ARIADNE

D13.2: Initial services implementation report

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2 Document history

Date	*Activity*	*Contributors*
7th October 2015	Quality control, last changes	CNR, ADS, PIN
September 2015	Quality Control Review	Holly Wright
26th August 2015	Contribution by ITABC, Section 6.2.2, and IDAI	CNR, DANS, IDAI
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June 2015	First version of the Deliverable	Matteo Dellepiane, Carlo Meghini, Roberto Scopigno
April-May 2015	Initial draft	Matteo Dellepiane

3 Introduction

This document gives an overview of the initial implementation of the services of the ARIADNE infrastructure, which are the objective of Work Package 13 (WP13).

WP13 is informed by the output of WP2 (mainly Task 2.1, User needs and community building and Task 2.2, Special Interest Groups), and parallels the data integration effort in WP12. Moreover, the services to be made available within WP13 will also incorporate those developed within WP14 through WP17. As these WPs are still under development, their services will be incorporated in to a later deliverable.

The main goal of ARIADNE is to bring together existing archaeological research data infrastructures, and integrate their data and services, thereby enabling researchers to access the datasets and take advantage of the resulting services at item and collection level. These services will include functionality that is already available, and will be offered to communities who may not currently have access to it, but will also include new functionality created *ad-hoc* by the partners on the basis of the requirements that were collected at the beginning of the project. The main modality of the implementation of this new functionality will be a web-based service, although other types of services (local tools, guidelines) will be integrated as well.

This Deliverable is organized as follows: Section 4 gives a short description of the services that rely on the ARIADNE Catalogue. Section 5 offers an overview of the Services provided by the ARIADNE partners, which will be adapted and integrated in the Infrastructure. Section 6 presents the Services developed from specifically for the Infrastructure, together with a description of their current state of completion and the first steps of evaluation. Finally, Section 7 outlines the conclusions and a roadmap for WP13 until the end of the project.

The Deliverable will refer, where necessary, to D13.1, which provides a design of the services, grouped by functional similarity. The implementation described here covers all the use cases proposed in the Deliverable, taking into account the structure of the Infrastructure that is currently under implementation.

4 Services provided within the ARIADNE Catalogue

The ARIADNE Catalogue is based on the ARIADNE Catalogue Data Model (ACDM), which has been developed to describe the archaeological resources made available within the ARIADNE infrastructure to the researchers wishing to access and use them.

As shown in Figure 1, the central notion of the ACDM is the class ArchaeologicalResource that has as instances the main resources described in the Catalogue. These resources are categorized in:

- data resources, representing the various types of data containers that can be discovered, accessed and possibly integrated on the ARIADNE infrastructure. Data resources are categorized in collections, datasets, databases and GIS.
- services, representing the services made available by the ARIADNE infrastructure;

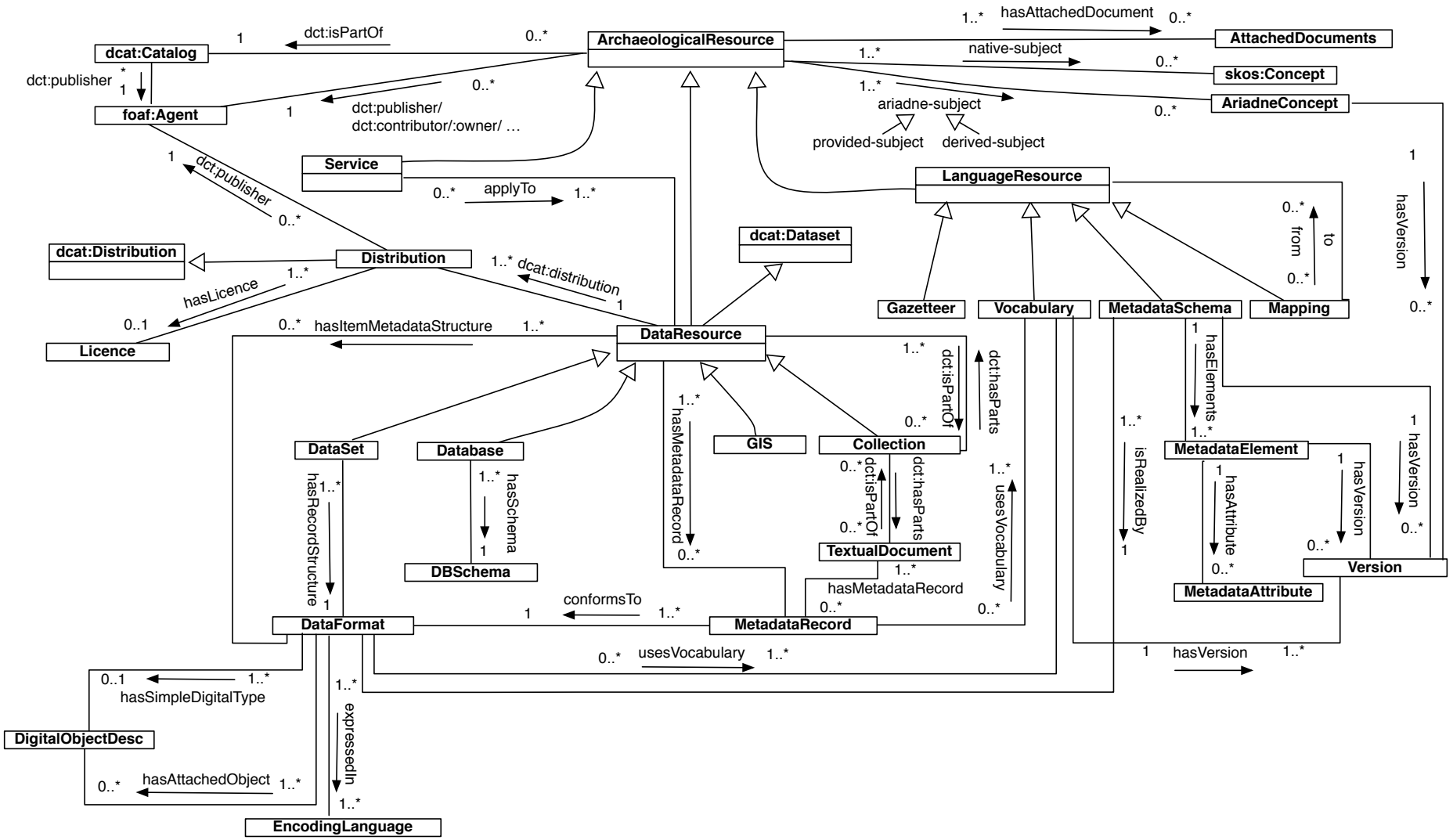

Figure 1: The UML Diagram describing the ACDM (extracted from the Specification document version 2.5.5)

- language resources, representing vocabularies, ontologies, metadata schemas, mappings (between language resources in general) and gazetteers that are available within the ARIADNE infrastructure.

Please refer to the specification of the ACDM (ARIADNE internal deliverable) for a detailed description.

The search and retrieval functionalities for all kinds of resources described in the Catalogue are currently under development in the context of WP12.

The ACDM defines a rich structure to discover the large number of resources provided by the ARIADNE infrastructure, either by querying the Catalogue or by browsing the information space described in it. Given the size of that information space, it is expected that most of the queries will return a large result. For the same reasons, browsing of the information space will be difficult. It is therefore paramount to create the discovery service with powerful visualization functionality, allowing users to consume the query results and to browse the ARIADNE information space in an easy and useful way.

To this end, a set of visualization services (in addition to the basic search and retrieval functionalities) will be made available within WP13 for exploring query results and for browsing the ARIADNE information space. These services will provide the front-end to the back-end services implemented by WP12; therefore their implementation is the result of a tight collaboration between WP12 and WP13. These services will have to cover the use cases 7.1, 7.2, 7.3, 7.5 and 7.6 described in D13.1.

More specifically, two main services will be available when discovering Data Resources:

- Spatial display of query results: since the data resources are associated with spatial data (expressed in terms of GPS coordinates, or postal address) it is possible to visualize the result of a query on a map (like the example shown in Figure 2). The same display is available in the context of a browse session, for instance when navigating a collection.

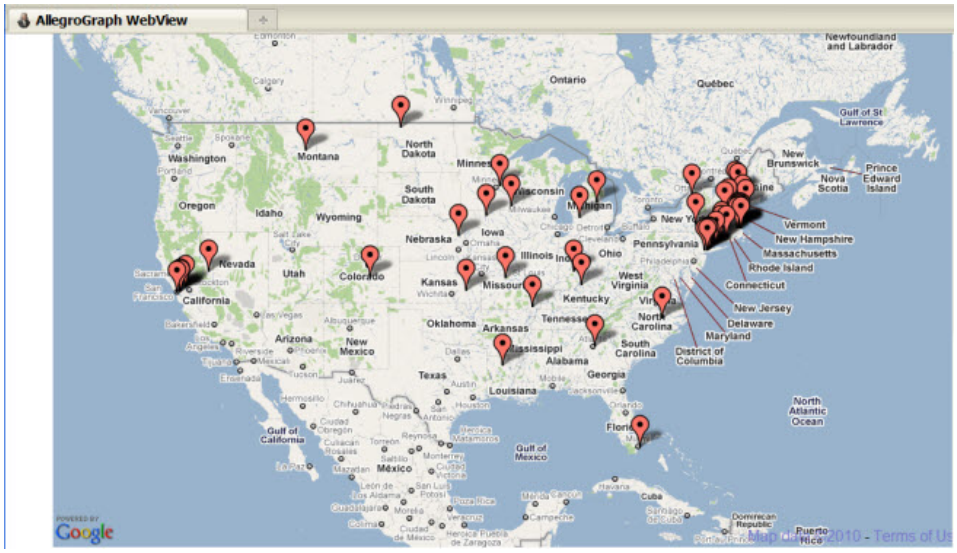

Figure 2: An example of spatial visualization of a query result

- Timeline display of a query result: as temporal information (timeframe, generic period) is also available for any resource described in the Catalogue, results may be visualized graphically on a timeline as well, as shown in Figure 3. Again, the same kind of visualization can be obtained by browsing a certain region of the information space, for instance all resources available at an institution.

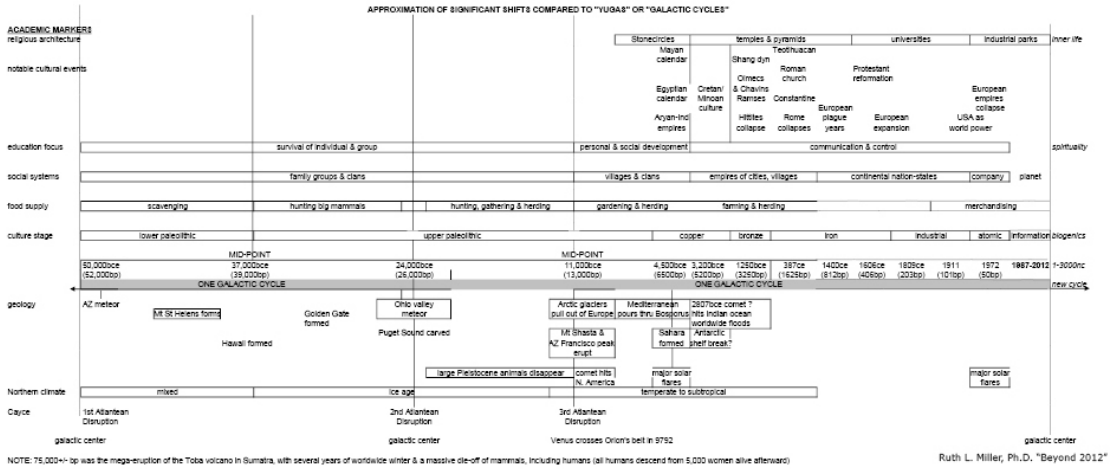

Figure 3: An example of timeline visualizing several elements in a graphical way

The services above provide functionalities which are also outlined in several use cases in Deliverable 13.1. Both visualization services are currently under implementation within the context of the creation of the ARIADNE Portal.

5 Services provided by ARIADNE Partners

The aim of the ARIADNE project is not only to integrate the data from a variety of archaeological datasets, but to also share services that partners have already implemented and tested. For this reason, a survey of the available services was conducted during Year 1 of the project, also including any new service that may be developed by any partner during the project lifetime.

Following the results of the survey, the potential services were grouped in three categories in order to better steer their integration and their provision through the ARIADNE Portal.

The three categories are related to the types of resources on which a service will act: data resources, language resources or items. Each category of service is described in a separate Section below.

5.1 Services for data resources

Data resources play a central role in the ARIADNE infrastructure. Hence, the services to create and maintain data resources play a major role in the infrastructure. These services account for use cases 7.4 and 7.6 in Deliverable 13.1.

Currently, several of the partners provide services for data resources: some of these services are already under integration in ARIADNE, while others are currently under consideration for full integration later in the project (see Section 7 for details).

In the following, a short description of the services is provided, together with some information about the partner that will maintain the service and collaborate during the integration with the ARIADNE portal.

5.1.1 University of York: Archaeology Data Service

Type of service: Data deposit and preservation service

Short Description: The Archaeology Data Service is the national digital data archive for archaeology the UK and a world-leading data management centre for archaeology and heritage sector. It was established in 1996 and now comprises some 15 staff. It is hosted by the Department of Archaeology in the University of York. It supports research, learning and teaching with free online high quality and dependable digital resources and preserves them in the long term. The ADS operates according to the OAIS model for digital archives and holds the Data Seal of Approval, the internationally recognized quality mark for trusted digital repositories. In 2012 the ADS was awarded the Digital Preservation Coalition's Decennial Award for the most outstanding contribution to digital preservation of the last decade. ADS-Easy provides an online costing tool and data deposit service.

Homepage: archaeologydataservice.ac.uk

First release: 1997

Last Update: N/A

Provided by: Archaeology Data Service

Authentication: N/A

Integration mode: the service will be integrated within the ARIADNE infrastructure via a direct link. ADS services will also be integrated with the preservation services provided by DANS (see next subsection).

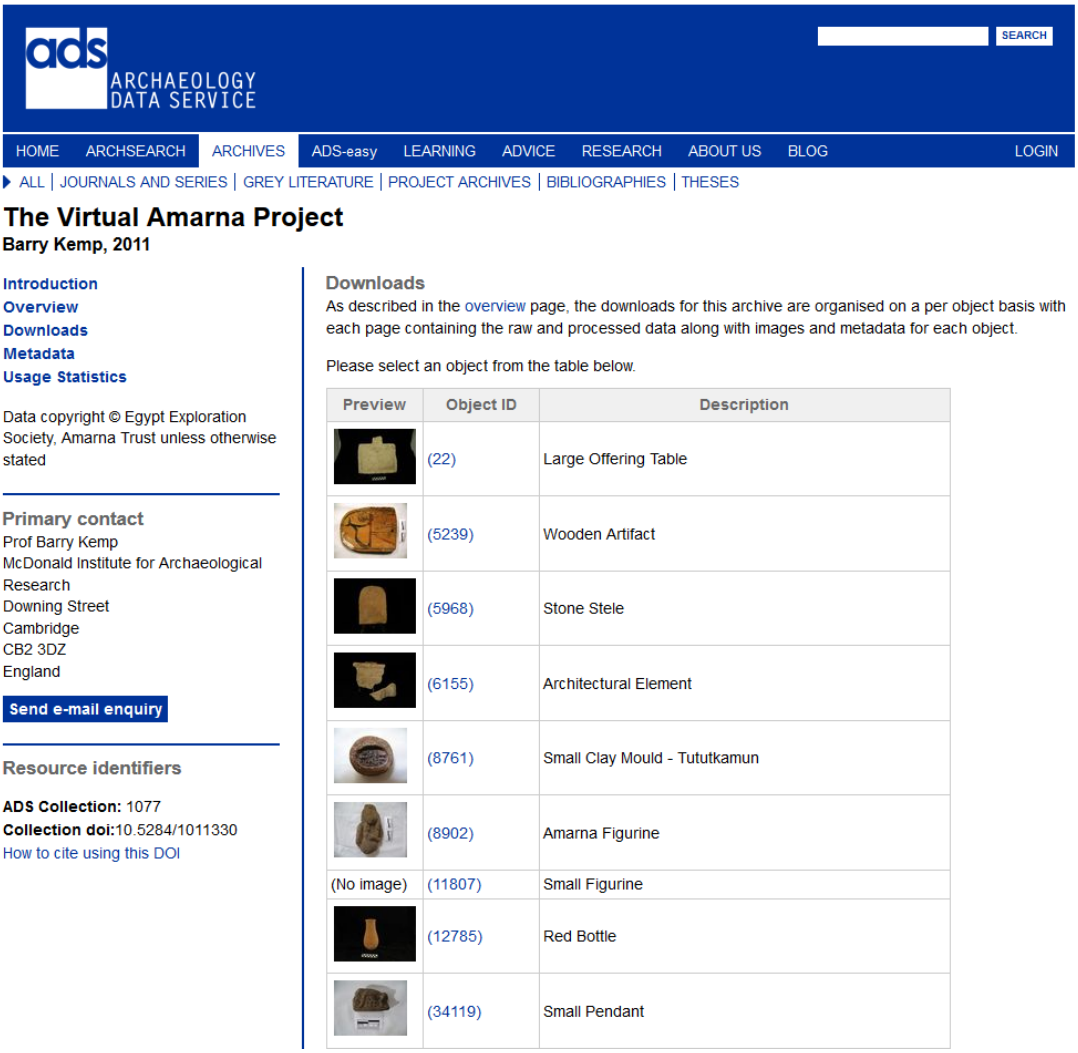

Figure 4: An example of a dataset hosted by the Archaeology Data Service

5.1.2 DANS: Data Archiving and Networked Services

Type of service: Data deposit and preservation service

Short Description:

The e-depot for Dutch archaeology is accommodated at DANS, the national digital research data archive for the Netherlands. A wealth of digital archaeological excavation data such as maps, field drawings, photographs, tables and publications is accessible via EASY, DANS' online archiving (deposit, preservation and reuse) service. DANS operates according to the OAIS model for digital archives and holds the Data Seal of Approval, the internationally recognized quality mark for trusted digital repositories.

DANS was established in 2005, with predecessors dating back to 1964, and now comprises some 45 staff. DANS's activities are centred around 3 core services: data archiving, data reuse, training and consultancy. Driven by data, DANS ensures the further improvement of sustained access to digital research data with its services and participation in (inter)national projects and networks. DANS is an

institute of the Royal Netherlands Academy of Arts and Sciences (KNAW) and co-founded by the Netherlands Organization for Scientific Research (NW0).

Homepage: dans.knaw.nl

First release: 2005

Last Update: N/A

Provided by: DANS

Authentication: N/A

Integration mode: the service will be integrated with ARIADNE infrastructure via a direct link. DANS services will also be integrated with the preservation services provided by ADS (see next subsection)

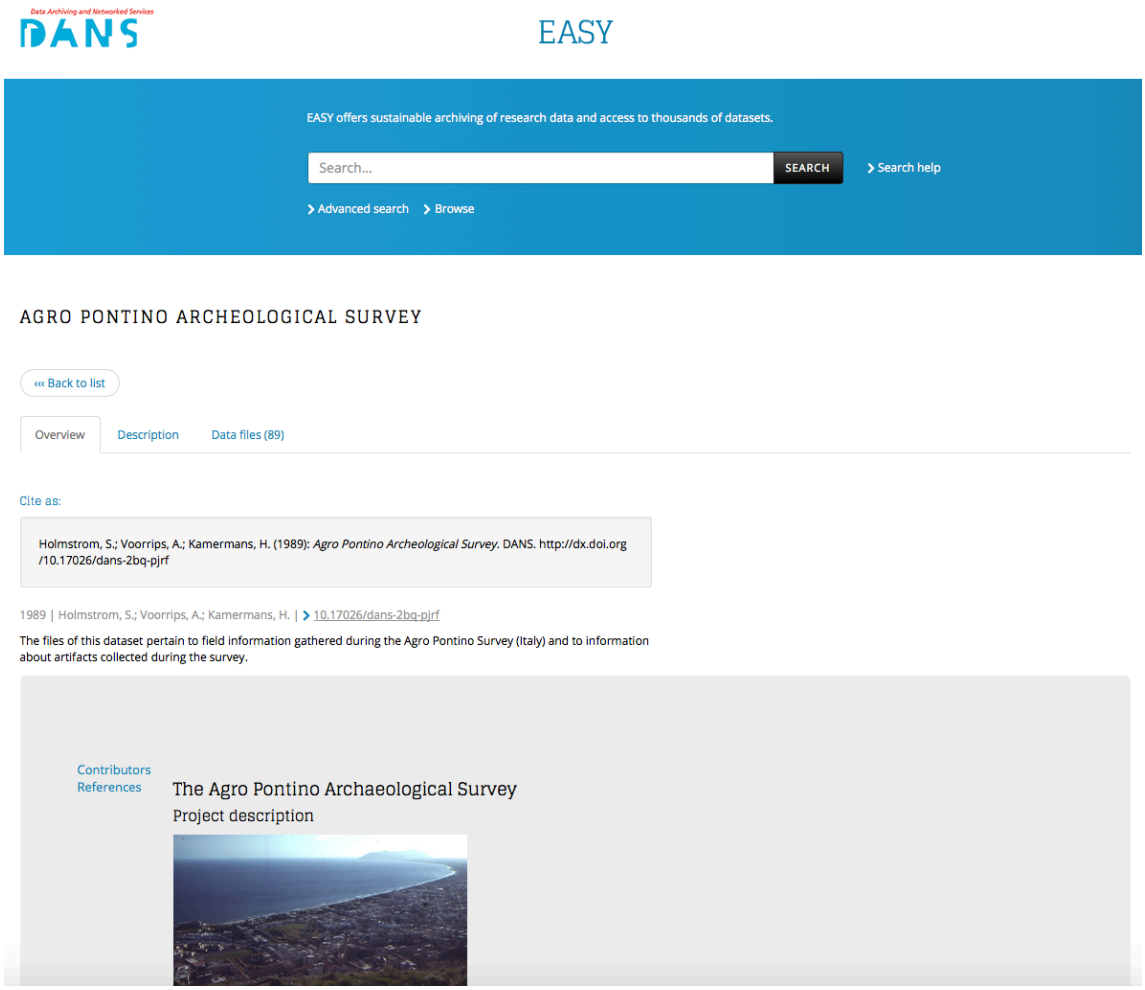

Figure 5: an example of a dataset hosted by DANS service

5.1.3 Arachne

Type of service: Data deposit and preservation service

Short Description: **Arachne** is the central Object database of the German Archaeological Institute (DAI) and the Archaeological Institute of the University of Cologne.

Arachne is intended to provide archaeologists and Classicists with a free internet research tool for quickly searching hundreds of thousands of records on objects and their attributes. This combines an ongoing process of digitizing traditional documentation (stored on media which are both threatened by decay and largely unexplored) with the production of new digital object and graphic data. Wherever possible, Arachne follows a paradigm of highly structurized object-metadata which is mapped onto the CIDOC-CRM, to address machine-readable metadata strategies of the Semantic Web. This “structured world” of Arachne requires large efforts in time and money and is therefore only possible for privileged areas of data. While there is an ever-increasing range of new, “born digital” data, in reality only a small effort-per-object ratio can be applied. It therefore requires a “low-threshold” processing structure which is located in the “unstructured world” of Arachne. All digital (graphic and textual) information is secure on a Tivoli Storage System (featuring long-term multiple redundandancy) and distributed online through the Storage Area Network in Cologne via AFS.

Homepage: http://arachne.dainst.org

First Release: 1995

Last Update: 2015

Provided by: DAI, Germany

Authentication: Not needed for downloading and browsing the data; data entry and import only for authenticated users

Integration and other notes: This service will be accessible through ARIADNE. The authentication protocol could be integrated with the authentication in ARIADNE Portal.

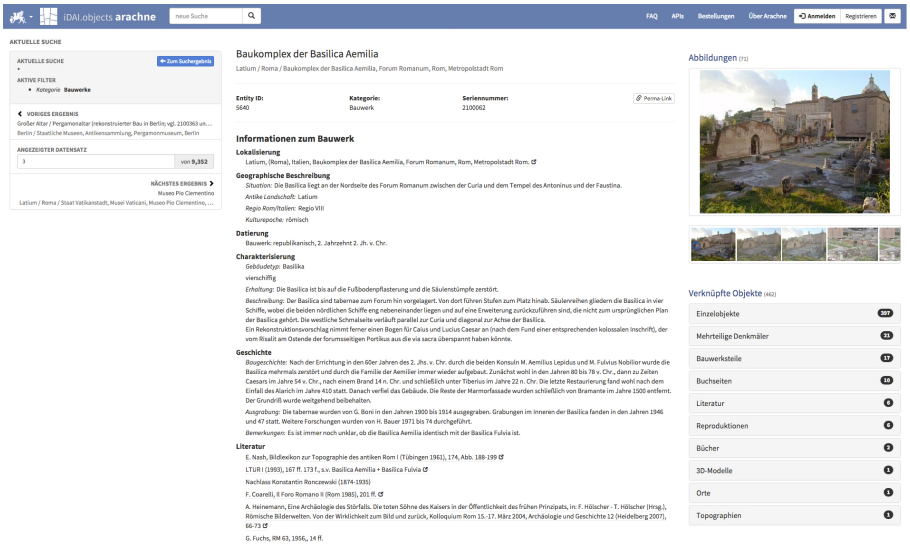

Figure 6: an example of a dataset in Arachne service

5.1.4 Digital Collaboratory for Cultural Dendrochronology (DCCD)

Type of service: Service software tool to set up a digital repository for dendrochronological data

Short Description: To improve European integration of dendrochronological data, DANS has now made it possible for others to use the same software as the DCCD-repository of DANS, and use existing components to create their own dendrochronological archive that is also ARIADNE compatible. This open source software is available from the following GitHub repository: https://github.com/DANS-KNAW/dccd-webui

The DCCD software is an online digital archiving system for dendrochronological data. A recent version of this software (system) is deployed as 'Digital Collaboratory for Cultural Dendrochronology' (DCCD) at http://dendro.dans.knaw.nl.

More information about the Digital Collaboratory for Cultural Dendrochronology (DCCD) project can be found here: http://vkc.library.uu.nl/vkc/dendrochronology.

DANS was established in 2005, with predecessors dating back to 1964, and now comprises some 45 staff. DANS's activities are centred around 3 core services: data archiving, data reuse, training and consultancy. Driven by data, DANS ensures the further improvement of sustained access to digital research data with its services and participation in (inter)national projects and networks. DANS is an institute of the Royal Netherlands Academy of Arts and Sciences (KNAW) and co-founded by the Netherlands Organization for Scientific Research (NW0).

The DCCD is the primary archaeological/historical tree-ring (meta)data network existing in Europe. It became operational in 2011. Within the DCCD Belgian, Danish, Dutch, German, Latvian, Polish, and Spanish laboratories have joined data in a manner that suits their shared and individual research agendas. In its present state the DCCD contains measurement series of different wood species derived from objects and sites dating between 6000 BC and present. All data sets are described with very detailed metadata according to the newly developed international dendrochronological data standard TRiDaS (Jansma et al. 2010). The collection is derived by research from archaeological sites (including old landscapes), shipwrecks, historical architecture and mobile heritage (e.g. paintings, furniture).

Homepage: http://dendro.dans.knaw.nl/

Last Update: 2015

Provided by: DANS

Authentication: Needed to insert and browse data

Integration and other notes: This service will be accessible through ARIADNE. The authentication protocol could be integrated with the authentication in ARIADNE Portal.

Figure 7: the homepage of DCCD service

5.2 Services for Language resources

As explained in Section 4, Language resources represent vocabularies, ontologies, metadata schemas, mappings (between language resources in general) and gazetteers. While the description of this type of resource is still under finalization, some services have been found that are already available. They will be integrated into the ARIADNE infrastructure.

These services are linked to the use cases 7.4 and 7.6 of Deliverable 13.1, where the general term *collection* was used. Given the new structure of the ACDM, these services are intended to give the possibility for the user to access and possibly add new language resources.

In the following, a short description of the services is provided, together with some information about the partner that will maintain the service and collaborate during the integration with the ARIADNE portal.

5.2.1 iDAI.vocab

Type of service: German Thesaurus of Archaeological Concepts with support for multilingualism

Short Description: The new DAI Thesaurus of Archaeological Concepts was designed from the onset as a thesaurus of German words and phrases with significant multilingual support. The core of the thesaurus is a list of concepts related to the domain of archaeology (nouns, verbs, less frequently adjectives, but also complex phrases that point to a specific object, such as “carrarischer Marmor”) all linked to corresponding translations in a wide spectrum of different languages; we also established a minimal set of relations between the German terms (synonyms, direct hyper- and hyponyms), and grouped the equivalent terms together; whenever it is possible, we also resolved equivalent terms by selecting one preferred concept. In addition we connect terms and concepts by SKOS links to external thesauri, like the Arts & Architecture Thesaurus of the Getty Institution.

Homepage: http://archwort.dainst.org/thesaurus/de/vocab/index.php

First release: Jan 2014

Last Update: 2015

Provided by: DAI, Germany

Authentication: Not needed for downloading and browsing the data; data entry and import only for authenticated users

Integration mode: This service will be accessible through ARIADNE. The authentication protocol could be integrated with the authentication in ARIADNE Portal.

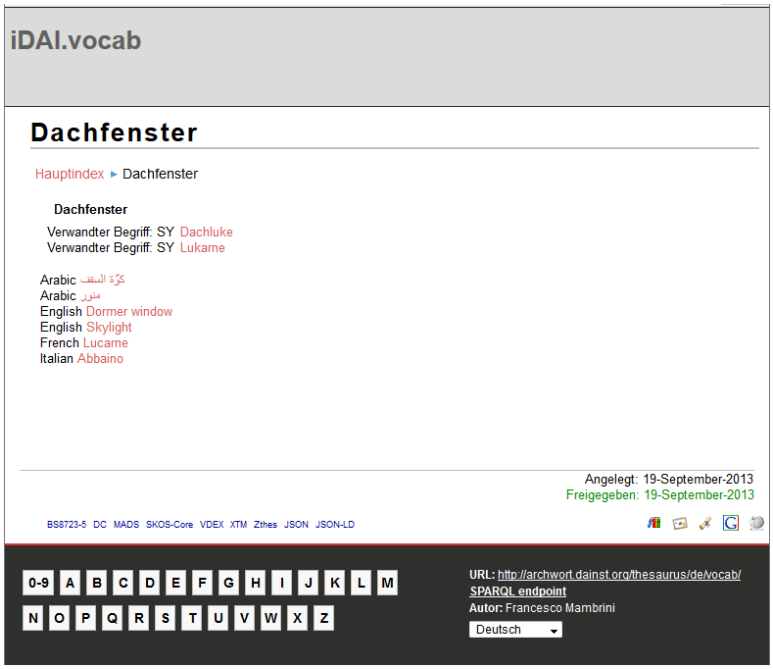

Figure 8: An example of a term in IDAI Vocabulary service

5.2.2 iDAI.gazetteer

Type of service: Gazetteer

Short Description: The German Archaeological Institute together with the Cologne Digital Archaeology Laboratory is developing the iDAI.gazetteer - a web service connecting toponyms with coordinates. It was initially built as an authority file/controlled vocabulary for any geo-related information in information systems of the DAI. Furthermore it is meant to link these data with other worldwide gazetteer-systems.

Homepage: http://gazetteer.dainst.org/

First release: Nov 2012

Last Update: April 2015

Provided by: DAI, Germany

Authentication: Not needed for downloading and browsing the data; data entry and import only for authenticated users

Integration mode: This service will be accessible from ARIADNE. It may be used as a controlled vocabulary for spatial extent of archaeological data provided within ARIADNE. The authentication protocol could be integrated with the authentication in ARIADNE Portal.

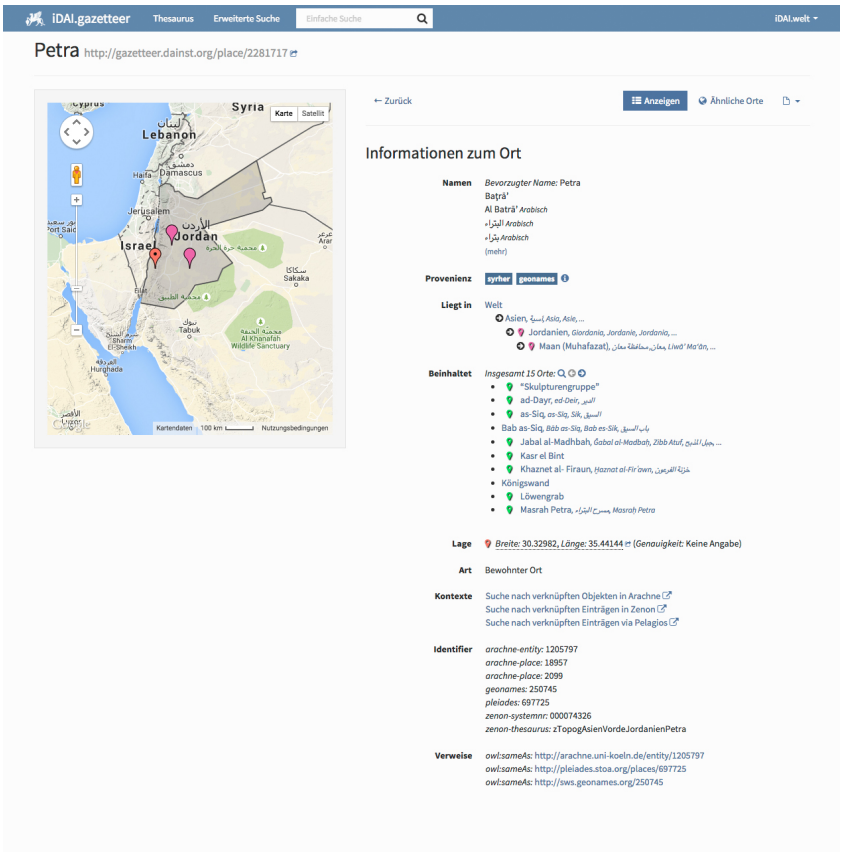

Figure 9: an example of a dataset in the iDAI gazetteer

6 Services developed within the ARIADNE project

While the goal of ARIADNE is essentially to create a common Infrastructure of data and services, obtained mainly integrating existing resources, a part of the effort of WP13 is devoted to the development of new services.

Preliminary work during Year 1 was devoted to analysing the types of data in archaeological collections for which the services provided by the community are considered to be not sufficiently adequate. It turned out that visual media was indicated as not sufficiently supported in any of the considered communities. In the next Sections, we will provide an overview of the different visual media, with a discussion on the available service for their integration with collections, and a description of the services which are under development in the context of ARIADNE. These services account for use case 7.7 in Deliverable 13.1.

6.1 Visual Media in Archaeological collections

A sub-focus in the ARIADNE project is to provide support for the management of visual media. The concept of visual media in archaeology can be broadly described as any type of visual representation of archaeological findings or assets, i.e.: conventional 2D images (including high resolution, high dynamic range, HDR), special images (such as relightable or panoramic images), 3D models and videos. Therefore, the term visual data encompasses any media that could help archaeologists to better represent, document and communicate the artworks under investigation or study. Visual media are not new instruments of work for archaeologists, since drawings and images have been used for centuries, and are part of common working practice. The new issue is how to make a proficient use of those media when different digital incarnations are made available by the progress of ICT technology. A number of new, low cost and easy-to-use opportunities for the acquisition of digital visual representations are now available and widely used on the field. What is still cumbersome however is how to open data to all potential users (considering both those working within the domain and the general public), and how to publish in an easy and efficient manner. Specific to the archaeological domain is the range of scales involved: archaeological data may include representations of small findings (a few centimeters) up to representations of an entire archaeological site (hundreds of meters).

The next subsections present views on the main types of visual data (derived from discussion at an ARIADNE WP13 workshop held in Pisa in October 2013, and guidelines for supporting them. The technology will be briefly described (some of which is highly innovative). It is planned to deploy services to make it easier to publish and share visual data resources on the web.

6.1.1 The 2D realm of visual data

Images are the most common visual medium, and they have been part of archaeological datasets right from the very beginning, originally by means of the analogue, printed version and more recently by digital means of (either digitally native images or scanned from old prints/slides). Those data are part of many digital archives and collections. As an example, more than 800K images are stored in the **Arachne** archive managed by the **DAI - German Archaeological Institute** (Section 5.1.3). Images are also an important component of the archives of the **Archaeology Data Service** (ADS), York University, UK (Section 5.1.1).

Even for existing datasets, the number of available images (sometimes of very good quality) is already very high.
While images are a medium that is fully integrated within the Web and HTML since its inception, there are aspects that lack a standard solution for archival and visualization purposes.

6.1.1.1 2D images – Coping with high resolution images

Most of the images produced nowadays are very high-resolution. High-resolution images are now a highly available resource, with the impressive evolution of digital photography (just to mention a single example, a recent off-the-shelf smartphone provides a 41 MPix camera).

When high- or very high-resolution images are available, visualization on the web can be difficult, due to the amount of data that has to be transferred before a Web browser can display it, as browsers must receive the entire file before visualizing it. Another important and critical issue could be the necessity to protect the data, in the sense that the access to high quality ones may be granted by request only.

A possible solution may be providing a visual feedback approach adopted by map viewers. For example, *Google Maps* (http://maps.google.com) handle its huge maps by re-encoding them in a sequence of decreasing resolution. Each image within this sequence splits into square tiles of fixed size (usually 256 pixels) to allow data management at high granularity. The client in the browser "composes" the portion of the image selected by the user on the fly using the tiles more suitable according to the size of the portion under view. This is a simple multi-resolution approach that has been demonstrated to be very efficient for visualizing this type of data. The same approach can be employed to visualize high- or very high- resolution images.

From a technical viewpoint, tiles can be:

1. Stored on a server and served by a web server. This has the disadvantage of requiring management of hundreds of files (one for each tile) for each image. For example, if an image of 4000 x 4000 pixels is stored in three different resolutions (e.g. 2000 x 2000 and 1000 x 1000) and decomposed in tiles of 200 x 200 pixels, 525 files (400 + 100 + 25) would be needed to store each image.

2. Computed on the fly, starting from a suitable format such as TIFF or JPEG2000. This requires additional CPU cost, and an increased effort in the installation and configuration of the server.

It is proposed to follow this approach but make it more efficient, i.e. compress in a single file all the tiles, and serve them to the browser using the *http-partial requests*. This uses AJAX technology and Javascript, avoiding the inconveniences of both solution 1 and 2.

A first prototype of a similar viewing system has been implemented by ISTI-CNR on top of the SpiderGL layer. In this case the classic approach of storing a large number of files on the server (one file for each tile) has been employed. This prototype, enriched with a preloading system which may have potential to be improved, has been experimented with in the Cenobium project (http://cenobium.isti.cnr.it/)) to visualize high-resolution images of figurative capitals.

Note that the same multiresolution-tiling approach will be used also in two other application contexts: for the visualization of HDR images and for the visualization of RTI images.

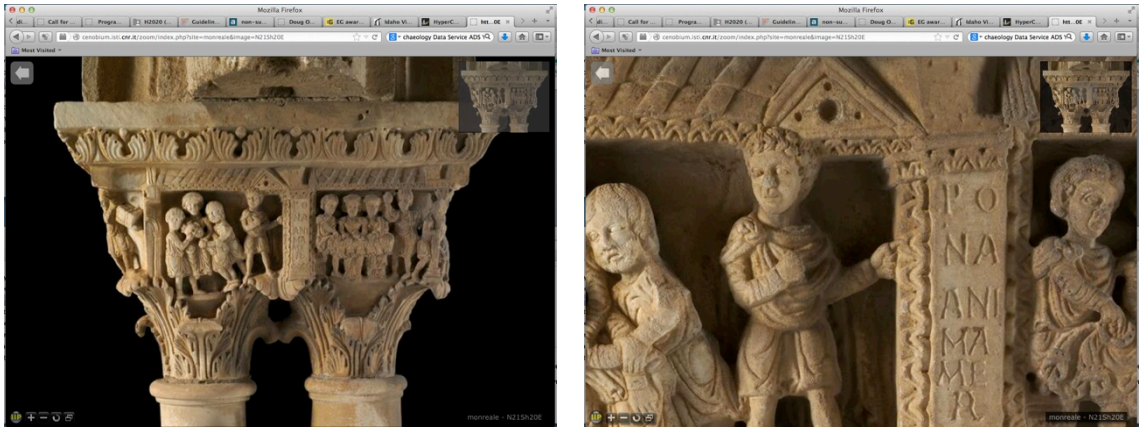

Figure 10: Progressive transmission and visualization of high-resolution images on the Web (Cenobium system).

6.1.1.2 2D images - Visualization of High Dynamic Range (HDR) images

HDR images are images acquired by combining shots taken at different f-stops, in order to acquire a higher dynamic range and so have richer images. Such images have better representation of dark and illuminated zones in the view field with respect to standard images. Standard images are usually called LDR (low-dynamic range) images in this context. The use of this type of data is becoming more and more usual in these last years, and HDR data will soon be a standard part of any archaeological documentation campaign. Archaeology is an ideal domain for the application of HDR images, as in many cases images must be acquired in contexts characterized by a strongly uneven distribution of light (i.e. an archaeology excavation in southern Europe which presents direct sharp sun illumination and several zones within the view may be under shadows, or photos taken in the interior of a tomb with scarce and uneven illumination).

HDR images can be hard to store and visualize, especially because Low Dynamic Range (LDR) monitors cannot visualize the data in a proper way. For this reason, the current approach is to transform the HDR data into a standard LDR image. Unfortunately, by converting an HDR image into an LDR image much visual content may be lost.

WebGL, through SpiderGL, can provide an easy way to visualize HDR images using their original data, without converting the image to an LDR format. The *HDR Web Viewer* we propose follows the idea of exploiting all the HDR information producing an on-the-fly LDR image, according to the user's needs. The user can indicate interactively where he/she wants to focus the region, and the HDR viewer will adapt the image to that region (by adjusting the virtual exposure). The user can interactively vary the focus area (in real time, during the visualization session) in order to spot all the details of the image and avoid losing or compressing the content. A first demo of this interactive approach is provided at the following web address: http://spidergl.org/example.php?id=13.

From a technical viewpoint, the HDR textures are stored using PNGHDR, a format that encodes extra information in the alpha channel of a PNG file. (https://github.com/banterle/HDR_Toolbox). In order to handle high-resolution HDR images, the viewer can adopt the same multi-resolution tile-based approach described in previous Subsection.

Figure 11: Visualization in SpiderGL of the same HDR image with two different exposition values

6.1.1.3 2D Images - Visualization of big images datasets

The number of images stored in archaeological archives can be extremely high, often in the order of thousands (if not tens or hundreds thousand). Hence, the search and navigation to find these images can be time consuming and difficult. The standard approach is currently still a keyword search, which could be frustrating in many cases; for example, when searching for artworks similar to one under study. Browsing over a large set of image icons (the approach provided by most operating systems or by common interfaces to browse images) is an alternative, but the efficiency may not be good. For this reason, a method supporting *easier navigation* and *semantic ordering* over large numbers of images can be very useful for many purposes.

A possible solution is the use of smart visualization of big datasets, where the images can be grouped following a semantic (i.e. similar colors, or similar point of view), in order to help the user. An example is the ***Pilebars*** approach, which allows the images to be ordered/sorted and visualized

following several possible semantics. After that the specific semantic is embedded in the Pilebars by implementing a proper "distance" function between the images. The Pilebars visualization tool works in an interactive way, presenting the image according to a "smart" layout which gives the user easy and fast navigation between the image sets (Figure 12).

Figure 12: An example of the appearance of the Pilebars browsing interface

6.1.1.4 Enhanced 2D Images – Production and visualization of panoramic images

Panoramic images are now a common resource, after the adoption by Google's StreetView application (https://www.google.com/maps/views/streetview?gl=us), now integrated with Google maps. They are extremely useful for visually presenting an archaeological context/site, the interior of a building, etc. Panoramic images are also extremely fast and easy to produce.

6.1.1.5 Enhanced 2D Images – Production and visualization of RTI images

Relightable images (also called Reflection Transformation Images, or RTI) are becoming an increasingly used technology to acquire detailed documentation on small *quasi-planar* objects. This is particularly useful especially for objects characterized by a complex light reflection attributes. The advantage of this representation is the possibility of changing the light direction over the image in real time (i.e. during visualization), and the availability of using enhanced visualization modes to better inspect fine details of the objects' surface (Figure 15).

RTI images have been successfully applied in a number of applications, such as collections of coins, cuneiform tablets, inscriptions, carvings, bas-reliefs, paintings and jewellery. Moreover, RTI images allow the creation of digital representations of artworks made of materials that cannot be acquired by usual 3D scanning technologies (highly reflective materials, semi-transparent objects, etc.).

Typically, this type of image is generated starting from a set of photographs acquired with a fixed camera under varying lighting conditions. RTI encodes the acquired data in a compact way, using view-dependent per-pixel reflectance functions, which allows the generation of the relighted image using any light direction in the hemisphere around the camera position. This per-pixel reflectance function varies between different RTI types. For PTM (Polynomial Texture Maps) the function is a biquadratic polynomial (six coefficients are required to define it). For more advanced RTI, hemi-spherical harmonics are usually employed (nine coefficients are used in this case).

In this last type of RTI, the image is subdivided in nine layers, one layer for each HSH coefficient (Figure 13), where each layer contains one of the coefficients of the three RGB colour channels. Then for each layer a multi-resolution quad-tree is created in the analogous way described in Section

7.1.1, and a tile for each node of the tree is saved in JPG format. To visualize a specific pixel, nine JPG images that contain its HSH coefficients need to be loaded.

Figure 13: Images representing the different coefficients of the HSH per-pixel function

Concerning the acquisition of this type of image, CNR-ISTI built an automatic acquisition device (a dome) that permits the acquisition of up to dozens object in a single day, and produces the RTI images in an automated way (Figure 14).

The dome is composed of four aluminium shells that are easily assembled and disassembled (to simplify transport). It has 116 cold white LEDs (6 Watt, 750 lumen) used to change the lighting conditions and an overhead high-resolution reflex camera (Nikon D5200, 24Mpixel). The dome is computer controlled to allow completely automatic acquisition by synchronizing the switching on of each LED with the shutter of the camera.

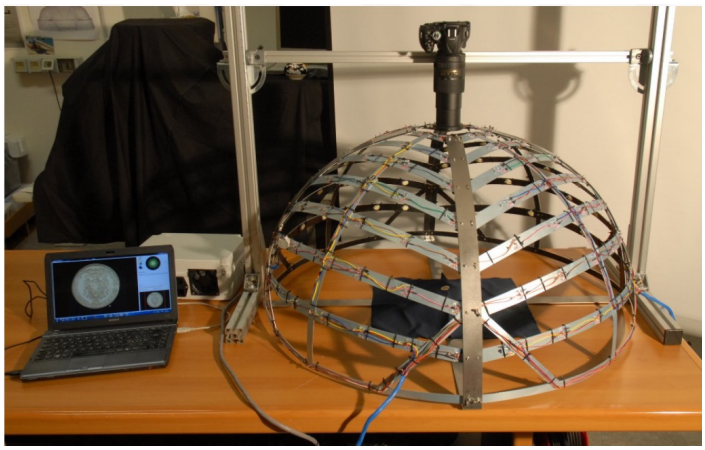

Figure 14: The RTI acquisition device developed by CNR-ISTI

Moreover, the interactive visualization of RTI images can be supported locally, using freely available tools, and on the web, using a WebGL component. As stated previously, because RTI images ae usually hight resolution, this visualization component has to adopt the same tile-based approach described in previous subsections.

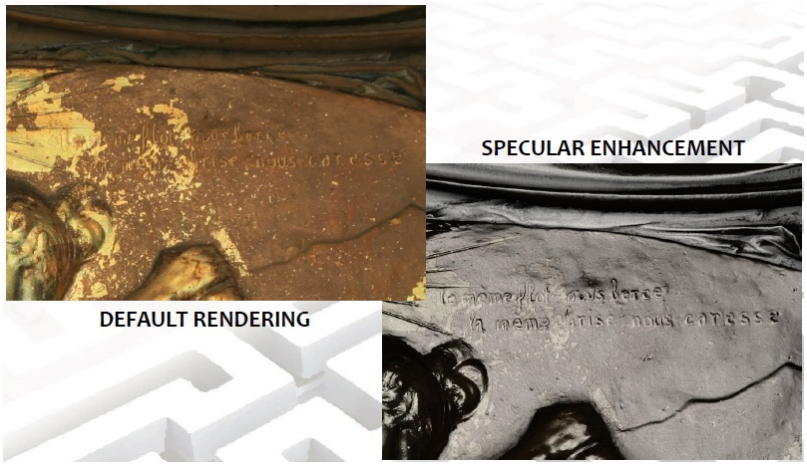

Figure 15: Examples of two different visualization modes applied to the same RTI image

6.1.2 Full 3D representations

3D representations are now becoming quite common in archaeology. Two classes of models are produced:

- *Sampled models*, usually produced using active 3D scanning (laser-based systems or systems using structured light), or adopting the recent photogrammetry approaches (production of 3D models from a stream of images);
- Modelled representations produced using the user-driven modelling systems designed for 3D modelling and computer animation applications.

In the context of professional archaeological applications, sampled models are more common, since they give much more control over the accuracy of the representation with regard to hand-modelled representations (this has been verified at a previous workshop held in Pisa, November 2013, where most of the 3D models presented by content providers were part of this first group, including excellent models demonstrated by the Discovery Programme, http://www.discoveryprogramme.ie). The latter, conversely, are more common in applications oriented to the public (e.g. to produce videos or virtual reconstructions of still images).

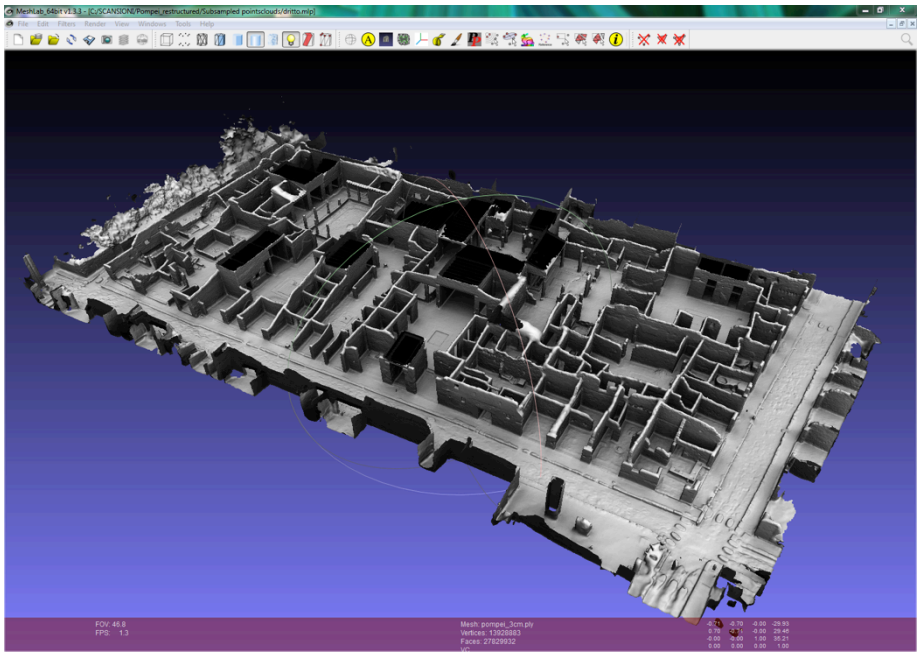

Figure 16: The MeshLab open source system, rendering a 3D model of an insula in Pompeii.

6.1.2.1 Sampled 3D models – Supporting the production phase

The open source geometry processing system MeshLab (see Figure 16) developed by CNR-ISTI is one of the most diffuse tools for processing sampled data resulting from 3D scanning or stereo-photogrammetry (http://meshlab.sourceforge.net/). With more than one million downloads (including around 350.000 in 2013), MeshLab now has a consolidated and very large community of users.

MeshLab has been widely used and improved within the context of previous and on-going EU projects, such as 3D-COFORM, 3D-ICONS and V-Must. The last release includes a number of different functionalities that could be used for the processing and presentation of 3D models.

The features that could be used within the ARIADNE infrastructure are:

- The complete pipeline for processing 3D scanned data
- The pipeline supporting colour projection on 3D models
- Topological features removal and fixing
- Snapshots production using several different rendering modes
- A command line version of MeshLab (***MeshLabServer***) to apply a set of filters on a large number of 3D Models (in batches, using unattended mode).

6.1.2.2 3D models – Presentation on the web

Presentation on the web of complex models (models composed by millions of samples, like the ones usually obtained by 3D scanning), is still very difficult to achieve. This is primarily because it is hard to transmit/render such data in real time, and publishing 3D material on the web is still a task that few developers can address. On the other hand, 3D models cannot be confined to the single archaeologist's archive, but should be shared with the community, to increase knowledge and stimulate further study.

CNR-ISTI has recently developed two resources to support easier publishing on the web of high-fidelity 3D models (this development has been funded mostly by the V-Must project http://www.v-must.net/).

3DHOP (*3D Heritage On-Line Presenter*, Figure 17) is a set of templates and components for the development of Virtual Museums or effective presentations on the Web of digital 3D assets. Its main features include: easy presentation of different types of multimedia content, including relightable images and single, high-resolution 3D models, sophisticated customization capabilities for Web presentation, seamless integration within a Web page allowing integration of different multimedia data (Figure 17). 3DHOP is designed to be easy-to-learn and easy-to-use. Its modular structure allows users with different levels of expertise to use it effectively, even when the user has very little or no knowledge of Computer Graphics and Web Programming. The framework also provides terrain visualization, different navigation/interaction modes, and picking and camera controls. Many of these components are designed to account for the needs that are often encountered in the development of Cultural Heritage applications (for example, it is particularly easy to build a web page showing a collection of objects).

The visualization of high-resolution 3D models is based on a WebGL and Javascript implementation of the *Nexus* multi-resolution framework: the model to be visualized is pre-processed and converted into a collection of small fragments of a few thousands of triangles, at different resolutions. These fragments can be assembled together to approximate the original surface. Depending on the viewpoint the fragments are selected to minimize the rendering error given a set amount of triangles. So, only the fragment effectively viewed by the users are required to be sent through the Web.

This approach is optimal for a number of reasons:

- It minimizes CPU usage, as the assembling algorithm is quite simple. This is especially important as the client side will be running Javascript.
- Using a collection of fragments supports a naturally out-of-core approach, which allows rendering to begin as soon as data is incoming, and chunk data processing to minimize the effects of network latency.
- It is possible to optimize the rendering quality for a given amount of bandwidth.
- Automatic pre-fetching is implemented to hide latency as much as possible.

- There is no need for special server support: as it only requires basic HTTP protocol, so the browser itself handles both the streaming and rendering tasks.

Another goal of V-MUST was the creation of a set of Web services for unattended handling of 3D data. The services will be mainly automatic, and aimed at performing the processing and preparation of 3D models for visualization on the Web. An example of this service is the **ModelConvert** (http://pipeline.v-must.net/) service, which automatically prepares the 3D model and embeds it into a web page depending on the application template chosen. The model is prepared by converting it in a format suitable for streaming on the Web (X3DOM proprietary format, which is the previously mentioned Nexus model format used by 3DHOP). The ModelConvert can also perform a standard cleaning and fixing procedure, in order to remove and fix topological artefacts within the models before converting it. The output of ModelConvert is a package containing the web pages generated, plus a URL to test them. ModelConvert employs many technologies, such as X3DOM, SpiderGL and a minimal version of 3DHOP, depending on the selected application template (Figure 18).

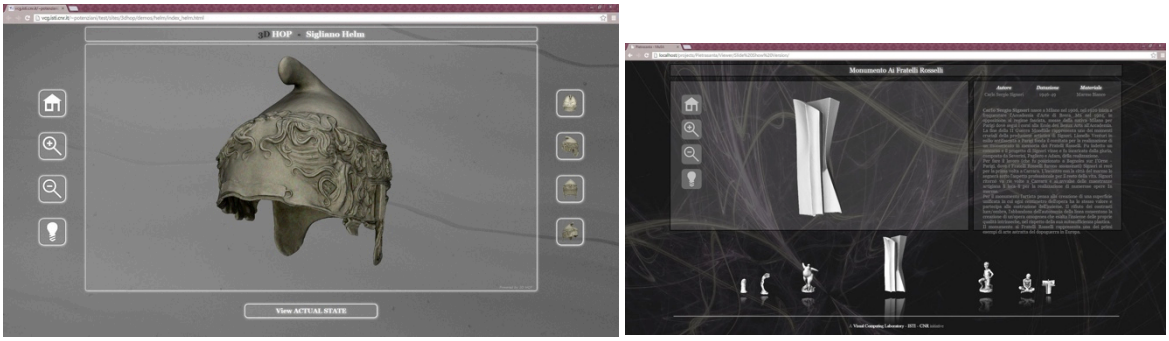

Figure 17: Two examples of different visualization layouts for 3D models supported by 3DHOP

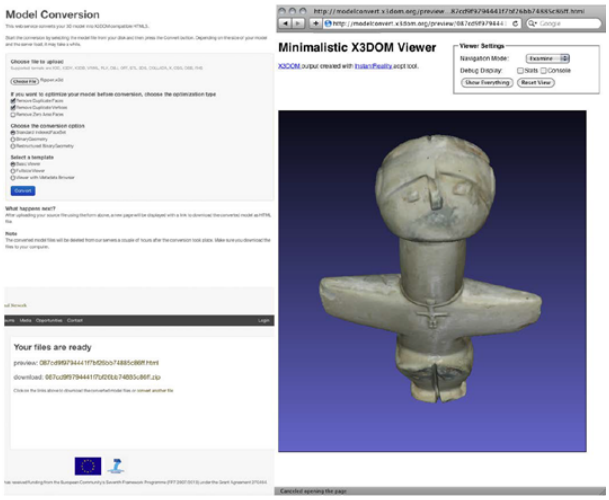

Figure 18: the ModelConvert service of V-Must

6.1.3 Videos

Videos (either captured with digital video or standard cameras, or documentation produced by using computer animation) are a well-known resource for visual presentation in archaeology.

Similar to panoramic images, many free and embedded solutions are available; hence it is quite easy to integrate videos in the context of a collection. It is unlikely that new services will be needed in this case.

6.2 Service under implementation in ARIADNE

Following the outcomes of the overview on visual media, a set of services were created to handle them in an automated way. The goal was to provide a service where users do not need a strong knowledge of the issues related to visual media. The interaction with the service must be simple, and provide easy to use results.

The next subsections briefly describe the services that have been released by ARIADNE partners. These services are currently under further implementation, and will be fully integrated in the context of the ARIADNE infrastructure.

6.2.1 ARIADNE Visual Media Service

Type of service: publication and presentation of complex media assets

Short Description: The ARIADNE Media Service is aimed at providing support for the easy publication and presentation of complex media assets on the Web. The idea is to build an automatic service able to transform any media file uploaded by ARIADNE archive managers into a format that will allow easy and efficient access and remote visualization on the Web. The service is based on a simple web interface and supports three types of visual media: high-resolution images, RTI (Reflection Transformation Images, i.e. dynamically re-lightable images), and high-resolution 3D models.

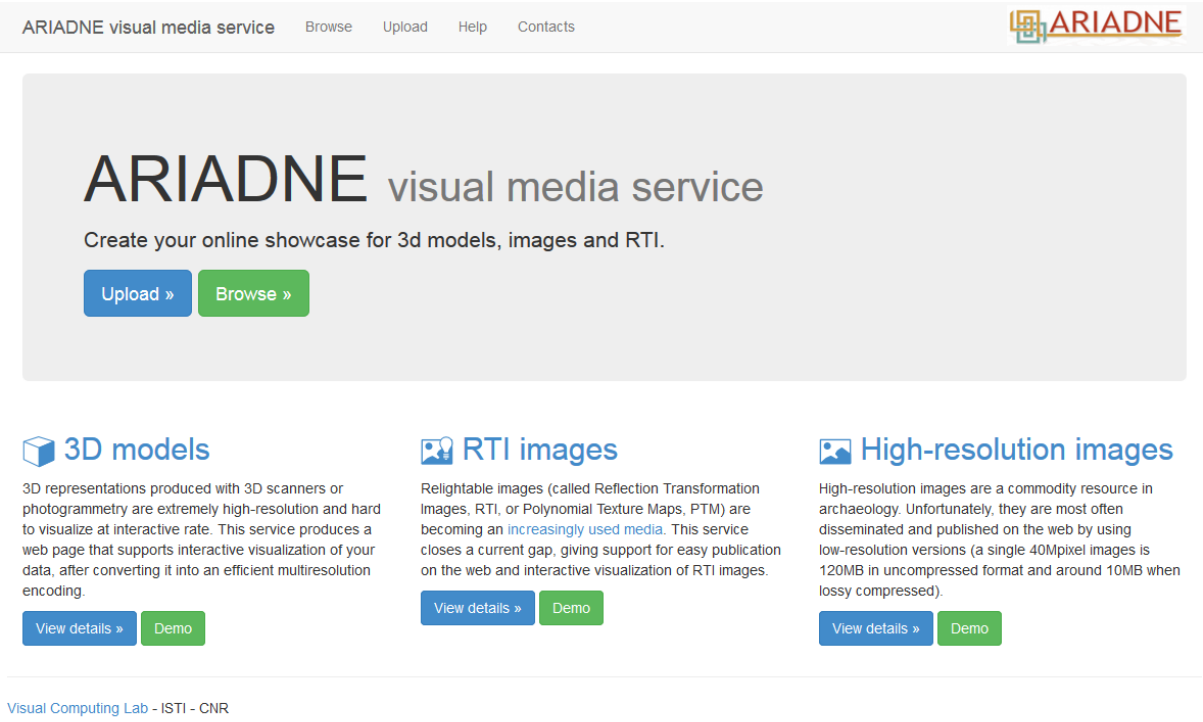

Figure 19: The Visual Media Service homepage

These types of media are not easy to display on the web, as entire files may need to be downloaded for them to be visualized, and dedicated software may need to be selected/installed. Moreover, the owner of high quality data may prefer not to give visitors the option to download them freely, in order to protect the ownership of the data.

After accessing the service, the user will find a simple Web form that allows them to upload their data (3D model, hi-res image or RTI) and to provide some basic information about the media. The service processes the input data in an automated way and creates an online page. At the end of the processing step, the user receives an email containing a link to the visualization page (hosted on the ARIADNE web-service and open to any external user) and to an admin page, where the associated data can be modified. It is also possible to download the page created (HTML code + processed 3D Model or image) in order to integrate the content on the user's local server or archive.

In the case of 3D models, the geometry is processed, converting a possible complex 3D model into a multi-resolution format (Nexus, http://vcg.isti.cnr.it/nexus). This multi-resolution structure is can be streamed, and is used to create a visualization webpage using a Web presentation tool (3DHOP, http://www.3dhop.net) based on WebGL and developed by CNR-ISTI.

Analogously, high resolution images are also transformed into a multi-resolution format, supporting progressive streaming; the service transforms each image into a web-compliant format: similarly to Google maps, the high-resolution image will be regularly divided into chunks, and a hierarchy of images at different resolutions is produced from these chunks; a rendering webpage is then created where it will be possible to navigate the model in a WebGL frame.

Figure 20: an example of a visualization page automatically generated by the Visual Media Service

RTI are managed similarly to hi-res images, even if the encoding for the Web streaming is more complex, and WebGL rendering also takes care of the input and calculation of the variable-lighting.

With this setup, even new users can easily create an efficient webpage to display complex 2D or 3D content. For more experienced users, these basic webpages may be the starting point for the development of more complex visualizations, or for the integration of visualizations inside existing websites, taking advantage of the features of the 3DHOP platform (www.3dhop.net). Finally, the data structures for remote visualization (multi-resolution for 3D models, image pyramids for images and RTI web encoding) protects the original data, as a direct download of the multimedia file in a single plain format is not possible.

Homepage: http://visual.ariadne-infrastructure.eu/

First release: Jan 2015

Last Update: April 2015

Provided by: ISTI-CNR, Italy

Authentication: Not needed for now, the service will be integrated within the authentication protocols of the ARIADNE portal

Integration and other notes: This service will be accessible directly from the ARIADNE portal.

6.2.2 Landscape Factory

Type of service: generation and 3D visualization of terrain datasets

Short Description: Landscape Services for ARIADNE are a set of responsive web services that include large terrain dataset generation, 3D landscape composing and 3D model processing, leveraging powerful open-source frameworks and toolkits such as GDAL, OSGjs, OpenSceneGraph and ownCloud.
The main components include: the cloud service, the terrain generation service, the terrain gallery and the front-end web component for interactive visualization.

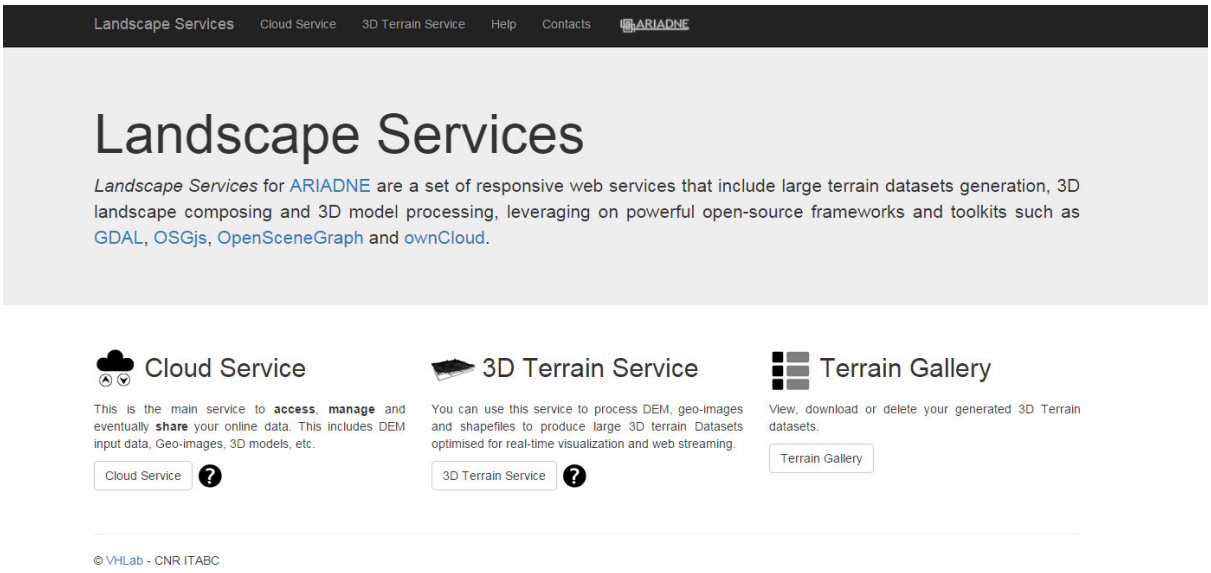

Figure 21: The Landscape Services main page

The *cloud service* aims to provide a way to access, manage and eventually share input (or output) data. This includes DEMs/DTMs, Geo-images, 3D models, etc. This is specifically designed for compact workflows or when dealing with massive amounts of data with special access policies. The service aims to not only provide a space to store data, but also to develop a collaborative environment online, where multiple users may work and modify data at the same time. For example, several users may work on the same landscape, enriching visualization, integrating documents and more.
The *3D Terrain service* works in a similar way to the Visual Media Service, but it provides processing and visualization for terrain datasets, which is a different type of 3D model. The service takes as input multiple DEM/DTM files, geo-images, shapefiles and ESRI *world files* (http://webhelp.esri.com/arcims/9.2/general/topics/author_world_files.htm) to georeference the final dataset. Advanced features are offered, including the ability to select specific areas of a generated dataset from a shapefile, set a vertical multiplier, switch to geocentric output mode, set resolution depth and much more. The output section provides several options, including:

- Common 3D formats for desktop segment (obj, 3ds, fbx, etc.), applied to landscape reconstruction workflow. Output includes optimized geometry and textures
- WebGL multi-resolution 3D visualization for modern browsers. Published output includes multi-resolution compressed geometries and textures for efficient streaming.
- Preview visualization by remote rendering of terrain dataset for devices not supporting WebGL. A set of interactive frames (images) is generated as output.

The WebGL Front-End provides efficient visualization of generated 3D terrain datasets and options to embed the interactive frame into external pages, or search queries within the ARIADNE portal. The developed component also includes support for mobile browsers (responsive HTML5 interface), spherical panoramas, presentation of external XML metadata, points-of-view and several input peripherals, including mouse, keyboard, joypad and multi-touch devices (desktop, tablets and smartphones, Figure 22).

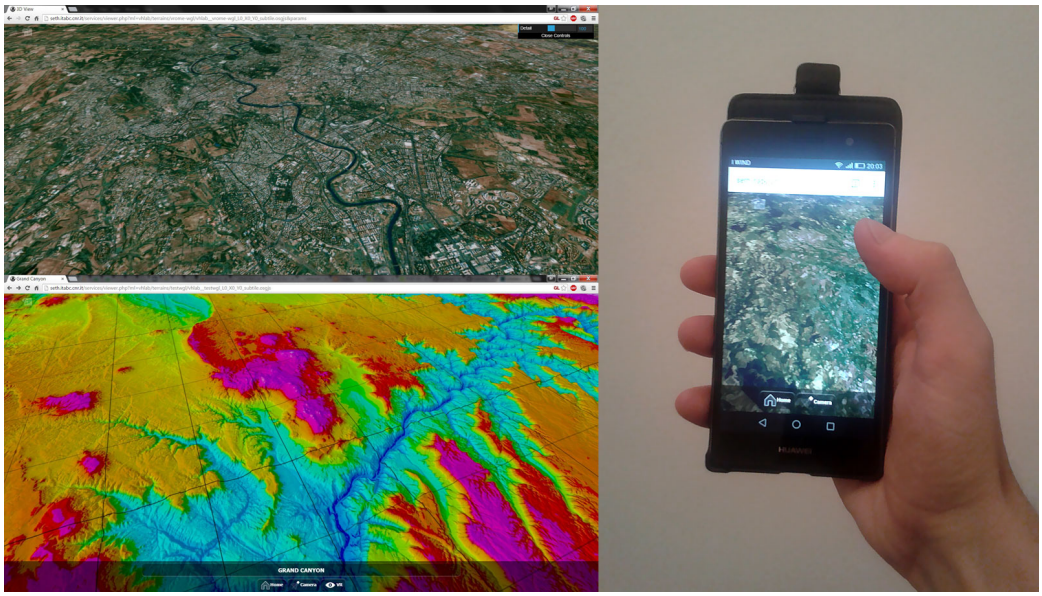

Figure 22: The interactive WebGL Front-End to visualize a multi-resolution 3D terrain DB on modern desktop browsers (left) and smartphones (right).

The *Terrain Gallery* allows display, editing and eventually deleting generated terrain 3D datasets for a current logged user/research institution. Each listed item also offers links for downloading full zip packages which contain the chosen 3D format and textures for the datasets produced, links to the preview service and links to the WebGL published page; with embed options for external integration.

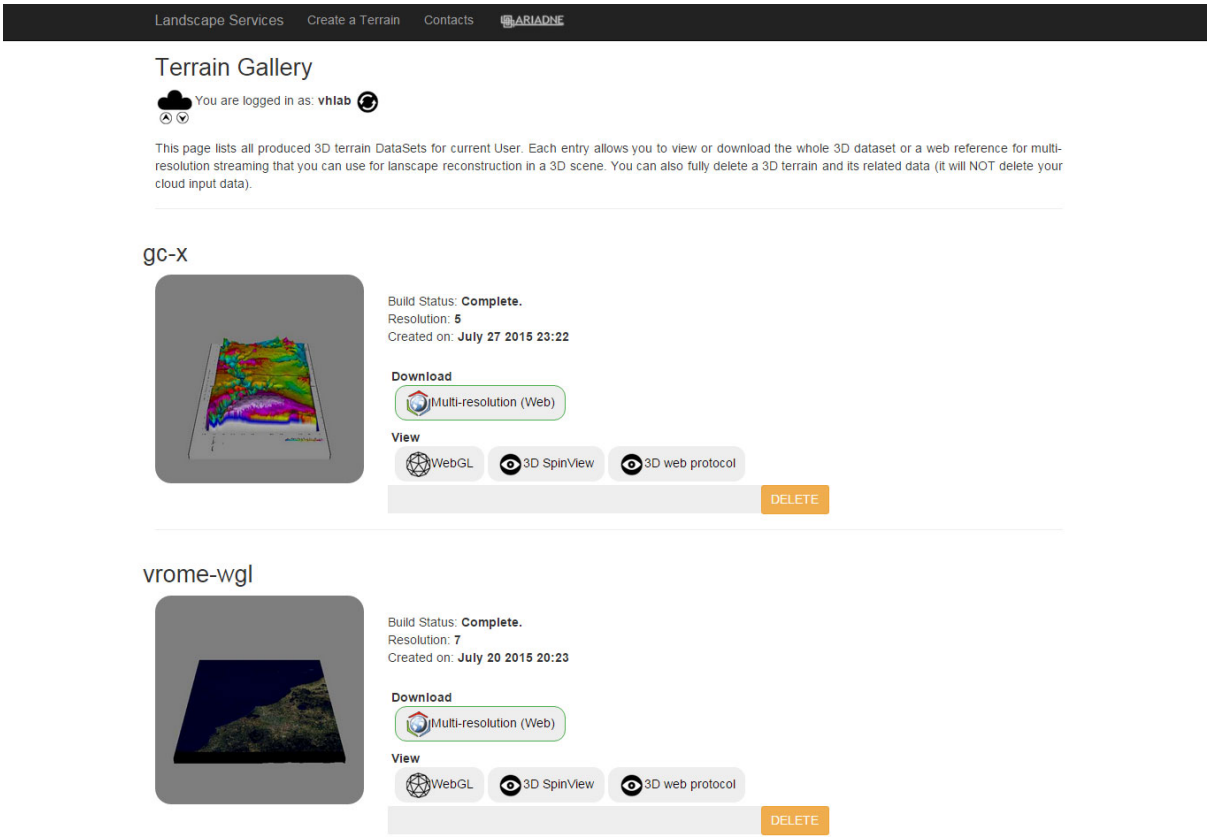

Figure 23: The Terrain Gallery listing produced terrain datasets for user "VHLab"

Homepage: http://seth.itabc.cnr.it/services/landscape/

First release: Jan 2015

Last Update: July 2015

Provided by: ITABC-CNR, Italy

Authentication: Needed for dataset generation, the front-end service and published datasets will be integrated and result queries performed within the ARIADNE portal

Integration and other notes: This service will be accessible directly from the ARIADNE portal.

7 Conclusions and Future improvements

This Deliverable presented the current state of integration and implementation of services in the context of the ARIADNE infrastructure.

The next step of the WP will be to consolidate the integration and implementation by strongly collaborating with WP12, and taking advantage of the testing phase which is currently ongoing.

To accomplish this, a technical meeting was conducted in July, 2015 to define a roadmap to reach the final integration of services by M36 of the ARIADNE project.

Given the current state of services, several conclusions can be drawn, and the future actions for the WP can be outlined. They are presented in the next Sections.

7.1 Afterthoughts on the ACDM

The services which are currently under implementation and integration within ARIADNE cover several elements of the ACDM. The general structure of the ACDM is currently under refinement, especially for the classes and properties used for the description of services, since the role and interaction of services depends also on the integration work provided by WP12. Nevertheless, the analysis of services conducted in the context of the work described here, allows us to make the following remarks:

- *The services and the data types*: In the current version of the model, services apply only to data resources, but there are existing services that apply to Language Resources, and the project is developing services that apply to the Catalogue itself. It is therefore necessary to extend the ACDM in order to accommodate the description of these services into the Catalogue.
- *The item level*: ARIADNE aims to provide (at least prototypal) services also at an item level, working on the single items of a collection. These are services already implemented and used by the partners (Section 6.2). In the current ACDM model, the item level is not taken into account. More generally, it will be necessary to better define how the *item level* will integrate in the ARIADNE infrastructure.

7.2 Long term preservation services

Task 13.3 of WP13 is devoted to the implementation of long term preservation services. These will be ensured for all the metadata and data that will be produced within the infrastructure (created from primary resources) and will be kept as secondary resources stored within the infrastructure.

Currently, the concept of long term preservation needs better definition, because some of the services that will be integrated into the infrastructure (for example, the ones in Section 5.2) already have their own long term preservation functionalities.

In the context of the ARIADNE infrastructure, long term preservation will have to be taken into account at least for:

- The ARIADNE catalogue: mechanism to preserve metadata are needed
- The item level: currently, the services presented in Section 6.2 are producing new data, and providing access to them. Long term preservation services will be needed, and they will be implemented as soon as the services will be fully integrated in the ARIADNE infrastructure.

7.3 Acceptance testing

Task 13.4 of WP13 is meant to test the services produced in Task 13.2 and verify their correspondence to design (Task 13.1), use requirements (Task 12.1) and users' specifications (Task 2.1 and Task 2.2).

The acceptance testing phase is currently ongoing; the services will be tested by users with different backgrounds and technical knowledge, in order to provide feedback about improvements in the integration with the infrastructure and in the further implementation of new services.

Acceptance testing is a crucial step to having solid feedback, and also ensures that services will survive beyond the project lifespan.

7.4 Future implementation and improvements

This Deliverable provided an overview of the initial implementation of services. The implementation is ongoing, including several current actions.

Following the structure of the deliverable, the main actions will be:

- *ARIADNE Catalogue Data Model:* the implementation of the ARIADNE portal will make it possible to better define, implement, and test the services for the Catalogue. This work will be done in collaboration with WP12.
- *Add new services:* the finalization of the structure of ACDM will allow new and existing services to be included as ARIADNE continues. This will likely comprise opening up general access to some of the services developed for use with the core services in WP12, including the service to allow mapping of multi-lingual vocabularies, using the Getty Art and Architecture Thesaurus (AAT) as a central spine (University of South Wales), the MORe aggregation and enrichment service (ATHENA RC), which includes metadata validation and enrichment using a variety of micro-services, and the RDF store for the delivery of resource discovery metadata for use in machine readable applications and queries using SPARQL (ATHENA RC). There may also be additional services included, either resulting from work by ARIADNE partners or elsewhere, that may be of use with ARIADNE metadata and beyond. All services that will be part of the final ARIADNE infrastructure will be described in detail in Deliverable 13.4 (Final services implementation report).
- *Services for data and language resources:* since most of the proposed services primarily need integration within the Infrastructure, further discussion and testing are ongoing. The main issues are: the degree of integration (from simple re-direction to full integration), the authentication protocol, the integration among services
- *Services for visual media:* the services for visual media are already available and used by the community. They will be tested and improved according to the outcomes of the testing phase. Technical improvements are also undergoing, including the use of compressed multi-resolution 3D structures.

- *Manage accounts in the ARIADNE Infrastructure:* as outlined in use case 7.8 in Deliverable 13.1, it is important to setup a robust mechanism to manage accounts within the ARIADNE portal. This is mainly a task for WP12, but a proper integration with service will be needed, in order to avoid problems during the testing phase.

8 References

ARIADNE Description of Work"- DoW

ARIADNE deliverable D2.1 "First report on Users' Needs" http://ariadne-infrastructure.eu/Resources/D2.1-First-report-on-users-needs

ARIADNE deliverable D12.1 "Use Requirements" http://ariadne-infrastructure.eu/Resources/D12.1-Use-Requirements

ARIADNE Deliverable D13.1 "Service Design" http://ariadne-infrastructure.eu/Resources/D13.1-Service-Design

Specification of the ARIADNE Catalogue Data Model v. 2.5.5 http://ariadne-support.dcu.gr/

ARIADNE website: www.ariadne-infrastructure.eu