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MASTER THESIS

Scalable Virtual Exhibition Web Application - Redesign & Implementation

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ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ

ΣΧΟΛΗ ΘΕΤΙΚΩΝ ΕΠΙΣΤΗΜΩΝ
ΤΜΗΜΑ ΠΛΗΡΟΦΟΡΙΚΗΣ ΚΑΙ ΤΗΛΕΠΙΚΟΙΝΩΝΙΩΝ

ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ
"ΤΕΧΝΟΛΟΓΙΑ ΣΥΣΤΗΜΑΤΩΝ ΥΠΟΛΟΓΙΣΤΩΝ"

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

Κλιμακώσιμη διαδικτυακή εφαρμογή εικονικής έκθεσης - Σχεδιασμός & υλοποίηση

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ABSTRACT

In the context of the EFG1914 European Project, a web application was created as a virtual exhibition which hosts stories about WWI and is based on media files produced on the same period. The web application is a server-side rendering application and is designed to serve information saved in XML format and uses XSLT rules to produce the HTML pages. The purpose of this project is to analyze the web application, identify its weaknesses and redesign it in a way that overcomes the identified weaknesses. During the analysis of the web application the major problem identified was that the Virtual Exhibition is not scalable, and a caching mechanism is mandatory in order to serve the exhibition properly to the end users. The main causes of this problem are the model used to represent the entities of the exhibition and the way the pages are rendered. In the first step of redesigning the application, it was important to create a model that fits the requirements of the exhibition and serves them in a fast, efficient and scalable way. As a second step, it was important to analyze the technologies used today, and choose those that can help to achieve the purpose of this project. Therefore, the format for the storage of exhibition entities and the technology for the web application had to change. The chosen format for saving the information is the JSON format and the web application is built on Angular, a JavaScript Framework. Angular renders the content on the client side, it is rich on user interactions and offers flexibility to users to view and download the content gradually. When the design and the implementation of the new virtual exhibition finished, comparisons between the two applications show very positive results for the new implementation. The new application is faster, even without the use of a caching mechanism, scalable as it can serve big exhibitions, lightweight, clear and responsive. In addition, the new web application can serve multiple exhibitions, that can be configured on how it will be presented.

SUBJECT AREA: Web application development

KEYWORDS: Single Page Application, Virtual Exhibition, Client-side rendering, Responsiveness, Scalability

ΠΕΡΙΛΗΨΗ

Στα πλαίσια του ευρωπαϊκού έργου EFG1914, δημιουργήθηκε μια εφαρμογή διαδικτύου, μια εικονική έκθεση η οποίο φιλοξενεί ιστορίες σχετικές με τον πρώτο παγκόσμιο πόλεμο βασισμένες σε εικόνες και βίντεο που παρήχθησαν κατά τη διάρκεια του πολέμου. Η εφαρμογή χτίζεται στη μεριά του διακομιστή (server), ο οποίος παράγει μία HTML σελίδα και τη σερβίρει. Η εφαρμογή σχεδιάστηκε να σερβίρει πληροφορία αποθηκευμένη σε XML μορφή, και χρησιμοποιεί XSLT κανόνες για να δημιουργήσει τις HTML σελίδες. Ο σκοπός αυτής της διπλωματικής είναι να αναλύσει την εφαρμογή, να αναδείξει τις αδυναμίες της και να την επανασχεδιάσει με τρόπο που να ξεπερνά τις υπάρχουσες αδυναμίες. Κατά τη διάρκεια της ανάλυσης της εφαρμογής, το μεγαλύτερο πρόβλημα που εντοπίστηκε ήταν ότι η εφαρμογή δεν είναι κλιμακώσιμη και η χρήση cache είναι υποχρεωτική ώστε να εμπειρία χρήσης της εφαρμογής να είναι ικανοποιητική για τον τελικό χρήστη. Η κυριότερη αιτία αυτού του προβλήματος είναι το μοντέλο που χρησιμοποιήθηκε για την αναπαράσταση του οντοτήτων και ο τρόπος που κτίζονται οι σελίδες. Στο πρώτο βήμα της επανασχεδίασης της εφαρμογής, ήταν σημαντικό να δημιουργηθεί ένα μοντέλο που ταιριάζει στις απαιτήσεις της εφαρμογής και θα σερβίρεται με τρόπο που θα επιτρέπει στην εφαρμογή να είναι γρήγορη, αποτελεσματική και κλιμακώσιμη. Σε δεύτερο βήμα, ήταν σημαντικό να αναλυθούν οι σύγχρονες τεχνολογίες και να αποφασιστεί ποιες θα χρησιμοποιηθούν ώστε να επιτευχθεί ο σκοπός της διπλωματικής. Κατά συνέπεια, η μορφή που αποθηκεύονται τα δεδομένα και η τεχνολογία της εφαρμογής άλλαξαν. Η μορφή των δεδομένων είναι JSON και η εφαρμογή κτίζεται με Angular που έχει σαν βάση την JavaScript. Η Angular κτίζει τη σελίδα της εφαρμογής στη μεριά του χρήστη είναι πλούσια σε διαδράσεις με το χρήστη και του προσφέρει την ευελιξία να βλέπει και να κατεβάζει το περιεχόμενο της εφαρμογής σταδιακά. Όταν ο σχεδιασμός και η υλοποίηση της νέας εφαρμογής τελείωσε, η σύγκριση μεταξύ των δύο εφαρμογών έδειξε πολύ ικανοποιητικά αποτελέσματα. Η νέα εφαρμογή είναι γρηγορότερη, ακόμα και χωρίς τη χρήση cache και κλιμακώσιμη γιατί μπορεί να σερβίρει μεγάλες εκθέσεις, απλοποιημένη. Επιπλέον, είναι πιο ευέλικτη αφού έχει τη δυνατότητα να φιλοξενεί περισσότερες από μία εκθέσεις και για κάθε έκθεση μπορεί να διαμορφωθεί ο τρόπος παρουσίασης της.

ΘΕΜΑΤΙΚΗ ΠΕΡΙΟΧΗ: Υλοποίηση Εφαρμογής Διαδικτύου

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Μονοσέλιδη Εφαρμογή, Εικονική Έκθεση, εκτέλεση στο φυλλομετρητή, Ταχύτητα Ανταπόκρισης, Δυνατότητα κλιμάκωσης

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PREFACE

The Virtual exhibition project is a beloved one, not only for the people who worked to create it, but also for the users that used it or proposed to use it in the context of the EFG1914 project or under several cases and different context. Thus, it was important to continue working on it, improve it and see a lot more use cases of it. During a meeting, we were discussing a new use case, the limitations of the current implementation and what changes would improve it and then the idea of this thesis came up. The idea was happily accepted, became a real project and the work started.

1. INTRODUCTION

The EFG1914[1] European project is a digitization project for film and non-film material related to the First World War. The purpose of the project was to digitize WWI related material, to give access to the public through the European Film Gateway[2] and the Europeana[3], and create a Virtual Exhibition[4] (VE) to present stories based on the digitized media. The VE ties together the media and the metadata in a thematic approach and presents them as stories (Themes). The created application is a server-side web application, that serves media files, their metadata and story text. The VE is the occasion of this thesis, because after the initial design and the decisions taken for its implementation, the evolution of technologies related to web applications, was rapid. Furthermore, user needs have changed the last few years, tending to use mobiles more and more. The technology used is slow and not scalable, and if it doesn't follow the trend flow it will become obsolete. The basis of this thesis is to study the current trends and the decisions taken from famous and successful platforms (e.g. Facebook, Pinterest, Instagram, Google, etc.), and finally analyze the needs of the VE and redesign it.

[1] http://project.efg1914.eu/

[2] http://www.europeanfilmgateway.eu

[3] https://www.europeana.eu/portal/en

[4] http://exhibition.europeanfilmgateway.eu/efg1914/

2. THE VIRTUAL EXHIBITION

2.1 Technologies

The VE consists of two parts, the backend service that stores and handles the information and the front-end that presents them. **Table 1** lists the main technologies used in both parts.

Table 1: Technologies used for the VE

Caching server	**Varnish** https://varnish-cache.org/
Media Server	**Nginx** http://nginx.org/
Web application Server	**Jetty** http://download.eclipse.org/jetty/
Information storage Database	**Sedna DB** http://www.sedna.org/

The VE information is stored in XML format, and the XML database used for storing the information is SEDNA DB. Sedna is a database management system that stores XML objects and provides a full range of database services, such as persistent storage, ACID transactions, security and indices. SEDNA creates collections in order to organize objects with common schema, similar to tables for relational databases.

XML format is chosen because the saved information could be easily transformed to HTML pages using XSLT transformation rules. The web application is built on Java servlets and uses XSLT transformation rules.

A JAVA service exists between the database and the web application, which gets the information from the database using a JAVA driver that Sedna offers. Then the service creates JAVA Objects using JAXB library (Java Architecture for XML Binding) to feed the web application.

The web application is deployed in Jetty Web Server. Jetty is a Java HTTP Web server and Java Servlet container, developed by Eclipse.

The media files are served by NGINX. NGINX is an HTTP Web Server and reverse proxy and it is known for high performance, stability, simplicity and light weighted.

Varnish Cache is used to succeed fast page loading. Varnish is a web application accelerator and a caching HTTP reverse proxy.

2.2 System Architecture

In **Figure 1**, the architecture of the VE is presented. The Metadata store is the Sedna DB that stores the XML metadata. The Fetcher is the Java service that uses a Sedna DB driver and gets the XML from the Metadata store and gives them as JAVA Objects to the Transformer. The Transformer gets the required JAVA Objects, transforms them when necessary, and creates a new XML that serves them to the Portal. The portal gets the XML and uses XSLT rules to transform it to the HTML pages. The Portal gets the images and videos from the Media store. Finally, a cache serves the content to the users (browser).

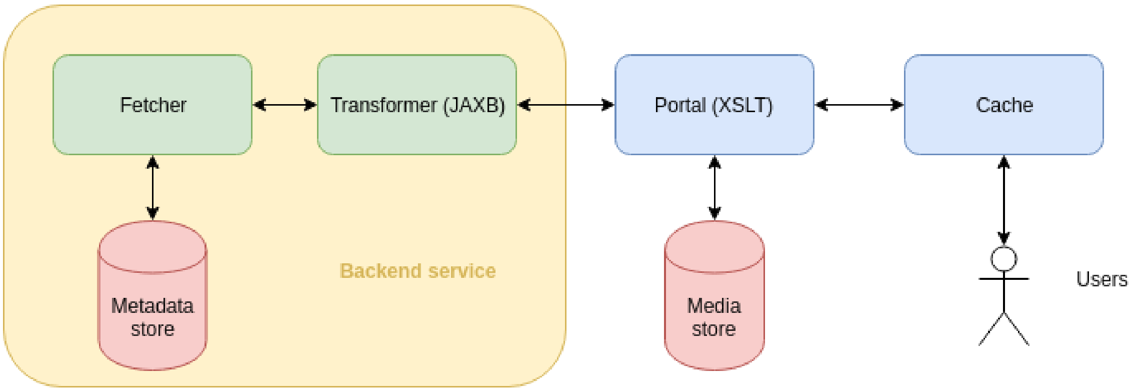


Figure 1: VE architecture

2.3 Model

The model of the VE consists of four entities, Theme, Topic, Frame and Item. An **Item** holds information about media files (ids of saved images and videos), and metadata related to the media (title, description, ratio, speed, production year, company, producer, etc.). The media files have two types, **images** and **videos**. For each media file of type image, three versions are saved, the normal size, a medium file size and a small size used as thumbnail (e.g. in chronology page). For the media of type video, apart from the video file, there is a poster image used as cover of the video, that is also saved in three sizes (the normal size, a medium file size and a small size). The poster image for the videos is not mandatory. A **Frame** groups together 1,2 or more Items by keeping a list of the Item ids, and metadata about the Frame (title, story text, template, etc.). A **Topic** is like a chapter and contains a list of Frame ids, along with the Topic's metadata (title, story text, etc.). A **Theme** is a story, it contains a list of Topic ids, along with Theme’s metadata like title and description, information about an image file that is the Theme’s image, and other metadata related to the visibility of the Theme.

$$\text{Theme} \xrightarrow{n:n} \text{Topic} \xrightarrow{n:n} \text{Frame} \xrightarrow{n:n} \text{Item}$$

Figure 2: Relation of entities

An Item, a Frame and a Topic can be reused several times in the same Theme or in other Themes. For example, an Item can exist in two different Themes. Thus, each entity keeps the id of the entities it contains, instead of the full information. In the following tables the XML representation of each entity is presented, and the list of sub-entity ids is highlighted with blue color.

Table 2: A Theme XML

```
<?XML version="1.0" encoding="UTF-8"?>
<Theme id="116b5f31-15dd-4cb5-8dc8-f86f9155854d">
  <header>
    <creationDate>06-12-2013</creationDate>
    <lastModified>2014-07-31 14:48:20</lastModified>
  </header>
  <alias>Commemorating-the-war</alias>

  <introFrameId>a2d32134-c380-4579-b9a7-050d0b33400b</introFrameId>
  <published>true</published>
  <thumbnail>34b87c3f-94c8-4aed-b180-ba89628bebda.jpeg</thumbnail>
  <title>Commemorating the war</title>
  <description>...</description>
  <shortDescription>...<shortDescription/>
  <Topics>
    <Topic>65fd014a-3057-4f6a-bdd0-5791c9eb2c0e</Topic>
    <Topic>b3b622bb-3486-4e8e-9706-ddb6a11444ce</Topic>
  </Topics>
</Theme>
```

Table 3: A Topic XML

```
<?XML version="1.0" encoding="UTF-8"?>
<Topic id="65fd014a-3057-4f6a-bdd0-5791c9eb2c0e">
  <header>
    <creationDate>06-12-2013</creationDate>
    <lastModified>2014-07-31 14:45:55</lastModified>
  </header>

  <Frames>
    <Frame>9533bea9-6c95-415a-86e9-e5699c3d552f</Frame>
    <Frame>d6dc8bfa-123a-41e6-8a3e-c8d109152042</Frame>
                          ...
    <Frame>37994195-49a6-4413-9746-2aed1e80fda0</Frame>
  </Frames>
  <description>...</description>
  <shortDescription>...</shortDescription>
  <title>The war in post-war films</title>
</Topic>
```

Table 4: A Frame XML

```
<?XML version="1.0" encoding="UTF-8"?>
<Frame id="d6dc8bfa-123a-41e6-8a3e-c8d109152042">
  <header>
    <lastModified>2014-07-31 14:44:42</lastModified>
  </header>
  <Items>
    <Item>1a704711-9bb0-446d-b7f1-2c725a4051b6</Item>
  </Items>
  <template>ft1</template>
  <title>La Belgique martyre (1919)</title>
  <description>...</description>
  <shortDescription>...</shortDescription>
</Frame>
```

Table 5: An Item XML of type video

```
<?XML version="1.0" encoding="UTF-8"?>
<Item type="video" id="1a704711-9bb0-446d-b7f1-2c725a4051b6">
  <header>
    <creationDate>10-12-2013</creationDate>
    <lastModified>2014-07-31 14:43:28</lastModified>
  </header>
  <affiliation>Deutsches Filminstitut</affiliation>
  <aspectRatio>4:3</aspectRatio>
  <category>Feature film</category>
  <creator>Charles Tutelier</creator>
 <EFGlink>...</EFGlink>
  <filetype>video/mp4</filetype>
  <length>0</length>
  <mediumImage>a52d27ce-50e9-4ead-80b1-bd92dc58c649.jpeg</mediumImage>
  <miniImage>bbbbde02-fe80-48ff-ac5f-635e0c9a761c.jpeg</miniImage>
  <originalTitle>La Belgique martyre</originalTitle>
  <productionCountry>Belgium</productionCountry>
  <productionYear>1919</productionYear>
  <provider>Cinémathèque Royale de Belgique</provider>
  <published>0</published>
  <snippet>true</snippet>
  <source>ee1d86b5-6a1a-419b-bbdc-a7fcad090d1e.mp4</source>
  <title>La Belgique martyre</title>
</Item>
```

Table 6: An Item XML of type image

```xml
<?XML version="1.0" encoding="UTF-8"?>
<Item type="image" id="528cd3ea-fe7a-4083-ab2f-51648dfe2749">
  <header>
    <creationDate>06-12-2013</creationDate>
    <lastModified>2014-07-31 14:42:54</lastModified>
  </header>
  <affiliation>Deutsches Filminstitut</affiliation>
  <aspectRatio>4:3</aspectRatio>
  <filetype>image/jpeg</filetype>
  <length>0</length>
  <mediumImage>21cc893c-857c-4580-8245-cb612e958d4c.jpeg</mediumImage>
  <miniImage>f04e4f64-948b-4203-87f5-0723264d67cb.jpeg</miniImage>
  <originalTitle>Tötet nicht mehr!</originalTitle>
  <productionCompany>Rex Film Berlin</productionCompany>
  <productionCountry>Germany</productionCountry>
  <productionYear>1919</productionYear>
  <source>f0de4d7f-6802-4594-8f3d-9be867892454.jpeg</source>
  <title>Tötet nicht mehr!</title>
</Item>
```

2.4 Rendering pages

The web application of the portal is responsible for rendering the pages of the VE on the server side, before serving the to the clients. The 3 main pages in the portal are:

- The home page
- The Theme pages
- The chronology page

2.4.1 Home page

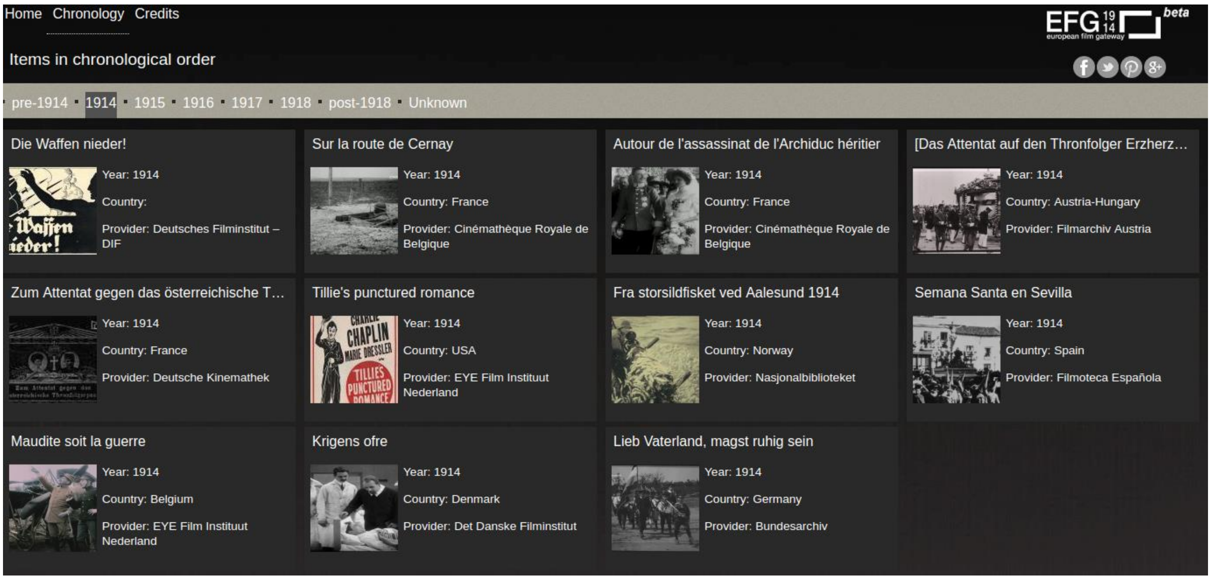
The web application asks the backend service to get a list of Themes. The web application gets an XML with the list of Themes and renders them in a HTML page using XSLT rules.

2.4.2 Theme page

When a request for a Theme page arrives, the web application asks the backend service for an XML with all the information about the Theme and the Topics, the Frames and the Items it contains. Then renders the HTML page using XSLT rules.

2.4.3 Chronology page

The web application gets a request for the chronology page and asks the backend service to get a list with **all Items**. The service sends an XML containing all the Items and transforms them in HTML using XSLT rules. Using JS, it categorizes the Items based on production year, and displays the Items for the selected period.



Items in chronological order

Die Waffen nieder!
Year: 1914
Country:
Provider: Deutsches Filminstitut – DIF

Sur la route de Cernay
Year: 1914
Country: France
Provider: Cinémathèque Royale de Belgique

Autour de l'assassinat de l'Archiduc héritier
Year: 1914
Country: France
Provider: Cinémathèque Royale de Belgique

[Das Attentat auf den Thronfolger Erzherz…
Year: 1914
Country: Austria-Hungary
Provider: Filmarchiv Austria

Zum Attentat gegen das österreichische T…
Year: 1914
Country: France
Provider: Deutsche Kinemathek

Tillie's punctured romance
Year: 1914
Country: USA
Provider: EYE Film Instituut Nederland

Fra storsildfisket ved Aalesund 1914
Year: 1914
Country: Norway
Provider: Nasjonalbiblioteket

Semana Santa en Sevilla
Year: 1914
Country: Spain
Provider: Filmoteca Española

Maudite soit la guerre
Year: 1914
Country: Belgium
Provider: EYE Film Instituut Nederland

Krigens ofre
Year: 1914
Country: Denmark
Provider: Det Danske Filminstitut

Lieb Vaterland, magst ruhig sein
Year: 1914
Country: Germany
Provider: Bundesarchiv

Image 1: Items chronology page

The thumbnail images that appear in this page, are the small-sized processed images of the initial image or poster of the video. The processed image size is crucial for this page, as all the content of the page is loaded at once, and the number of loaded images can be enormous.

2.5 Backend Service

2.5.1 Home page

The workflow in the backend service is simple as it queries only one collection (Theme) and returns all results that apply in the query with no further transformation.

2.5.2 Theme page

Each time the web application asks for a Theme, the backend service must make several requests to the database in order to create the Full Theme, that contains all the Topics, Frames and Items it consists of. The workflow is presented in the following flow chart in **Figure 3**.

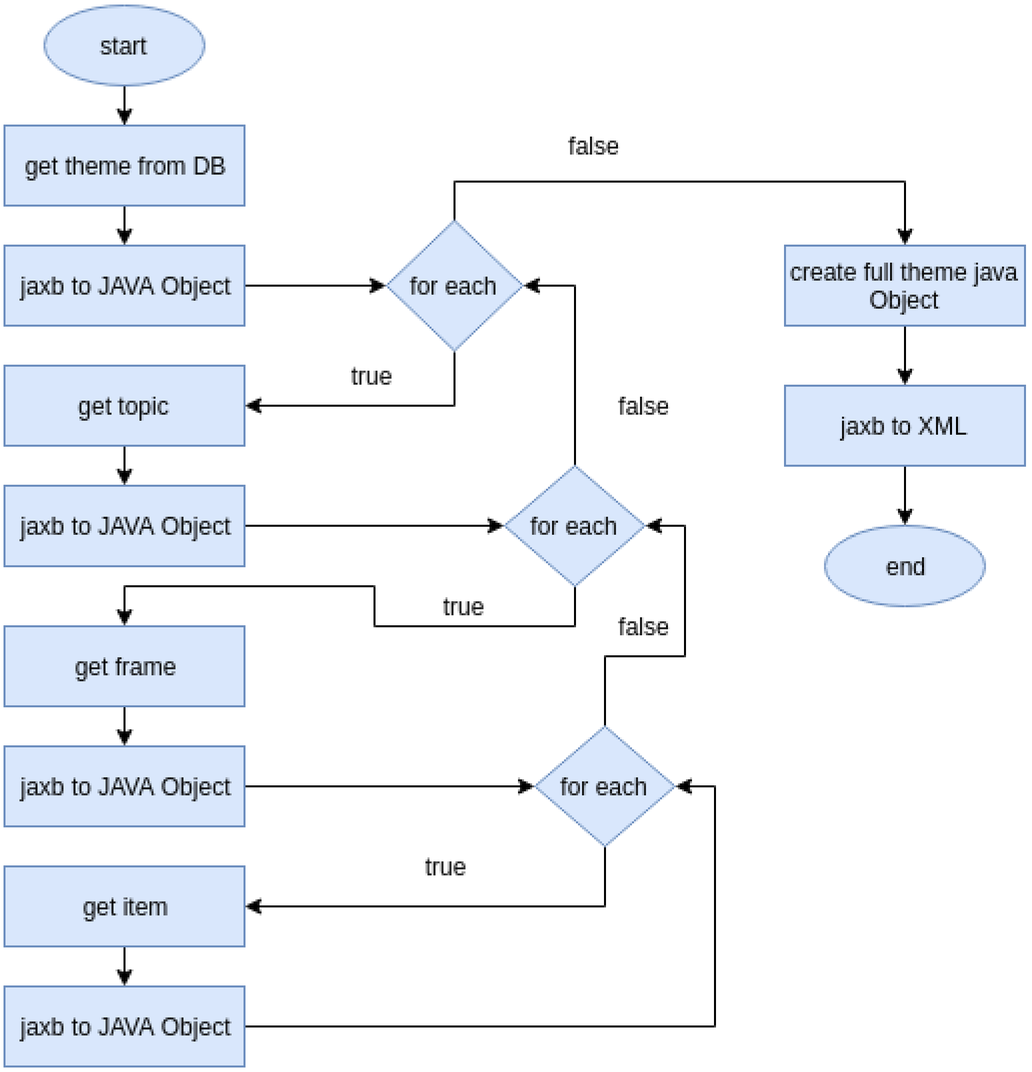


Figure 3: Full Theme transformation workflow

After each entity request from the database, the XML response has to be converted to JAVA Object, handle the JAVA Object to get the ids for the sub-entities, make a new request for each sub-entity, and finally transform the full information back in XML, that will be served as HTML after applying XSLT rules.

2.6 Design

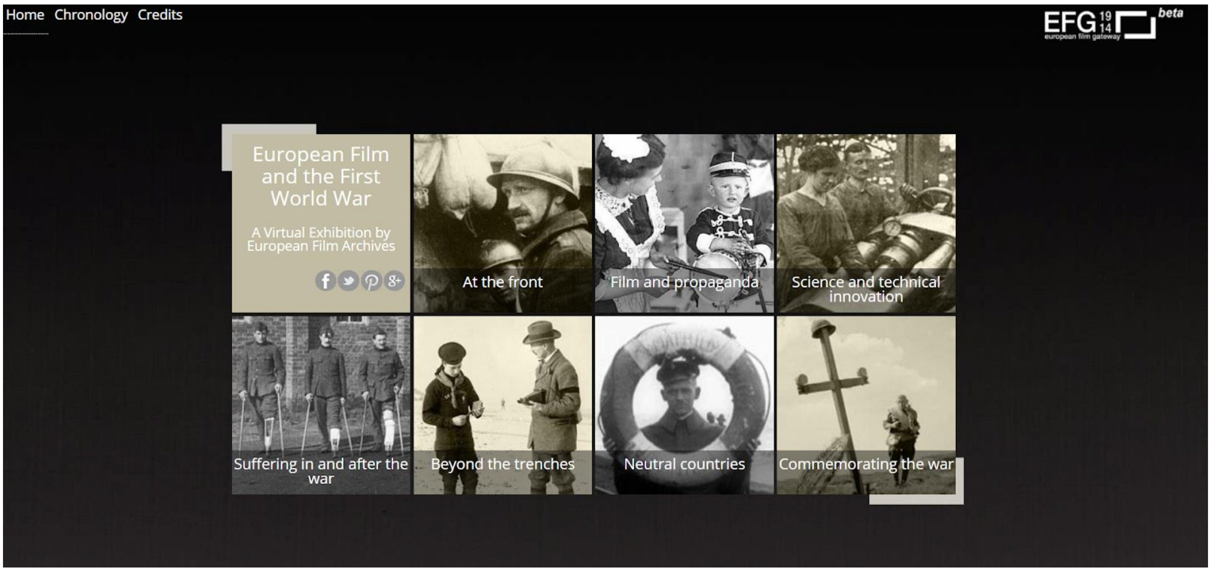
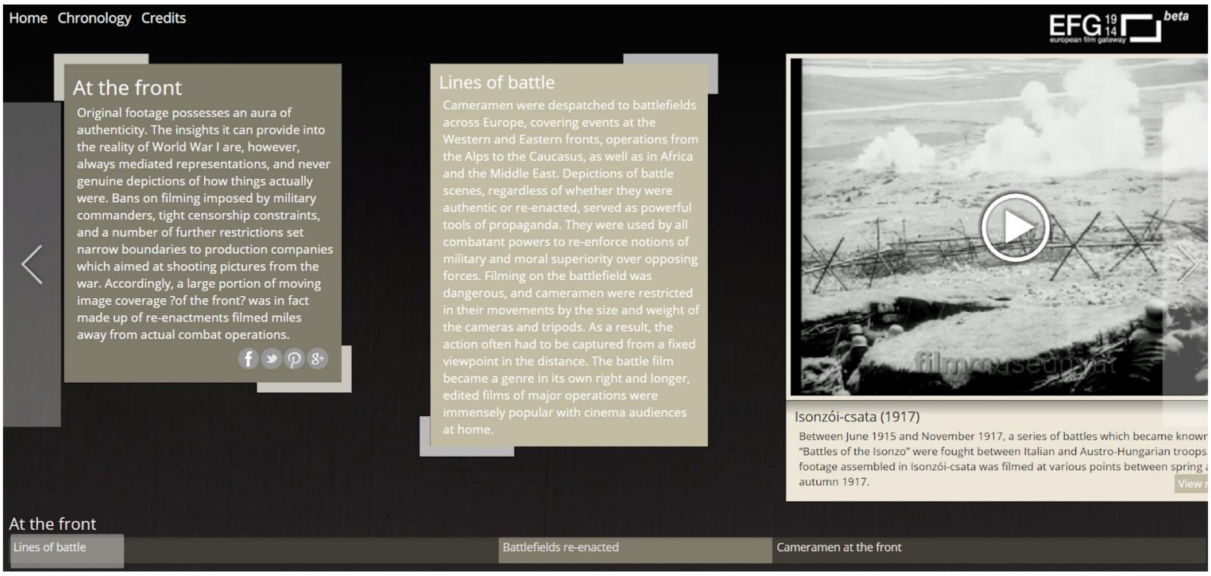

Home
Chronology
Credits
EFG 19 14 beta
european film gateway
European Film and the First World War
A Virtual Exhibition by European Film Archives
At the front
Film and propaganda
Science and technical innovation
Suffering in and after the war
Beyond the trenches
Neutral countries
Commemorating the war

Image 2: VE home page

The VE is designed to present the media in a thematic approach or a story. In the Theme presentation, users can move right or left to navigate to next or previous Frames (**Image 3**). A slider is used to help this motion throughout the Theme, as it can take the user to a specific point of the story or take him to a specific Topic. Furthermore, it works as a progress bar because it presents an indication of the length of the story and the length of each Topic and shows the current position of the user view in the story.

For example, in **Image 4** the user can see that the Theme "At the front" contains three Topics ("Lines of battle", "Battlefields re-enacted", "Cameramen at the front"), the user is the end of the first Topic and the next one is starting.



At the front

Original footage possesses an aura of authenticity. The insights it can provide into the reality of World War I are, however, always mediated representations, and never genuine depictions of how things actually were. Bans on filming imposed by military commanders, tight censorship constraints, and a number of further restrictions set narrow boundaries to production companies which aimed at shooting pictures from the war. Accordingly, a large portion of moving image coverage ?of the front? was in fact made up of re-enactments filmed miles away from actual combat operations.

Lines of battle

Cameramen were despatched to battlefields across Europe, covering events at the Western and Eastern fronts, operations from the Alps to the Caucasus, as well as in Africa and the Middle East. Depictions of battle scenes, regardless of whether they were authentic or re-enacted, served as powerful tools of propaganda. They were used by all combatant powers to re-enforce notions of military and moral superiority over opposing forces. Filming on the battlefield was dangerous, and cameramen were restricted in their movements by the size and weight of the cameras and tripods. As a result, the action often had to be captured from a fixed viewpoint in the distance. The battle film became a genre in its own right and longer, edited films of major operations were immensely popular with cinema audiences at home.

Isonzói-csata (1917)

Between June 1915 and November 1917, a series of battles which became knowr
"Battles of the Isonzo" were fought between Italian and Austro-Hungarian troops.
footage assembled in Isonzói-csata was filmed at various points between spring a
autumn 1917.

Image 3: Theme page

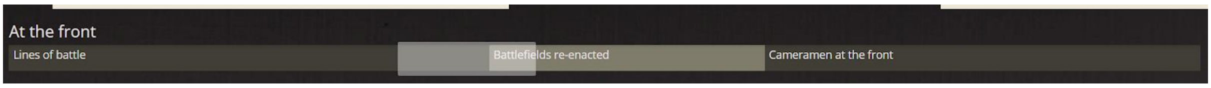


Image 4: Theme page slider

The design of the VE is cross browser compatible and it is designed to work with touch screens and tablet devices using Touch Punch library[5]. For the presentation of video, the MediaElement JS library[6] is used and it is cross browser compatible.

2.7 The Weaknesses

VE implementation has been completed and has been successfully used since the initial release in many different use cases. The decisions taken during the design and the development of the VE, seemed appropriate at that point, but as requirements changed, they lead to complicated workarounds in some cases. As new technologies evolved, simpler solutions became available. So far, the technologies, the architecture and the model used for the VE were presented, in this section, the problems of each part will be highlighted. The model that represents the metadata required for the VE, the way that the service serves the information to the portal, the way that portal renders and presents the information and the responsiveness of the design of the web application are the main weaknesses of the current version of the VE that the new implementation targets to solve.

2.7.1 The Model

Transformer changes original XMLs

The model is not effective when the VE needs to present a Theme page. As explained in **Section 2.5.2** the Transformer must make multiple requests to the service, and finally transform the responses to a **Full Theme** XML. A Full Theme (**Table 7**) contains the full information of the list of Topics, Frames and Items related to a Theme. The difference with the Theme explained in the model **Section 2.3**, is that the Full Theme contains a list of Frames, where the Theme and the Topics are represented as Frames as well, and not a simple list of ids. The tree representation of a Theme (**Figure 4**) is made flat for the Full Theme as it is shown in **Figure 5** as a list of Frames.

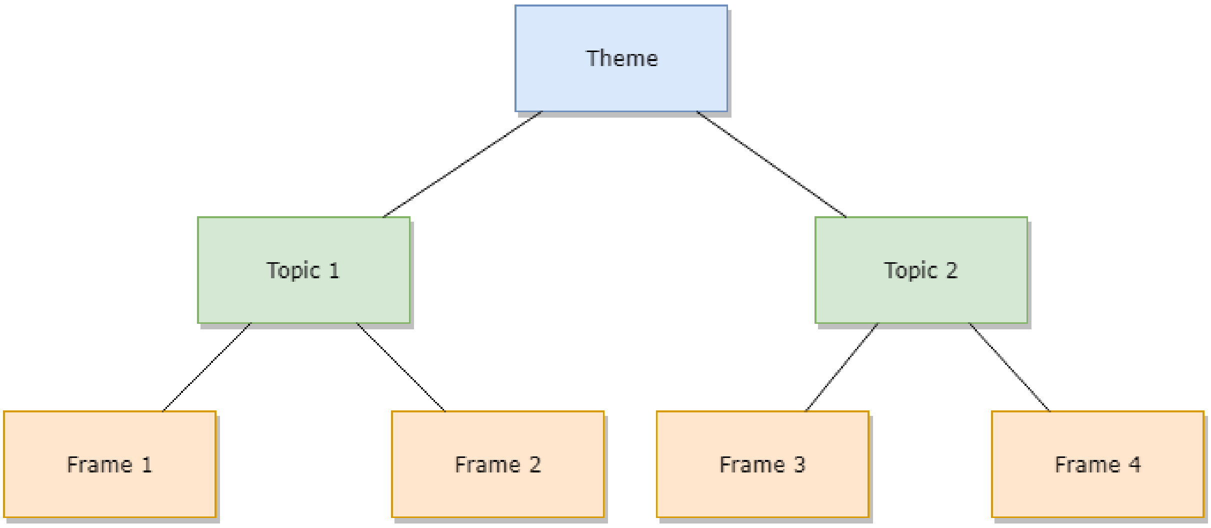


Figure 4: Model hierarchical representation

[5] http://touchpunch.furf.com/

[6] https://www.mediaelementjs.com/

Theme Intro Frame	Topic 1 Frame	Frame 2	Frame 3	Frame4	Topic 2 Frame	Frame 5	Frame 6

Figure 5: A full Theme

Table 7: A full Theme XML

```
<?XML version="1.0" encoding="UTF-8"?>
<fullTheme>
  <Frames>
<Frame type="Theme">
<published>true</published>
  <thumbnail>34b87c3f-94c8-4aed-b180-ba89628bebda.jpeg</thumbnail>
  <title>Commemorating the war</title>
  <description>...</description>
  <shortDescription>...<shortDescription/>
 </Frame>
<Frame type="Topic">
  <description>...</description>
  <shortDescription>...</shortDescription>
  <title>The war in post-war films</title>
 </Frame>
<Frame type="Frame">
  <Items>
<Item type="image" id="528cd3ea-fe7a-4083-ab2f-51648dfe2749">
  <header>
    <creationDate>06-12-2013</creationDate>
    <lastModified>2014-07-31 14:42:54</lastModified>
  </header>
  <affiliation>Deutsches Filminstitut</affiliation>
  <aspectRatio>4:3</aspectRatio>
  <filetype>image/jpeg</filetype>
  <length>0</length>
  <mediumImage>21cc893c-857c-4580-8245-cb612e958d4c.jpeg</mediumImage>
  <miniImage>f04e4f64-948b-4203-87f5-0723264d67cb.jpeg</miniImage>
  <originalTitle>Tötet nicht mehr!</originalTitle>
  <productionCompany>Rex Film Berlin</productionCompany>
  <productionCountry>Germany</productionCountry>
  <productionYear>1919</productionYear>
  <source>f0de4d7f-6802-4594-8f3d-9be867892454.jpeg</source>
  <title>Tötet nicht mehr!</title>
</Item>
  </Items>
  <template>ft1</template>
  <title>La Belgique martyre (1919)</title>
  <description>...</description>
  <shortDescription>...</shortDescription>
 </Frame>
<Frame type="Frame">... </Frame> …
<Frame type="Topic">... </Frame>
<Frame type="Frame">... </Frame>
<Frame type="Frame">... </Frame>…
</Frames>
</fullTheme>
```

Duplicate information

In order to achieve the flat representation of a Full Theme, for each Theme an intro Frame is created, duplicating the Theme basic information (title and description) in a special Frame that doesn’t contain Items. The id of the special Frame is saved inside the Theme XML, highlighted with red in Theme XML in **Table 2**.

XML format

The original idea to keep metadata in XML objects, doesn’t benefit at all, as the XML cannot be used directly by the web application and needs transformation. It could be saved in any format and finally transform it to XML for the web application.

2.7.2 Rendering results

2.7.2.1 Theme page

Large XML response

When a request for a Theme page arrives, the web application asks the backend service for a full Theme XML. The web application makes one request to the service, resulting in a large response.

No scalability

The way that a page is rendered, doesn’t offer scalability for the web application. In order to display a Theme with hundreds of Topics and thousands of Items, the full Theme created, will be huge, and there is no way to render a part of it, or render it dynamically on user demand. According to **Figure 6** the load time of the page increases as the number of Topics increases.

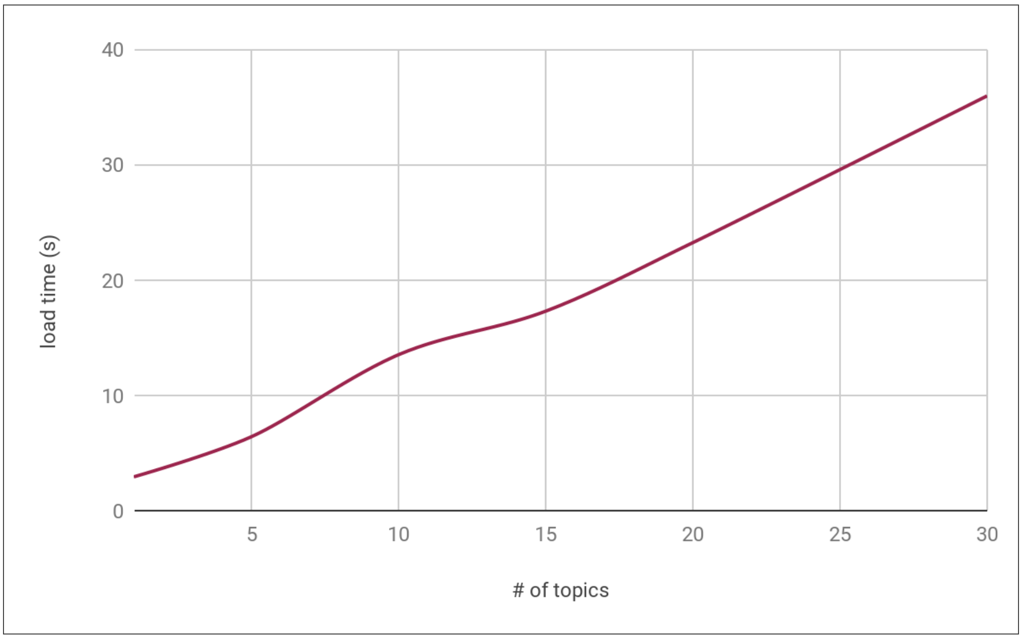


Figure 6: Load time of Theme page vs the number of Topics

Load all content at once

When a user loads a Theme page, all Theme content will be downloaded, even if the user doesn't browse to see the whole Theme. This is an important disadvantage for a user browsing on a mobile network.

Cache usage is mandatory

According to Google data, "53% of mobile site visitors leave a page that takes longer than three seconds to load" [1]. But, According to **Figure 7** the load time of a Theme page is more than three seconds, specifically it is between 4 to 12 seconds. This fact makes obligatory the use of a cache in order to accelerate the load time of a Theme page.

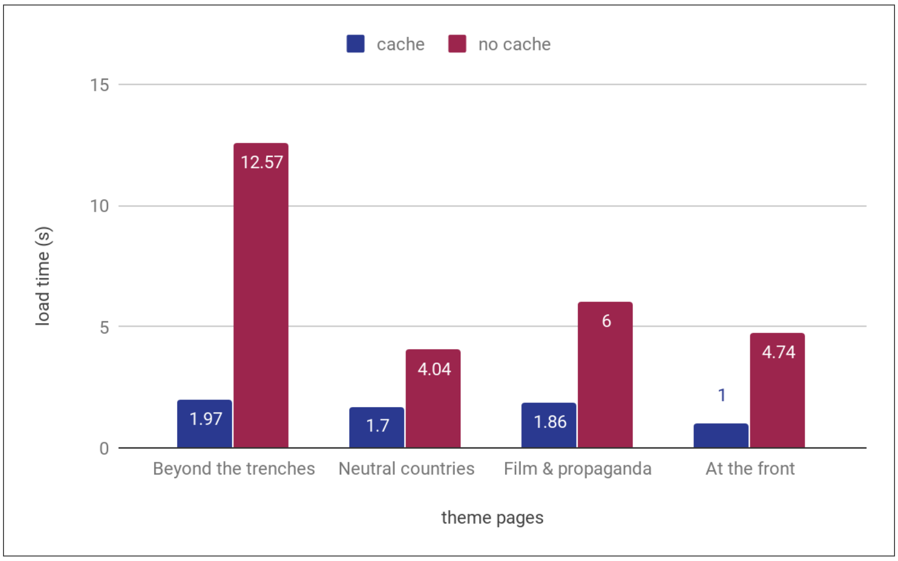


Figure 7: Load time for Theme pages

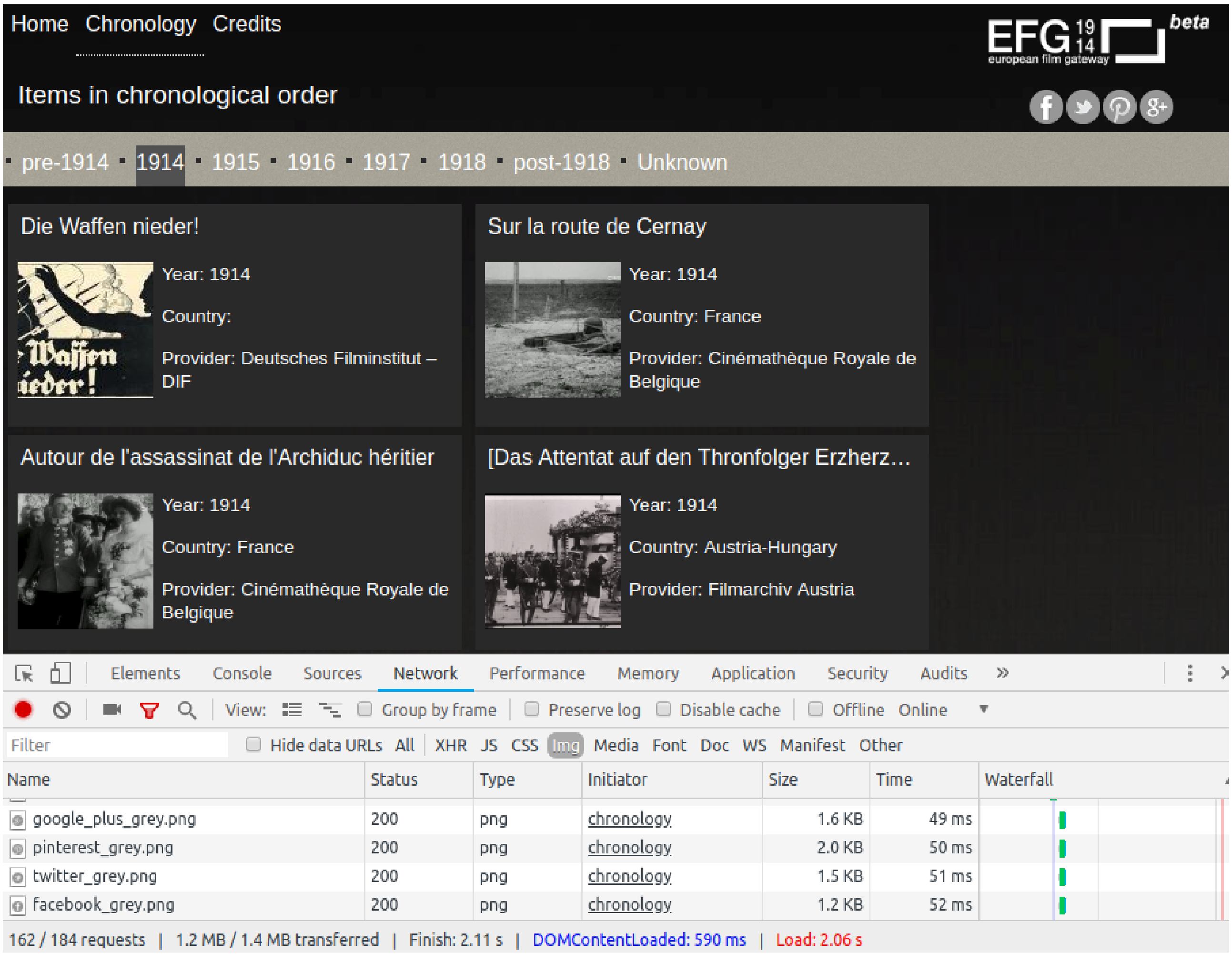
2.7.2.2 Chronology page

Large XML response

The web application gets a request for the chronology page and asks the service to get a list with all Items resulting in a large response.

Load all content at once

For this page, as displayed in the **Image 5**, the browser makes **184 requests** and loads **162 Items** in total. Without the thumbnails (smaller versions of original images), the load of a page with all this content is prohibitive high, specifically for mobile network users.



Items in chronological order

pre-1914 · 1914 · 1915 · 1916 · 1917 · 1918 · post-1918 · Unknown

Die Waffen nieder!

Year: 1914

Country:

Provider: Deutsches Filminstitut – DIF

Sur la route de Cernay

Year: 1914

Country: France

Provider: Cinémathèque Royale de Belgique

Autour de l'assassinat de l'Archiduc héritier

Year: 1914

Country: France

Provider: Cinémathèque Royale de Belgique

[Das Attentat auf den Thronfolger Erzherz…

Year: 1914

Country: Austria-Hungary

Provider: Filmarchiv Austria

Name	Status	Type	Initiator	Size	Time	Waterfall
google_plus_grey.png	200	png	chronology	1.6 KB	49 ms	
pinterest_grey.png	200	png	chronology	2.0 KB	50 ms	
twitter_grey.png	200	png	chronology	1.5 KB	51 ms	
facebook_grey.png	200	png	chronology	1.2 KB	52 ms	

162 / 184 requests | 1.2 MB / 1.4 MB transferred | Finish: 2.11 s | DOMContentLoaded: 590 ms | Load: 2.06 s

Image 5: VE requests for Chronology page

Cache usage is mandatory

According to **Figure 8**, the average load time of chronology page without caching the content is 14.25s, time that is not acceptable by users, thus cache is mandatory for this page.

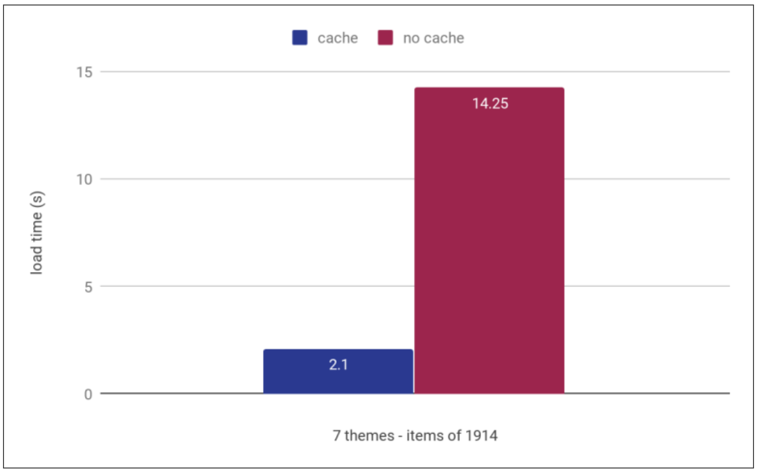


Figure 8: Load time of Chronology page

2.7.2.3 Home page

No scalability

Home page loads all available Themes at once. According to **Figure 8** and **Figure 9** the load time and the page size increases as the number of Themes increases.

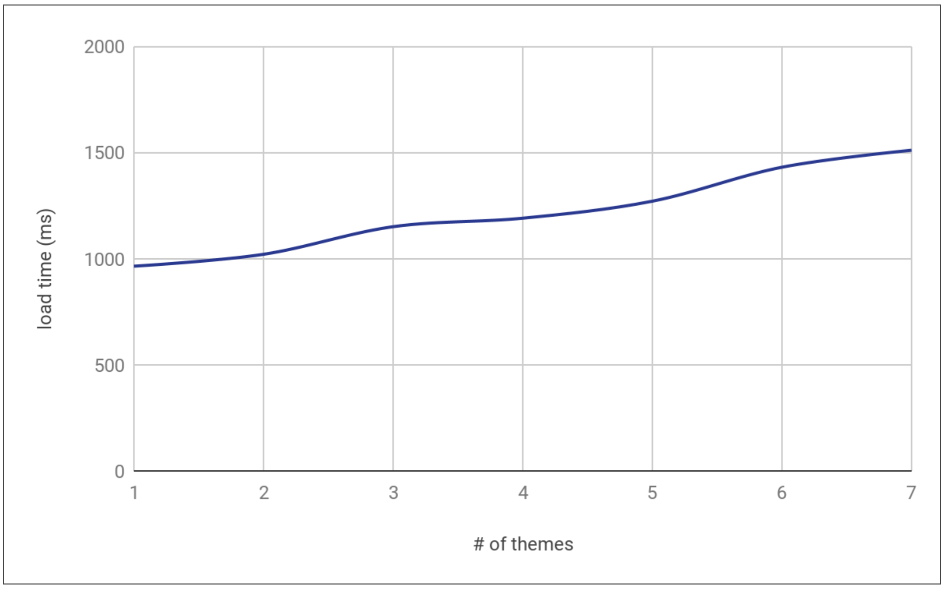


Figure 9:Home page load time vs number of Themes

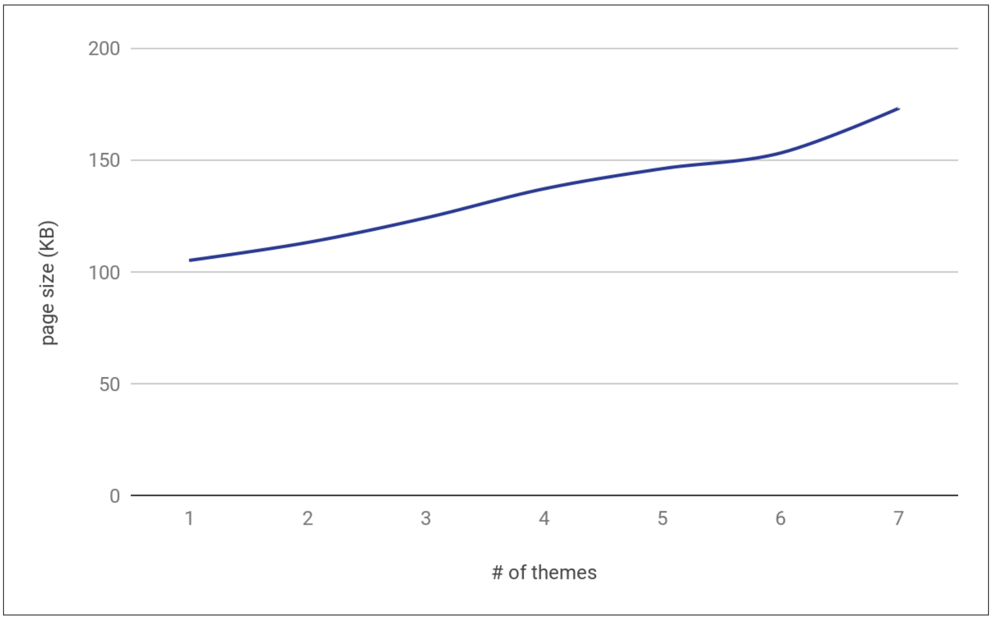


Figure 10: Homepage size vs number of Themes

2.7.3 Backend Service

2.7.3.1 Home and chronology pages

No paging of results

The service has not the notion of paging the results and serving them gradually. In both pages all content is loaded by a single request.

2.7.3.2 Theme page

Too many database request

The backend must make too many requests to the database to get the full information of a Theme.

Too many transformations (XML, JAVA Objects)

After each request in the database, the XML response must be converted to JAVA Object, handle the JAVA Object and transform it back in XML. It seems that keeping metadata in XML objects doesn’t benefit at all, as the XML cannot be used directly by the web application and needs transformation. It could be saved in any format and finally transform it to XML for the web application.

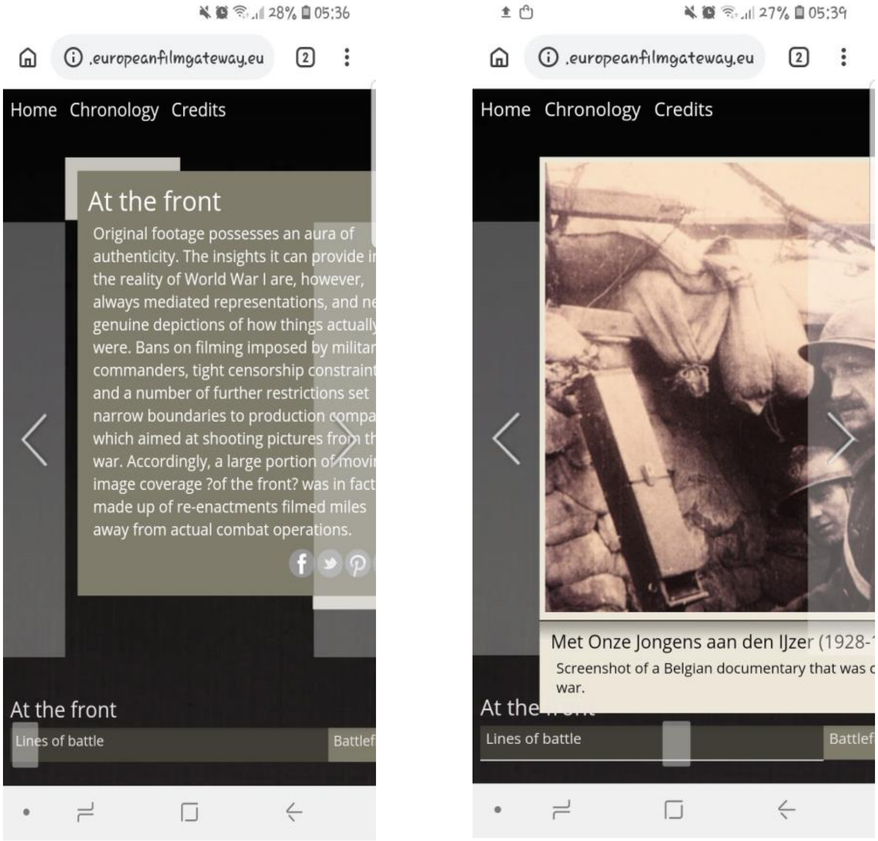
Database

In the XML Database queries are expressed using XQuery, which can make complicated the way that basic queries are expressed. The latest Sedna DB release (3.5) was announced in 2011.

2.7.4 Design

No responsive design

During the implementation of the VE, the requirements weren’t targeting the mobile phone use of the exhibition, thus the VE is not mobile friendly. In **Images 6, 7**, part of the page content is hidden or overlaps, and a user cannot read the text properly or browse through the page content.



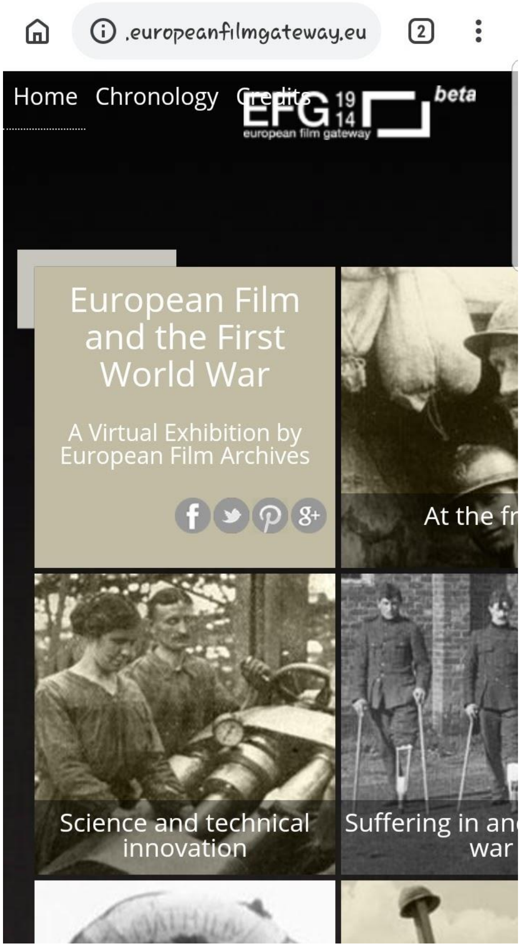
At the front

Original footage possesses an aura of authenticity. The insights it can provide i the reality of World War I are, however, always mediated representations, and n genuine depictions of how things actuall were. Bans on filming imposed by milita commanders, tight censorship constrain and a number of further restrictions set narrow boundaries to production compa which aimed at shooting pictures from th war. Accordingly, a large portion of movi image coverage ?of the front? was in fact made up of re-enactments filmed miles away from actual combat operations.

Met Onze Jongens aan den IJzer (1928-

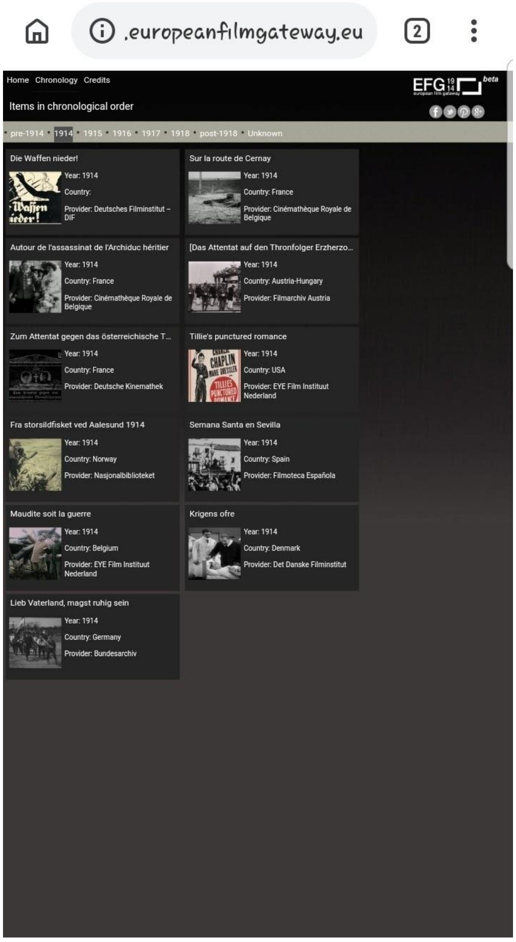
Screenshot of a Belgian documentary that was c war.

Image 6:Theme page from a mobile screen



European Film and the First World War

A Virtual Exhibition by European Film Archives


.europeanfilmgateway.eu
Home Chronology Credits
EFG 19 14 european film gateway beta
pre-1914 · 1914 · 1915 · 1916 · 1917 · 1918 · post-1918 · Unknown

Items in chronological order

Die Waffen nieder!
Year: 1914
Country:
Provider: Deutsches Filminstitut – DIF

Sur la route de Cernay
Year: 1914
Country: France
Provider: Cinémathèque Royale de Belgique

Autour de l'assassinat de l'Archiduc héritier
Year: 1914
Country: France
Provider: Cinémathèque Royale de Belgique

[Das Attentat auf den Thronfolger Erzherzo...
Year: 1914
Country: Austria-Hungary
Provider: Filmarchiv Austria

Zum Attentat gegen das österreichische T...
Year: 1914
Country: France
Provider: Deutsche Kinemathek

Tillie's punctured romance
Year: 1914
Country: USA
Provider: EYE Film Instituut Nederland

Fra storsildfisket ved Aalesund 1914
Year: 1914
Country: Norway
Provider: Nasjonalbiblioteket

Semana Santa en Sevilla
Year: 1914
Country: Spain
Provider: Filmoteca Española

Maudite soit la guerre
Year: 1914
Country: Belgium
Provider: EYE Film Instituut Nederland

Krigens ofre
Year: 1914
Country: Denmark
Provider: Det Danske Filminstitut

Lieb Vaterland, magst ruhig sein
Year: 1914
Country: Germany
Provider: Bundesarchiv

Image 7: Home and Chronology pages from a mobile screen

Touch library overhead

The slider, and the navigation in the Theme page requires a library for touch devices, that adds overhead and complexity to the page.

To summarize the weaknesses of VE presented in this section, the main problems identified are the following:

- The model: needs transformation to serve the content
- Service: no paging functionality, returns huge responses
- Database: XML format no benefit
- Rendering: Not scalable, load too much content
- Portal: Slow, cache only improves the performance, doesn’t solve the problem
- Design: No mobile friendly, touch library overhead

3. RELATED WORK

3.1 The trends

The development of web applications is constant. In this section, the current trends, that fit the VE needs and requirements and the redesigned VE should follow to avoid becoming obsolete in a short period of time, will be presented.

3.1.1 Mobile Friendly

According to a Techcrunch article [2], users spend 5 hours per day on mobile devices. As the time spent on mobile devices is increasing, users browsing in web pages through mobile devices has increased, too. 80% of internet users own a smartphone and they use it [3]. Thus, web application development not only focuses on a website to work in mobile devices, but it becomes obligatory to work best there. Users tend to browse through their mobile phone while walking or standing in the bus, hence an important point for the web application is to be easily navigated with one hand.

3.1.2 Progressive Web Applications

A progressive web application (PWA), is a web application designed like a mobile application. A PWA provides similar functionalities to a mobile application and seamless user interface. A PWA is cross browser compatible and requires less development effort. Developers don’t need to produce multiple apps across mobile platforms. Using a PWA increases the possible number of people using the app across all desired platforms. Installation is not required, an action that may discourage people from using an app, as it requires more clicks. A PWA should be reliable, fast and user engaging. It should work reliably no matter the network conditions, quickly respond to user interactions, have a feel like a natural app and deserve to be in the user's home screen [6].

On the other hand, a Native application is a software program that is developed for use on a platform or device, thus it can use device-specific hardware and software. Native apps can provide optimized performance based on the hardware and software capabilities and use technologies like GPS, gyroscope, accelerometer, etc.

3.1.3 Single Page Applications

A single page application (SPA) is a web application that re-renders its content on navigation actions (on clicking a link) without reloading the page in the browser. Popular SPAs are Facebook, Gmail, Google maps, etc. SPA loads new content through JavaScript without extra waiting time and page reloads. JavaScript Frameworks that adopt SPA principles are Angular, Ember.js, Knockout.js, Meteor.js, ExtJS, Vue.js and React. A SPA is fast as it loads all CSS, and JavaScript files once. A SPA can either keep an internal state or use external state (e.g. URL location). For internal state SPA, there is only one entry. Users always start from the main page of the application, can’t share a specific view and coming back users will start again from the main page of the application. On the other hand, in external state applications or location-based applications, users can navigate updating the location, can share a specific view, and can return to a specific view of the application, not necessarily in the main page.

3.1.4 Client-Side rendering

The conventional way to get a HTML page is using server-side rendering (SSR). Nowadays, static HTML pages are not very often, as almost every HTML page has a script attached and running on the page load, or after an event (click a button, scroll the page, etc.). There are Frameworks that serve the content using client-side rendering (CSR), where the whole page content is rendered by JavaScript. The HTML document is almost empty, including a JS file that will render the rest of the content. Frameworks like Angular, react, vue.js that use CSR are getting more and more popular. They are lightweight, offer rich interactions in a page, render content fast after the initial load and the server has less load as it gets requests only for the initial load.

3.2 Similar platforms

Webpages like Europeana, EFG, Collective Access[7], Contentdm[8] and Omeka[9] present media files similarly to the VE, but the main difference is that they present them as an archive (repository-centric approach), and they provide search, browse and paging functionalities. This repository-centric approach is beyond the concept of “Telling a story” and the thematic approach of presentation that the VE offers. Furthermore, the size of results can be predicted in a repository-centric presentation, as either the implementation constraints the number of results shown in a page or in the interface user can select the number of results shown in a page from a predefined list. In this approach, there is no scalability issue in the presentation of the results as the number is predefined.

3.2.1 Virtual Exhibition Platforms

Sway[10] and Google art & Culture[11] are two storytelling platforms, made by two established companies Microsoft and Google, respectively. Both present their stories in a thematic approach like the VE.

Sway

Sway is an online web application developed by Microsoft, used as a presentation program and is part of Microsoft Office suite of products. Sway is used to create presentations, documentation, newsletters, etc. and presents the content as a story. Sway is a SPA and is built on JS libraries like (jQuery, Hammer.js and Modernizr). Finally, Sway has a nice and intuitive interface in desktop and mobile devices. A sample presentation with title “The Universe”[12] is available online (**Image 7**).

[7] https://www.collectiveaccess.org/

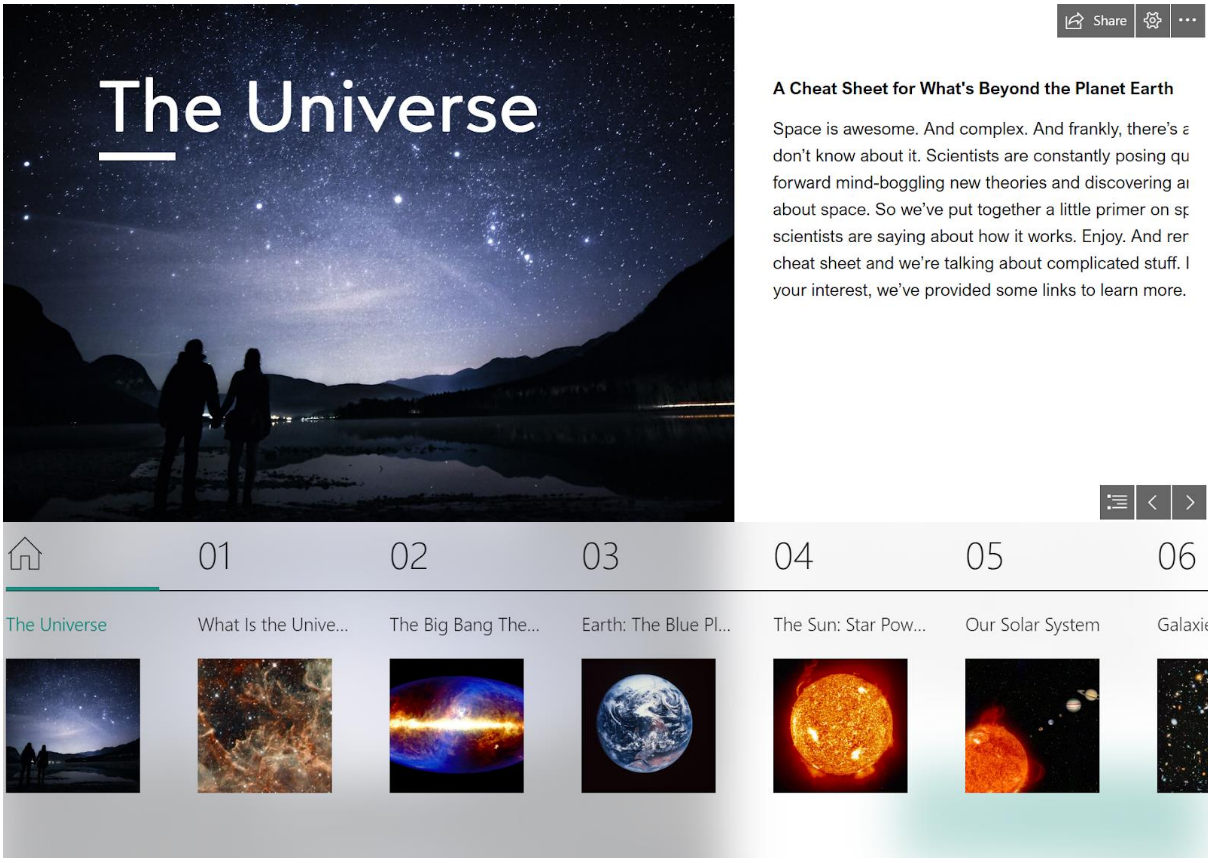
[8] https://www.oclc.org/en/contentdm.html

[9] https://omeka.org/

[10] https://sway.com/

[11] https://artsandculture.google.com/

[12] https://sway.com/universe_cheatsheet



A Cheat Sheet for What's Beyond the Planet Earth

Space is awesome. And complex. And frankly, there's a
don't know about it. Scientists are constantly posing qu
forward mind-boggling new theories and discovering a
about space. So we've put together a little primer on sp
scientists are saying about how it works. Enjoy. And rer
cheat sheet and we're talking about complicated stuff. I
your interest, we've provided some links to learn more.

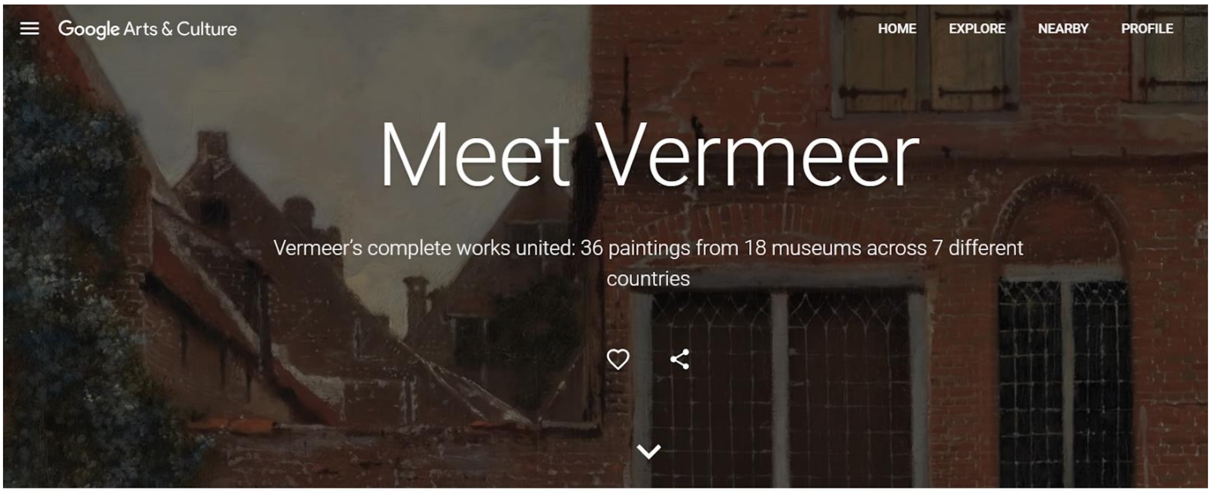
Image 8: Sway - "The universe"

Google Arts & Culture

Google Arts & Culture is an online web application that presents high-resolution images of artworks housed in several museums[13]. Information about the technologies that the application uses to present the content is not available. On the other hand, there is information about the technology used to digitize the content. They used known technologies from google maps and Picasa, and they invested in providing high resolution images. In Google Arts and Culture there are several projects that resembles thematic exhibition like a project about Johannes Vermeer called “Meet Vermeer[14]” (**Image 9**). The project gathers all content related to the work of the artist. Arts & culture web application has also a nice and intuitive interface both in desktop and mobile devices.

[13] https://artsandculture.google.com/partner

[14] https://artsandculture.google.com/project/vermeer



Google Arts & Culture
HOME
EXPLORE
NEARBY
PROFILE
Meet Vermeer
Vermeer's complete works united: 36 paintings from 18 museums across 7 different countries

Image 9: Google Arts & Culture - Vermeer Exhibition

3.2.2 Media Presentation Platforms

Plenty of known social networks like Facebook, Instagram, Pinterest, YouTube, etc. are sharing and presenting media files and they have millions of active users per day and petabytes of media files and metadata. Those platforms have proven the scalability of their systems, as a user doesn’t face significant delay while using them in analogy to the enormous number of active users and the enormous size of content downloaded or uploaded at the same moment.

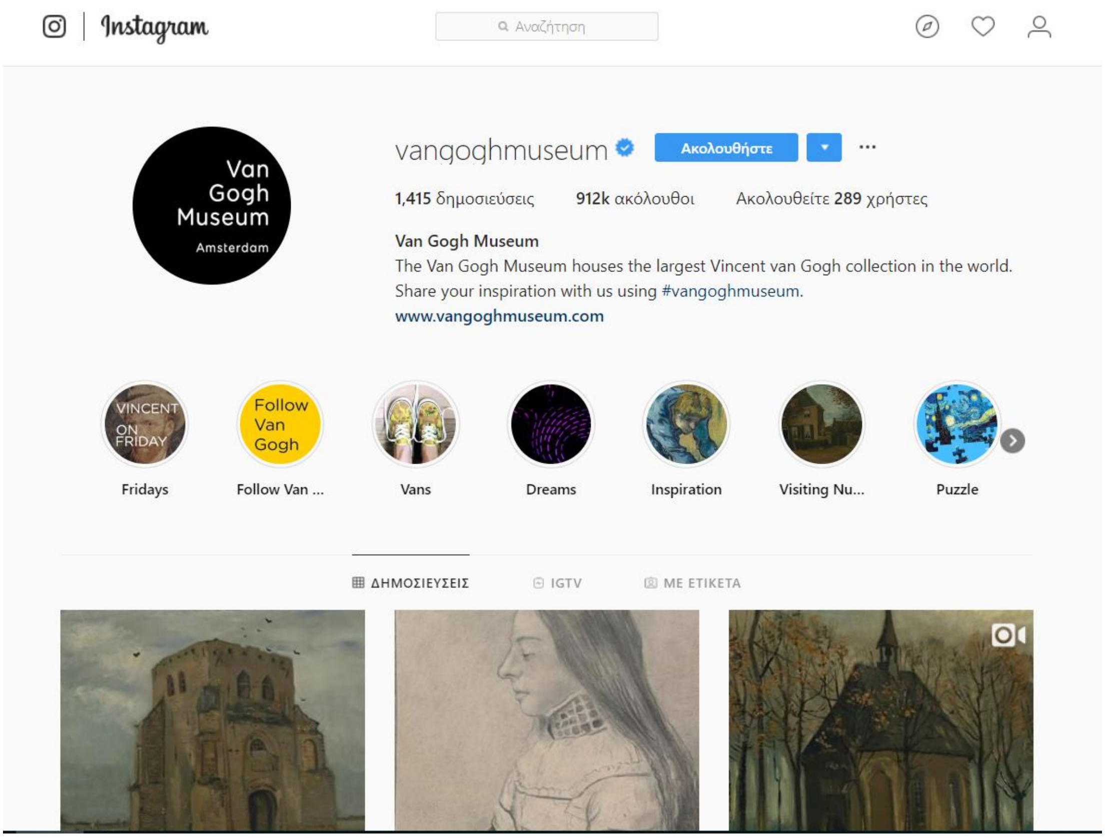
Facebook

Facebook is a social networking service which provides mobile applications on several platforms and a web application. The web application is a SPA and CSR application built using a JavaScript library (React). The web application interface is well designed both in desktop and mobile devices. There are 1.66 billion daily active users on Facebook on average for December of 2019 [10]. Facebook estimated that 2.89 billion people use Facebook, WhatsApp, Instagram, or Messenger each month and more than 2.26 billion people use at least one of the Facebook family of services every day on average [10]. Another fact for Facebook is that there are 300 million photos uploaded per day [10].

Instagram

Instagram is a photo and video-sharing social networking service owned by Facebook. Instagram provides mobile applications on several platforms, but also a web application. The web application is a SPA and CSR application built using a JavaScript library (React). The web application interface is well designed both in desktop and mobile devices.

There are over 1 billion Instagram users while 500 million users are active every day and there are 95 million photos and videos uploaded on Instagram per day [11].



1,415 δημοσιεύσεις 912k ακόλουθοι Ακολουθείτε 289 χρήστες

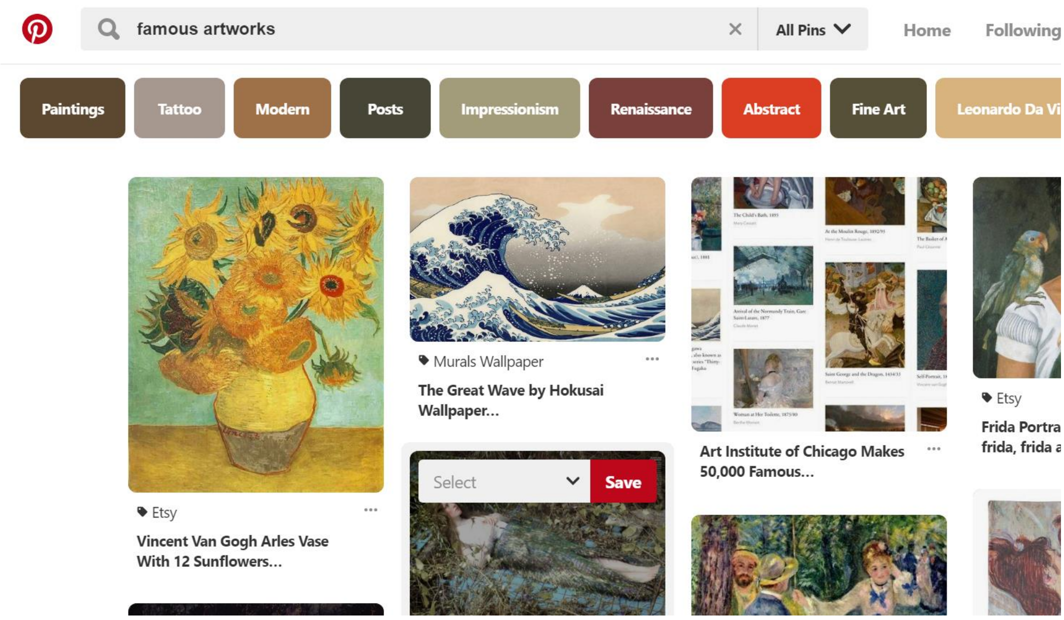
Van Gogh Museum
The Van Gogh Museum houses the largest Vincent van Gogh collection in the world.
Share your inspiration with us using #vangoghmuseum.
www.vangoghmuseum.com

Image 10: Instagram - Profile of Van Gogh Museum

Pinterest

Pinterest is a social network platform that offers mobile and web applications. The web application is a single page application, it is built on React and is client-side rendering.

When JS is disabled in the browser, the web application is not loaded, and a blank screen appears. This is common practice in client-side rendering applications and in some cases, there is a message that advises users to enable JS for the application to work, or to work properly. Pinterest serves more than 175 billion Pins to more than 250 million users [12].



famous artworks

Etsy

Vincent Van Gogh Arles Vase With 12 Sunflowers...

Murals Wallpaper

The Great Wave by Hokusai Wallpaper...

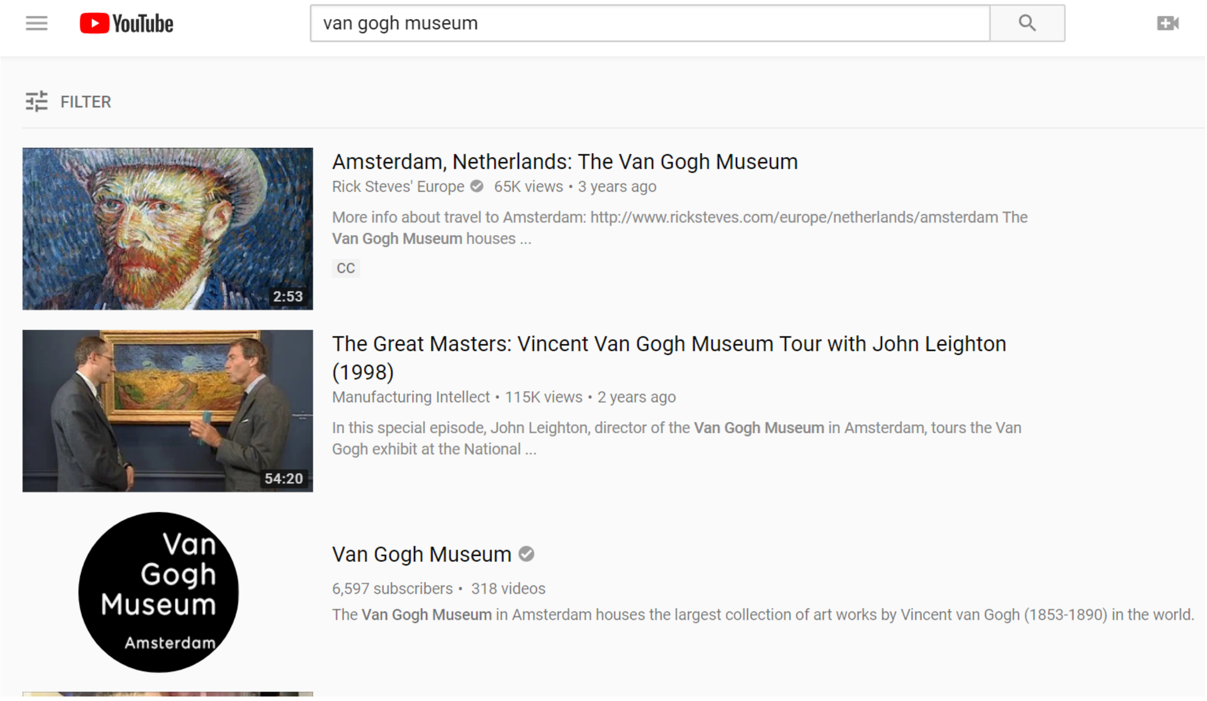
Art Institute of Chicago Makes 50,000 Famous...

Etsy

Frida Portra frida, frida a

YouTube

YouTube is a video sharing service that provides mobile and web applications. The web application is built on Web components and Polymer JS library [15]. YouTube has more than 30 million active users per day, 5 billion videos are watched per day and more than 5 billion uploaded videos in total [13].



van gogh museum

Amsterdam, Netherlands: The Van Gogh Museum

Rick Steves' Europe 65K views • 3 years ago

More info about travel to Amsterdam: http://www.ricksteves.com/europe/netherlands/amsterdam The Van Gogh Museum houses ...

The Great Masters: Vincent Van Gogh Museum Tour with John Leighton (1998)

Manufacturing Intellect • 115K views • 2 years ago

In this special episode, John Leighton, director of the Van Gogh Museum in Amsterdam, tours the Van Gogh exhibit at the National ...

Van Gogh Museum

6,597 subscribers • 318 videos

The Van Gogh Museum in Amsterdam houses the largest collection of art works by Vincent van Gogh (1853-1890) in the world.

Image 11: A view of YouTube

Most of the above platforms are built on a JS library, are a SPA and most of the content is rendered in the client. According to Instagram engineering blog [14], their core principles when choosing a system is to keep it very simple, don’t reinvent the wheel, go with proven and solid technologies when possible.

4. MY WORK: CREATING A SCALABLE WEB APPLICATION

When decided to redesign the VE, the approach was to solve current VE problems. The biggest concern was to make it **scalable**. As a first step, it was decided to create a client-side rendering web application instead of the server-side application used on the current VE implementation and serve the content gradually on user demand. This decision caused several concerns and changes in the service and the model that would be used. In this section, the system architecture, the model, the service, the way of rendering results and the design of the application of the redesigned VE will be presented.

4.1 Technologies

Angular

The Web application is built on Angular. Angular is a JS Framework based on Typescript. Angular allows to build modular user interfaces, it is based on components that make the code reusable, readable and maintainable. The decision to use Angular instead of other JS Frameworks was empowered by the fact that it is supported by Google, it is used by Instagram, and last but not least, there is previous experience using Angular in other projects. Angular builds a single page application (SPA) and keeps location-based state, as it provides a router component that enables browsing in different components as browsing in different HTML pages and understands the changes in the URL as loading a new HTML page. An Angular component is a class with properties and methods, that also supports a view and interacts with an HTML template that is viewed in the browser. The web application is client-side rendering, thus allows **user interaction** with the content of the page. A story can be loaded partially, a small part of it is initially loaded, and as the user interacts with the story, more content is loaded gradually. The user is responsible for how much of the story will be loaded. This approach will make be transparent to the user if the story consists of 10, 100 or thousands of Items and the web application is **scalable** no matter the size of a story.

JSON format

The metadata of the VE is saved in JSON format. JSON format is syntactically identical to the code for creating JavaScript objects, thus it seems the most proper format when using JS Frameworks, because there is no need for additional parsing and transformation of the object saved in the database. The JSON format is less expressive than the XML format, but for the purposes of this VE, the JSON format is enough. Furthermore, JSON format gives smaller responses for the same data.

MongoDB

MongoDB is a document Database that stores JSON-like documents called BSON and it is designed for high performance, high availability, and automatic scaling. It provides sorting and paging functionality, useful for the dynamic load of the content in combination with the client-side rendering.

RESTful API

A RESTful API is used to get documents from MongoDB and serve them in the Web Application that runs in client-side. The API is built on JAVA using Spring Boot and uses a MongoDB driver for JAVA. Spring Boot helped to create a stand-alone application and to automatically configure spring, and without the need of additional XML configuration. Furthermore, Spring Boot supports a Mongo Driver. Mondo Driver provides an interface that supports a declarative way to express database queries such as standard CRUD operations (create-read-update-delete) and user defined queries[15], by declaring a JAVA method signature (examples in **Table 8**). Mongo Driver also supports pagination and sorting of the results without extra development effort.

This API helped to get exactly what portal needed without further transformation of the results providing **better performance** for the web application.

Table 8: Example of methods signature used by the new-VE

findAll ()	Get all results from an entity
findById (String id)	Get an entity by Id
findByTypeAndPublished (String type, Boolean published)	Get all results that have this specific type and they are published or not
findByProductionYear (String year)	Get all results from an entity of this specific year
findByProductionYearGreaterThan (year)	Get all results from an entity that their year is greater than this specific year
findByProductionYearLessThan (year)	Get all results from an entity that their year is smaller than this specific year

Tomcat Server

The API is deployed in a Tomcat Server.

Apache server

The Apache Server is used to serve the web application files and the media files.

4.1.1 Caching

There are two types of caching: Server-Side Caching and Client-Side Caching. In client-side rendering, the cached files are stored in the user's device, and a user can remove or empty the cached files. On the contrary, Server-side caching is managed by server

[15] https://docs.spring.io/spring-data/jpa/docs/current/reference/html/#repository-query-keywords

and the server or the developer is responsible to make sure that the clients get an up-to-date version of the webpage.

Browser Caching

Browser caching is client-side caching. The VE takes advantage of the browser caching to store media and JS files. Each browser uses a cache where files are saved after the first load of a webpage, in order to avoid downloading them again when in the webpage reload. The benefit is less load time of the webpage. Browser caching is helpful for files that don’t change often, such as a website logo. If the content of a webpage changes often, there is a risk that the browser will load outdated content. The amount of time that a file will be cached is declared in the HTTP header of the file. The server that sends the files to the browser is responsible to send the proper expiration time, depending on the type of the file, and how often it may change.

Thus, the Apache Server, used to serve media files and the Angular application, was configured to enable browsers to cache the files for longer periods.

Table 9: Apache Configuration

Configuration for media	Configuration for Angular application files

<IfModule mod_expires.c>
  ExpiresActive On
 	
  # Images
  ExpiresByType image/jpeg "access plus 1 year"
  ExpiresByType image/gif "access plus 1 year"
  ExpiresByType image/png "access plus 1 year"
  ExpiresByType image/webp "access plus 1 year"
  ExpiresByType image/svg+XML "access plus 1 year"
  ExpiresByType image/x-icon "access plus 1 year"
 	
  # Video
  ExpiresByType video/mp4 "access plus 1 year"
  ExpiresByType video/mpeg "access plus 1 year"
</IfModule>
	<IfModule mod_expires.c>
	  ExpiresActive On
	
	  # Images
	  ExpiresByType image/jpeg "access plus 1 year"
	  ExpiresByType image/gif "access plus 1 year"
	  ExpiresByType image/png "access plus 1 year"
	  ExpiresByType image/webp "access plus 1 year"
	  ExpiresByType image/svg+XML "access plus 1 year"
	  ExpiresByType image/x-icon "access plus 1 year"
	
	  # CSS, JavaScript
	  ExpiresByType text/css "access plus 1 month"
	  ExpiresByType text/javascript "access plus 1 month"
	  ExpiresByType application/javascript "access plus 1 month"
	</IfModule>

Server Caching

The VE application is client-side rendering, thus it cannot use a server cache to store an HTML page, as the static content is minimal. Server caching can be used on the level of Restful API, that makes queries to the database and serves the responses. The API responses can be saved, in order to **eliminate the database access** and **provide quicker response**. Thus, a NGINX server is used as a proxy cache. The first time that an API request comes to the proxy cache, it forwards it to the RESTful API, then the response is cached, and the next time NGINX server provides directly the saved response.

4.2 Architecture

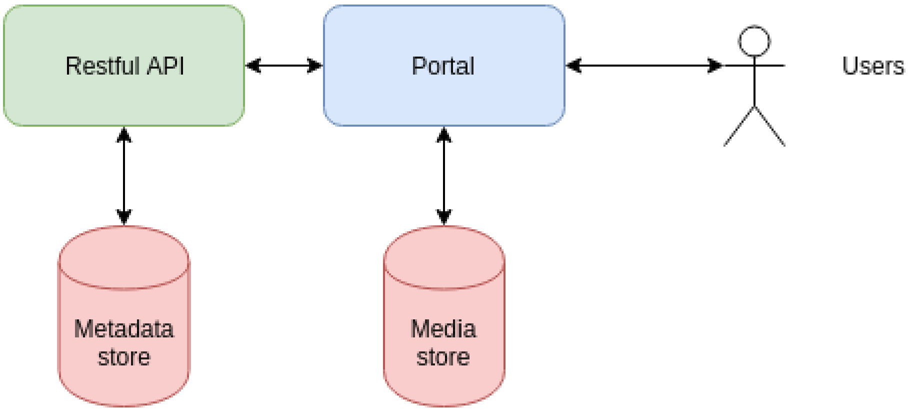


Figure 11:New VE architecture (without cache)

In **Figure 11** the architecture of the new-VE is presented. The Metadata store is now a MongoDB. The Restful API is a JAVA restful web service that communicates with mongo DB and returns responses in JSON format that serves to the portal. The portal is built on angular and is a client rendering application. The main difference from VE's architecture is that there is no transformer because no further changes on stored metadata required and there is no cache required.

As a second step, cache was added in the new implementation. The cache was added in front of the RESTful API and the configuration of the portal took advantage of the Browser Cache, as shown in **Figure 12.**

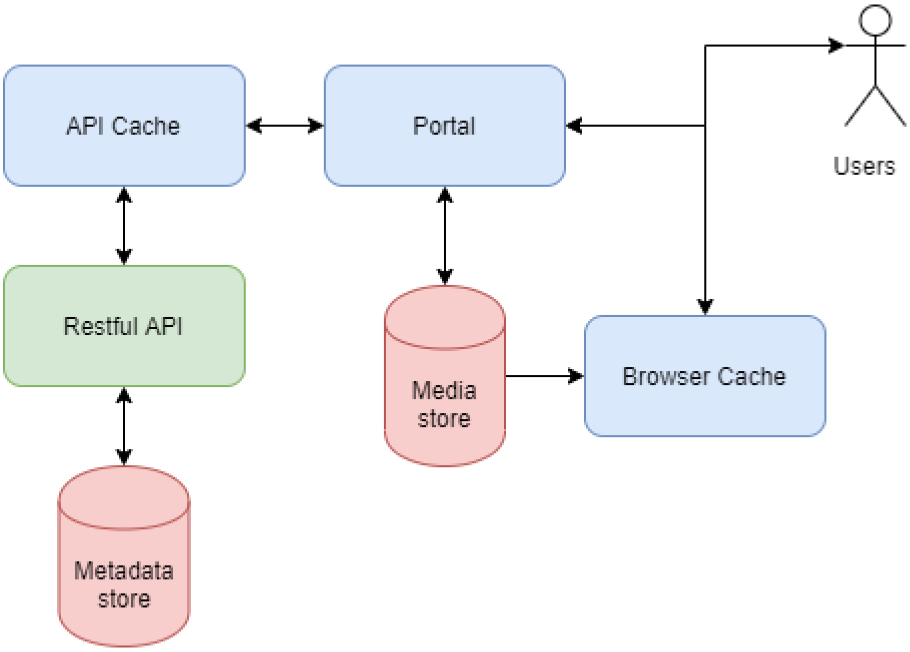


Figure 12: New VE architecture (includes cache)

4.3 Model

A major change was related to the model representation. In the new model there are three entities, **Storyline**, **Box** and **Item**.

- The entity **Item** is the same as the previous model.
- The entity **Box** is a generic one that represents the Theme, Topic and Frame entities from the old model. The entity Box has an attribute “type” and its value can be “Theme”, “Topic” or “Frame”.
- The Entity **Storyline** is a list of pairs with Box ids and their types (<Box_id, Box_type>).

Table 10: Storyline JSON

```
{
  "efgid": "116b5f31-15dd-4cb5-8dc8-f86f9155854d",
  "Boxes": [
    {
      "type": "Theme",
      "id": "5c10d0bdf908452b72618324"
    },
    {
      "type": "Topic",
      "id": "5c10d0bcf908452b72618314"
    },
    {
      "type": "Frame",
      "id": "5c10d0bcf908452b726182ee"
    },
    {
      "type": "Frame",
      "id": "5c10d0bcf908452b726182e9"
    },
    {
      "type": "Frame",
      "id": "5c10d0bcf908452b72618296"
    },
   ...
  ]
}
```

Entity **Box** contains metadata common to all entities (e.g. id, title, description) and metadata related to the specified type. More specifically:

- a Box of type “Theme” contains the common metadata and Theme specific metadata (e.g. visibility, Theme image, etc.)
- a Box of type “Topic” contains the common metadata.
- a Box of type “Frame” contains the common metadata, Frame specific metadata (e.g. template information, list of Item ids, etc.)

Table 11: A Box of type Theme

```
{
   "id":"5c10d0bdf908452b72618324",
   "efgid":"116b5f31-15dd-4cb5-8dc8-f86f9155854d",
   "title":"Commemorating the war",
   "shortDescription":null,
   "longDescription":"The foundations of the commemoration of World War One were
already laid during the war, when the combatant nations established memorial sites,
arranged exhibitions, erected museums, and performed national ceremonies on the
occasion of particular military events.... ",
   "type":"Theme",
   "imageId":"34b87c3f-94c8-4aed-b180-ba89628bebda.jpeg",
   "published":true,
   "storyLineId":"5c10d0bdf908452b7261832b",
}
```

Table 12: A Box of type Topic

```
{
  "id": "5c10d0bcf908452b72618314",
  "efgid": "65fd014a-3057-4f6a-bdd0-5791c9eb2c0e",
  "title": "The war in post-war films",
  "alias": "The-war-in-post-war-films",
  "shortDescription": "Throughout the history of mankind and as long as wars were fought,
monuments commemorat-ing those wars have existed.",
  "longDescription": "Throughout the history of mankind and as long as wars were fought,
monuments commemorat-ing those wars have existed. According to military historian and
theorist Martin Van Creveld, war monuments can be divided into three types. The first
group immortalizes, sometimes in a highly exaggerated fashion, the victory of one nation
or country. A secondary purpose of this kind of monument is to warn the defeated as well
as future enemies for the consequences of a new at-tack. A second group of monuments
commemorates those who died heroically for their country and a third group warns against
war itself. Often the second and third groups are in many ways closely related.",
  "type": "Topic"
}
```

Table 13: A Box of type Frame, containing one Item

```
{
  "id": "5c10d0bcf908452b726182ee",
  "title": "La Belgique martyre (1919)",
  "shortDescription": "“La Belguique martyre” plays on the image of the “poor little Belgian”,
which was created in Entente propaganda. In Belgium there was a lot of hostility towards
Germany, which did not cease after 1918.",
  "longDescription": "“La Belguique martyre” plays on the image of the “poor little Belgian”,
which was created in Entente propaganda…",
  "type": "Frame",
  "Items": [
"5c10d0bcf908452b726181c5"
  ],
  "template": "ft1"
}
```

Table 14: Item with media of type video

```
 {
     "id": "5c10d0bcf908452b726181c5",
     "title": "La Belgique martyre",
     "shortDescription": null,
     "longDescription": null,
     "type": "video",
     "image": null,
     "video": {
       "id": "ee1d86b5-6a1a-419b-bbdc-a7fcad090d1e.mp4",
       "mediumId": "a52d27ce-50e9-4ead-80b1-bd92dc58c649.jpeg",
       "miniId": "bbbbde02-fe80-48ff-ac5f-635e0c9a761c.jpeg",
       "type": "video/mp4"
     },
    …
   }
```

Table 15: Item with media of type image

```
{
  "id": "5c10d0bcf908452b726181e9",
  "title": "Tötet nicht mehr!",
  "shortDescription": null,
  "longDescription": null,
  "type": "image",
  "image": {
    "id": "f0de4d7f-6802-4594-8f3d-9be867892454.jpeg",
    "mediumId": "21cc893c-857c-4580-8245-cb612e958d4c.jpeg",
    "miniId": "f04e4f64-948b-4203-87f5-0723264d67cb.jpeg",
    "type": "image/jpeg"
  },
  "video": null,
  …
}
```

The reason for introducing the Box as a new entity, is to avoid every Theme, Topic and Frame to contain the list of its Topics, Frames and Items respectively, because the retrieval of a Full Theme will lead to a similar workflow as the one described in **Figure 3** (Section 2.5.2). This linear representation treats Frames and Topics as dividers of the story. It doesn't matter how many Topics there are, and how many Frames each has, since it is known in which position it starts and in which position follows the next one. The Storyline succeeds in creating the **flat representation** that in the previous model the Transformer had to create with the complicated workflow that creates the entity Full Theme. Furthermore, with the new model there is no need to duplicate the information and the JSON format allows the web application to directly use the model entities as they are, resulting to better performance of the webapp.

4.4 Rendering Pages

4.4.1 Home page

In the Angular portal, when a request for the home page comes, the portals ask the service for the Boxes of type Theme. The result comes partially as the service supports paging. Initially a small number of Boxes is loaded, depending on the device's screen. If there are more Boxes, as the user scrolls down the page the portal requests the service and loads a configurable number of more Boxes until the user reaches the end of the page. With this approach the web application can host and serve a very large number of Themes making the application **scalable**.

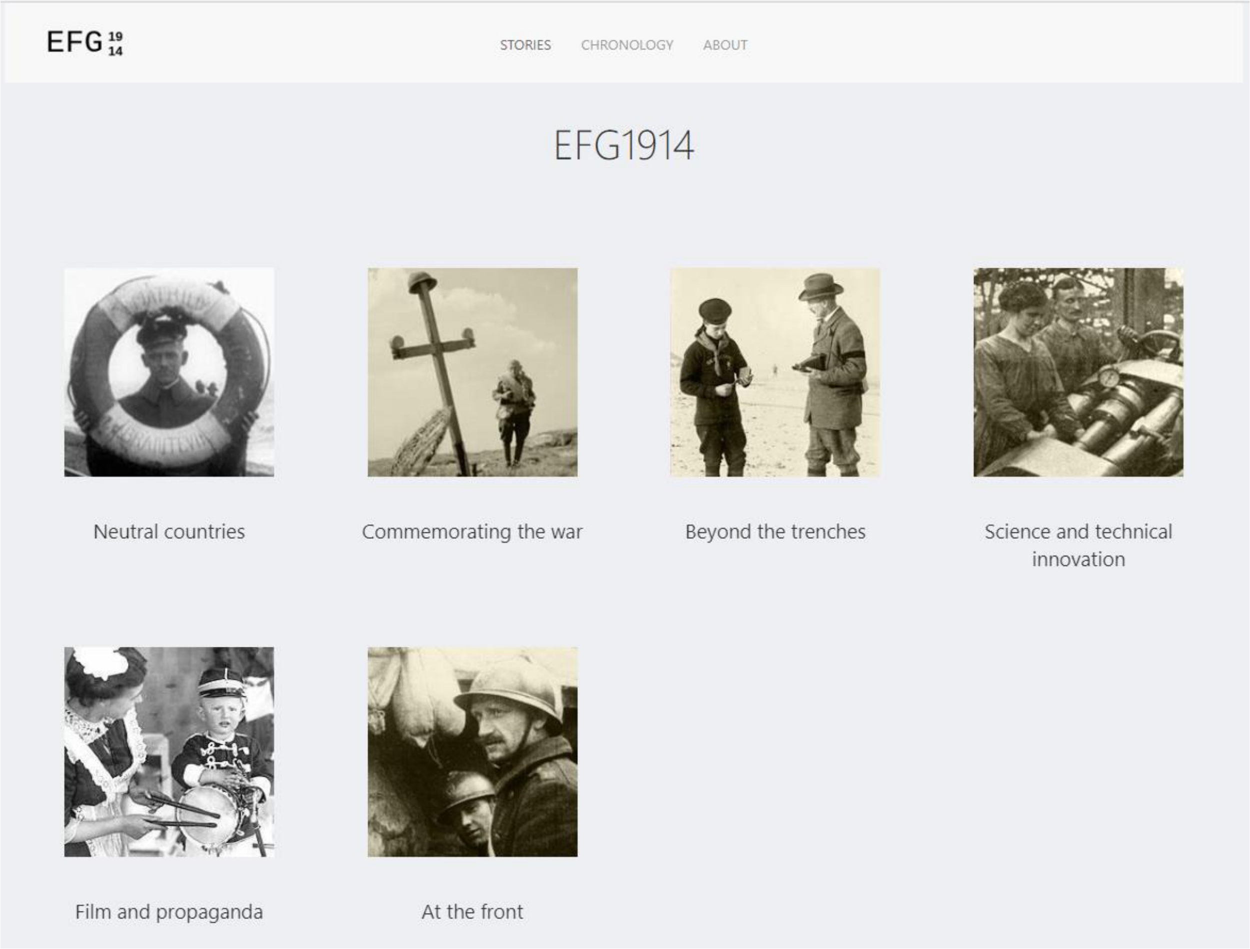
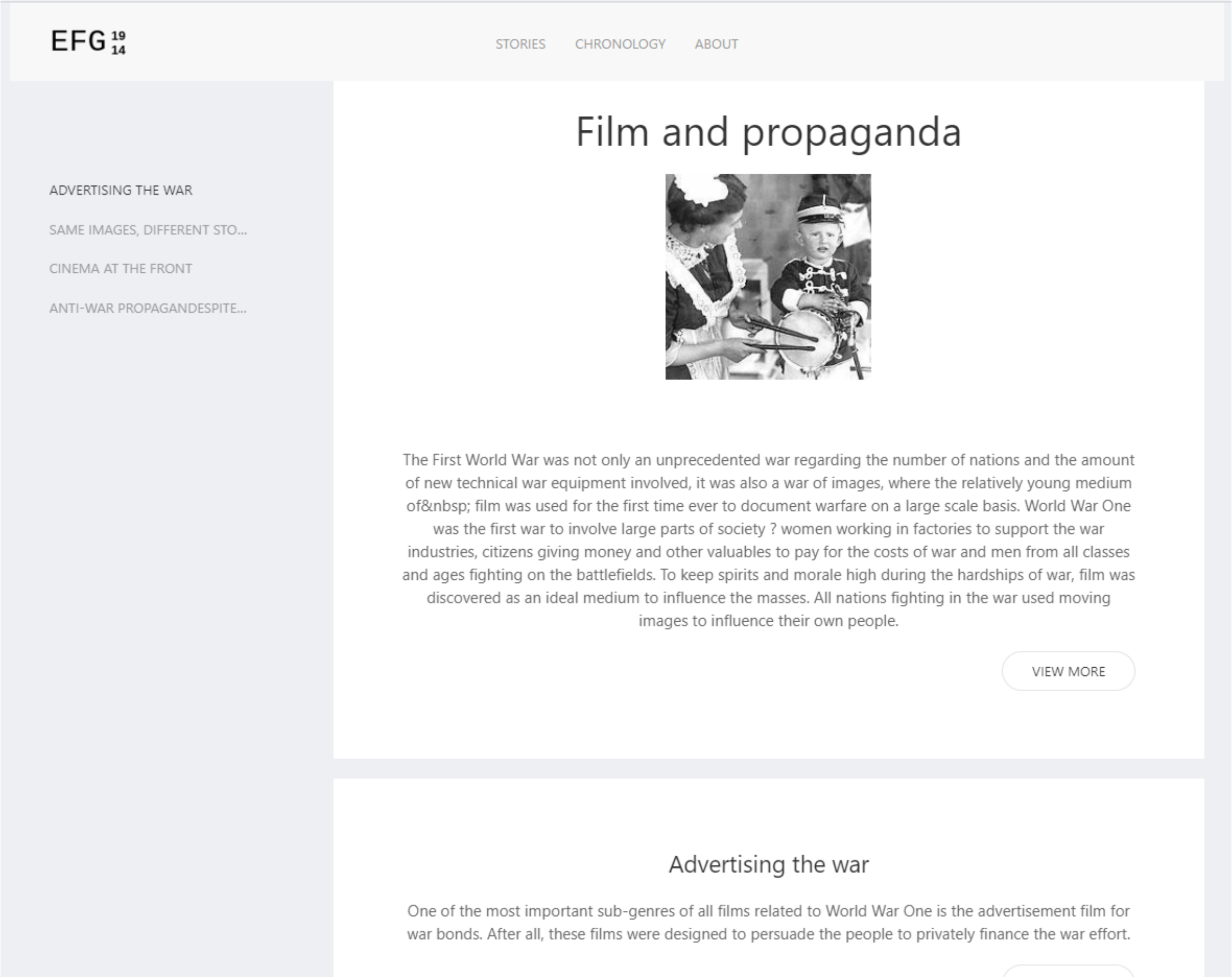


Image 12: New VE - Home page

4.4.2 Theme page

In the redesigned Angular application, whenever a request for a Theme page arrives, the web application asks the service for a Storyline. The Storyline has only pairs of Box ids and types, thus for each id the web applications asks the service for a Box. Initially it loads a small number of Boxes, depending on the user's device. As the user scrolls down the page, the portal requests the service and loads a configurable number of Boxes each time, until the user reaches the end of the page.



Film and propaganda

The First World War was not only an unprecedented war regarding the number of nations and the amount of new technical war equipment involved, it was also a war of images, where the relatively young medium of film was used for the first time ever to document warfare on a large scale basis. World War One was the first war to involve large parts of society ? women working in factories to support the war industries, citizens giving money and other valuables to pay for the costs of war and men from all classes and ages fighting on the battlefields. To keep spirits and morale high during the hardships of war, film was discovered as an ideal medium to influence the masses. All nations fighting in the war used moving images to influence their own people.

Advertising the war

One of the most important sub-genres of all films related to World War One is the advertisement film for war bonds. After all, these films were designed to persuade the people to privately finance the war effort.

Image 13: New VE - Theme page

In the initial rendering of the page, there is a window of the Boxes that the web application loads. For a Box of type “Frame”, the application will also load the Items that it contains. The initial number of Boxes loaded, should be small enough to avoid rendering more Boxes than the user is going to see, but not too small to influence the smooth rendering of the page. The number of initial Boxes loaded depends on the user’s screen. For example, in **Figure 13** there is a Storyline of 10 Boxes. For the following examples the initial number of loaded Boxes is 6. The application will load the first 6 (blue Boxes) and the rest (grey Boxes) will be loaded on user demand. The user can view a few Boxes each time, the number of visible Boxes depends on the screen and the device that uses it. For the following examples that number is 3 and what users can see each time is called “Browser window”.

Loaded	🟦
Not loaded	▨
Loaded Topic	t
Visible to user	🟩

timeline	🟦	t	🟦	🟦	🟦	t	▨	▨	▨	▨
index	1	2	3	4	5	6	7	8	9	10
Browser window	←	🟩	→							

Figure 13: Initially loaded Boxes (Story of 10 Boxes)

Furthermore, the application will load the first 6 Topics. If a user clicks a Topic that is not inside the window, the application will load 2 Boxes before the requested Topic and 2 Boxes after the Topic and will move the browser window to the position of the Topic. For example, in a Storyline with 14 Boxes (**Figure 14**) the Boxes 1- 6 are initially loaded together with first Topics in positions 2,6 and 10.

timeline	🟦	t	🟦	🟦	🟦	t	▨	▨	▨	t	▨	▨	▨	▨
index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Browser window	←	🟩	→											

Figure 14: Initially loaded Boxes (Story of 14 Boxes)

If a user clicks to go to Topic in position 10, the application will also load Boxes 8,9,11,12 and the browser window will be moved around Box in position 10 (**Figure 15**).

timeline	🟦	t	🟦	🟦	🟦	t	▨	🟦	🟦	t	🟦	🟦	▨	▨
index	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Browser window									←	🟩	→			

Figure 15: Boxes loaded when user a Topic10 is selected

When the user starts scrolling, the application detects the motion and loads two more Boxes on demand. For example, the user in **Figure 15** starts scrolling to the 12th Box, and the web application will load Boxes 13 and 14, as shown in **Figure 16**.

timeline	🟦	t	🟦	🟦	🟦	t	▨	🟦	🟦	t	🟦	🟦	🟦	🟦
index	1	2	3	4	5	6	7	8	9	10	11	12	13	14

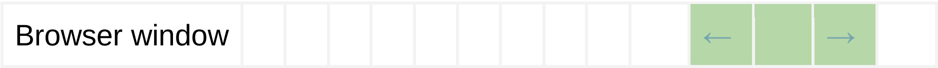
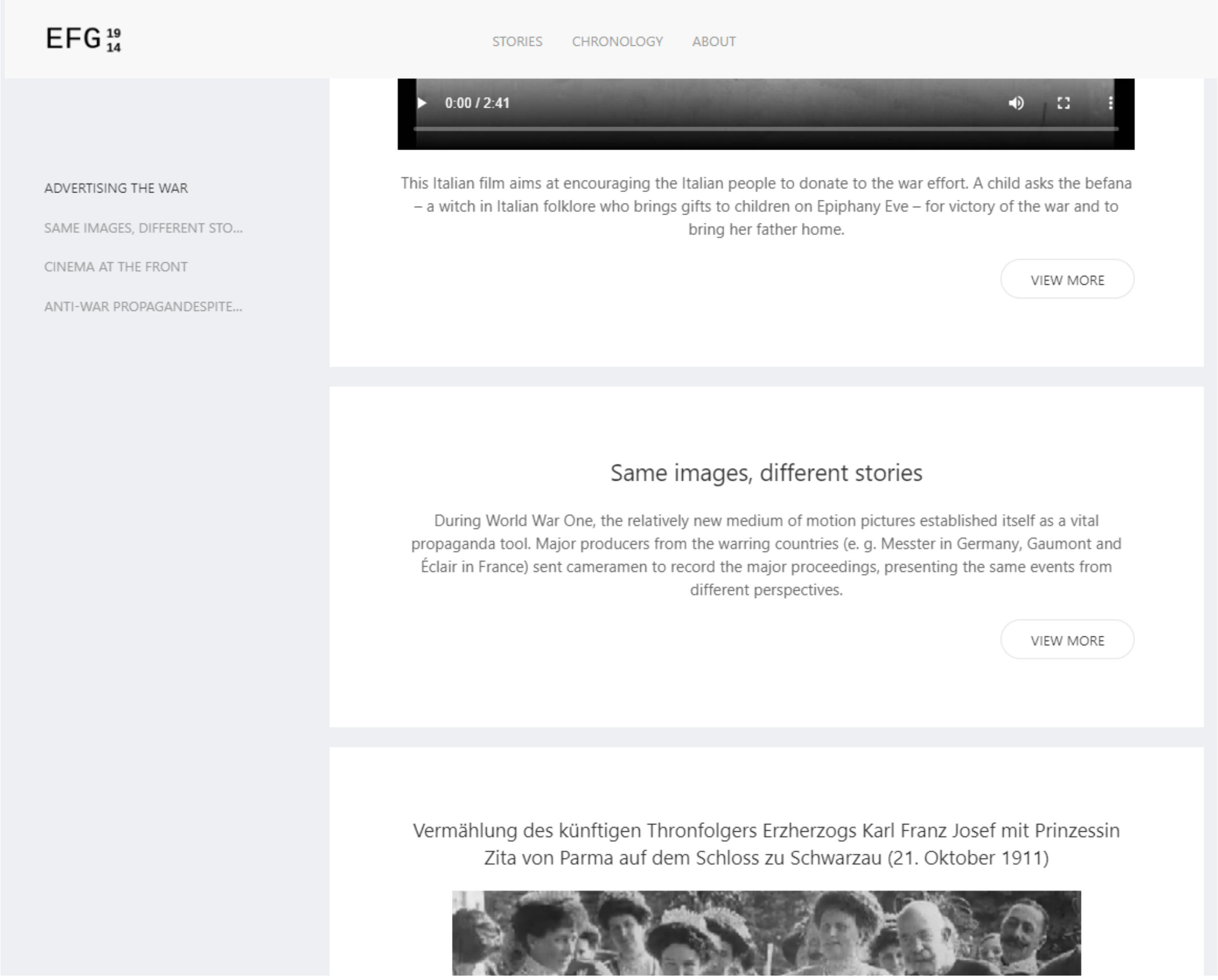


Figure 16: Boxes loaded when user scrolls down to Topic 12

Rendering results dynamically on user demands, allows to render Storylines with hundreds or thousands of Boxes, making the rendering of this page **scalable**.



ADVERTISING THE WAR

SAME IMAGES, DIFFERENT STO...

CINEMA AT THE FRONT

ANTI-WAR PROPAGANDESPITE...

This Italian film aims at encouraging the Italian people to donate to the war effort. A child asks the befana – a witch in Italian folklore who brings gifts to children on Epiphany Eve – for victory of the war and to bring her father home.

Same images, different stories

During World War One, the relatively new medium of motion pictures established itself as a vital propaganda tool. Major producers from the warring countries (e. g. Messter in Germany, Gaumont and Éclair in France) sent cameramen to record the major proceedings, presenting the same events from different perspectives.

Vermählung des künftigen Thronfolgers Erzherzogs Karl Franz Josef mit Prinzessin Zita von Parma auf dem Schloss zu Schwarzau (21. Oktober 1911)

Image 14: New VE – “Film and Propaganda” Theme

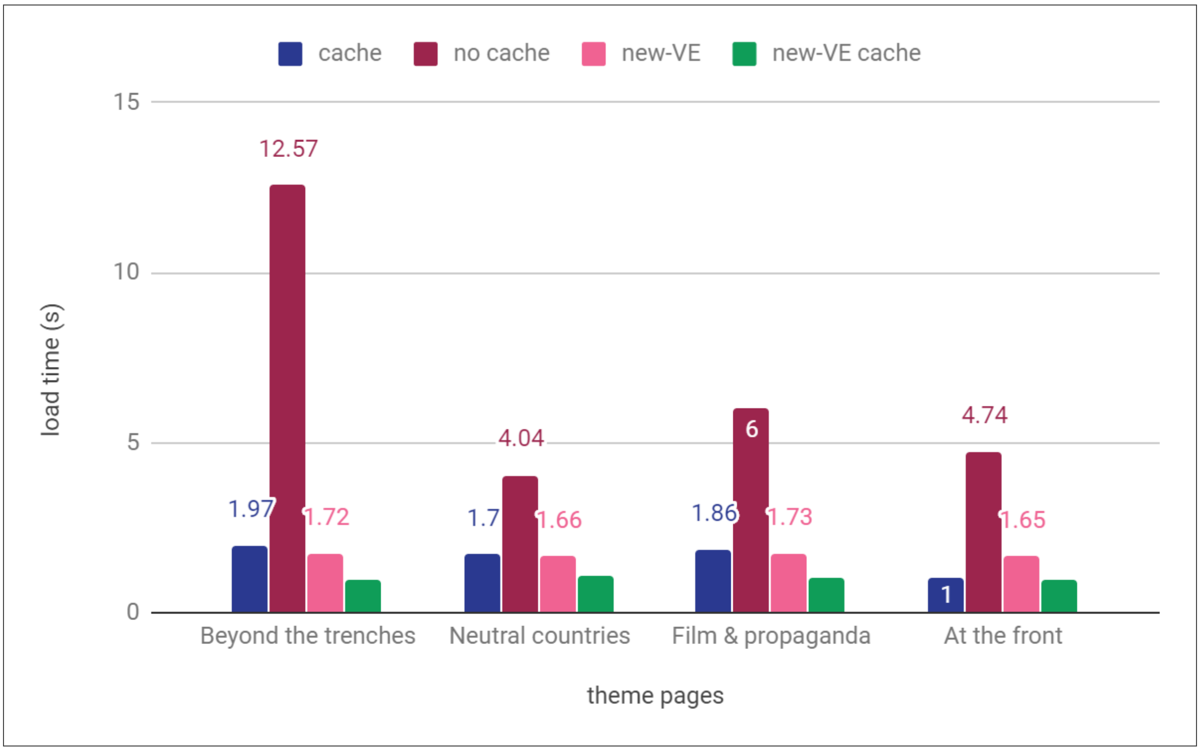
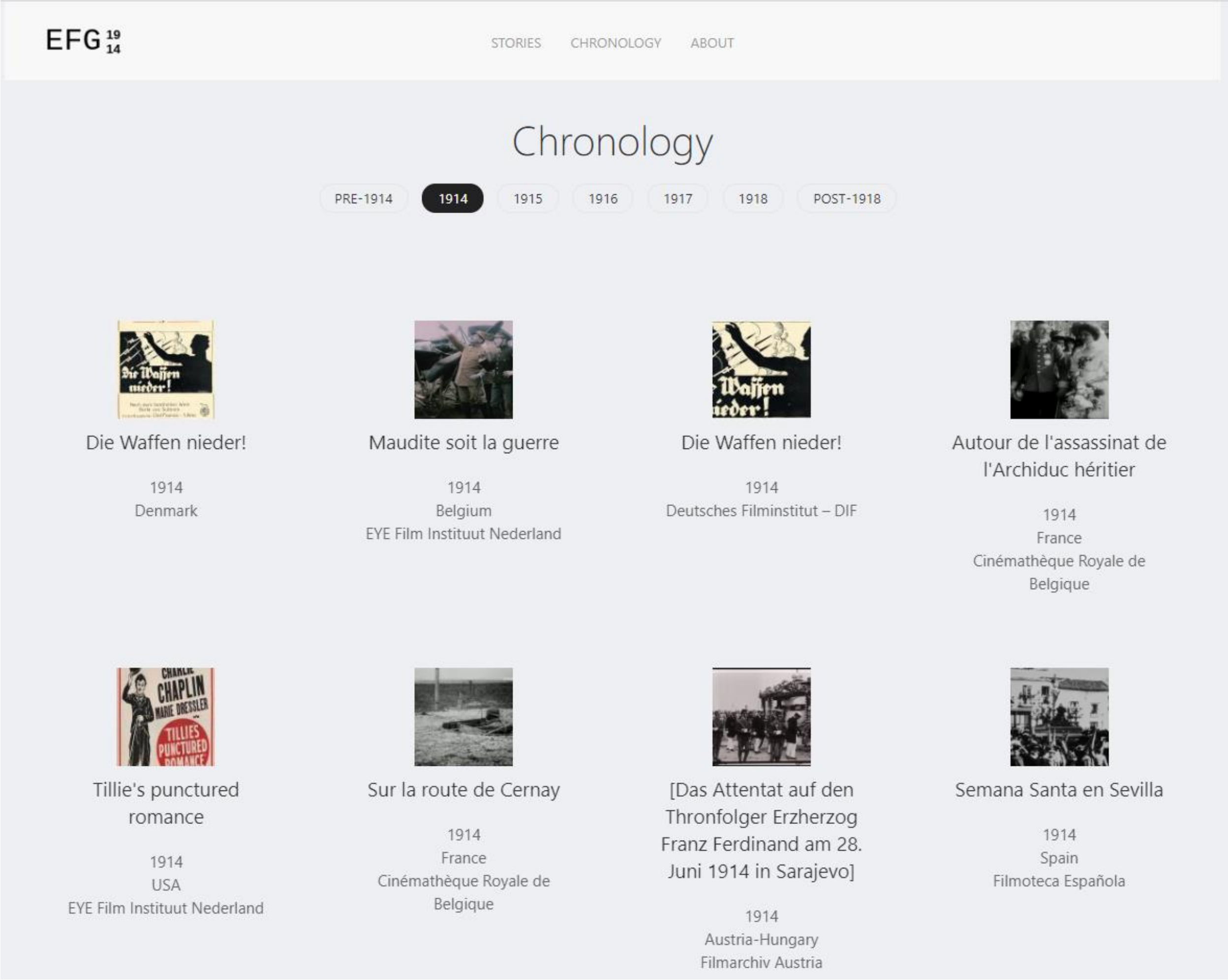


Figure 17: Comparing load times of Theme pages

The rendering of Theme pages in the new VE is faster than the old VE. As shown in **Figure 17** the load time of several Themes is smaller or close to the load time of cached pages in previous VE. The loading of a Theme page in the new VE is under 2s (and under 1.1s with the use of cache) while in the old VE load time can reach almost 13s. The **small and quick responses** of the service contribute to the overall **fast performance** of the web application. In addition, loading content on user demand makes this page **scalable**.

4.4.3 Chronology page



Chronology

Die Waffen nieder!
1914
Denmark

Maudite soit la guerre
1914
Belgium
EYE Film Instituut Nederland

Die Waffen nieder!
1914
Deutsches Filminstitut – DIF

Autour de l'assassinat de l'Archiduc héritier
1914
France
Cinémathèque Royale de Belgique

Tillie's punctured romance
1914
USA
EYE Film Instituut Nederland

Sur la route de Cernay
1914
France
Cinémathèque Royale de Belgique

[Das Attentat auf den Thronfolger Erzherzog Franz Ferdinand am 28. Juni 1914 in Sarajevo]
1914
Austria-Hungary
Filmarchiv Austria

Semana Santa en Sevilla
1914
Spain
Filmoteca Española

Image 15: New VE - Chronology page

In the chronology page (**Image 15**), the Items are presented based on production year. Thus, the portal requests from the service the list of all available dates and then for the earlier date (e.g. 1914) loads a small number of Items produced that year. The number of Items initially loaded depends on the device. The number is smaller for devices with a small screen and bigger for desktops. When the user scrolls down the next Items of that year will appear, until there are no more Items to show. When the user selects another date, the portal requests a small number of the Items of the new date.

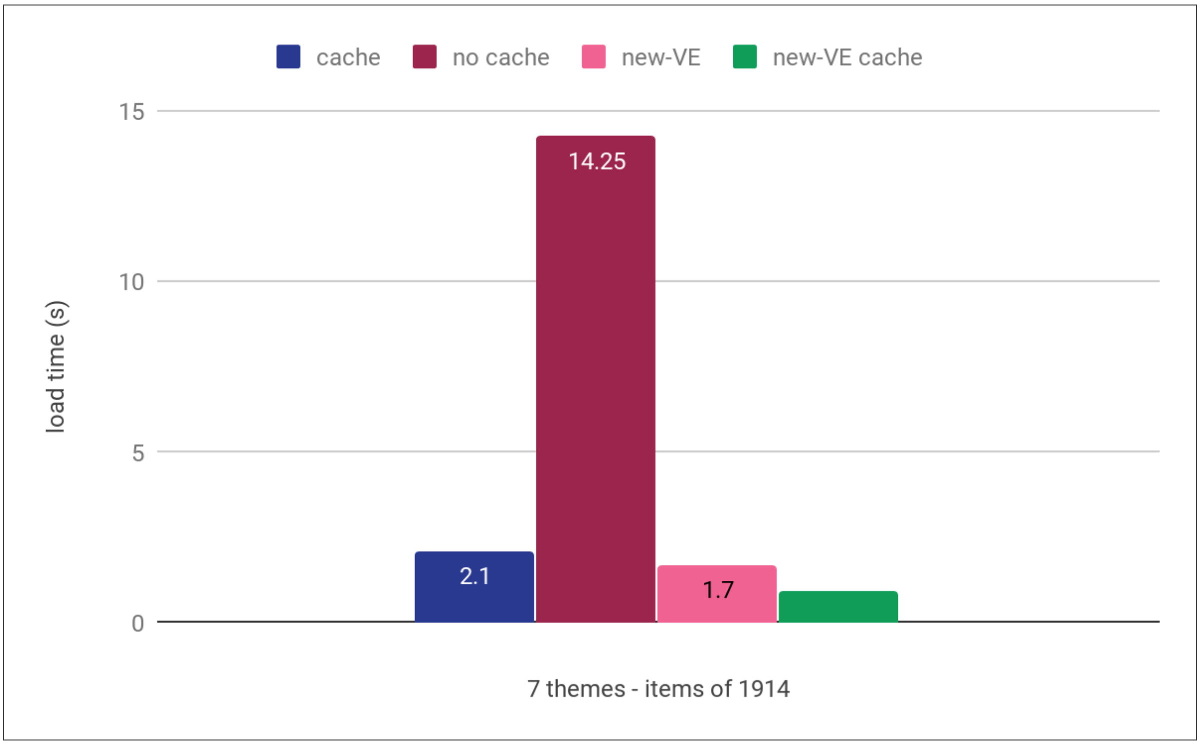


Figure 18: Comparing load times of chronology page

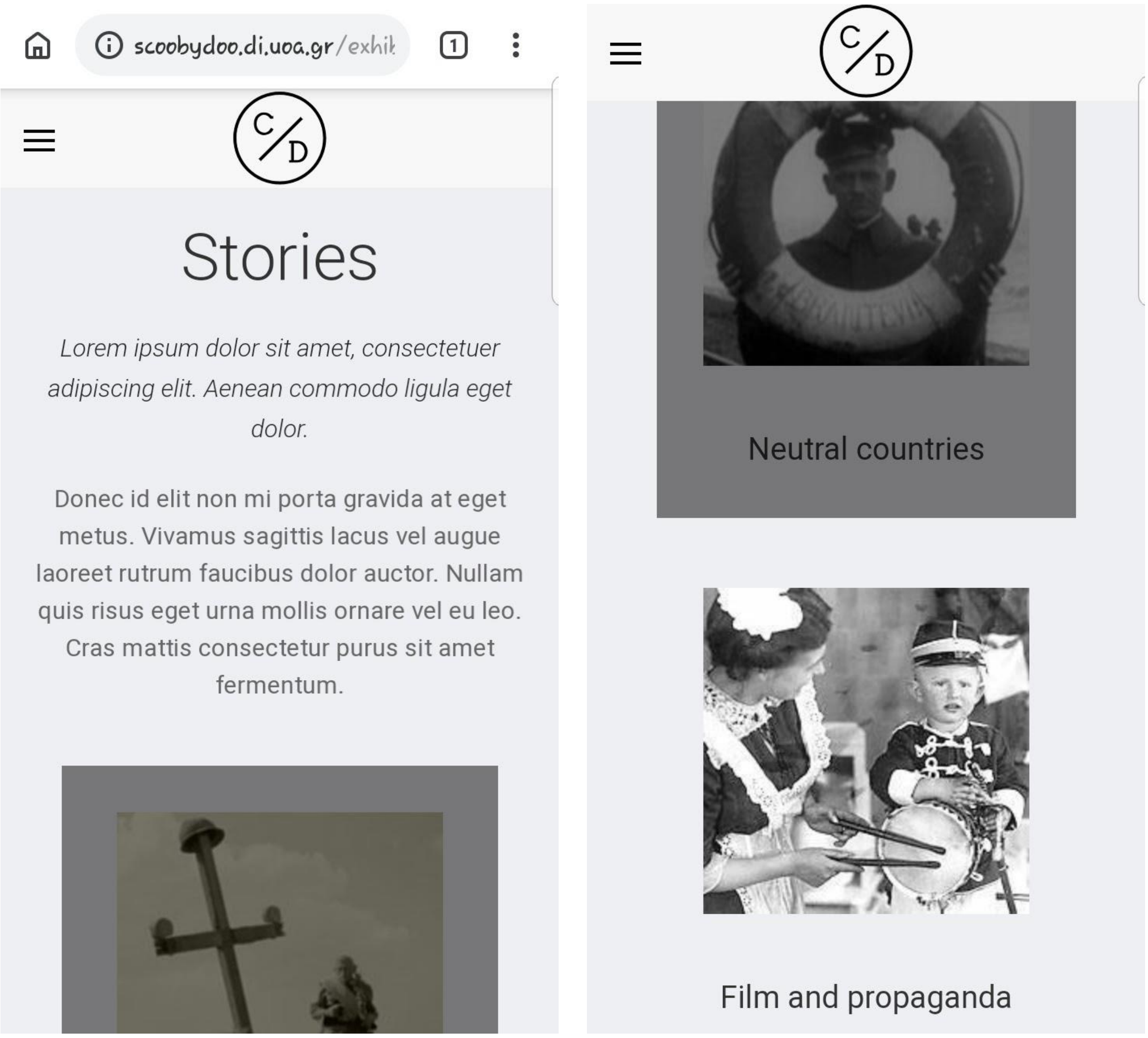
The rendering of the chronology page in the new VE is faster than the old VE. As shown in **Figure 18** the load time (1.7s) is less than the load time of the cached chronology page in previous VE (2.1s) while the load time of the cached version of the new VE is even lesser (0.911s).

Chronology page also benefits from the **small and quick responses** of the service, resulting in **better performance** compared to the old application. Loading content is also **scalable** for this page.

4.5 Design

The CSS Framework used for the redesign of the VE is the UIkit[16]. The UIkit is a lightweight Framework that offers responsive views, motion elements and a variety of components that can create an attractive web application. The UIkit helped to provide a mobile friendly VE as the web applications uses the UIkit width component, that splits the content into responsive columns, and provides expand and automatic width units that fill the available space, regarding the device. Also, the scroll and animation components help to provide a smooth browsing experience for the user.

[16] https://getuikit.com/



Stories

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Aenean commodo ligula eget dolor.

Donec id elit non mi porta gravida at eget metus. Vivamus sagittis lacus vel augue laoreet rutrum faucibus dolor auctor. Nullam quis risus eget urna mollis ornare vel eu leo. Cras mattis consectetur purus sit amet fermentum.

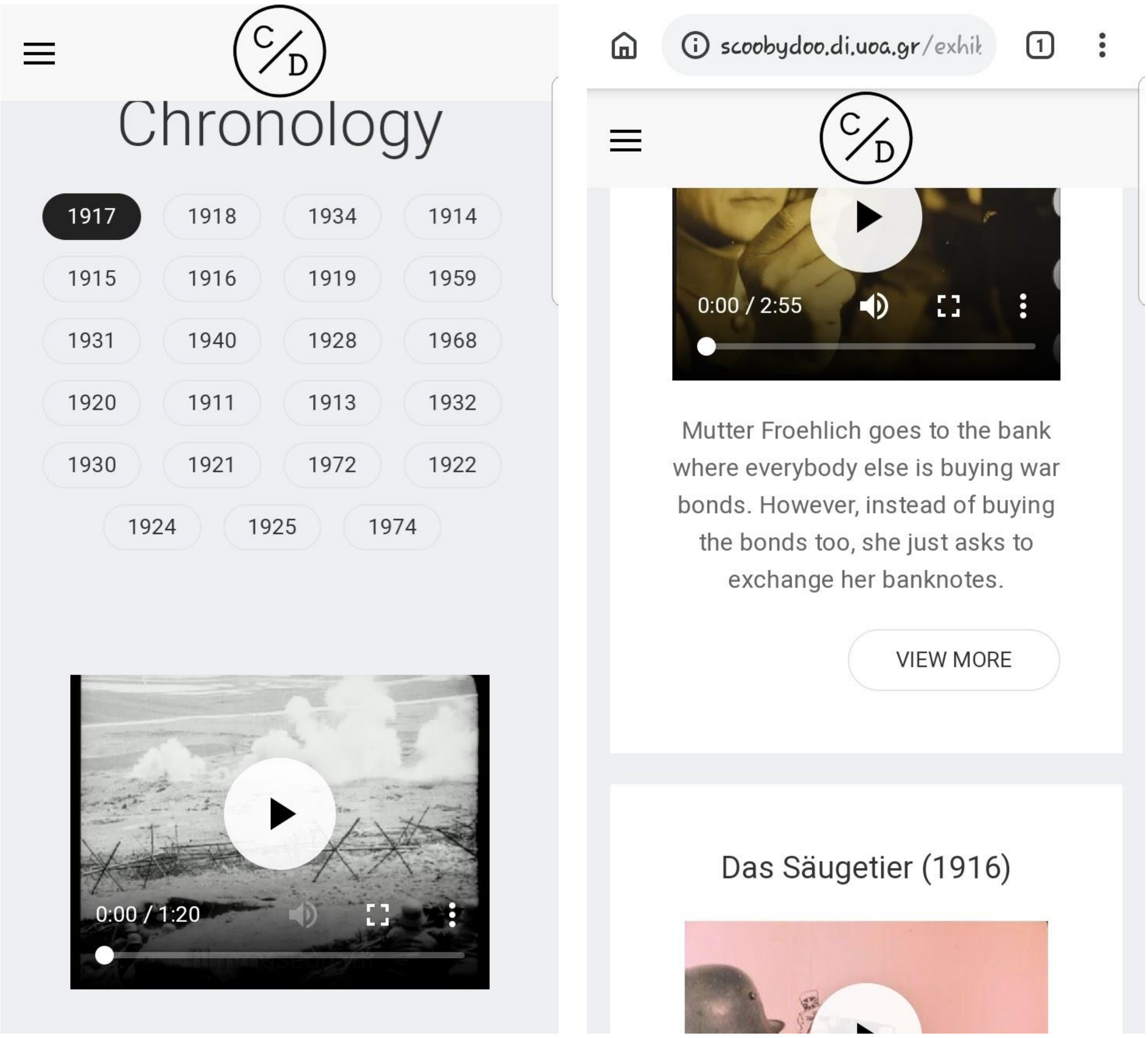
Neutral countries

Film and propaganda

Image 16: New VE – mobile view

In addition, a simple and clear Theme was used, as the old dark and heavy Theme used is old-fashioned according to the latest trends.

The new design takes advantage of the default horizontal scrolling that browsers offer, and therefore it doesn’t increase page complexity by adding additional JS code and libraries for touch effects and swiping pages horizontally.



Chronology

Mutter Froehlich goes to the bank where everybody else is buying war bonds. However, instead of buying the bonds too, she just asks to exchange her banknotes.

Das Säugetier (1916)

Image 17: New VE – Chronology and Theme page

4.6 Flexibility of the new VE

The old VE can host only one exhibition, while the new VE is implemented in a way that can host more than one exhibition and each exhibition is customizable in the way it is presented. Thus, in the new VE implementation, except the entities used to represent the old VE content, contains one more entity called **Exhibition**. The exhibition entity holds two types of metadata. Information about the Exhibition and the stories, like exhibition title, logo, welcoming text, description of the exhibition, etc. and configuration settings of how or which pages will be shown.

Table 16: An Exhibition JSON

```
{
  "id":"5e30304af908451692fd87f6",
  "title":"EFG1914",
  "alias":"EFG1914",
  "welcomeText":"A Virtual Exhibition by European Film Archives",
  "aboutText":"The exhibition “European Film and the First World War” is part of the
European Film Gateway, a web portal facilitating online access to hundreds of thousands
of historical film documents as preserved in European film archives and cinémathèques.
The exhibition was developed within the context of EFG1914, a project running from 2012
to 2014 and targeted on digitising films and non-film materials from and related to World
War One for the European Film Gateway.",
  "logoUrl":"http://scoobydoo.di.uoa.gr/exhibition/assets/logo.png",
  "mediaPath":"http://scoobydoo.di.uoa.gr/efg_media/",
  "showAboutPage":true,
  "showItemsPage":true,
  "showStoriesPage":true,
  "showItemsPageAsHomePage":false,
  "showItemsByYear":true,
  "chronologyStartYear":"1914",
  "chronologyEndYear":"1918"
}
```

The entities that built a story, Storyline, Box and Item, contain a field **exhibition ID** to easily identify and query the Storylines of an exhibition or the Items of an exhibition.

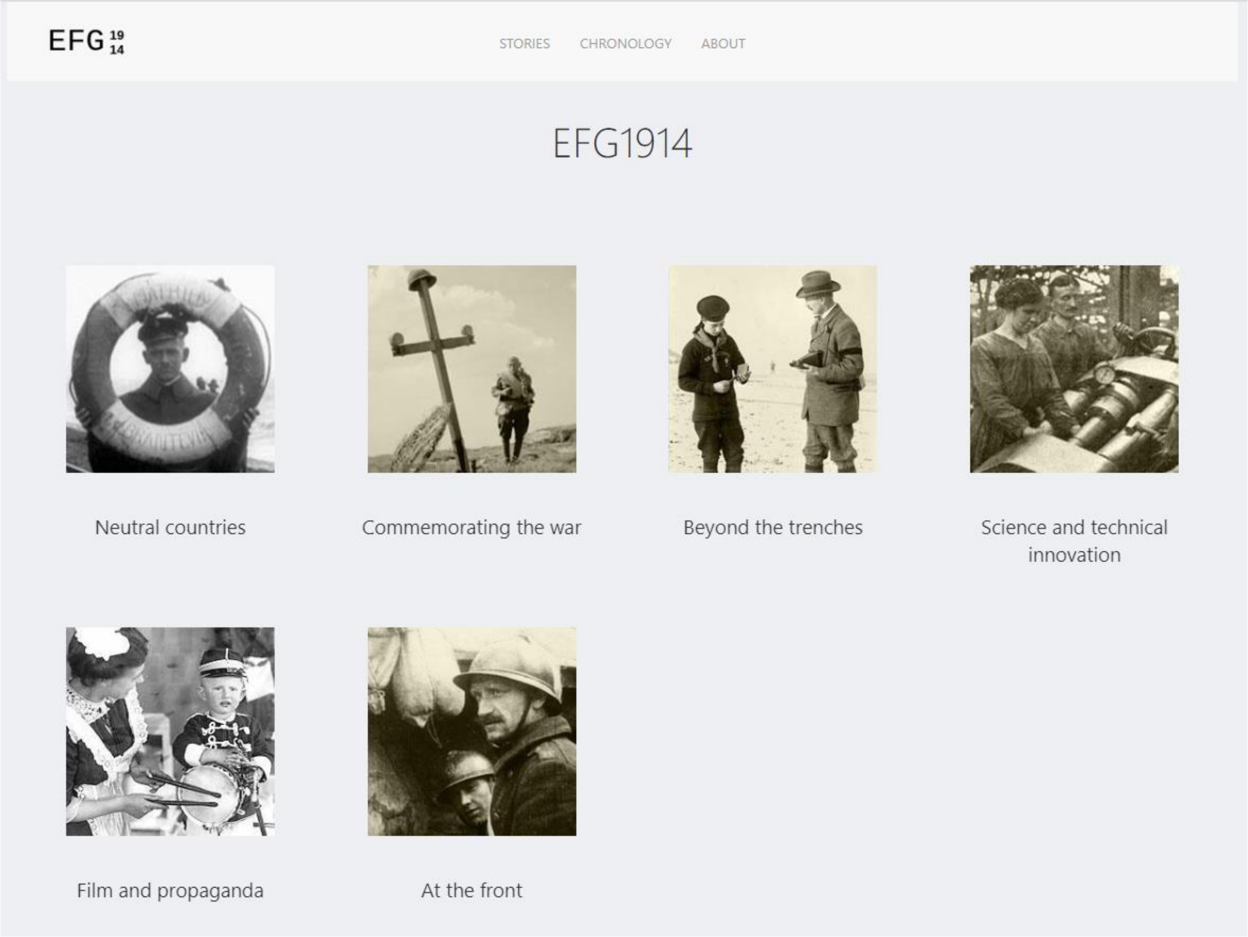
Examples of Configurations

A single exhibition can be presented in several ways based on the configuration settings.

For example, the EFG 1914 exhibition can be presented in 3 different ways. In Exhibition A, the exhibition starts with the stories page (**Image 18**), contains the chronology page (**Image 19**) and the Items are focused on years 1914-1918.

Table 17: Exhibition A Configuration

Exhibition A Configuration	Collection: yes Chronological order Focus on years: 1914 - 1918 Stories page: yes Home: Stories page About page: yes



EFG1914

Neutral countries

Commemorating the war

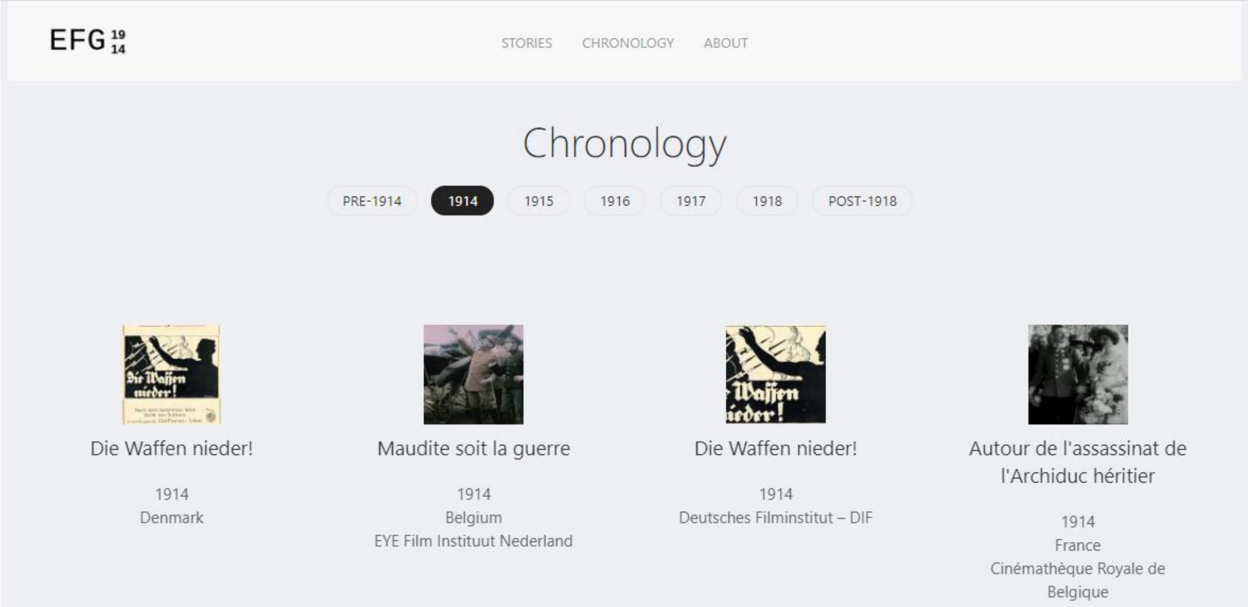
Beyond the trenches

Science and technical innovation

Film and propaganda

At the front

Image 18: Exhibition A - Stories page



Chronology

Die Waffen nieder!
1914
Denmark

Maudite soit la guerre
1914
Belgium
EYE Film Instituut Nederland

Die Waffen nieder!
1914
Deutsches Filminstitut – DIF

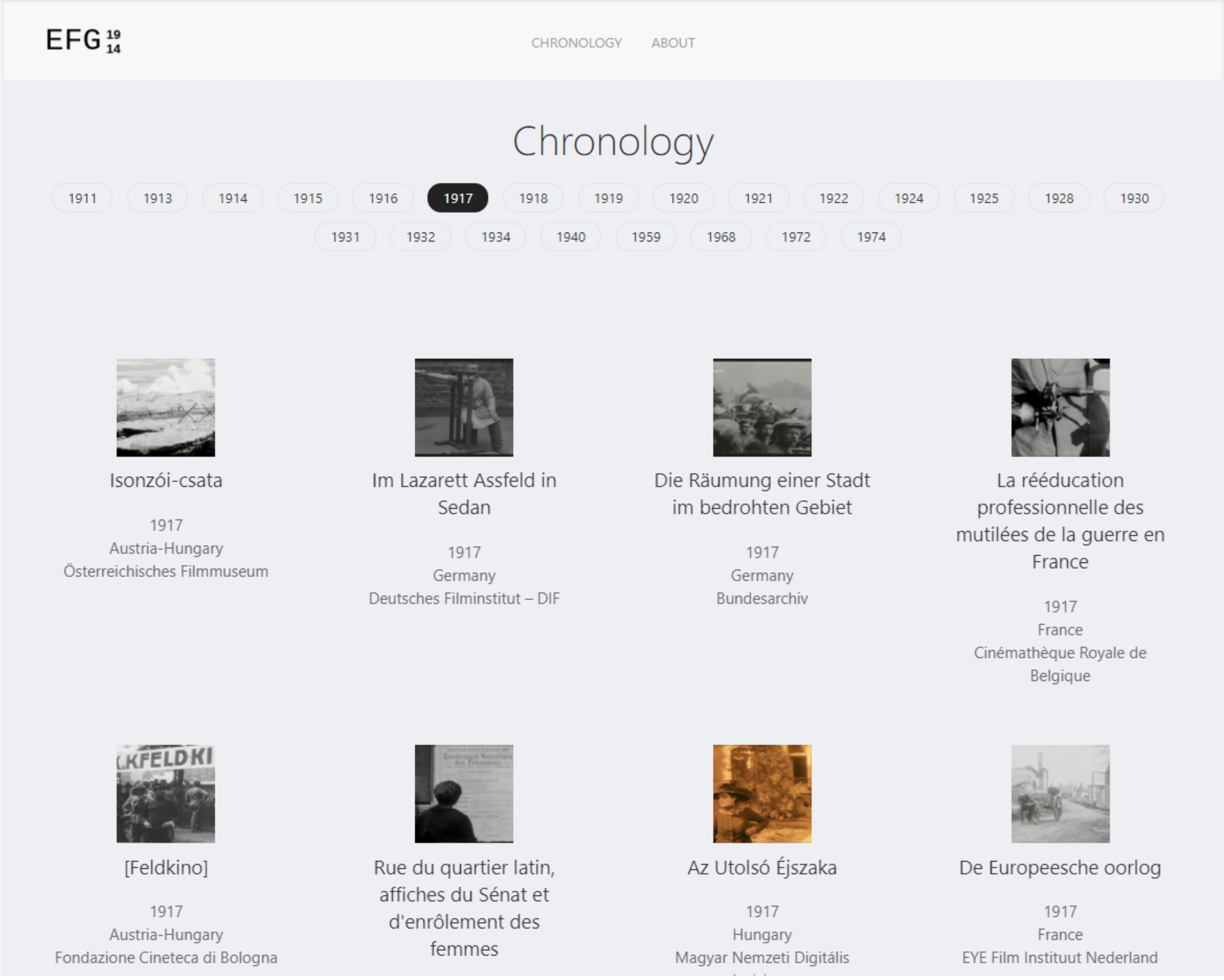
Autour de l'assassinat de l'Archiduc héritier
1914
France
Cinémathèque Royale de Belgique

Image 19: Exhibition A - Items page

The Exhibition B (**Table 18**) starts with the chronology page that is not focused on specific years (**Image 20**) and has no stories.

Table 18: Exhibition B Configuration

Exhibition B Configuration	Collection: yes Chronological order Focus on years: no Stories page: no Home: Collection page About page: yes



EFG 19 14

CHRONOLOGY ABOUT

Chronology

1911 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1924 1925 1928 1930
1931 1932 1934 1940 1959 1968 1972 1974

Isonzói-csata
1917
Austria-Hungary
Österreichisches Filmmuseum

Im Lazarett Assfeld in Sedan
1917
Germany
Deutsches Filminstitut – DIF

Die Räumung einer Stadt im bedrohten Gebiet
1917
Germany
Bundesarchiv

La rééducation professionnelle des mutilées de la guerre en France
1917
France
Cinémathèque Royale de Belgique

[Feldkino]
1917
Austria-Hungary
Fondazione Cineteca di Bologna

Rue du quartier latin, affiches du Sénat et d'enrôlement des femmes

Az Utolsó Éjszaka
1917
Hungary
Magyar Nemzeti Digitális

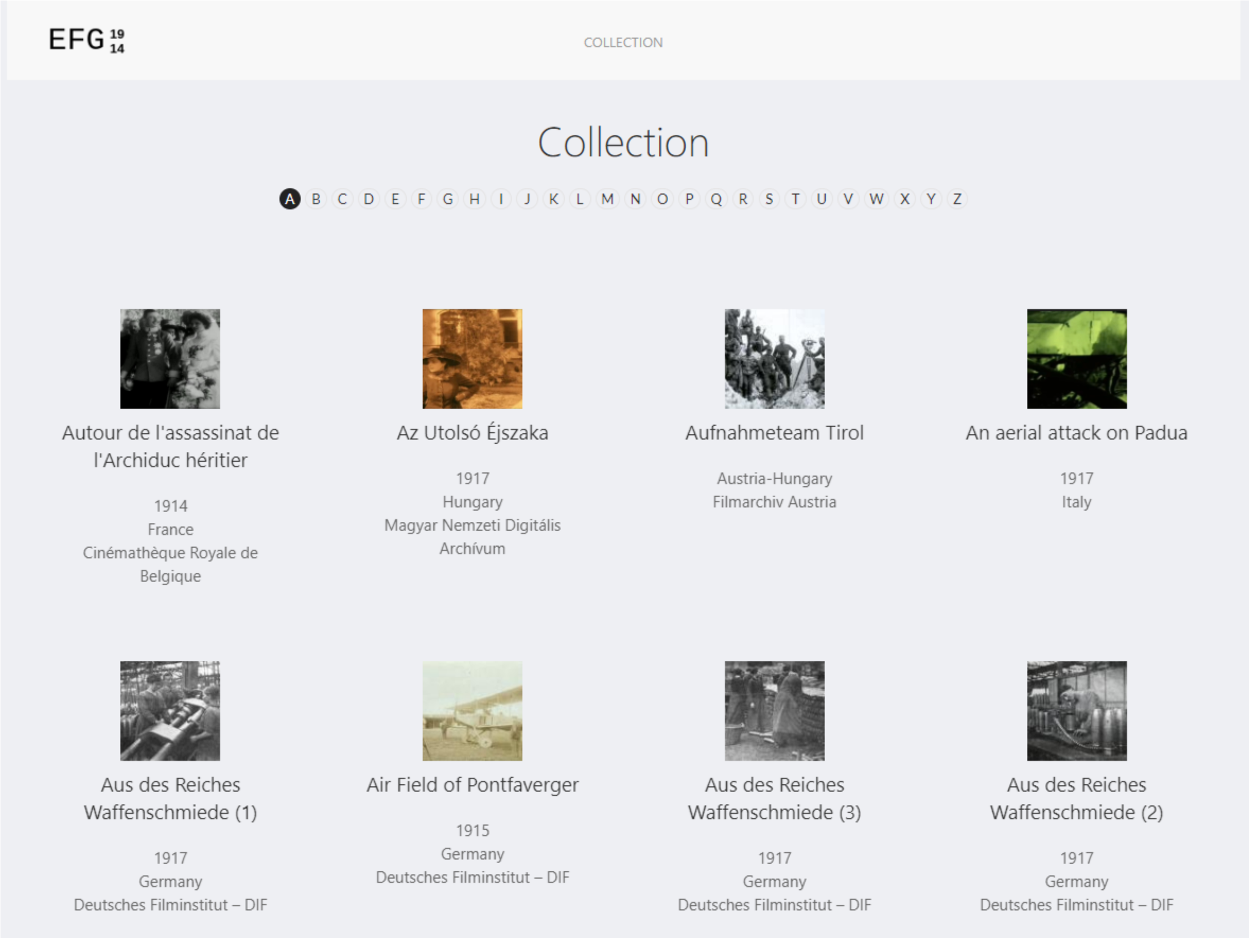
De Europeesche oorlog
1917
France
EYE Film Instituut Nederland

Image 20: Exhibition B - Items page

The Exhibition C (**Table 19**) starts with the Items collection page, where the Items are ordered alphabetically (**Image 21**) and has no stories and no About page.

Table 19: Exhibition C Configuration

Configuration 3	Collection: yes Alphabetical order Stories page: no Home: Collection page About page: no



Collection

Autour de l'assassinat de l'Archiduc héritier
1914
France
Cinémathèque Royale de Belgique

Az Utolsó Éjszaka
1917
Hungary
Magyar Nemzeti Digitális Archívum

Aufnahmeteam Tirol
Austria-Hungary
Filmarchiv Austria

An aerial attack on Padua
1917
Italy

Aus des Reiches Waffenschmiede (1)
1917
Germany
Deutsches Filminstitut – DIF

Air Field of Pontfaverger
1915
Germany
Deutsches Filminstitut – DIF

Aus des Reiches Waffenschmiede (3)
1917
Germany
Deutsches Filminstitut – DIF

Aus des Reiches Waffenschmiede (2)
1917
Germany
Deutsches Filminstitut – DIF

Image 21: Exhibition C - Items page

5. OTHER USE CASES OF THE VE

The original VE has been used in several use cases, for different users and in different contexts. Apart from the EFG1914 exhibition, and in the context of the project Capsella[17], the exhibition was used from farmers as a storytelling tool[18], to attract customers for their products, establish good relations with citizens and promote agriculture.

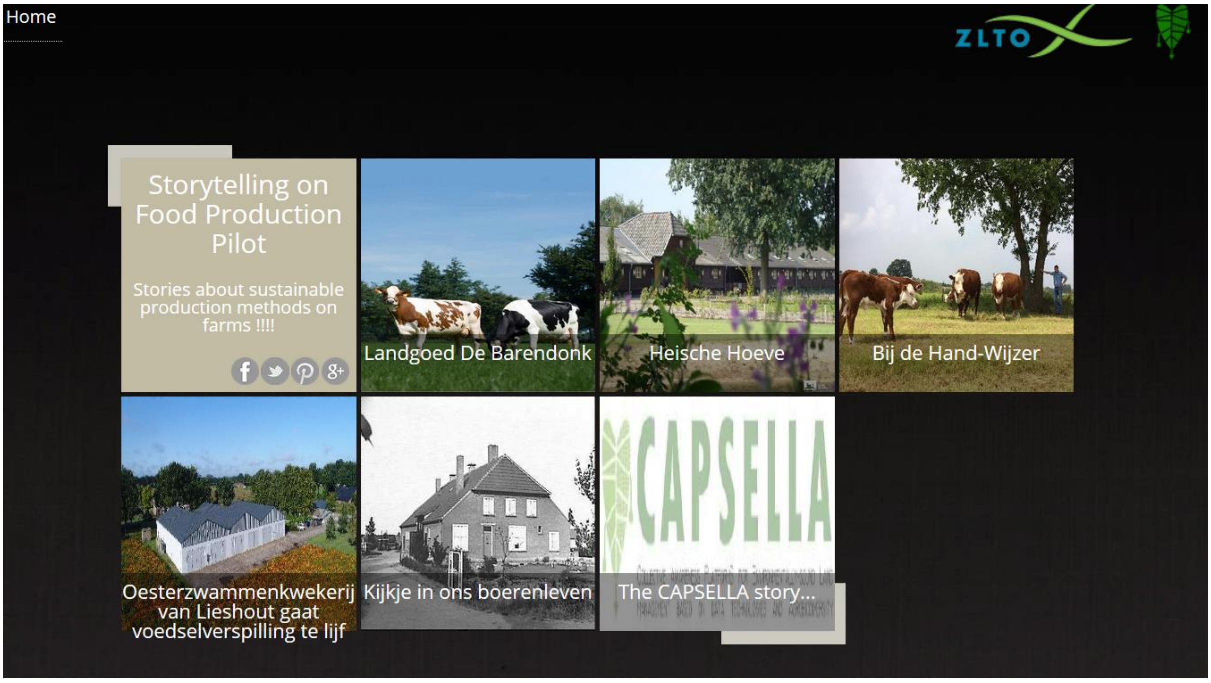

Home
ZLTO
Storytelling on Food Production Pilot
Stories about sustainable production methods on farms !!!!
Landgoed De Barendonk
Heische Hoeve
Bij de Hand-Wijzer
Oesterzwammenkwekerij van Lieshout gaat voedselverspilling te lijf
Kijkje in ons boerenleven
CAPSELLA
The CAPSELLA story...

Image 22: Capsella Pilot VE

It has been used by students in workshops in the Researcher's Night 2015 and the Athens Science Festival 2016.

It has been used from teachers of the Geraka's Art school[19], in order to promote and share the art activities and the artworks that their students created in Ancient Agora of Athens.

[17] http://www.capsella.eu/

[18] http://capsella-pilots.madgik.di.uoa.gr/storytelling-pilot/welcome

[19] http://dl110.madgik.di.uoa.gr/kallitexniko-geraka/welcome

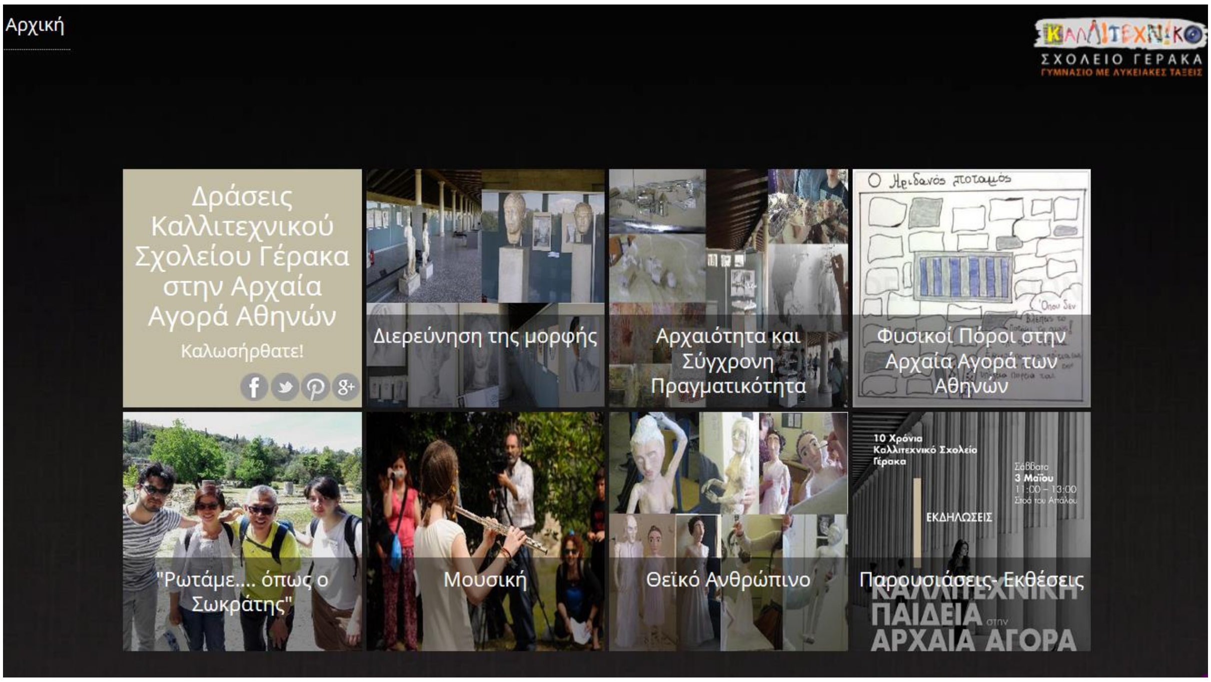

Αρχική
ΚΑΛΛΙΤΕΧΝΙΚΟ
ΣΧΟΛΕΙΟ ΓΕΡΑΚΑ
ΓΥΜΝΑΣΙΟ ΜΕ ΛΥΚΕΙΑΚΕΣ ΤΑΞΕΙΣ
Δράσεις Καλλιτεχνικού Σχολείου Γέρακα στην Αρχαία Αγορά Αθηνών
Καλωσήρθατε!
Διερεύνηση της μορφής
Αρχαιότητα και Σύγχρονη Πραγματικότητα
Φυσικοί Πόροι στην Αρχαία Αγορά των Αθηνών
"Ρωτάμε.... όπως ο Σωκράτης"
Μουσική
Θεϊκό Ανθρώπινο
Παρουσιάσεις- Εκθέσεις

Image 23: Art school VE

In all the use cases, the different stakeholders succeeded to present their different stories, but the weaknesses of the VE described in **Section 2.7**, were visible. When the model of the new VE was designed, special care provided so that the instances of old VE could be migrated to the new implementation and benefit from its advanced features. To better showcase the new VE, the EFG1914 exhibition was added with the original configuration, and two more versions of it with different configuration (**Image 24**). Furthermore, the art school exhibition was added (**Images 25-27**).

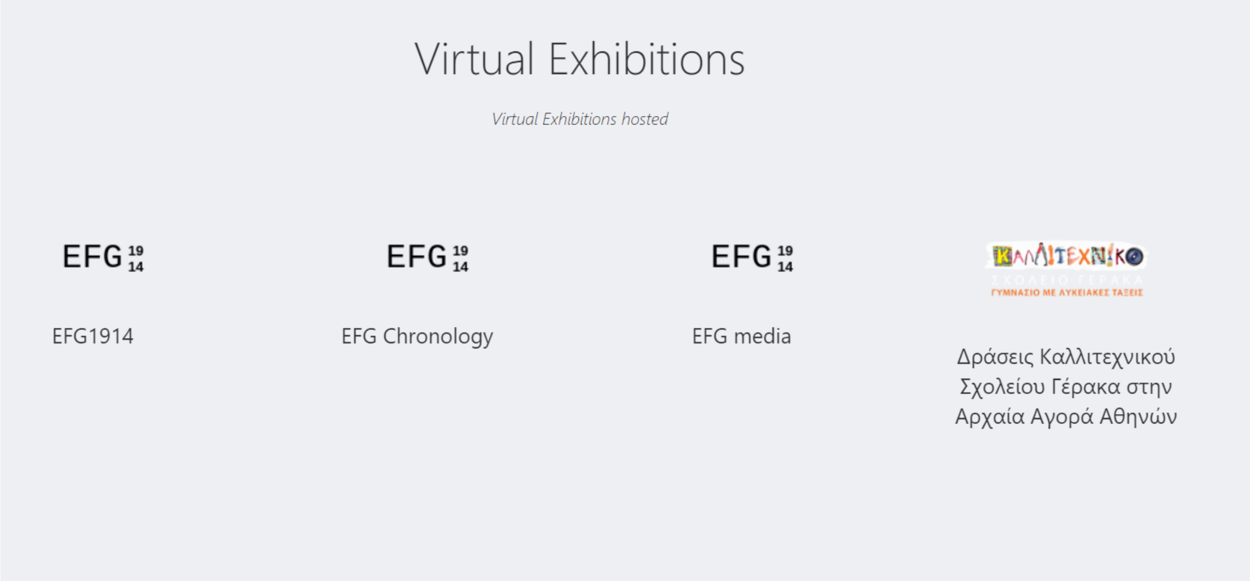

Virtual Exhibitions
Virtual Exhibitions hosted
EFG 19 14
EFG1914
EFG 19 14
EFG Chronology
EFG 19 14
EFG media
ΚΑΛΛΙΤΕΧΝΙΚΟ
ΓΥΜΝΑΣΙΟ ΜΕ ΛΥΚΕΙΑΚΕΣ ΤΑΞΕΙΣ
Δράσεις Καλλιτεχνικού Σχολείου Γέρακα στην Αρχαία Αγορά Αθηνών

Image 24: Exhibitions

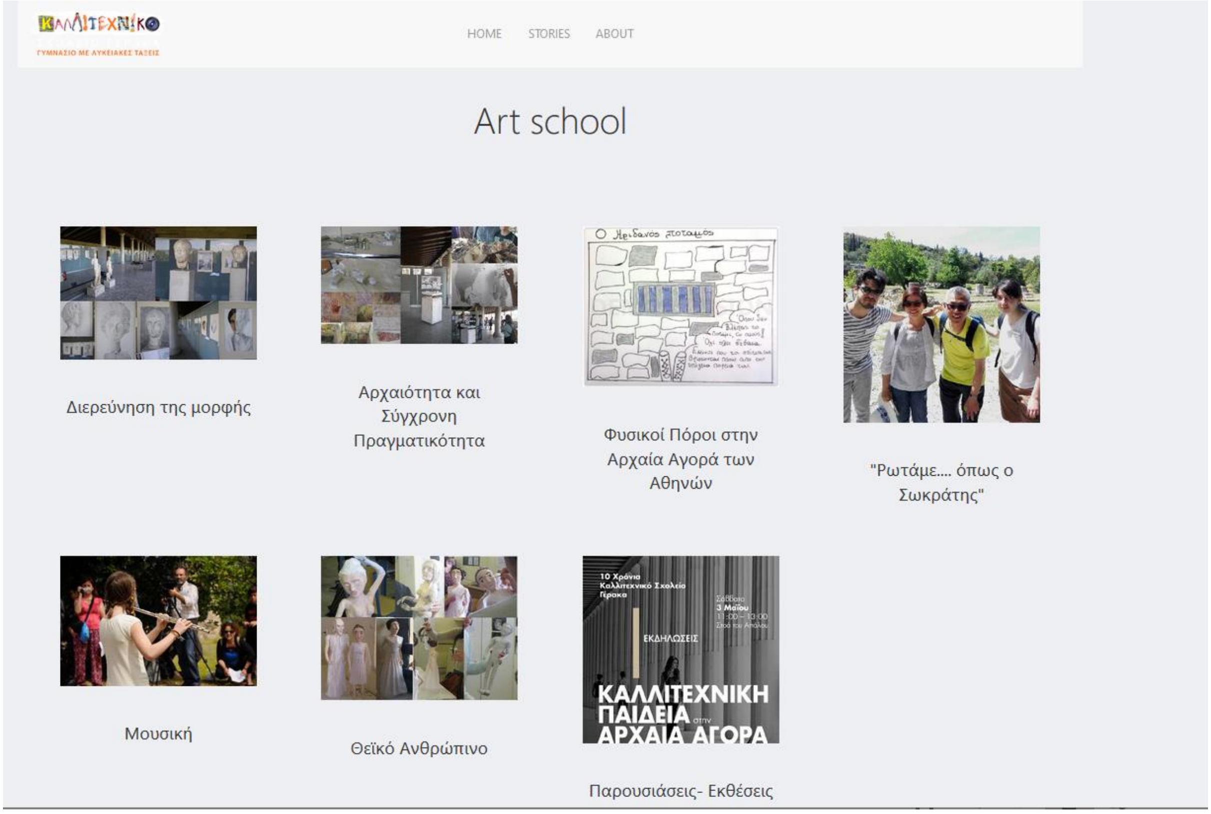
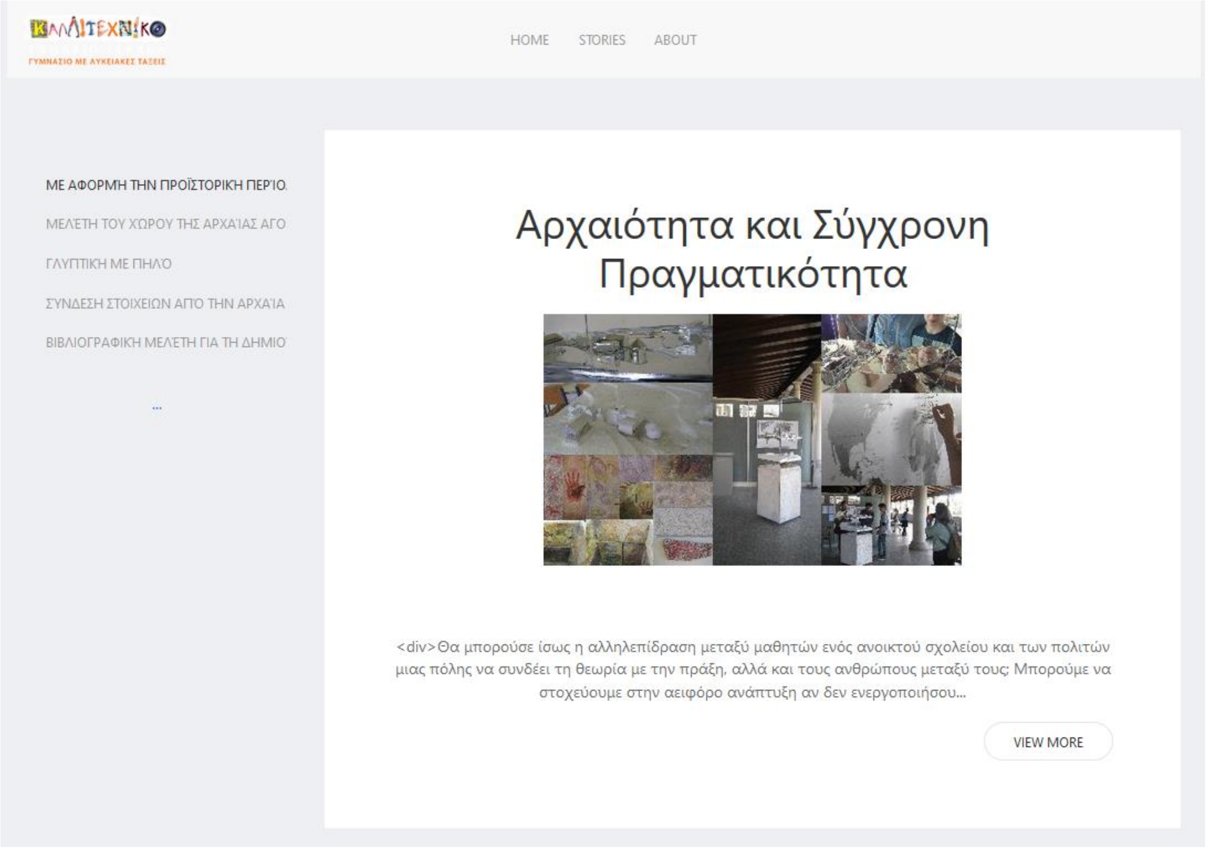
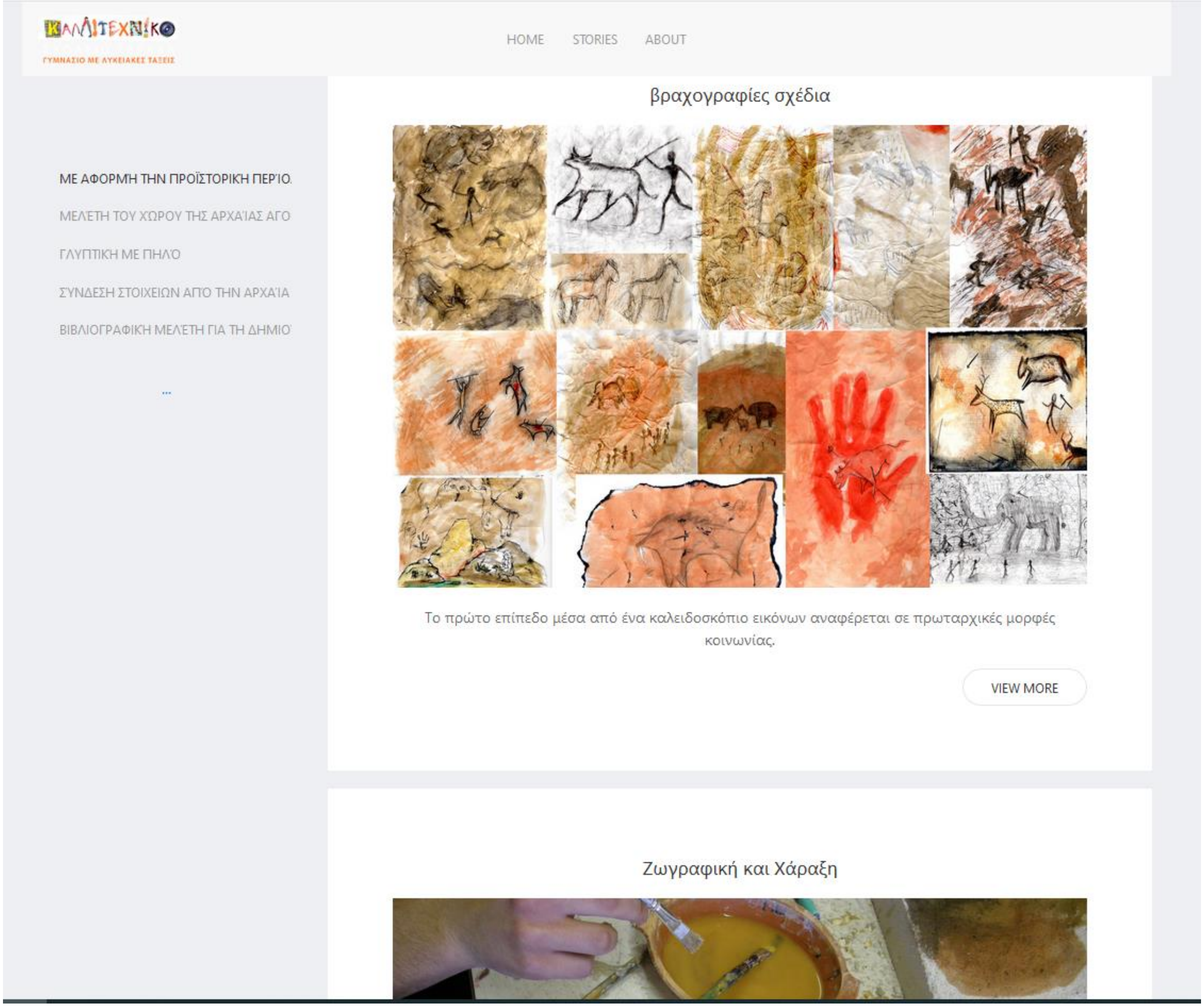

ΚΑΛΛΙΤΕΧΝΙΚΟ
ΓΥΜΝΑΣΙΟ ΜΕ ΛΥΚΕΙΑΚΕΣ ΤΑΞΕΙΣ
HOME
STORIES
ABOUT
Art school
Διερεύνηση της μορφής
Αρχαιότητα και Σύγχρονη Πραγματικότητα
Φυσικοί Πόροι στην Αρχαία Αγορά των Αθηνών
"Ρωτάμε.... όπως ο Σωκράτης"
Μουσική
Θεϊκό Ανθρώπινο
Παρουσιάσεις- Εκθέσεις
ΚΑΛΛΙΤΕΧΝΙΚΗ ΠΑΙΔΕΙΑ στην ΑΡΧΑΙΑ ΑΓΟΡΑ

Image 25: Art school new VE


ΚΑΛΛΙΤΕΧΝΙΚΟ
ΓΥΜΝΑΣΙΟ ΜΕ ΛΥΚΕΙΑΚΕΣ ΤΑΞΕΙΣ
HOME
STORIES
ABOUT
ΜΕ ΑΦΟΡΜΗ ΤΗΝ ΠΡΟΪΣΤΟΡΙΚΗ ΠΕΡΙΟ
ΜΕΛΕΤΗ ΤΟΥ ΧΩΡΟΥ ΤΗΣ ΑΡΧΑΙΑΣ ΑΓΟ
ΓΛΥΠΤΙΚΗ ΜΕ ΠΗΛΟ
ΣΥΝΔΕΣΗ ΣΤΟΙΧΕΙΩΝ ΑΠΟ ΤΗΝ ΑΡΧΑΙΑ
ΒΙΒΛΙΟΓΡΑΦΙΚΗ ΜΕΛΕΤΗ ΓΙΑ ΤΗ ΔΗΜΙΟ
...
Αρχαιότητα και Σύγχρονη Πραγματικότητα
VIEW MORE

<div>Θα μπορούσε ίσως η αλληλεπίδραση μεταξύ μαθητών ενός ανοικτού σχολείου και των πολιτών μιας πόλης να συνδέει τη θεωρία με την πράξη, αλλά και τους ανθρώπους μεταξύ τους; Μπορούμε να στοχεύουμε στην αειφόρο ανάπτυξη αν δεν ενεργοποιήσου...

Image 26: Art school new VE - Theme page


ΚΑΛΛΙΤΕΧΝΙΚΟ
ΓΥΜΝΑΣΙΟ ΜΕ ΛΥΚΕΙΑΚΕΣ ΤΑΞΕΙΣ
HOME
STORIES
ABOUT
ΜΕ ΑΦΟΡΜΉ ΤΗΝ ΠΡΟΪΣΤΟΡΙΚΗ ΠΕΡΊΟ
ΜΕΛΈΤΗ ΤΟΥ ΧΏΡΟΥ ΤΗΣ ΑΡΧΑΊΑΣ ΑΓΟ
ΓΛΥΠΤΙΚΉ ΜΕ ΠΗΛΌ
ΣΥΝΔΕΣΗ ΣΤΟΙΧΕΙΩΝ ΑΠΌ ΤΗΝ ΑΡΧΑΊΑ
ΒΙΒΛΙΟΓΡΑΦΙΚΉ ΜΕΛΈΤΗ ΓΙΑ ΤΗ ΔΗΜΙΟ
...
VIEW MORE

βραχογραφίες σχέδια

Το πρώτο επίπεδο μέσα από ένα καλειδοσκόπιο εικόνων αναφέρεται σε πρωταρχικές μορφές κοινωνίας.

Ζωγραφική και Χάραξη

Image 27: Art school new VE - Theme page 2

6. CONCLUSIONS

When developing a web application, it is difficult to stay up to date with the latest technologies. Using a new technology has risks. It needs to invest time for learning, it can lack documentation or ways to solve problems that are already solved with older technologies. In some cases, it can be unstable or even ephemeral. It is important to use proven technologies to reduce the risks. On the other hand, sticking to proven technologies may lead to missing better development solutions or technologies with better performance and features. An important factor while designing a new application is to have an overall understanding of the model and the requirements. The technologies used for the VE, could have worked better on a different model approach. The main problem is that the model, the service, and the way of rendering the results weren’t efficient when combined and as the requirements changed. The implementation of the new VE is focused on the from scratch analysis of the requirements and the creation of a model that best matches the way that the information will be requested and presented. In that direction the goal of this thesis is achieved. The weaknesses on the VE identified in **Section 2.7**, are overcome and the problems are resolved. More specifically, the new model doesn’t need transformation, the Service is able to serve small responses and serve the content gradually on user demand, providing low response time and better performance. The JSON format is directly readable from the Angular and has no overhead to transform it. The VE serves content on user demand, handles a lot of content, is scalable and provides fast responsiveness. Most importantly, the VE response time is independent of the exhibition size and the number of the items it contains, while in the old VE the load time increases as the number of items increase. That results to a new VE that has constant load time that complies with the range of the ideal waiting time of loading a web page. As the load time is constant, Cache is not required and the overall design of the new VE is mobile friendly, simple, clear and responsive.

TABLE OF TERMINOLOGY

Ξενόγλωσσος όρος	**Ελληνικός Όρος**
Virtual Exhibition	Εικονική έκθεση
Web Application	Διαδικτυακή Εφαρμογή
Scalable	Κλιμακώσιμος
Server	Διακομιστής
Client	Φυλλομετρητής
Scalability	Δυνατότητα κλιμάκωσης
Responsiveness	Ταχύτητα Ανταπόκρισης
Single Page Application	Μονοσέλιδη Εφαρμογή

ABBREVIATIONS - ACRONYMS

VE	Virtual Exhibition
XML	eXtensible Markup Language
ACID	atomicity, consistency, isolation, durability
XSLT	Extensible Stylesheet Language Transformations
HTML	Hyper Text Markup Language
PWA	progressive web application
SPA	Single Page Application
SSR	Server-Side Rendering
CSR	Client-Side Rendering
JS	JavaScript
JSON	JavaScript Object Notation
API	Application Programming Interface
HTTP	Hypertext Transfer Protocol
CSS	Cascading Style Sheets

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