital data.

- Where digital data exists within an organisation there are little resources available for the sharing of resources via the web. Except for the efforts of the Archaeological Survey of Ireland 's web map services (www.archaeology.ie), access to digital records is ad hoc with copies of data being distributed via usb sticks causing the proliferation of multiple copies of the same dataset being distributed, or researchers would access data by physically utilising the intranet of an organisation.

- Except for the use of a single tired monument classification scheme, there are no formal adoptions of controlled vocabularies within the heritage domain.
- As no formal repository has been available for digital archaeology data, the formalised creation of metadata has not taken place across the domain.
- Where rich digital data exist within organisations, e.g. digital image catalogues, there was a lack of resources to expose these to external users via services, and a belief in doing so could result in a loss of potential commercial value.

Under the auspices of ARIADNE in Ireland a formal grouping of a Cultural Data Framework representing the range of archaeology institutions aims to identify the potential solutions to combat the problems raised in this study. These include:

- Working in conjunction with the recently formed Digital Repository of Ireland (DRI) in the ingestion of firstly archaeological reports, and subsequently the data which supports these, including the creation of formalised metadata schemes and creation of DOIs.
- Where digital datasets do exist within organisations effort will be made to enable access to these resources through web services, which will be subsequently integrated into the ARIADNE framework.
- Utilising the support of the Royal Irish Academy (RIA) committee for archaeology, formalised vocabularies will be developed for periods and artefacts with the creation of SKOSified versions in parallel. The experiences of those within ARIADNE who have gone through this process will be utilised. In addition the framework will promote the use of data records adopting the Place names Database of Ireland (logainm.ie) which will enable the utilisation of Linked Open Data through use of place name URIs.

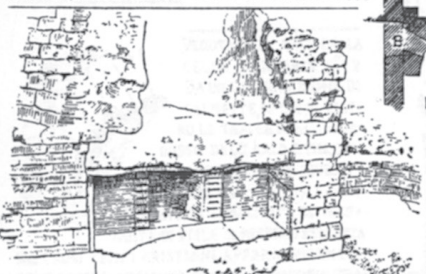
One of the mayor aims of ARIADNE project is to develop infrastructure that will bring together existing archaeological digital metadata and data. Above presented study cases of Slovenia and Ireland show that the way in which archaeological digital data currently resides is far from the likes of the ADS or DANS. Based on our personal experience with many European colleagues we feel that this may be the case for many European countries.

Coming into ARIADNE 2 years ago we were not fully aware of this. It was the activities within ARIADNE that gave us the insight and these issues have risen to the top. It is only by resolving these fundamental challenges and issues in the management and reuse of archaeological data that the real foundations for the development of a European archaeological research data infrastructure can be created. Therefore, should the effort in ARIADNE be focussed upon the establishment of a strong foundation of interoperable and standardised datasets, or the harmonisation of the disjointed datasets which currently exist?

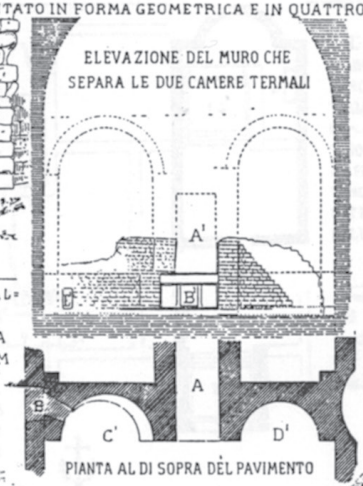
FIRENZE ANTICA~TERME A TERGO DEL CAMPIDOGLIO~STRUTTURE PARTICOLARI TRA LE DUE GRANDI SALE DEL CALIDARIO
SI MOSTRA IL RUDERE RAPPRESENTATO IN FORMA GEOMETRICA E IN QUATTRO VEDUTE TRATTE DALLE FOTOGRAFIE N°XLV, N°XLVI, N°XLVII, N°XLVIII

N°XLVI.

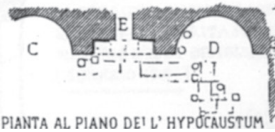
A, A'. CORRIDOIO DI PASSAGGIO DA UNA ALL'ALTRA DELLE DUE CAMERE DEL CALIDARIO
B, B'. GOLA O CONDOTTO DELL'ARIA CALDA DA UNA CAMERA ALL'ALTRA DELL' HYPOCAUSTUM



ELEVAZIONE DEL MURO CHE SEPARA LE DUE CAMERE TERMALI



PIANTA AL DI SOPRA DEL PAVIMENTO



PIANTA AL PIANO DELL' HYPOCAUSTUM

N°XLVII.

LE NICCHIE C, C' E D, D' ORIGINARIAMENTE ERANO EGUALI; MA POI PER UN RIORDINAMENTO DELLE BALINEAE LA NICCHIA C VENNE INGRANDITA: ORA SE SI NOTA CHE QUESTA, DALLA PARTE DI TRAMONTANA È ATTRAVERSATA DA UN' APERTURA E, E' LARGA 40 CM. CHE IMBOCCA NELL' HYPOCAUSTUM, SI PUÒ RITENERE PER TUTTOCIÒ CHE QUIVI SI FACESSE FUOCO PER RISCALDAR L'ACUA DELLE CALDAIE CHE SI SUPPONGONO COLLOCATE NELLA NICCHIA STESSA

ARIADNE and Sector Feedback

Kate Fernie
PIN

The mission of the ARIADNE is to bring together and integrate existing archaeological research data infrastructures so that researchers can use distributed datasets and new technologies as an integral part of archaeological research methodology. As part of this mission we have been working to raise awareness of ARIADNE amongst the community of scholars, researchers, students, deans, repository managers, directors of research institutions, international networks and related disciplines.

ARIADNE has an active programme of dissemination activities. During the first eighteen months, partners participated in over 90 conferences and events organizing one-day workshops, conference sessions, presenting papers and posters, giving invited talks and keynote speeches and distributing project literature.

During 2013 ARIADNE carried out a survey of user needs, which was advertised widely through international mailing lists and social media channels to research institutions. 692 researchers and 52 repository managers completed an online questionnaire, and 26 took part in face-to-face interviews, all giving their feedback to the project.

"Archaeological research data is becoming more and more complex, projects like this are increasingly important."

"The ARIADNE project addresses major issues of archaeological data. Many archaeologists are waiting for the results of this project."

Researchers and partners at the launch of ARIADNE

Scientific Data Special Interest Group meeting in Crete

The feedback that we received from researchers in this survey will be invaluable to ARIADNE as it develops its services and infrastructure.

"Very interesting project. Is there any further way to collaborate with it?"

As part of its community building activities, ARIADNE has established Special Interest Groups for those with an interest in: 3D and visualization; Archaeological Research Practices and Methods; Remote Sensing and Spatial Data; Scientific Data; Excavation and Monument Data; Grey Literature; Metadata and Semantics; and Linked Data. These groups have met in person and virtually to share information about the state-of-the-art in their fields, to exchange information, identify issues and plan future activities.

Archaeological institutions can become associate partners in ARIADNE. In Europe, we have exchanged cooperation agreements with several institutions who have become associate partners including the Centro Nacional de Investigación sobre la Evolución Humana, the Centre National de la Recherche Scientifique, the Instituto Universitario de Investigación en Arqueología Ibérica, the Archaeological Institute of the Andalusian Heritage and the Museum of Cultural History at the University of Oslo. Outside Europe we have established associations with FAIMS (Federated Archaeological Information Management Systems) in Australia and in the US with Digital Antiquity and tDAR (the Digital Archaeological Record).

ARIADNE partner, the Archaeology Data Service, hosted Felix Schäfer of IANUS on a training placement.

"IANUS is very happy to see other successful institutions and learn from their experiences (and failures). And what better place to go than the ADS and look over the shoulders of the staff members, asking them numerous questions, inspecting their present and future systems, discussing issues about standards and guidelines and even processing some of my own German-type project collections according to the ADS's workflows and checklists. All this has proven to be very inspiring and informative for me."

"Another motivation for my visit to ADS was to write a case study about a specific aspect, namely the selection and retention of files in big data collections ."

Participants at the Archaeological Datasets summer school

ARIADNE collaborates with international networks and Research Infrastructures by sharing information and exchanging news. The networks we collaborate with include DARIAH (Digital Research Infrastructure for the Arts and Humanities), EHRI (European Holocaust Research Infrastructure), CENDARI (Collaborative European Digital Archive Infrastructure), DCH-RP, the EAGLE project, EAA (European Association of Archaeologists) and CAA (Computer Applications in Archaeology).

There are also opportunities for individuals to participate in ARIADNE through training events, summer schools and exchanges with partner institutions.

Three summer schools providing trans-national access to the ARIADNE infrastructure, and its people, were held during 2013.

The summer schools offered participants opportunities to work with new tools in a structured context and to gain hands-on experience for their research projects. The feedback from participants at the summer schools was very positive.

"The main achievements (I) experienced during the summer school are related to the possibility to manage and handle 3D models from pictures: this means that in a very short time it would be possible to document archaeological features, and share them very easily." Paola Derudas

"From the course of this summer school…. Now I am able to develop the right project work plan and budgets for the project." Yuan Yuan

ARIADNE partner, Carlo Meghini presenting during a summer school.

"The course gave me a very good overview on how metadata can be organized, and suggested some good tools that can help me in carry out my project. I also got in contact with other people in the field that share my problems with metadata management, and we will have the possibility to share our future experience and solutions." **Carlotta Capurro**

Moyne Abbey

ARIADNE publishes reports, guidelines, training materials, news and other information on the project website: http://www.ariadne-infrastructure.eu. The website statistics show that interest in ARIADNE is international with visitors being referred to the site by project partners' websites and social networks such as SlideShare, LinkedIn and Twitter. Through its partners and followers @ARIADNE_ Network is part of a network community of around 185,000 on Twitter, sharing and exchanging news about access to archaeological research datasets amongst other topics.

One of ARIADNE's partners, FASTI-Online, was recognized by the Archaeological Institute of America for its outstanding word in digital archaeology in January 2013.

"Dr. Fentress has tried to create a model of what American archaeology abroad can be: collaborative rather than colonial"… "The Fasti Online is a natural outgrowth of this view, bringing together the archaeology of a number of countries in a single website which is greater than the sum its individual parts".

This commendation shows ARIADNE's potential for impact on the archaeological research community by bringing together distributed research datasets.