ARCHES

H2020 – 693229

Deliverable D3.1 “Report on system architecture definition”

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Deliverable nature:	R: Report
Dissemination level: (Confidentiality)	PU: Public
Contractual delivery date:	03-2017
Actual delivery date:	03-2017
Version:	1.0
Total number of pages:	31
Keywords:	System architecture, hardware, software, accessibility, privacy and security, stakeholders

Abstract

This is the initial design of the system architecture, including the definition of the main aspects and containing all the specifications of hardware needed for the software platform and communication protocols between the different elements of the system envisioned in ARCHES “Accessible Resources for Cultural Heritage EcoSystems”.

Executive summary

This document describes the technical architecture of the ARCHES system that satisfies business requirements as documented in the Description of Action (DoA) – dated on 21st June 2016 – implements the functionality and fulfils technical, operational and transitional requirements.

The goal of this technical architecture is to define the software and hardware necessary to develop and support the system, and to ensure that the system components are compatible and comply with the enterprise-wide standards.

The main part of the document is structured as follows:

- In section 1 a brief introduction of the deliverable is shown.
- In section 2 the High Level Requirements (HLRs) of the website are described. This section is divided into two subsections: functional and non-functional requirements. The functional requirements document the operations and activities that a system must be able to perform while the non-functional requirements refer to the attributes, including performance levels, security, and the various "ilities", such as usability, accessibility, reliability and availability.
- In section 3 “System architecture”, the architecture that will be implemented to develop the ARCHES platform is described. The architecture diagram provides an overview of an entire system, identifying the main components that will be developed for the online platform and its interfaces. This section has several subsections:
    - Components: Detail of each component one by one.
    - Technology architecture: Infrastructure that supports the application and information architecture.
    - Security and privacy architecture: Key aspects related to security.
- In section 4 “Stakeholders”, these groups or individuals, who can affect or be affected by the decisions adopted and subsequent outputs, are identified.
- In section 5 a complementary list of the requirements already presented in section 2 so as to make the major concerns apparent for further analysis.
- In Section 6 some connections of ARCHES with previous EU projects are commented.
- Conclusions are drawn in section 7.

Document Information

IST Project Number	**H2020 - 693229**	**Acronym**	**ARCHES**
Full Title	Accessible Resources for Cultural Heritage EcoSystems		
Project URL	http://arches-project.eu		
Document URL			
EU Project Officer	Luis García Domínguez		

Deliverable	**Number**	D3.1	**Title**	Report on system architecture definition
Work Package	**Number**	WP3	**Title**	Development of an accessible software platform
Date of Delivery	**Contractual**	M6	**Actual**	M6
Status	Version 1.0		final ☒	
Nature	Prototype □ Report ☒ Demonstrator □ Other □ Ethics □ ORDP □			
Dissemination level	Public ☒ Confidential □			

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Version Log			
Issue Date	**Rev. No.**	**Author**	**Change**
03-03-2017	---	Ana Belén Rodríguez Arias	Template
03-03-2016	---	Ana Belén Rodríguez Arias	Table of contents
06-03-2017	0.1	Ana Belén Rodríguez Arias	Main sections
13-03-2017	0.2	Ana Belén Rodríguez Arias	Content
23-03-2017	0.3	Vladimir Kopric	Contributions from Coprix
24-03-2017	0.4	Ana Belén Rodríguez Arias	Integration
30-03-2017	0.4	Andreas Reichinger	Minor changes
30-03-2017	0.4	Christoph Bitzner	New comments and review
30-03-2017	0.5	Ana Belén Rodríguez Arias	Integration
30-03-2017	0.5	Javier Gutiérrez Meana	Review
31-03-2017	1.0	Ana Belén Rodríguez Arias	Final version
31-03-2017	1.0	Javier Gutiérrez Meana	Final version – generation of PDFs

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Abbreviations

API: Application Programming Interface

AR: Augmented Reality

ARCHES: Accessible Resources for Cultural Heritage EcoSystems

CH: Cultural Heritage

CSS: Cascading Style Sheets

DMP: Data Management Plan

DoA: Description of Action

EU: European Union

FP7: Seventh Framework Programme

GUIs: Graphical User Interface

HLD: High Level Design

HLRs: High Level Requirements

HTML: HyperText Markup Language

HTTP:Hypertext Transfer Protocol

H2020: Horizon 2020

ICT: Information and Communication Technologies

INSIDDE: INtegration of technological Solutions for Imaging, Detection, and Digitisation of hidden Elements in artworks

IN3DGuide: Integral Indoor 3D Guidance and Access-Control System

J2EE: Java Platform Enterprise Edition

JS: JavaScript

JSON: JavaScript Object Notation

MVC: Model View Controller

OAI: Open Achieves Initiative

REST: REpresentational State Transfer

SPARQL: SPARQL Protocol and RDF Query Language

THz: Terahertz

TTS: Text-To-Speech

WCAG: Web Content Accessibility Guidelines

WS: Web Service

XML: eXtensible Mark-up Language

WP: Work Package

W3C: World Wide Web Consortium

1 Introduction

The objective of this document is to design an initial approach of an open architecture for ARCHES, using standardised methods and tools and so providing a clear picture of what the ARCHES system is doing, which are the components that form it and what are the relationships among them.

1.1 Methodology

Partners specialised in Information and Communications Technology (ICT) will actively support the creation of more inclusive environments. They are putting their experience and expertise at the disposal of the exploration groups composed of people with differences and difficulties associated with perception, memory cognition and communication to design, implement and test a wide range of applications, functionalities and tools.

The first step has been to clearly identify digital cultural assets that will be used and are of relevance to our participating cultural heritage (CH) sites; i.e. the Victoria and Albert Museum and The Wallace Collection in the UK, the Fine Arts Museum of Asturias, Thyssen Museum and Lázaro Galdiano Museum in Spain and the Kunst-Historisches Museum Wien in Austria. The intention is to bring together multiple data sources in the CH field and improve the connectivity capabilities to generate accessible tools for the target audiences. These sources include, for example, digital assets available in archives, libraries or museums and will be the inputs of the three actions and the corresponding work packages (WP) as illustrated in Figure 1:

- An **accessible software platform** that will implement several options to facilitate the interpretation of digital images and models obtained from the Internet or uploaded by the visitor. In addition, newly developed tools will enable the generation of innovative educational materials.
- **Applications for handheld devices** that will allow people with differences and difficulties associated with perception, memory, cognition and communication to enjoy their visit to museums – on their own or with other people – thanks to the functionalities that take advantage of Augmented Reality (AR) and real-time processing techniques. Two alternatives will be developed: (i) a basic version ready to be used at any museum and (ii) an extended version in which extra functionalities are incorporated, resulting from close collaboration between the designers and the CH sites, sharing knowledge of the collection, the facilities and the nature of the digital assets.
- **On-site multisensory activities** that will be organised in collaboration with the participating CH institutions, exploring and encouraging novel ways of understanding artefacts – not yet possible with desktop and handheld devices – through the capitalisation of the state of the art technologies.

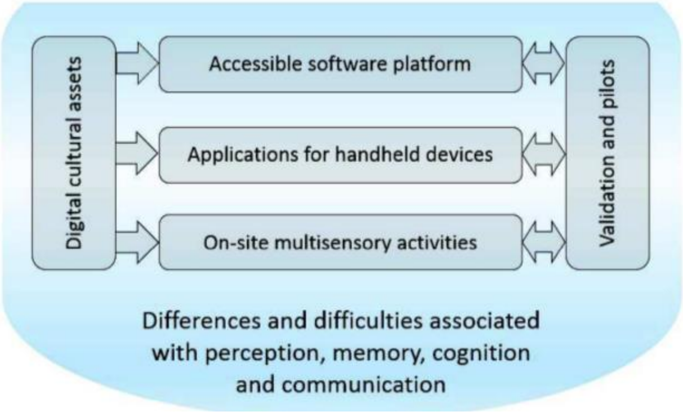
Digital cultural assets
Accessible software platform
Applications for handheld devices
On-site multisensory activities
Validation and pilots
Differences and difficulties associated with perception, memory, cognition and communication

Figure 1: Scheme of the overall approach.

An intense test battery is planned to ensure that all the applications and prototypes work properly and have achieved the desired performance. Most importantly, the appropriateness of any solution will be assessed during the validation and pilot phases. In opposition to a sequential scheme, in which these tasks would be executed right after the completion of the technological development, we propose an iterative model in which a great deal of interaction is expected between the designers and the users. This will allow all partners to duly agree modifications, adaptations or improvements of the applications based on the feedback from the people with differences and difficulties associated with perception, memory, cognition and communication, leading to more appropriate and effective results. This concept is presented in Figure 2.

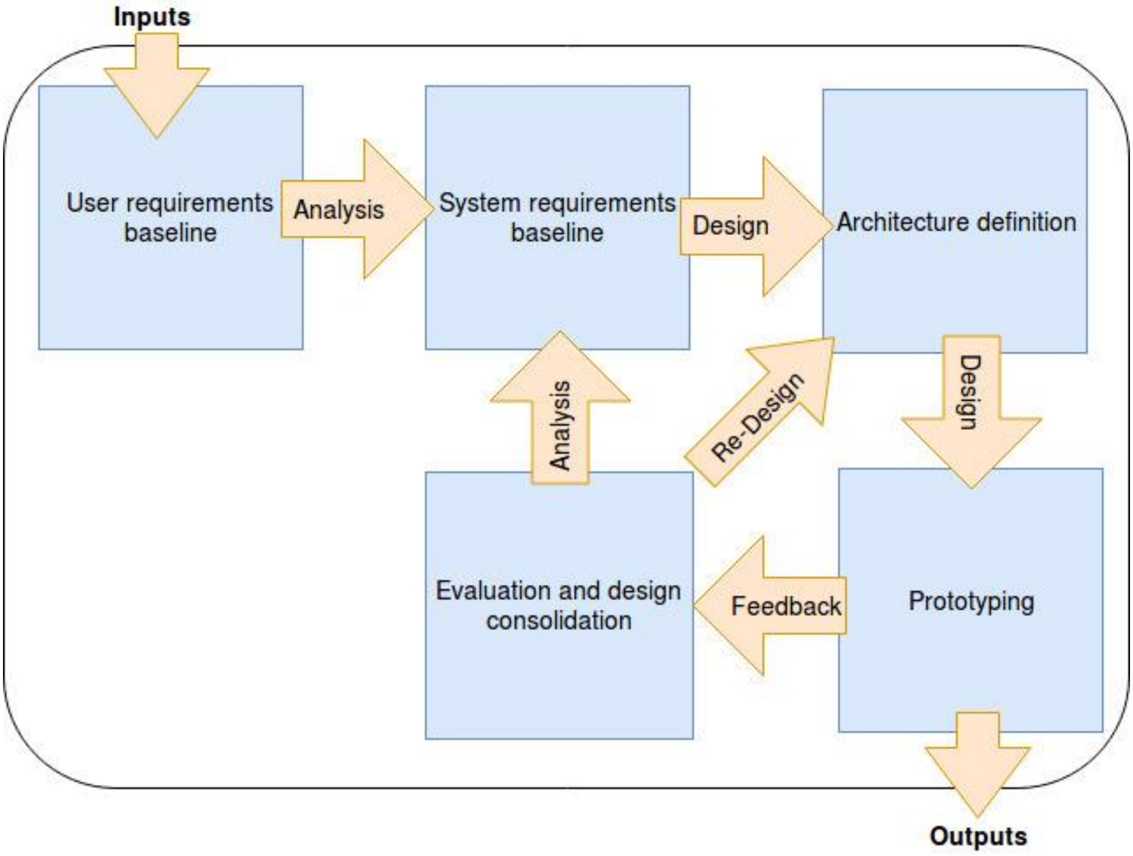

Figure 2: Architecture and design process.

2 Web System Requirements

The purpose of this section is to describe the HLRs for the web platform of ARCHES. This section provides the objectives that the system will achieve by the end of the project cycle.

2.1 Functional requirements

The functional requirements describe the core functionality of the online platform (see Table 1). The key themes identified through user requirement analysis are the following:

- Authentication and permissions
- Profile and configurations
- Works of art
- Games
- Assistive technologies

Table 1: Functional requirements.

1.0 AUTHENTICATION & PERMISSIONS	
1.1	The system shall enable the user to register a profile using a valid email address and password
1.2	The system shall enable the user to log in once successfully registered
1.3	Users shall be allowed to request a password reset (lost password)
1.4	The system shall enable authorised users to access administration areas
1.5	Only the administrator shall create a user profile
1.6	Only the administrator shall change a user's password
1.7	Only the administrator shall activate/inactivate a user account
1.8	Only the administrator shall view/export all user profiles
2.0	**PROFILE & CONFIGURATIONS**
2.1	Users shall be granted access to their respective profiles
2.2	The system shall enable registered users to change their personal details (password, name …)
2.3	The system shall enable registered users to configure the profile according with their access needs and preferences
2.4	Each user preferences shall combine different kind of access needs and assistive technologies
3.0	**WORKS OF ART**
3.1	The website shall enable users to view artworks and related information
3.2	The user shall have the ability to filter according to the features of interest
3.3	The user shall have access to a search function that enables them to search for specific works of art or a group of them using a set parameter of categories (author, period, place…)
3.3	Data shall be collected from both external resources – through Application Programming Interfaces (APIs) – and the partners of the consortium (especially museums) and stored in a repository
3.5	The system shall collect metadata from different digital resources so as to provide a connected description of the works of art
4.0	**GAMES**
4.1	The website shall enable users to play with web educational games
4.2	The games shall be designed/tested for people with differences and difficulties associated with perception, memory and communication
5.0	**ASSISTIVE TECHNOLOGIES**
5.1	The Text To Speech (TTS) functionality shall convert written text into natural sounding audio

5.2	The text to sign language functionality shall convert written text into sign language using 3D avatars
5.3	The image processing functionality shall modify images according to the user profile.
6.0	**INTEROPERABILITY**
6.1	A REpresentational State Transfer API (REST-API) following the HyperText Transfer Protocol (HTTP) shall be created so as other systems can retrieve information about CH objects stored in the ARCHES repositories

2.2 Non-Functional requirements

Within the non-functional requirements all items specifically related to the operation of the system rather than specific features are described. The following areas are covered within this section and summarised in Table 2:

- **System accessibility**: It refers to any issues on user access to the system and covers the usability of the web portal itself as well as accessibility for users with different disabilities through, for example, sign language, multi-language (English, Spanish and German), etc.
- **Security**: User requirements indicating the necessity for user privacy and security. In this context, it is important to guarantee that the system offers suitable protection to data submitted by the ARCHES users as described in the Data Management Plan (DMP) in deliverables D1.2 and D1.3.
- **User interface**: Characteristics and features based on the exploration sessions organised at the participating museums in London tackling how the system should look and be interacted with.

Table 2: Non-Functional requirements.

7.0	**SYSTEM ACCESIBILITY**
7.1	The website shall be accessible via the Internet and handheld devices (smartphones and tablets) to all the communities
7.2	The user interface of the ARCHES online platform shall be user-friendly and will be accessible to everyone
7.3	The system shall follow major accessibility guidelines and best practises for the front-end of the platform, in particular WCAG 2.0 (Web Content Access Guidelines) with level AAA of accessibility
7.4	System shall provide multiple language options
8.0	**SECURITY**
8.1	The system shall provide control about authentication and authorisation of the users to access the platform
8.2	The system shall encrypt passwords with high level security
9.0	**USER INTERFACE**
9.1	The user interface of ARCHES shall be intuitive , functional and efficient
9.2	The system’s user interface when collecting data about the user shall make clear that personal and sensitive data is not mandatory
9.3	The website shall have clear navigation options
9.4	The website shall have a clear focus of what each page is about

3 System Architecture

The following section presents the architecture of the ARCHES system to be implemented. It consists of multiple hardware and software components. The architecture of this engine is presented in Figure 3.

As shown, most of the data consumed by the mobile applications and the web platform is obtained through external APIs. Although each API has its own communication protocol, most of them are based in REST calls over HTTP and JavaScript Object Notation (JSON) format based responses. The rest of the data is stored in a multimedia repository and in a PostgreSQL database.

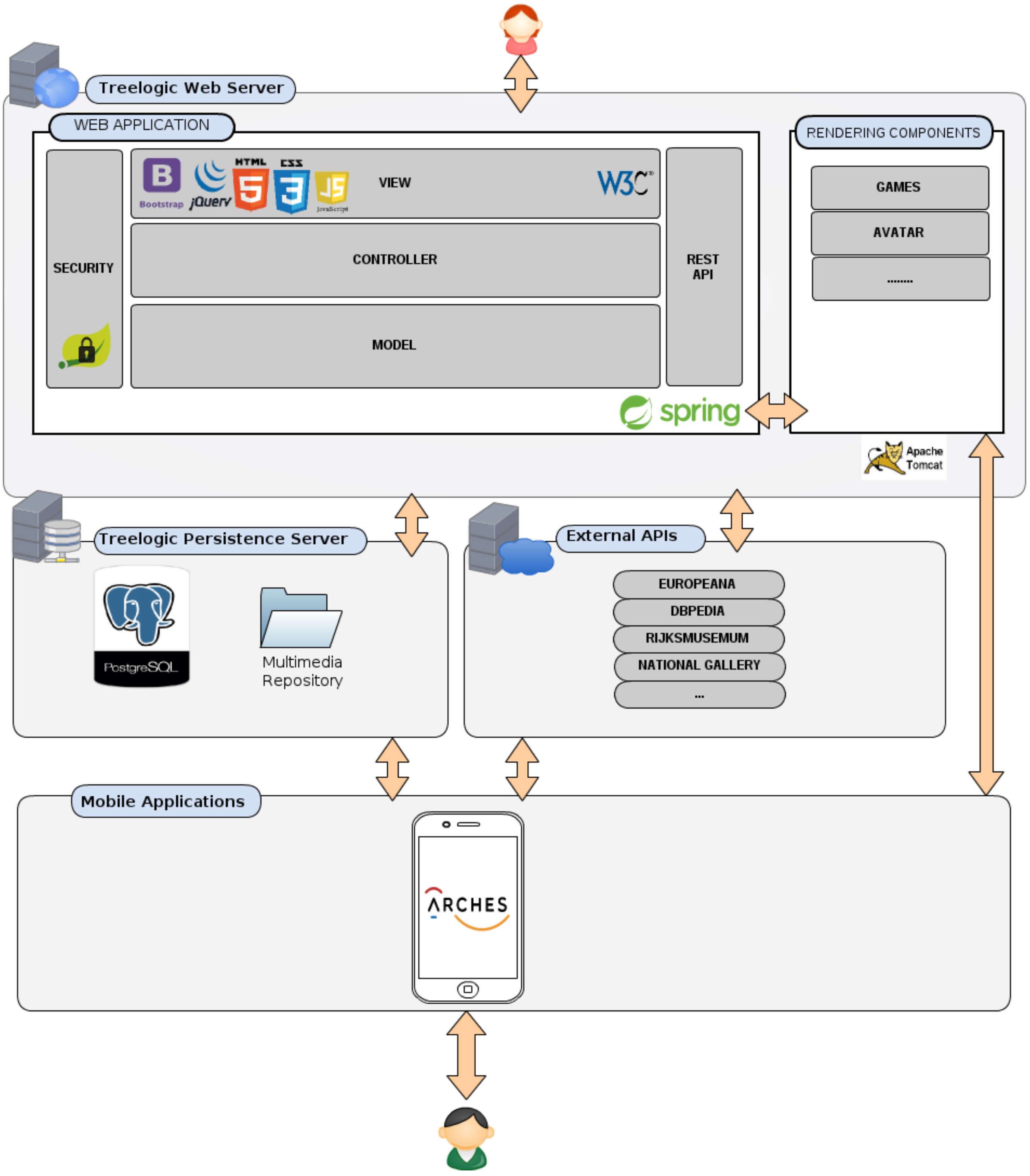

Figure 3: System architecture.

4 Components

4.1 Web application

4.1.1 Treelogic framework

The website will be developed taking advantage of Treelogic’s framework. This is based on the use of Java 2 Platform Enterprise Edition (J2EE) and the Spring Framework [13]. The overall scheme is shown in Figure 4.

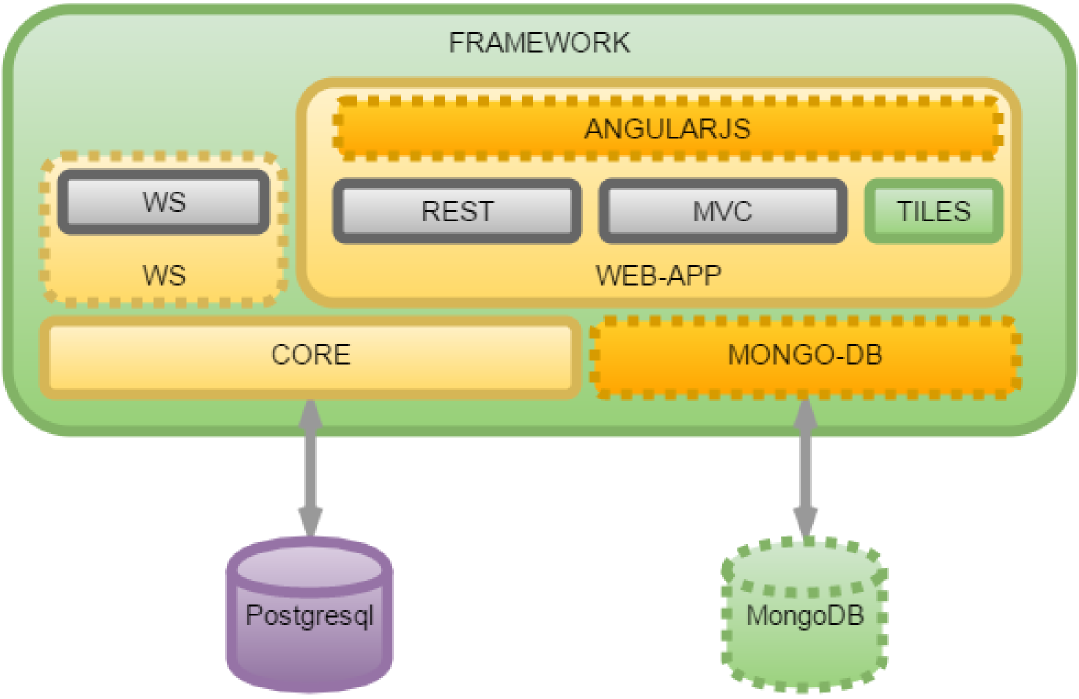

Figure 4: Treelogic’s framework.

The framework has different modules that can be combined in different ways according to the project needs. This capability allows developers to create applications with:

- A **Model View Controller pattern** (MVC): The website will be developed with this architectural pattern used primarily to create Graphic User Interfaces (GUIs). The major advantage of this pattern relies on the modularity, distinguishing among three different key aspects of the GUI – see diagram in Figure 5:
    - **Model or data of the application**: This represents the underlying, logical structure of data in a software application and the high-level class associated with it. This object model does not contain any information about the user interface.
    - **View**: A collection of classes representing the elements in the user interface (all the elements a user can see and respond to on the screen, such as buttons, display boxes, etc.).
    - **Controller**: Classes connecting the model and the view and used to communicate between classes in the model and view.
- **REST-API services**: APIs that uses HTTP requests to *GET*, *PUT*, *POST* and *DELETE* data.
- **Web services**: Collection of open protocols and standards used to exchange data between applications and/or systems.

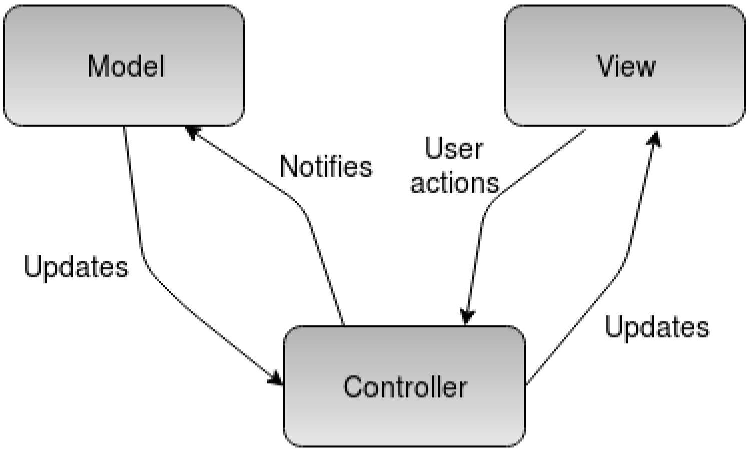

Figure 5: Model view controller pattern.

When referring to the front-end, the framework supports AngularJS (a JavaScript structural framework for dynamic web applications) and Tiles (a free open-sourced templating framework for modern Java applications).

Regarding data storage, the framework supports Mongo-DB and PostgreSQL, but new databases can be added if needed.

4.1.2 Web implementation

As previously commented, the web application will implement the MVC pattern and it will be divided into three layers:

- **View layer**: It provides the interface to the web application. The main objective is to make the web page responsive and adaptable to all devices. The view layer will be implement with different technologies: AngularJS, Bootstrap, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript (JS) and jQuery. Related to the accessibility we will follow the World Wide Web Consortium (W3C) [17] standards with level of accessibility AAA.
- **Business layer**: This is the logic of the application. It includes the image processing module and obtains data from external APIs through REST requests. It connects with the different rendering components to get games, videos, 3D data, etc.
- **Data access layer**: A simplified access to data stored in the PostgreSQL database and in the repository.

These three layers are close connected to the:

- **Security layer:** Authentication and authorisation to the Java web application with Spring security.
- **REST API**: The ARCHES REST API will allow the users to build applications that use the wealth of cultural heritage objects stored in the system repository. The API will use the standard web technology of REST calls over HTTP. The responses will be returned in JSON format.
- **PostgreSQL database** [10]: Storage of personal data from users.
- **Repository**: Storage of educational material, multimedia data (images, video or audio), etc.

4.1.3 External APIs

In order to reach the goals defined in ARCHES, it is very important to identify the digital CH assets that will be collected to be re-used by the developed tools. The objective is to combine multiple sources in this field and exploit the connectivity capabilities. These sources include, for example, digital assets available in archives, libraries or digital collections of the participating museums. While these resources will be stored in the multimedia repository and in the postgresSQL database, others will be collected by means of external APIs.

Although the identification of external APIs is still in progress and subjected to the findings of the exploration groups, at this moment the integration of different external sources is possible:

- **Europeana** [3]: A European network that builds on Europe’s rich heritage and make it easier for people to use, whether for work, for learning or just for fun. The API uses the standard web technology of REST calls over HTTP. Responses are returned in the JSON format. A personal API key is required for API requests.
- **DBpedia** [2]: A community effort to extract structured information from Wikipedia and to make this information available on the web. DBpedia allows everyone to ask sophisticated queries against Wikipedia and to link other datasets on the web to Wikipedia data. The DBpedia data set can be accessed online via a SPARQL query endpoint and as Linked Data or with a web API. Two REST APIs are offered:
    - **Keyword Search**: The Keyword Search API can be used to find related DBpedia resources for a given string. The string may consist of a single or multiple words.
    - **Prefix Search**: The Prefix Search API can be used to implement autocomplete input boxes. For a given partial keyword like ‘berl’ the API returns URIs of related DBpedia resources.

  By default all data is returned as XML. The service also returns JSON to any request including the *Accept: application/JSON* header.
- **Rijksmuseum** [11]: Access to the digital collection of the Rijksmuseum. The API uses the standard web technology of REST calls over HTTP. Responses are returned in the JSON format. Since 2011, the Rijksmuseum has also offered an API with the Open Achieves Initiative (OAI) protocol. In the cultural sector, OAI is a standard that is mainly used by organisations such as Europeana, the National Library of the Netherlands and the Netherlands Institute of Sound and Vision. A personal API key is required for API requests.
- **Finnish National Gallery** [4]: Access to the digital collection of the Finnish National Gallery. The API is based on REST requests over HTTP. The response format is Dublin Core XML, Dublin Core JSON or Dublin Core Text. A personal API key is required for API requests.

4.1.4 Mobile Applications

Other important components in the system are the applications for smartphones and tablets, especially designed for satisfying the needs and demands of people with differences and difficulties associated with perception, memory and cognition. Two types of mobile applications are envisioned:

- One that implements general-purpose to be used in any CH site.
- One designed in collaboration with the participating museums that will include more specific functionalities (guidelines, avatars, etc.).

The mobile applications will be connected with the rendering components and get data from the postgresSQL and from the multimedia repository. Android and iOS versions will be available.

In addition to the two cited mobile applications, ARCHES is working on the adaptation of an existing application for iOS devices called “Our Story” [9] and originally developed by The Open University. This is aimed to create short stories with multimedia content generated by the users. However, this application is not expected to interact with the rest of the ecosystem.

Since the design and implementation of applications for smartphones and tablets is specifically addressed in WP4 “Development of applications for handheld devices”, the following sections will simply summarise the key points with as part of the overall system architecture.

4.1.4.1 Functionalities

The exploration groups have been working at the Victoria and Albert Museum and The Wallace Collection and have already identified some functionalities:

- A functionality that enlarges text.
- A functionality that enlarges an object or aspects of an object.
- A functionality that reads text.
- A functionality that acts as a torch to make dark objects more visible.
- A functionality that ‘plays’ a short dramatization of the information about an object.
- Some kind of functionality that would be able to tell users the height and width of an object and then encourage them to inspect in more detail the bits that are easily missed, e.g. the ornate carvings on the tops and bottom of objects.
- A functionality that shows images in photonegative.
- A functionality that can read a Quick Response (QR) code and can verbally image.
- A functionality to show touch objects/brightly coloured (friendly).
- A directional functionality so as to guide the visitor inside the museum.
- A functionality that alerts about changes on the routes due to building or roadworks – important for wheel chair users too.
- A functionality to caption descriptions of tactile images available in the museums and make comments or share with other users.

4.1.5 Rendering Components

Developing for mobile devices requires tailoring certain aspects for design and creation to fit within the guidelines, advantages and limitations that are inherent to the mobile form factor. Part of the planned applications will be rendering components that allow presenting content within that form factor on mobile devices with a low amount of data need and instant availability. To achieve the best experience the rendering components will build upon existing and well tested open source components and engines.

The list of engines for mobile apps is huge and finding the perfect engine for a product will be tough. Fortunately, the needs of the components of the apps that require rendering on the device are foreseeable and are covered by all big engines. This is the reason why the two most recommended engines will be evaluated, i.e. Unity (Unity mobile) [14], and UDK (Unreal Developer Kit) and choose the most suitable ones for the use-case. With both engines, technology developers in ARCHES will be able to make the apps highly-optimised, attractive and easily deployable on all platforms. Thus, it will be possible to make the rendering components usable for iOS and Android. In addition, these engines are completely free to use for non-commercial use-cases. This makes it cost effective and in the development process, all resources can be used for the development of the application itself.

4.1.5.1 Games

Content for the educational games will be fixed by museums and as such it will produce a fixed type of game that does not need access to digital cultural assets APIs but will take advantage of the multimedia resources provided by the consortium.

According to the DoA, one game will be designed for each of the six participating museums, accounting for a total of 6 games, with references and integration of specific contents from that museum. The conditions to design these games are:

- Content must be defined and fixed as soon as possible to be able to test the games with the exploration groups. A preliminary selection will be available by June 2017.
- Each game will feature up to 10 artworks from that participating museum.
- Each game will be stored on the web platform and embedded for usage via WebGL.
- The potential use of avatars in this context will be agreed.
- Games will be produced in Unity 3D, to support multiplatform deployment.

4.1.5.2 Avatar

Animations of sign language with a 3D character (simax) will fit well as a real time rendered component for the mobile apps, thus making it one of the ideal use-cases for the rendering components described above. For the user the avatar will look like a pre-recorded video which includes one textured character with one static, basic light set up (see Figure 6). Thus, only limited geometry, surroundings or effects are needed. The full capacity of the rendering component will be used to guarantee a nice looking picture with smooth movements. By using mobile friendly frame rates, simplified shades and proper light mapping the needed computing power will also be reduced to a minimum.

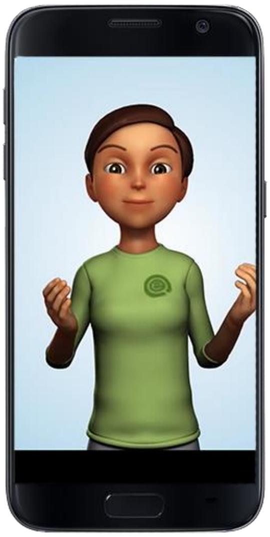

Figure 6: Avatar.

The apps will be able to interact with the avatar component in a way that it can be used to translate or explain the general content in sign language. Therefore, the avatar component will have its own sign database where the translations and sentences are pulled from (see Figure 7). The avatar component will build upon the rendering engine in order to combine the signs for single words to whole sentences.

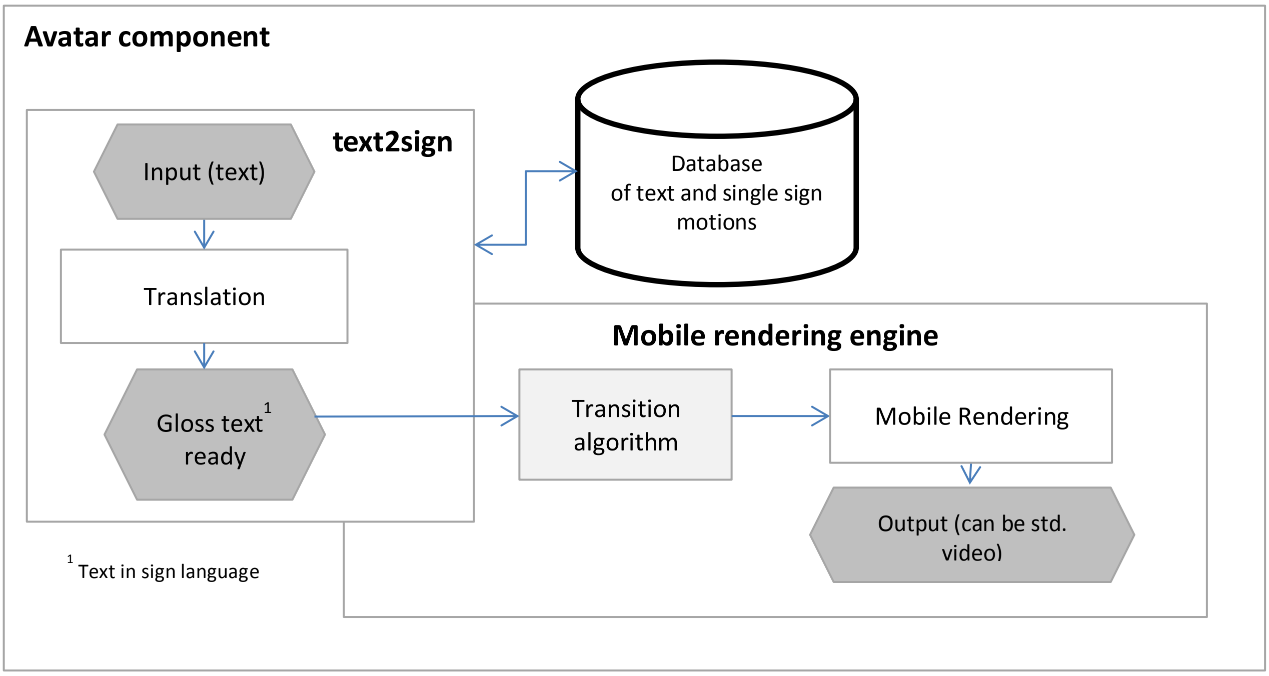

Figure 7: Avatar component.

While the architectural point of the avatar component is planned, there are still challenges to face, which can only be discovered by evaluating the progress made. For example, it is important not only to translate content word by word but also put it together into a grammatical correct, well understandable sentence. Also understandability in sign language is tightly linked with quality of the output, which has to be tested during development with the target audiences.

Since ARCHES wants to ensure the best possible outcome, the option to work with pre-defined texts (e.g. on specific topics in the museum apps) will be considered too. Text, signs and body movement of the character can be fixed before and saved as one data set into the application. Then, it would be passed to the rendering component. In addition, an implementation following an iterative process, where pre-rendered videos are developed firstly, will guarantee a satisfying look as well as a simple GUI to operate it.

4.2 Technology architecture

This section describes the infrastructure that supports de application and information architecture. According to the diagram in Figure 8, two servers are needed:

- A **web server** to host the web application and rendering components and
- a **persistence server** to store the database and the multimedia repository.

The characteristics of the former are presented in Table 3.

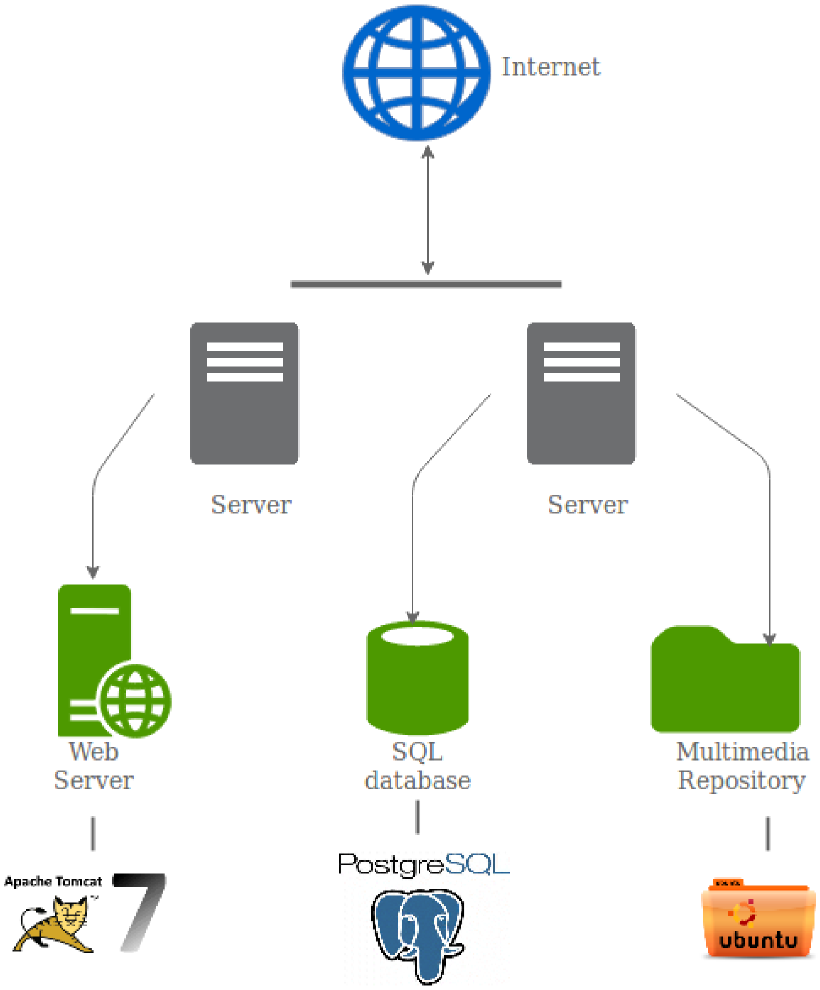

Figure 8: Technology architecture.

Table 3: Web server requirements.

Web Server Requirements	
Web Server	Apache Tomcat 7
Operating System	Ubuntu 14.05
Environment	JRE/JDK 7
Other requirements	Access to PostgreSQL

4.3 Security and privacy architecture

This section describes the aspects related to the security that will be implemented in the system.

4.3.1 Authentication and authorisation

First of all it is necessary clarify what is the difference between authentication and authorisation: Authentication is the process of identifying an individual, usually based on a username and password, while authorisation is the process of giving someone permission to do or have something. In our case there will be two roles: admin (person responsible for maintaining the website) and general user.

The system will implement both processes with Spring Security [12]. Spring Security is a framework that focuses on providing both authentication and authorisation to Java applications. The real power of Spring Security lies in how easily it can be extended to meet custom requirements. This is complemented with other relevant features:

- Comprehensive and extensible support for both authentication and authorisation
- Protection against attacks like session fixation, cross site request forgery, etc.
- Servlet API integration.
- Optional integration with Spring Web MVC.

A simplify scheme of the Spring Security flow is shown in Figure 9.

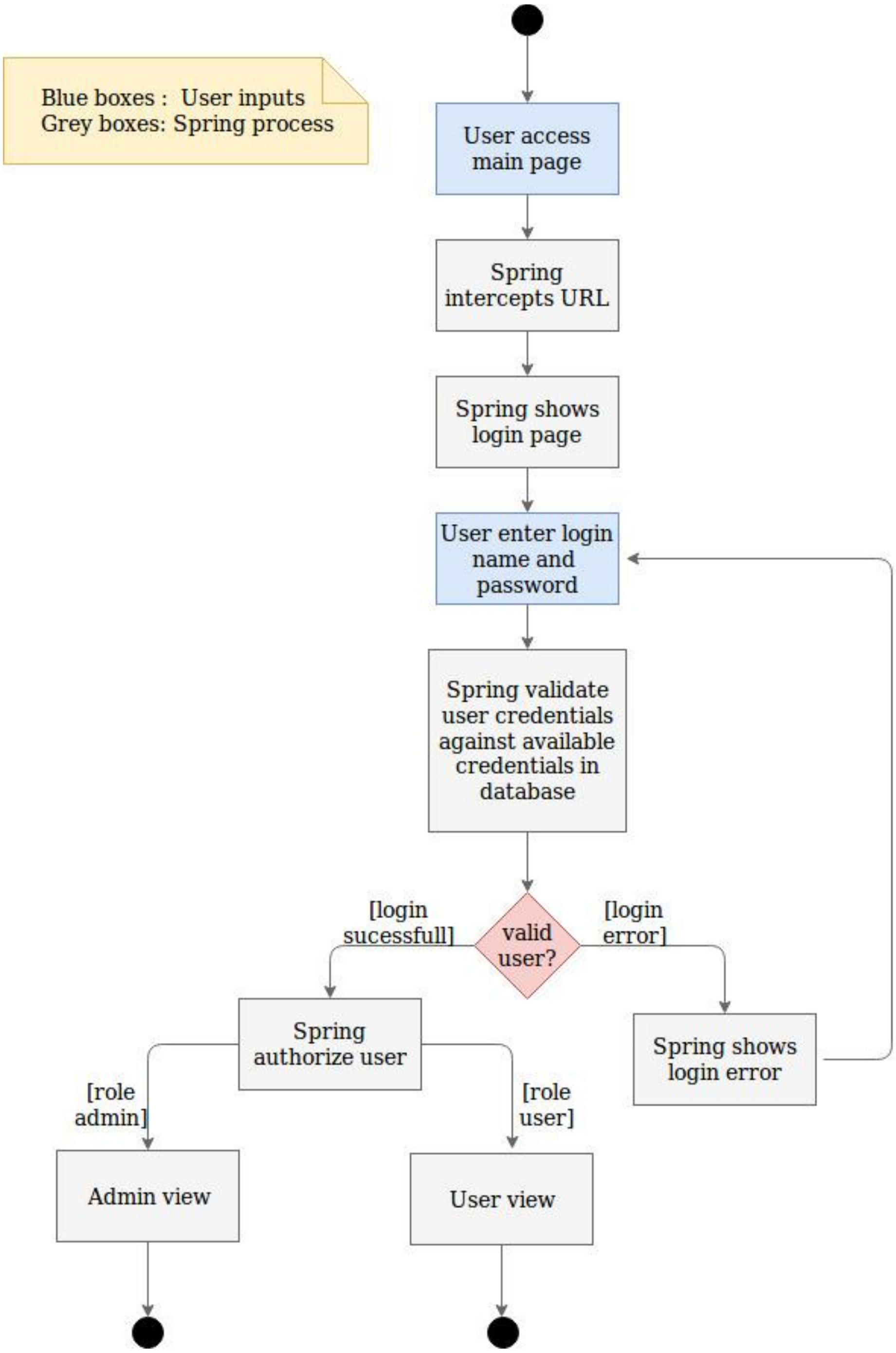

Figure 9: Spring Security flow.

4.3.2 Password encryption

In any web application with authentication the password security is a critical aspect to consider. The system must ensure that passwords are stored in a way in which malicious users would have an impractically difficult time compromising them. The following general rules should be applied to passwords stored in a database:

- Passwords shall not be stored in plain text.
- Passwords supplied by the user shall be compared to recorded passwords in the database.
- A user’s password shall not be supplied to the user upon demand (even if the user forgets it).

The system will implement one-way encoding or encryption of passwords as well as some type of randomisation of the encrypted passwords. One-way encoding provides the security and uniqueness properties that are important to properly authenticate users with the added bonus that once encrypted, the password cannot be decrypted.

If the user forgets the password the application will provide the user the ability to reset their password thought an email-based system.

4.3.3 Security logs

The system will include security logs. The security log can record security events such as valid and invalid login attempts as well as events related to resource use, such as creating, opening, or deleting files. With good security event information it is easier to

- detect attacks
- detect compromised user accounts
- detect fraud
- detect abuse of privileges and
- respond to events

5 Stakeholders

There is a large body of literature in the strategic management area which discusses organisations in terms of a stakeholder model and how they should be taken into account when designing a new system. An oft-quoted definition of stakeholder is:

“Stakeholder in an organisation is (by definition) any group or individual who can affect or is affected by the achievement of the organisation’s objectives” [5].

Following this definition several stakeholder groups can be identified in ARCHES.

5.1 ARCHES system end users

This type of stakeholders represents the audience for whom the ARCHES platform and application is intended. End users actively participate in the definition of use cases and the evaluation of the developed tools and activities. The following list summarises the key actors in this field:

- People participating in the exploration groups
- People with difficulties associated with perception, memory, cognition or communication
- Citizens in general and especially older people, scholars, etc.
- Museums

5.2 ARCHES project consortium partners

The ARCHES consortium is made of 13 institutions bound by contract that will work together to deliver the ARCHES system and successfully complete the tasks described in the DoA. They are:

- Treelogic Telemática y Lógica Racional para la Empresa Europea S.L.
- University of Bath
- The Open University
- Sign Time GmbH
- Neumüller Moritz (ArteConTacto)
- Centro de Regional de Bellas Artes de Oviedo (Fine Arts Museum of Asturias)
- Coprix Media
- VRVis Zentrum fur Virtual Reality und Visualisierung Forschungs GmbH
- KHM-Museumsverban (Kunst-Historisches Museum Wien)
- The Wallace Collection
- Fundación Colección Thyssen-Bornemisza (Thyssen Museum)
- Fundación Lázaro Galdiano (Lázaro Galdiano Museum)
- Victoria and Albert Museum

5.3 ARCHES developers

This group of stakeholders includes the academic researchers, technicians, software engineers, analysts and system administrators that are employed by their organisations in order to analyse design and implement the ARCHES system.

5.4 ARCHES system administrators

In general the system administrators are responsible for running and maintaining the network itself and communication among computers and peripherals, in particular handheld devices. They are in charge, among other functions, of installing hardware and software, issuing login names, maintaining security, fixes bugs and crashes, and monitoring the network.

5.5 ARCHES testers

This group of stakeholders involved with or invested in the testing process, include test-takers, administrators, developers, end users...They will put stress on the issues like:

- Usability and accessibility
- User interface
- Functionality
- Security

6 Concerns

The aforementioned stakeholders hold several concerns regarding the ARCHES system. The following subsections concentrate on a complementary list of the requirements already commented in the current document, being of special interest to the project’s stakeholders

6.1 Accessibility

One of the main goals of the ARCHES project is to create an accessible software platform, but what is web accessibility and why is this important? According to the W3C [1] the term web accessibility means that people with disabilities can use the web. More specifically, web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the web, and that they can contribute to the web. Web accessibility also benefits others, including older people with changing abilities due to aging.

Millions of people have disabilities that affect their use of the web. Currently most web sites and web software have accessibility barriers that make it difficult or impossible for many people with disabilities to use the web. As more accessible web sites and software become available, people with disabilities are able to use and contribute to the web more effectively.

The web is an increasingly important resource in many aspects of life: education, employment, government, commerce, health care, recreation, and more. It is essential that the web becomes accessible in order to provide equal access and equal opportunity to people with disabilities. An accessible web can also help people with disabilities to more actively participate in society.

The web offers the possibility of unprecedented access to information and interaction for many people with disabilities. That is, the accessibility barriers to print, audio and visual media can be much more easily overcome through web technologies.

The ARCHES system will be developed according to the WCAG 2.0. It is a stable, reference-able technical standard. It has 12 guidelines that are organised under 4 principles: perceivable, operable, understandable, and robust. For each guideline, there are testable success criteria, which are at three levels: A, AA, and AAA. The project aims to achieve AAA level.

6.2 Usability

Other important aspect for this project is the usability. Usability can be defined in many ways. We see usability broadly according to the ISO 9241 definition: “the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments” [15]. Where effectiveness, efficiency and satisfaction are defined as:

- **Effectiveness**: the accuracy and completeness with which specified users can achieve specified goals in particular environments.
- **Efficiency**: the resources expended in relation to the accuracy and completeness of goals achieved.
- **Satisfaction**: the comfort and acceptability of the work system to its users and other people affected by its use

Usability defects are often quite general. For instance, many sites lacking usability have problems with their:

- **Structure**: A logical and effective structure that supports the common tasks is needed.
- **Navigation**: A context for the user (where am I? where did I come from? where can I go to?) helps to improve the experience.
- **Consistency**: Designing templates for the layout, presentation and interaction of individual pages builds a corporate image.
- **Feedback**: Highlighting important information and providing feedback about user actions favour the involvement of the users.
- **Search-ability**: Metadata can support effective search, providing context of the site on any page and facilitating the interconnection of multiple sources.
- **Control and safety**: A balance between maximising user control while providing constraints that prevent errors and misunderstandings.

6.3 Interoperability

The ARCHES API aims to allow building applications that re-use CH assets stored in the ARCHES repository. The API will use the standard web technology of REST calls over HTTP. Responses will be returned in JSON format.

6.4 Security/privacy of information

ARCHES system store sensitive user data. For this reason, it is required increased focus in the data management workflows in respect with the users’ sensitive data. Moreover, special attention should be given to the way the users are informed about the usage of their personal data and how they interact with the system. This is addressed in the DMP and already integrated in the system architecture.

6.5 On time delivery

The ARCHES project is bound by specific deadlines and milestones for completion of tasks and the delivery of the various system components, the platform and related documents/deliverables.

Deviations from the timeline could endanger the project funding and thus its successful completion. This concerns are taken into consideration by the ARCHES developers and the participating partners in the consortium.

6.6 Exploitation and impact after the end of the project

The ARCHES consortium partners should ensure that the system developed during the project will be properly disseminated so as to achieve its adoption from end user organisations. The compilation of a proper exploitation plan during the lifetime of the project is the pre-requisite for this. This concern is held by the ARCHES consortium partners.

7 Connections with other EU projects

The previously described system architecture, especially regarding the interconnection of devices, communication protocols and functionalities, make use of the previous experience of the coordinator in the other European projects.

7.1 INSIDDE

7.1.1 The project

INSIDDE [6] is a European project under the Seventh Framework Programme (FP7) aimed at unveiling unknown features – hidden paint layers, over paintings, possibly under drawing steps, brushstroke textures, sealed contents – of both 2D and 3D artworks for enhancing the knowledge-sharing of and the access to the digitised surrogates of the original cultural resources.

The combination of terahertz technology, image processing techniques, and 3D high-resolution scanning was the basis for the development of an innovative AR application for smartphones to be used at museums and the integration of the digital models into Europeana.

The scientific and technical objectives focused on the:

- Development of a cost-effective high-performance terahertz (THz) system for the specialised digitisation of 2D and 3D artworks.
- Implementation of new techniques to process and analyse THz images from paintings.
- Improvement of existing equipment and techniques for a better modelling of 3D artworks and their contents.
- Integration of digital surrogates of artworks into the online collection of Europeana and development of a smartphone application to improve visitor’s experience at museums.

7.1.2 Strategy and concepts

The strategy to achieve these goals was based on a hierarchical model consisting of three layers and four actions – each one corresponding to a specific work package:

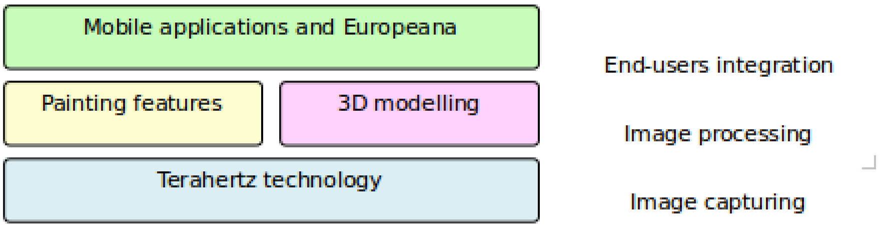

Figure 10: INSIDDE approach.

Apart from being non-harmful and non-ionising, which guarantees the perfect conservation of artworks, THz radiation – frequencies between 300 and 3 THz – can penetrate through dielectric materials up to 1 cm, so it allows recovering information about inner layers that cannot be seen by the human eye.

This initial step was followed by 2D image processing techniques, which addressed an automatic analysis of THz images – including brushstroke segmentation – in order to extract author’s features and other aspects that dwell inside.

Analogically, albedo reconstruction and content identification of sealed objects by means of spectroscopy tried to enhance the perception of 3D artworks through highly detailed and accurate digital surrogates.

The generated information was the input to create an innovative and attractive application for citizens when visiting the participating museums.

7.1.3 End users, scenarios and applications

Preliminary test and validation activities for the AR-based application and the integration into Europeana were carried out at the Fine Arts Museum of Asturias (Spain) and the Regional Museum of History of Stara Zagora (Bulgaria) employing real artworks so, at the end, the results may be transferred to a wider range of users of cultural resources – not only CH professionals but also citizens and visitors. The knowledge gained in this particular area of INSIDDE will be re-used to develop at least one of the functionalities envisioned in ARCHES.

7.2 IN3DGuide

7.2.1 The project

The main goal of this project [7] was to develop a product to guide people to their indoor destination using only their mobile phone and local communication networks (without necessarily using cellular operators' infrastructure). Augmented reality assisted them in identifying their destination or the object they were looking for (e.g. an artwork). The system was intended to increase macroscopic efficiency and people's mobility. The system was accessible from fixed terminals within the building (static information points with the building's 3D directory preloaded).

To achieve this, the project took advantage of all the smartphone's capabilities (camera, screen, location system, compass, Wi-Fi, Bluetooth, etc.). Images taken by the camera were used to guide the user and provide virtual information in a superposed layer of AR.

The main objective was creating a unique guiding technology by integrating 3 existing technologies by addressing 3 major challenges:

- Precise mobile device-based indoor location system development, considering non-intrusiveness to the user as well as privacy and anonymity principles.
- Use of AR for dynamic indoor guidance, taking into account the particularities in indoor scenarios, different from traditional outdoor guiding systems. Thus, 3D-based AR contributed to improving an immersive user experience.
- Integrating together with location and guidance systems a mobile based access control subsystem, enabling an integral solution ready to be deployed in several application domains.

The outcomes and capabilities will be re-used in the framework of ARCHES.

8 Conclusions

In this deliverable the system architecture – also called high level software design – of ARCHES has been described. The first step has been to analyse and identify the HLRs for the system so as to clearly define the specific objectives the system will pursue all along the lifespan of the project and achieve by September 2019. The requirements have been established taking into account three different aspects: the DoA, the experience and expertise of the consortium and initial feedback from the exploration groups that are at the heart of the proposed research methodology with end users.

Once the functional and non-functional requirements have been defined, the software architecture is designed by identifying all the components and the communication protocols between the different elements. In section 3 “System architecture”, an overview of the entire system and an explanation for each component of the architecture was provided. In addition, the infrastructure that supports de application, the information architecture was part of this section too as well as all the aspects related to the security that will be implemented in the system.

It is important to highlight that all the issues that are relevant for the implementation of the overall system and, in particular, for the online platform, have been pointed out in this document. Nevertheless, the user-centred methodology adopted by the ARCHES project, where exploration groups actively participate in all the phases of the value chain, may lead to redefine some of the points described in the above sections.

The final result of this deliverable is a first design of the system that will be built during the next months, being the main input for task T3.5 “Platform integration and testing”.

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