This deliverable describes the problem statements and requirements related to the BLUE experiment, which focuses on providing enriched experience of museum’s visitors through context-aware recommendations based on their cognitive profile, driving their visits and allowing them to set-up and share their museums experiences on social networks. It also provides the model and description of the experimental setup, knowing the constraints of the FHW venue in which the experiment will be conducted, including the experiment’s different components, their characteristics and how they communicate. Finally, it includes a technical description of the software applications dedicated to the personalized museum visit that will be developed.
<table>
<thead>
<tr>
<th><strong>Project acronym</strong></th>
<th>EXPERIMEDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full title</strong></td>
<td>Experiments in live social and networked media experiences</td>
</tr>
<tr>
<td><strong>Grant agreement number</strong></td>
<td>287966</td>
</tr>
<tr>
<td><strong>Funding scheme</strong></td>
<td>Large-scale Integrating Project (IP)</td>
</tr>
<tr>
<td><strong>Work programme topic</strong></td>
<td>Objective ICT-2011.1.6 Future Internet Research and Experimentation (FIRE)</td>
</tr>
<tr>
<td><strong>Project start date</strong></td>
<td>2011-10-01</td>
</tr>
<tr>
<td><strong>Project duration</strong></td>
<td>36 months</td>
</tr>
<tr>
<td><strong>Activity 4</strong></td>
<td>Experimentation</td>
</tr>
<tr>
<td><strong>Work package 4.8</strong></td>
<td>EX8: BLUE</td>
</tr>
<tr>
<td><strong>Deliverable lead organisation</strong></td>
<td>Henri Tudor Public Research Centre</td>
</tr>
<tr>
<td><strong>Authors</strong></td>
<td>Ioanna Lykourentzou, Yannick Naudet, Eric Tobias (Henri Tudor Public Research Centre), Angeliki Antoniou, George Lepouras, Costas Vassilakis (University of Peloponnese)</td>
</tr>
<tr>
<td><strong>Reviewers</strong></td>
<td>Martín López Nores (UVIGO), Stefan Prettenhofer (Infonova)</td>
</tr>
<tr>
<td><strong>Version</strong></td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>Final</td>
</tr>
<tr>
<td><strong>Dissemination level</strong></td>
<td>PU: Public</td>
</tr>
<tr>
<td><strong>Due date</strong></td>
<td>PM16 (2013-01-31)</td>
</tr>
<tr>
<td><strong>Delivery date</strong></td>
<td>2013-02-05</td>
</tr>
</tbody>
</table>
Table of Contents

1. Executive summary ....................................................................................................................... 5
2. Introduction ...................................................................................................................................... 6
3. The EXPERIMEDIA-BLUE experiment .......................................................................................... 7
   3.1. Experiment objectives and relation to the main EXPERIMEDIA project .................................... 7
   3.2. Scientific background ............................................................................................................... 8
      3.2.1. Cognitive Style ....................................................................................................................... 8
      3.2.2. Visiting style ......................................................................................................................... 9
      3.2.3. Gaming for personality aspects deduction ............................................................................ 9
      3.2.4. Recommending systems .................................................................................................... 10
   3.3. Main project artefacts: Overview ............................................................................................. 11
   3.4. The experiment from the visitor’s point of view: A three-phase scenario ............................... 11
4. Experimental setup: existing infrastructure, restrictions and decisions taken ................................ 13
   4.1. The venue FHW ...................................................................................................................... 13
   4.2. EXPERIMEDIA Components ................................................................................................. 15
      4.2.1. Experiment Content Component ....................................................................................... 15
      4.2.2. Social Content Component ............................................................................................... 16
      4.2.3. Pervasive Content Component ......................................................................................... 16
   4.3. Decisions taken ....................................................................................................................... 16
5. Methodology ..................................................................................................................................... 18
   5.1. Value Impact Assessment (VIA) ............................................................................................... 18
      5.1.1. Quality of Service ................................................................................................................. 18
      5.1.2. Quality of Experience ........................................................................................................ 19
      5.1.3. Quality of Community ...................................................................................................... 20
   5.2. Privacy Impact Assessment (PIA) ............................................................................................ 20
      5.2.1. Doing good ........................................................................................................................ 21
      5.2.2. Doing no harm .................................................................................................................... 21
      5.2.3. Participants / Recruiting .................................................................................................... 21
      5.2.4. Informed consent ............................................................................................................... 21
      5.2.5. Confidentiality .................................................................................................................. 22
      5.2.6. Deception .......................................................................................................................... 22
      5.2.7. Withdrawal ....................................................................................................................... 22
      5.2.8. Data protection ................................................................................................................ 22
5.2.9. Limited duration........................................................................................................... 22
5.3. Checklists...................................................................................................................... 22
  5.3.1. Checklist for general ethical issues ........................................................................... 23
  5.3.2. Checklist for location data issues............................................................................ 24
  5.3.3. Checklist for profiling issues.................................................................................. 25
  5.3.4. Checklist for tracking issues .................................................................................. 25
  5.3.5. Checklist for consent issues ................................................................................... 25
  5.3.6. Checklist for anonymisation issues ........................................................................ 25
6. Experimental artefacts implementation: Technical Description ...................................... 27
  6.1. Facebook .................................................................................................................... 27
  6.2. My Museum Story application.................................................................................... 28
  6.2.1. Basic Requirements............................................................................................... 28
  6.2.2. Gameplay design requirements.............................................................................. 28
  6.3. Mobile Application's role and operations.................................................................... 31
  6.4. The Profile Manager’s role and operations................................................................. 32
  6.5. The Recommender's role and operations................................................................. 32
  6.5.1. User profiling......................................................................................................... 32
  6.5.2. Recommendations .............................................................................................. 33
  6.6. Server's role and operations...................................................................................... 34
  6.7. Database's role and operations................................................................................. 35
  6.8. Database schema and stored data............................................................................. 35
7. Use Cases ....................................................................................................................... 37
  7.1.1. Use Case 1: A guided visit through a museum...................................................... 38
  7.1.2. Use Case 2: Playfully discovering one’s cognitive profile .................................. 39
  7.1.3. Use Case 3: Establish a visitor profile................................................................. 40
  7.1.4. Use Case 4: Recommend an exhibition object..................................................... 41
8. Experiment evaluation................................................................................................. 42
  8.1.1. Baseline success ................................................................................................... 42
  8.1.2. Moderate success ............................................................................................... 42
  8.1.3. Success ................................................................................................................ 42
  8.1.4. Exceptional success ............................................................................................. 42
9. Risks .............................................................................................................................. 44
10. Conclusion.................................................................................................................... 46
11. References..................................................................................................................... 47
Appendix A. Detailed Use Cases ................................................................. 49
  A.1. Use Case 1: A guided visit through a museum ........................................ 49
  A.2. Use Case 2: Playfully discovering one's cognitive profile ......................... 51
  A.3. Use Case 3: Establish a user profile ..................................................... 52
  A.4. Use Case 4: Recommend an exhibition object ......................................... 53
1. Executive summary

This deliverable describes the problem statements and requirements related to the BLUE experiment, which focuses on providing enriched experience of museum’s visitors through context-aware recommendations based on their cognitive profile, driving their visits and allowing them to set-up and share their museums experiences on social networks.

After a short introduction on the idea, rationale and problem statement behind the BLUE experiment (Section 2), the latter is detailed in Section 3. The experiment objectives are presented, together with some scientific background related to the concepts exploited. An overview of the project’s artifacts is presented and finally a scenario illustrating the user experience is given. Section 4 presents the Foundation of the Hellenic World (FHW) venue, the components of the EXPERIMEDIA framework that are exploited, and the decisions taken regarding the constraints induced by the first and the functions and state of the second, relatively to the actual experimental setup of BLUE and its requirements. Section 5 is dedicated to the methodology related to the realization of the experiment, in relation to the Value Impact Assessment (VIA) and Privacy Impact Assessment (PIA) as described in deliverable D2.1.1. Section 6 goes into the details of the technical description of the IT architecture and experimental artifacts dedicated to the personalized museum visit. Principles and requirements are given, and their use is illustrated by the use cases in section 7. Section 8 discuss the experiment evaluation and conditions for success, while section 9 provides a list of risks associated to the realization of BLUE and how they can be managed. Section 10 concludes, giving the current development state and future work. Last, an appendix detailing the use-cases is provided.
2. Introduction

Museums are places that people visit for learning and entertainment purposes. What each visitor is interested in seeing varies and it can be related to a number of different factors (e.g. available time, personal interests, etc.).

A problem often faced by museum visitors is that, in the course of their visit, they may lose time viewing items that do not interest them and miss those that do, due to time restrictions, or perhaps the tiredness that inevitably occurs during the visit. In parallel, the audio/visual explanations provided to visitors regarding the exhibits, may not always be tailored to their specific cognitive preferences and available time, for example giving too few or too many details. Missing important exhibits, viewing items that the visitor is not so much interested and receiving not suitable exhibit explanations may significantly lower visitor experience.

This is also true in a multi-exhibition space like the Foundation of the Hellenic World that is hosting at the same time different exhibitions, as information provided to make a choice between the different exhibitions is not personalized to the visitor’s cognitive profile and interests and might not give him discriminatory elements to make a choice.

To tackle this issue, the BLUE experiment aims at investigating the use of people’s cognitive profiles and visiting style to personalize their museum’s visits through smart routing and recommendations, and the exploitation of social networks tools to obtain this profile while extending their experience within the museum towards the electronic world. This implies implementing and experiment a solution that would help visitors identify the exhibitions and items that match their interests the most and to provide them with explanatory material that is suited to their particular cognitive and learning needs. The idea developed here supports an adaptable smart recommender system that will suggest people which exhibitions they should see next, as they move from one museum room to another, based on the visitor's cognitive style, determined as such by a custom-made social network application. To enhance further this approach, the recommendation strategy can also take into account the visitor’s visiting style, which is highly correlated with the cognitive profile and can also give insights on the latter.

The expected outcome of the BLUE experiment is to both improve researchers' ability to match museum visitors to cognitive profiles and, most importantly, to improve user experience within the museum and beyond, through their life in electronic social networks.
3. The EXPERIMEDIA-BLUE experiment

As said in the introduction, the target of BLUE is to explore the use of visitors’ cognitive styles and content interest in order to personalize their experiences inside a museum. The BLUE experiment will be conducted at the Foundation of the Hellenic World’s privately owned cultural centre in Athens. Chosen as one of the three experimentation venues of the EXPERIMEDIA project, the Foundation of the Hellenic World is an ultramodern cultural Centre and museum, which fosters visitor experience through technology (e.g. through interactive exhibitions, virtual reality tours and educational programs).

Before and after a visit respectively, visitors will be able to setup their cognitive profile and preferences regarding things they like and their visiting style when in museums, and to share their visits experience with others through a custom-made social application, titled "My Personalized Museum Experience". During the visit, this application offers visitors smart routing recommendations on their mobile device for exhibitions and content to see, as well as personalized content descriptions based on their extracted cognitive profile and content preferences. Visitors can also mark favourite exhibitions and other museum-related data into their personal “Story Line”, which they can later on share with friends in their social networks.

While conducting the experiment, the behaviour of visitors when they use the “My Personalized Museum Experience” application and especially their reactions against recommendations will be recorded and analysed. After the visit, visitors fill in questionnaires related to their Quality of Experience (QoE), providing also direct feedback for the experiment.

We detail hereafter the experiment’s objectives, recalling how the experiment matches EXPERIMEDIA requirements. Then we provide the scientific background needed to understand the main concepts on which the BLUE approach relies, and an overview of the four artefacts to be developed for the experiment. Last, we detail a general scenario illustrating the user experience with BLUE.

3.1. Experiment objectives and relation to the main EXPERIMEDIA project

The BLUE experiment has two main objectives:

1. Develop a prototype of a social application for museum visitors, "My Personalized Museum Experience", combining a dedicated social-network application (“My Museum Story”) and an adaptable mobile recommending application (“My Museum Guide”), that will:
   a. Accompany visitors before, during, and after the museum visit; help identify their cognitive profile and visiting style. Furthermore, it can personalise their experience through the use of social network technology.
   b. Suggest certain exhibitions of interest to visitors and schedule their optimal visit route, based on individual cognitive styles and content preferences.
   c. Deliver for each exhibition of interest informative material adapted to the cognitive profile of the visitor.
2. Expand our current research regarding cognitive style extraction and its use for enriching user-targeted applications, as well as user routing and recommendations in the physical space of a museum.

In accordance with the requirements of EXPERIMEDIA first open call for experiments, EXPERIMEDIA BLUE is in line with the targets that EXPERIMEDIA has set for each of its experiments, conducting the experiment in one of the chosen venues, the Foundation of the Hellenic World, and exploiting the methodologies and IT platform provided by the project.

The experiment to be conducted in EXPERIMEDIA BLUE contributes to the vision of the FMI initiative for the “creation of perceptual congruity between real and virtual worlds” by creating a participative user experience. It is based on a two-way continuous interaction between real-world and online communities. Specifically, through its custom-made social application, it involves users in the museum and extracts data (cognitive profile, visiting style, and content-related preferences) that will be useful afterwards during their actual visit to the museum premises. From another perspective, the real-world community also interacts with the online one, by enabling of users to upload online their personal museum “Story Lines” (featuring exhibits that the users found interesting during their visit, as well as personal comments/notes to share with one’s friends) and share it with their social network circles. This way, data from the online community are used to improve user experience and data from the accomplished museum visit are used to spread user experiences, and motivate more users to visit the museum.

Finally, the experiment is expected to have a positive impact on both the main users of the FHW (i.e. the visitors), as well as on directly interested stakeholder (like museum curators, who, through the large-scale visitor movement observations that will be performed, can obtain valuable knowledge regarding highlight exhibitions or the optimal rearrangement of the exhibition).

3.2. Scientific background

Before going in the details of the experiment description, this section provides the scientific background required to understand the artefact manipulated in BLUE: cognitive and visiting style of persons, gaming concepts (which will be used in the “My Museum Story” application), and recommendation concepts.

3.2.1. Cognitive Style

Cognitive style is a person’s preference and habitual approach to the organization and representation of information[13]. Different researchers have described different aspects of cognitive style, the most common of which are field dependent-field independent [17, 18], impulsive-reflective [6], divergers-convergers [5], holist-serialists [9] and verbalizers-imagers [14]. Cognitive style is a research construct assisting the study of cognitive issues related to learning and it has been found to have a strong relation to the individual’s personality. It remains relatively constant over situation and time, or at least it is not that easily influenced by the different learning situations.

A widely used assessment tool for cognitive style is the Myers-Briggs Type Indicator [2]. The MBTI is based on Jung’s theory of psychological types and it uses self-reported questionnaires
and is based on Jung’s theory of psychological types. Participants are described using four dimensions: Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling, and Judging-Perceiving. The combination of the four dimensions provides 16 personality types, identified by the first letter of each dimension that they belong to (e.g. ESFJ means Extravert, Sensing, Feeling, Judging personality). Figure 1 summarizes the cognitive style dimensions from MBTI.

<table>
<thead>
<tr>
<th>Where a person focuses his or her attention</th>
<th>Extraversion (E)</th>
<th>Introversion (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People who prefer Extraversion tend to focus on the outer world of people and things</td>
<td>People who prefer Introversion tend to focus on the inner world of ideas and impressions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The way a person gathers information</th>
<th>Sensing (S)</th>
<th>Intuition (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People who prefer Sensing tend to focus on the present and on concrete information gained from their senses</td>
<td>People who prefer Intuition tend to focus on the future, with a view toward patterns and possibilities</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The way a person makes decisions</th>
<th>Thinking (T)</th>
<th>Feeling (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People who prefer Thinking tend to base their decisions primarily on logic and on objective analysis of cause and effect</td>
<td>People who prefer Feeling tend to base their decisions primarily on values and on subjective evaluation of person-centered concerns</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How a person deals with the outer world</th>
<th>Judging (J)</th>
<th>Perceiving (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People who prefer Judging tend to like a planned and organized approach to life and prefer to have things settled</td>
<td>People who prefer Perceiving tend to like a flexible and spontaneous approach to life and prefer to keep their options open</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Cognitive Style dimensions. From [http://redpillpolitics.wordpress.com/](http://redpillpolitics.wordpress.com/)

### 3.2.2. Visiting style

According to visiting style literature, there are four main types of user movement inside a museum, described by animal metaphors [12]. Ant visitors move linearly, visiting almost all exhibits, showing interest in the detail, avoiding empty spaces and following a clear path and the curator’s suggestions. Fish visitors move in the centre of rooms, seeking to see the “larger” picture, not approaching most exhibits and not stopping very frequently. Butterfly visitors move nonlinearly, they do not follow the curator’s suggestions, they often change the direction of their movement, approach exhibits, are interested in the detail and are affected by environmental affordances (the accessibility of the exhibit, the visitor traffic etc.) [7]. Finally, Grasshopper visitors are persons of particular interests, they only approach certain exhibits, cross empty spaces and spend a significant amount of time in front of items of interest.

### 3.2.3. Gaming for personality aspects deduction

Games have proven to be efficient tools outside the pure entertainment domain and have been used for different purposes as education and learning, health (therapy, re-education). The most known deviated uses of games are probably serious games [21] and games with purpose [22]. But additionally to support learning (serious games) or the solving of complex task (games with
purpose), games can also provide information on players and their psychological and cognitive profile. The literature on the subject of extracting a user's cognitive style from gaming is very limited and in fact to the best knowledge of the authors this is a novel approach. In this subsection we explain briefly how certain game elements or user behaviours could be indicators of cognitive profile, based on indications provided by general psychology literature.

First, the user's preference for collaboration, inside and outside of a game, can be extracted by her game preference, i.e. whether user selects multitasking or single tasking game, whether she opts for collaborative games as well as for those that require communication.

Moreover, using the fact that stereotypes and stereotypical images can provide useful information about the personality of the user [19], gaming concepts such as avatars, tools and pets with different abilities and characteristics can be used to identify the gamer's personality traits. For example dog avatars may represent friendship inclination, cats a more egocentric personality, owls to function as symbols of wisdom etc. Similarly stereotypical views of item symbolisms can also be used (i.e. a heart represents love, a clock represents punctuality, a disco ball represents parties and fun, etc.) to reveal additional personality characteristics.

Gestalt images [20] can also be used, since the perceived viewing angle adopted by the player could provide information about the Sensing-Intuition cognitive style dimension, while additional gameplay features such as the choice of background music, the customization of avatars according to fashion style but also the organization and decoration of the games virtual spaces can all be extremely useful in mapping personality traits such as cognitive and visiting style to the specific player. All the above represent experimental hypotheses, to be tested within the framework of EXPERIMEDIA BLUE.

3.2.4. Recommending systems

Coming from the rather old research fields of information retrieval and information filtering, recommender systems have emerged to help users facing the overload of data they face in today’s communication networks and more specifically the Web. Burke [3] described the goal of recommender systems as guiding the user in a personalized manner to interesting items within large space of possible option. For Deshpande and Karypis [4], a recommender system is as a personalized information filtering technology, used to either predict whether a particular user will like a particular item, or to identify a set of items that will be of interest to a certain user. According to Schafer and colleagues [15], recommender systems are systems that provide users with an ordered list of items and information that help them to decide which items to consider or look at based on the individual user preferences. On the same line, Porcel [11] describes that recommender systems help online users in the effective identification of items suiting their wishes, needs or preferences. They have the effect of guiding the user in a personalized way to relevant or useful objects in a large space of possible options.

Generally, whatever the definition taken, a recommender system aims at providing personalized suggestions about items, actions or content considered of interest to the user [12]. Different approaches exist taking into account either the user own interests (content-based filtering or recommendation), or the neighbourhood of content or users (collaborative filtering based on
content consumption in a community of users, through content or users similarity computations). For a few years now, some well-known e-commerce web sites propose such recommendations with good success factors, based on record of user actions, user ratings, or correlations between different users or consumed content.

3.3. Main project artefacts: Overview

Four IT artefacts will be developed for the needs of the experiment, all together constituting the “My Personalized Museum Experience” bundle that supports the BLUE experiment:

i) The “My Museum Story” social application, used to extract the cognitive profile of the user, as well as his/her preferences related to the content of museum’s exhibitions and his/her visiting style when in museums. The main part of this application is a game, from which the user’s behaviour will be profiled. The application can also be used to create the visitor’s personal museum “Story Line” (by adding to it the exhibits that the user finds interesting during the visit) and at the end of the visit, in order to publish the created “Story Lines” online.

ii) The “Movement tracker”, which tracks the movement of users, as they walk inside the museum.

iii) The “Recommending engine” which makes routing and exhibitions/exhibits recommendations to the users, based on their content and cognitive profiles (extracted from profiling data provided by the “My Museum Story” application). Due to the ticketing policy restrictions applied in the Foundation of the Hellenic World (i.e. a ticket purchase determines a priori the visitors’ access to a specific number of exhibitions), the recommendation engine offers recommendations at exhibition level, rather than at individual exhibit level.

iv) The “Personalized exhibition descriptor”, which provides personalized exhibition descriptions to the visitors, based on their cognitive profiles. The algorithm offering personalized descriptions of exhibitions can be applied to offering personalized descriptions of individual exhibits.

The “My Museum Story” social application is provided as a web-based application, which is made for use preferably with Facebook, but can be used on standalone, and the remaining three artefacts (movement tracker, recommending engine and personalized exhibition descriptor) are provided to the users through a mobile application, named “My Museum Guide”, that they use during their visit in the museum.

3.4. The experiment from the visitor’s point of view: A three-phase scenario

Below we briefly describe the experiment from the visitor’s point-of-view. It takes place in three phases:

1. Phase 1 - Before the visit. During the first stage, visitors can play the game of “My Museum Story”. The application will be available through Facebook or, after registration, as a simple web application for those users that do not have a Facebook account. The application will have as a goal to extract the cognitive profile of the user, her content interests in regards to the museum exhibitions, as well as her perceived visiting style, through a series of casual games. The application will also allow users to check their cognitive profile also through the MBTI questionnaire.
2. **Phase 2 – During the visit.** At the second stage, visitors are in the physical space of the museum. Here, they will use a mobile device, provided by the experiment, which runs the “My Museum Guide” application, in order to navigate inside the museum. The mobile application allows them to log into “My Museum Story” (using either Facebook or their registration details in case they used the simple web application) and retrieve their cognitive profile and content interests. Using these, as well as some additional initialization data (e.g. “how much time do you plan to spend inside the museum?”) the mobile application then recommends an itinerary to the visitor: This itinerary which consists of different exhibitions and timeframes, according to the content interests and time restrictions that the visitor has. In addition, the mobile application provides the visitor with information about the exhibition that she is about to see, or gets close to, based on her retrieved cognitive profile. The application also allows the visitor to “keep” a digitalized version of her experiences inside the museum, by assembling images and keeping digital notes about the visited exhibitions. The data gathered by the visitor during her visit altogether formulate the visitor’s museum “Story Line”, which at the end of the visit she can post on Facebook and share it with her social circle.

3. **Phase 3 – After the visit.** At the end of her visit, the visitor is asked to fill in a user satisfaction questionnaire. She can, as also stated above, share her experiences (her personal museum “Story Line”) in Facebook through a social functionality that the mobile application provides. Finally, if deemed necessary (since respondents will be mobile and may not be easy for them to fill-in a questionnaire) the visitor might be asked to participate, if she wishes, to a structured interview to measure the quality of her gained experience.
4. Experimental setup: existing infrastructure, restrictions and decisions taken

In the previous section we presented an overview of the BLUE experiment and of the main artefacts that will be developed for its execution. In this section we present the experimental setup, i.e. the infrastructure available to the consortium for the experimentation, the constraints that exist and the subsequent decisions taken to ensure a successful experiment design and implementation.

4.1. The venue FHW

The Foundation of the Hellenic World (FHW)\(^1\) is a high technology, user experience-oriented museum, situated in Athens, Greece and is one of the three experimentation venues of the EXPERIMEDIA project.

Exhibitions

The venue of FHW hosts a number of exhibitions and activities, either long-lived (the “Is there an Answer to Everything? A journey to the world of Greek mathematics” exhibition runs for more than 10 years) or short-lived (temporary exhibitions lasting for about 6-10 months, like for example the exhibition on the life and work of Kazantzakis). In addition to the exhibitions, the FHW has two Virtual Reality halls: “Tholos”/“Dome” and “Kivotos”/“Arc”. Both offer virtual reality installations but have different hosting and timing capacities (“Dome”: up to 131 people, fixed hours of shows, “Arc”: ~ 1-20 persons, on-demand installation projections). Finally, at the same time with the BLUE experiment, another EXPERIMEDIA experiment, namely REENACT, will take place at the premises of FHW.

Ticketing policy

A ticket must be purchased before accessing the exhibitions/activities. A distinct ticket is issued for each exhibition/activity, but a day pass is also available giving entrance to one show at the "Dome", one show at the "Arc", to the permanent exhibition on Greek mathematics "Is there an Answer to Everything? A journey to the world of Greek mathematics" and to the temporary exhibition on Kazantzakis, "Nikos Kazantzakis: 130 years since his birth".

The partners of the EXPERIMEDIA BLUE project visited the FHW venue twice, on the 19/11/2012 and on the 04/01/2013 to analyse the capabilities and constraints of the venue in regards to the experiment. The results of these visits showed that, the EXPERIMEDIABLUE experiment should be conducted, subject to the following restrictions:

- **No modification of exhibits**: the physical exhibits should not be modified or altered in any way.

\(^1\)http://www.fhw.gr
- **No adaptation of pricing or ticketing policy**: the ticketing policy cannot be changed to allow for more flexibility, e.g. viewing only certain exhibits from different collections for the price of one ticket. This constraint, combined with the typically small number of exhibits that each exhibition has (1 for Dome and Cave, and up to 20-30 for permanent or short exhibitions -once a ticket has been paid for, the visitor is bound to view all of them) reduces the applicability of item-level recommendations, which was initially thought; on the contrary, making suggestions at exhibition level appears to be a prominent approach, especially for people opting for a day pass, as also verified after discussions with museum staff and curators.

- **Fixed schedule for some exhibits**: some exhibitions, mostly the “Dome” and secondly the "Arc" (Arc) have a fixed schedule, which the visitors must follow. This leads to the requirement that in case a user has bought a ticket for either of the two, the application should build the personalized itinerary of that visitor around the fixed timeframe of the selected installation.

- **No long-time plans for exhibits**: Most of the exhibits are short-lived, rendering inexpedient the development of exhibit-specific content to match the different cognitive profiles and learning styles. Furthermore exhibits of the permanent exhibition are of "hands-on" nature ("re-create Archimedes Displacement "Eureka!" Experiment") making inappropriate the creation of different contents. This is another factor leading to the adoption of adaptivity and recommendations at exhibition level.

- **Minimum/maximum number of participants for some exhibits**: Some exhibitions have a minimum number of participants for the exhibition to commence, while some other exhibitions have a maximum attendance capacity. These parameters could be taken into account when suggesting an exhibition for visiting, e.g. do not suggest an exhibition whose full capacity has been booked or group together visitors and route them towards the same VR projection.

- **Wireless Infrastructure**: Installing wireless network hot-spots, to enable us to use the WIFI-triangularisation technology for indoor user localisation, is feasible with the help of the technical staff. To better define the exact technical requirements in terms of WIFI coverage, researchers have measured the dimensions and obstacles in every exhibition room.

- **QR Codes**: QR codes cannot be used, as their use is considered alteration of the museum’s exhibition, something that is not allowed according to the museum’s policy also mentioned above.

Under this light we find one main difference between the requirements of the submitted proposal and those of the current proposed approach. In specific, the nature and content of the museum’s exhibitions (very few, often just one item per exhibition – for example one VR projection) make the initial idea of making recommendations at the level of exhibits (and subsequently the use of visiting style) inappropriate. Nevertheless, the very large spaces in between and the different thematic scopes of the exhibitions allow us to use the original project’s...
idea, but revised to the exhibition rather than exhibit level. Thus, instead of focussing on one museum exhibition and making recommendations at the level of its exhibits, we will work with multiple exhibitions, at exhibition level. Subsequently, the visitor's cognitive style extracted through the web-based application, will be used to offer personalised descriptions regarding the exhibitions' content, while routing advice will also be offered to visitors according to time and group size restrictions. As an additional functionality, we will benefit from the museum's open spaces to engage visitors in the social network aspect of the experiment. To this end we plan to allow visitors using the social network application to leave messages to friends as they walk from one exhibition to the other, which will be then displayed and discovered by their friends when the latter visit the museum (and use the mobile application) themselves.

The above direction in the implementation of the experiment was adopted after discussions with FHW, as an alternative, more feasible means of improving user experience that respects the museum’s own policies and nature. Apart from this difference the experiment retains its original basic directions. A web application will be employed to extract cognitive style and content preferences. In the museum, indoor localisation will be used to locate the visitors' position and send appropriate recommendations. After the visit the visitors will be able to upload their personalised visit timeline and items to Facebook, posting it on their wall.

4.2. EXPERIMEDIA Components

The BLUE experiment is based on two software components available through the main EXPERIMEDIA project as described in D2.2.1 EXPERIMEDIA Baseline Components v1.01. In the following we describe their use and adaptation for the targets of the experiment. Furthermore, we also justify the technological restrictions that render inappropriate the use of a third component, as well as its replacement by another better fit for the project’s implementation technology.

4.2.1. Experiment Content Component

The ECC is the component that gives coherence to the overall collection of components provided by EXPERIMEDIA, and is responsible for monitoring and managing all EXPERIMEDIA software.

From ECC, two sub-components are used, the: i) Experiment Monitoring (EM) and ii) Experiment Data Managing (EDM). To loosely quote the above-mentioned document, their role is the following: i) “The EM caters to the monitoring of both, the experimental resource status and metrics generated by resources managed by the EM. It queries components deployed by the EDM for metric generating capabilities and gathers that data at run-time.” and ii) “The EDM manages the access and persistence of metric data collected by the EM. Storage of this data is allocated on a per-experiment basis and metrics can be accessed within a time-frame for subsequent analysis.”

BLUE considers multiple museum visits, from one or different visitors, as one experiment. Hence, the structure offered by the ECC is insufficient at the moment as it does not allow for a dynamic addition or removal of subjects (i.e. visitors). Modifications to the ECC have been
proposed and our requirements stated. We expect that the new version allows us to conduct one experiment over a longer period of time with multiple test subjects.

4.2.2. Social Content Component
The role of the Social Content Component is to provide easy integration with social network services while operating transparently for experiment participants.

The sub-component of Social Content Component (SCC) that will be used in BLUE is the Social Integrator (SI). The SI provides, by wrapping the SocialAuth library, facilities to log users into social media. In BLUE we only provide the possibility to log into Facebook. The token received as a result of the login process can then be used to retrieve data about the use, permissions given, and enable the user to interact with the social medium through our application.

From the SI only the authentication facilities and not the server-side monitoring facilities are used, since the “My Museum Story” developed for BLUE does not require the continuous monitoring of any social application but instead communicates only with the involved player. Furthermore, the sample application of the SCC did not provide enough insight into the secure handling of the token and, hence, leaves us with unresolved problems in terms of data protection and security. It is, therefore, preferable to keep the token in one place and access user information solely through the application that acquired the token.

4.2.3. Pervasive Content Component
The Pervasive Content Component (PCC) was intended to be used as a means to locate the indoor position of users, inside the physical space of the museum. However, upon investigation of the possibilities provided by the component, its functionality is based on the GPS technology, which is not suitable for indoor localization. Therefore, the use of this component is abandoned. In its place BLUE will use a technology (already foreseen as alternative to the PCC from the proposal elicitation) of WIFI triangularisation that allows an accurate, for the purposes of the experiment, identification of the indoor position of users. The technology is already in place and has been developed by CRP Henri Tudor.

4.3. Decisions taken
Based on the above, a summary of the decisions taken regarding the project implementation follows:

<table>
<thead>
<tr>
<th>Facts/Restrictions</th>
<th>Type of restriction</th>
<th>Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>FHW has exhibitions rather than exhibits</td>
<td>Venue policy</td>
<td>We will work on exhibition level.</td>
</tr>
<tr>
<td>Facts/Restrictions</td>
<td>Type of restriction</td>
<td>Decisions</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Some exhibitions are short-lived, i.e. they will not last for the whole duration of the experiment.</td>
<td>Venue policy</td>
<td>During the experiment, we will use the Greek mathematics as a permanent exhibition and the Dome and Arc (with the different VR projections regarded as distinct exhibitions). We will also try to include temporary exhibitions (for example Kazantzakis exhibition if still running) and finally to use also the REENACT experiment as an Augmented Reality exhibition.</td>
</tr>
<tr>
<td>Ticketing policy</td>
<td>Venue policy</td>
<td>We will restrict user routing only to exhibitions available to the visitor</td>
</tr>
<tr>
<td>Large empty spaces in museum/between exhibitions</td>
<td>Venue structure</td>
<td>Opportunity for delivering: Exhibition content descriptions to users (enough time, as they walk from one exhibition to the other) Engaging user to social network activities (e.g. send messages to friends through FB in specific locations)</td>
</tr>
<tr>
<td>Some exhibitions have fixed schedule (e.g. dome) others more flexible</td>
<td>Venue policy</td>
<td>Additional restriction in optimizing user routing for fixed-schedule exhibitions. Opportunity for optimizing user routing on the other hand (e.g. gather enough people for REENACT’s exhibition, see EXPERIMEDIA deliverable D4.9.1, or for Cave)</td>
</tr>
<tr>
<td>Exhibitions cannot be in any way altered</td>
<td>Venue policy/Technological</td>
<td>We will not alter in any way the exhibitions, and will not install QR codes in them.</td>
</tr>
<tr>
<td>It is possible to install wireless hotspots</td>
<td>Venue/Technological</td>
<td>We measured the needs (dimensions, physical obstacles) of each physical space in the museum that has to be covered and can install the necessary equipment, together with the museum’s technical staff.</td>
</tr>
<tr>
<td>The ECC component considers each visit as one experiment</td>
<td>Technological</td>
<td>Communicate the needs of the BLUE experiment (to view multiple visits as one single experiment) to the ECC developing team.</td>
</tr>
<tr>
<td>The SCC component (SI part) entails some unresolved problems in terms of data protection and security</td>
<td>Technological</td>
<td>Use the authentication facilities of the SI, not the server-side monitoring. Keep the user authentication token in one place and access user information solely through the application that acquired it.</td>
</tr>
<tr>
<td>The PCC component works only outdoors (GPS technology)</td>
<td>Technological</td>
<td>Will work with WIFI triangulation technique already developed by the CRP Henri Tudor, to achieve the indoor user localization.</td>
</tr>
</tbody>
</table>
5. Methodology

5.1. Value Impact Assessment (VIA)
As a scientific-oriented experiment, BLUE is mainly concerned with phase one and two of the EXPERIMEDIA’s VIA framework, i.e. the “Value Opportunity Assessment” and the “Value Opportunity Validation and Macro Modelling” phases (see. Deliverable D2.1.1). Phase three (Industrialisation Assessment), will be the subject of further investigations after the EXPERIMEDIA project.

5.1.1. Quality of Service
For BLUE, the following Quality of Service (QoS) related concerns have been identified. However they will be considered only as variables to monitor because they can impact the quality of experience. Since those concerns are related to the hardware requirements rather than to the experiment itself, it was chosen to neglect, for the first iteration of the experiments at least, the implementation of a dedicated ECC client to monitor QoS. Depending on first user’s feedbacks, such a client might be implemented for next experiment rounds.

- **Responsiveness of the mobile application.** While it is impractical to put hard metrics on the factor of responsiveness, it can easily be determined by testing the application or a prototype thereof. The reason is that the responsiveness on Android devices does not only rely on the computing power but also on open background tasks, services, and the carefulness of the software developer when it comes to correctly threading processing power heavy tasks.

- **WIFI throughput, bandwidth.** The throughput and bandwidth of the WIFI installed in the FHW is one of the main bottlenecks in the network architecture and must be able to cope with the load induced by the My Museum Experience. At this stage it is not yet possible to give concrete data but care will be taken to document any requirements and allowances. We assume that we are not able to measure peak values for bandwidth or throughput and can only measure response times.

- **Load handling.** In line with the previous point, the wired network infrastructure and server must be able to cope with the load induced by the experiment. Ideally, we would like to measure the load on the server but this seems to have to be done outside of the monitoring parameters of the ECC. We are not sure that implementing another ECC client to monitor server-side parameters is feasible.

- **Location tracking performance.** Indoor location tracking will be realised with a resolution of <10m at worst and a position refresh time of 5 seconds. These are, however, dependent on the access point coverage and thereby the infrastructure of the FHW. The parameters are given for an architecture composed of at least three access points. Installation of the WIFI access points at FHW as well as calibration of the tracking system will be done on site, to ensure a best possible resolution regarding the FHW infrastructure. The accuracy
will be gauged by the final survey which will include questions to cover possible inconsistencies in regard to location tracking.

- **Battery consumption on mobile devices.** The battery consumption must be low enough to enable visitors to complete a complete visit of the museum. However, since draining the phones completely is not an option, we will limit the maximum battery consumption to 50% on the target device. With a complete visit taking several hours, this should be acceptable. The measure will be noted on the final survey in the form of a range. Alternatively, depending on the hardware accessibility, the battery consumption can also be read automatically and fed to the ECC.

- **Recommendation engine responsiveness.** Recommendations need to be provided in near-real-time. A preliminary design of the recommendation engine shows us that profiles and recommendations can be generated in either less than a second without a full semantic engine or in less than 10 seconds using a full semantic engine. This load is an estimate for one visitor. To cope with the load, the server might need to dispatch multiple recommender engines. However, it is yet unsure how locks on data will impact the QoS. Individual response times can be measured in the case where recommendations are actively pulled by the My Museum Guide. In the alternative case, only server side measures are available.

### 5.1.2. Quality of Experience

Knowing that Quality of Experience (QoE) is the focus of BLUE, it will be evaluated on the following basis:

- **Preparation for experiment efficiency.** Visitors need to be given adequate explanations on the nature of the experiment and its targets. Online this will be done through one or more initial explanatory screens of the web application. On-site a person from the research group or provided by the museum will be available to familiarize users with the experiment and the use of the mobile device. To measure this aspect, the number of visitors handled versus the total number of visitors using the application (and requesting help) will be recorded, as well as their responses to the final questionnaire given at the end of the visit, in regards to the efficiency of the provided help.

- **User Interface friendliness.** Both the web-based and the mobile device need to be accessible and simple to use. Examples: the web-based application needs to respect basic accessibility guidelines, the mobile device is expected to enable visitors to easily generate a visit timeline and automatically post it, with all pictures and comments, etc. To gauge user friendliness, the final survey will elicit points to be rated by the users. Together with statistics on functionality usage, an accurate picture of the interface’s friendliness should be possible.

- **Recommendations accuracy.** The accuracy of the cognitive and content-based profiling of the user, as well as the accuracy of the recommended routing to the actual needs of the

---

2See for example the W3C Accessibility Standards: [http://www.w3.org/standards/webdesign/accessibility](http://www.w3.org/standards/webdesign/accessibility)
visitor during the visit are important. Recommendation accuracy can be measured implicitly, e.g. by comparing the actual exhibitions visited, and times selected to do so, with the predicted and suggested ones. Another means of measuring recommendation accuracy is explicitly, through comparing the answers of visitors to the questionnaires given after the visit, to the foreseen and suggested routing and recommendations.

- **Final survey.** A survey, by the means of a questionnaire, will be given to the visitors (if they choose to participate) at the end of the visit, to judge their satisfaction of the whole experiment, measure explicitly the above-mentioned criteria, as well as additional QoE factors such as responsiveness. Questions will target in particular knowing if users have liked the gaming approach and if they find it useful and funny to extend their museum experience, the usefulness of recommendations, the pertinence of suggested visit paths and of exhibitions personalised descriptions. Through this, we expect to capture the aspects of their visit that cannot be measured implicitly through the My Museum Guide and My Museum Story applications.

### 5.1.3. Quality of Community

The Quality of Community (QoC) aspects that will be measured by BLUE are the following:

- The "My Museum Experience" will measure how much the user will interact with community features. Examples: Will the user disseminate the experiment using Facebook either by logging in the "My Museum Guide" or "My Museum Story" applications? Does she recommend or express her sentiment (like, unlike) about these applications to her social circle? If so, how much (with like only, additional comments, etc)? Does she share her visit timeline and does she leave messages for friends to find in the museum? All these questions will be captured.

- A relevant section will be added to the final, after-visit survey regarding the intent of the user to disseminate her experience to their social circle.

### 5.2. Privacy Impact Assessment (PIA)

The experiment requires that user data be stored for an extended time period in order to realize the experiment. Furthermore, the collected data may be connected to a social media user profiles and as such they will require special attention. It is of uttermost importance that data is not mishandled and that the user has complete access and retains the rights to his personal data. To ensure this, some simple rules, stated below, need to be observed.

These guidelines will be under the scrutiny of EXPERIMEDIA’s Ethics Advisory Board (EAB) and Data Protection Board (EPB). Additionally, the experiment will comply with the guidelines laid out for the FHW as well as the European Directive 95/46/EC. The national bodies on data protection, the “Commission Nationale pour la Protection des Données” of Luxembourg (CNPD), and the “Hellenic Data Protection Authority” (DPA), will be contacted and made aware of collected and used data as soon as a complete list of all to be collected data has been established. Their recommendations will be followed as will any restrictions imposed by them.
5.2.1. Doing good
The experiment aims to enhance the user’s experience during his visit to the FHW venue. As such, we expect an improvement of the overall quality of his visit. Several aspects of the user experience will be thus addressed in terms of space, time, and content accessibility. The experiment aims to capture visitors' response in both qualitative and quantitative terms. It will help assess the usability and effectiveness of the proposed application in relation to the visitors' experience. Furthermore, in terms of research progress, the experiment aims to improve the understanding related to recommendation engines, the extraction of cognitive style from gaming applications and the effectiveness of user routing, based on their available spatiotemporal constraints.

5.2.2. Doing no harm
The experiment does not directly interact with users. It recommends museum visits and establishes a cognitive profile. We do not consider that any harm can come from a broad, top-level, cognitive profiling. Users should be unconsciously aware of their profile either way. The recommended routes in the museum do not have to be followed and recommendations can be ignored. Therefore, at most, users will not use the system if it does not work for them.

5.2.3. Participants / Recruiting
The participants of the experiment are individual adults, visitors or the museum. At the current requirements stage, the experiment will be limited to those visitors who borrow one of the experiment's mobile devices, with the prospect to potentially allow visitors to download the application. The initial recruitment of participants will start with students of the UOP, who will be invited to participate, with the incentive of being accustomed with a current research effort, as well as with the opportunity to participate afterwards in a special lecture explaining the research behind their museum experience (and aspects such as recommender systems, indoor localization, cognitive style and its extraction from gaming, etc). In addition, we will potentially have one person, from the museum on-site in order to recruit, publicize and explain the experiment to the potential participants, as well as to check the mobile devices after each visit's end. Furthermore, given the high participation that the museum has, and its technological-oriented character (most visitors of this museum are interested in new technologies) we expect to face no problems in ensuring the participation of additional individuals. Finally, after discussions with the research team behind the REENACT experiment (the second experiment taking place at the same time with BLUE at the premises of FHW), participants of the BLUE experiment will be "shared", i.e. they will have the chance to participate, and if they select so they will also be given routing suggestions, with the REENACT experiment.

5.2.4. Informed consent
Before any data will be collected, the user is confronted with a dialogue that will present the experiment to him. The description will be very brief but should enable the user to see why his data is necessary and how it will be used. The user can choose to give his consent and continue or not to give his consent. In the latter case, using the applications and participating in the experiment will not be possible.
5.2.5. Confidentiality
User data will only be collected during the experiment and will only be accessible by the experimenter or technical staff related to the experimenter’s infrastructure. No third party will be permitted access to the data.

5.2.6. Deception
The experimenter commits to not mislead the user. The description of the experiment will be given as best as possible and the full public description will be accessible by the user. User data will not be kept beyond what is specified in this document or what the user desires.

5.2.7. Withdrawal
The visitor can withdraw his consent by quitting the main application and choosing to delete all data tied to his identity. In that case, the data set will be fully anonymised.

5.2.8. Data protection
Data will be stored in a database which is to be protected from intrusion using all necessary measures to ensure that the data and thereby the privacy of users is protected. Communication between the different applications and the database will be secured with standard measures respectively those provided by EXPERIMEDIA components.

5.2.9. Limited duration
User data will be stored for a fixed period only. All user related data will be deleted at most two months after the end of the experiment. Derived data that is essential for the scientific basis of the results will, however, be kept in a derived form, be it as graphs in publications or other documents. This data can for obvious reason not be deleted.

5.3. Checklists
This section reports the checklists regarding ethical issues as asked initially for the purposes of Deliverable D5.1.4 1st Open Call Ethics Review Report. The question catalogue was slightly modified, taking into account the constraints imposed by the FHW and the decisions taken as a result of the constraints. Before going into the details, we recall here the principles of data collection adopted for the BLUE experiment.

Data is collected for non-commercial purposes only. The goal of collecting user specific data is to determine his preferences and interests. As such, the collected data is highly personalised and private. However, all private data has been directly filled by the user and marked as being publicly accessible. The data is used to infer domain specific preferences and use a recommender to enhance the visitor’s quality of experience. To ensure that goal, data will be collected during the experiment as well and cater to his location or items he actively interacts with. The principle of data minimisation will be applied as best as can but it is yet unknown what data needs to be collected in order to improve recommendations. Hence, the data sets may be refined during the project.
5.3.1. Checklist for general ethical issues

- **What are the key values behind the service/application?** The approach proposed in this experiment will:
  - Try to defer the user’s cognitive profile as well as his/her preferences related to the content of the exhibitions, by means of a social application (Facebook). The application can also be used to create the visitor’s personal museum and publish it on the Facebook.
  - Make personalised recommendations to the users for museum exhibitions, things to see, and visit paths, based on their preferences and cognitive profiles.

- **What are the conditions for participating?** BLUE will allow any adult that is able to use a mobile device, compliant with the hardware requirements of BLUE, to participate. Those with a Facebook account may also use the social application on Facebook. Furthermore, participants will need to have purchased the rights to enter the museum and attend the exhibitions.

- **Where will the data be located?** Any experimental data will be stored in a database hosted by a server in Greece, either at the University of Peloponnese or directly at the FHW. Data may be temporarily transferred to Luxembourg to enable data processing. However, no data, other than the results of the processing, will be stored in Luxembourg.

- **What is the content of the processing of data?** The user’s profile will be stored. It comprises in particular the cognitive profile that will be determined through the use of an appropriately designed game, corresponding to the use of a MBTI questionnaire, as well as interests and preferences regarding museums. User movement will be recorded by means of a mobile application. Recommendations that are made will also be stored along with what recommendations were followed. Users will be able to compose a timeline of their museum visit and enrich it with artefacts such as photos and comments. The visit will be locally and temporarily stored on the mobile device before being, if the user chooses, committed to his Facebook wall. Metadata about the visit will be stored on the server such as number of visited items, pictures taken and comments made.

- **What is the purpose of the processing of the data?** The purpose is to establish user’s cognitive profile as well as preferences and visiting habits regarding museums, in order to provide recommendations to users. Other data processing has the purpose of judging Quality of Experience and the overall quality of the experiment.

- **What is the data lifetime?** Social application data (as preferences, game points, etc) will be kept through the whole duration of a game. Other data such as user movements, user interests and preferences will be kept during the experiment lifetime. User-related data will be kept at most two month after the end of the experiment. After that time, all data will be anonymised or deleted. Derived data will be kept probably indefinitely to keep track and validate results.

- **How is the informed consent obtained?** All participants will be presented with a privacy statement and can choose to give their consent. It is not possible to use the application and participate in the experiment without giving the consent. Prior to installing the social application or using the mobile application users will be informed of the data being captured and their consent will be asked. The movement tracking consent
inside the museum will be explicitly solicited through the mobile application before the beginning of its use.

- **Must the consent be written or not?** No. The users give their consent, or choose not to do so, by using buttons. The consent can only be given by explicit action. Inaction will not lead to any consent. Since interaction with the users is done through the applications, any consent given will be in electronic format.

- **Who are the participants of the experiment?** Participants of the experiment will be adult volunteers who are visiting the FHW, mainly voluntary students, professors, researchers and other staff of the University of the Peloponnese, preferably having a Facebook account (this condition is however not mandatory).

### 5.3.2. Checklist for location data issues

- **Is it necessary to store the personal data?** At least temporary, yes. It would otherwise not be possible to identify users in between uses of the application. As the goal is to establish pinpoint recommendations, knowledge about the user is required.

- **When should the data be stored?** Data will be stored prior to the user’s visit to the museum to establish a profile. During the visit, data will be stored that will enable us to evaluate the visit and the recommendations given as well as determine the quality of experience.

- **Does the user have any choice?** Yes. The user can choose not to participate, not to record any preferences, or withdraw his consent.

- **Can the consent be withdrawn?** Yes. The user can at any point uninstall the applications.

- **Will the data be erased after use? Or after a certain period?** The data will be stored a maximum of two month after the experiment concludes after which it will be anonymised or destroyed. By uninstalling the applications or on user demand, all related data will be deleted.

- **Is it possible for the user to opt-out for one day or is such an opt-out a permanent choice? And in the former case, how long will you keep the information when the server is switched off?** The user can choose to opt-out but at that point, if he chooses to anonymise his data, he will not be able to opt-in again and benefit of all features unless he aids in re-establishing his profile. Once the user uninstalls the applications, all personal data kept on the server will be deleted. Data (such as exhibit preferences) published by the user (through the application) on her Facebook wall cannot be automatically deleted by the application.

- **Is it possible for the user to change its pseudonym on a daily basis?** BLUE does not use pseudonyms but the ID given to users by Facebook. This ID is stable and will not change.

- **Who can access the data?** The members of the experimenters’ research group and more generally a server administrator.

- **Is there an admin log for every data file? Who can change these logs? Who can access them and who can delete them?** There will be admin logs for every data file. Only administrators can access, change or delete the logs.

- **For what time period are the data stored?** As noted above, the data will be stored for at most the duration of the experiment plus two month. Anonymised data will be kept.
• Can the administrator manipulate the data? Yes

5.3.3. Checklist for profiling issues

• Is it possible to connect the data from different locations? No, only FHW location will be monitored.

• Is the data being used for profiling? Is location data used to reach other inferences: e.g. is the person rich? Does he live nearby? No, the data used for profiling will be used to deliver visiting recommendations. Any inference will remain in the scope of the experiment and in the domain of Museums.

• Is the processing of the data only for improvement of content? Or also for tracking characteristics/traits of persons? The first question is accurate. The goal is not to track characteristics, but to provide visiting recommendations. However, changes in a user’s profile might be tracked to draw conclusions on the accuracy of recommendations and to validate experiment data. They will not be related to a person as such.

• Does the service need to know the real identity of the users? Are nicknames enough? BLUE does not care for identities. However, a means must be used to link a user’s use of the system at different points in time. This can only be done, without using accounts, when the data is linked to his identity.

• To which other data will the users' feedback be linked to? User's feedback will be used only to assess the application's usability and evaluating the QoE.

• Who can access the ECC? The members of the experimenters' research group and whoever should be granted access according to the rules of the project.

5.3.4. Checklist for tracking issues

• Will the user be followed between two usages of the service? No. The user’s dealing in between usages of the application is transparent to the experiment. User’s location will only be tracked inside FHW and only as long as s/he uses the mobile application.

5.3.5. Checklist for consent issues

• What happens when the mobile phone (or other device) is given to someone else? Applications will delete all tokens and locally stored information upon exit. Hence, if the experiment lifecycle is followed, users will only be handed “clean” devices. However, if they choose to hand the device to another person without quitting the experiment, that person will not have access to any information.

• Real name? E-mail address? Only if we presume that the user has used the real values on Facebook and given permission to access the data. Otherwise, the user does not have to reveal her/his name. Communication with the user can be carried through the social or mobile application and no need for providing an e-mail address is envisaged.

5.3.6. Checklist for anonymisation issues

• Will the data be anonymised? Not at first. See above.

• Where will the data be kept? Is this a territorial location? Is there a cross-border exchange? The data will be kept in a database hosted by a server owned by the
experimenters’ research group, which will be physically deployed either in the FHW or the University of Peloponnese. Data may be accessed from Tudor in Luxembourg.
6. Experimental artefacts implementation: Technical Description

This section describes the infrastructure and high level system architecture that will be developed to enable the BLUE experiment, explaining the interaction of different system modules and their responsibilities. The following paragraphs will focus on the architectural pillar from Figure 2 at a time and give details about its concepts and function.

Figure 2: BLUE system architecture

6.1. Facebook

The interactions with Facebook are an important cornerstone of the system. The architectural element as such is to be considered a black box that we will be able to interact with in two ways. First, we can address the exposed Facebook API from the mobile application’s Social Content Component to request user login and logout, posting of content, and viewing of content. The latter two are depicted by the generic Post… and Get… operations as there are many different API calls to consider.

The second type of interaction with Facebook stems from a Facebook application that we will use to propose a game to the users. While an argument could be made that Facebook and an application running on Facebook are the same element, as one is a black box and the other is implemented and, hence, controlled by us, we chose to separate them. The application will transcend into regular Facebook elements such as Walls and Status posts by enabling the user to invite friends to play the game, recommend the game to friends, post on the application’s public Wall, and share the results of the game. We hope that the active sharing of content generated...
and proposed by the application will lure other users to try the application and participate in the experiment.

6.2. **My Museum Story application**
The “My Museum Story” web application features the web-based part of the “My Museum Experience”, and it is designed to capture the cognitive profile and content interest of the user.

6.2.1. **Basic Requirements**
Based on the cognitive style dimensions described in Section 3.2.1 and aiming to extract the cognitive style by playing a game, different approaches were explored and evaluated. In the following the basic requirements for the "My Museum Story" game application are outlined in relation to the cognitive style dimensions they support.

### "My Museum Story" application: basic requirements
- This is a role playing game. The purpose for the user is to “build their personalised museum”.
- This should be a web-based game.
- The game can be run as a Facebook application or a simple web-based application.
- For users opting for the simple web-based application, a registration form should be available.
- The application should retain user preferences upon log-out.
- A user can delete her account and all related data.

### "My Museum Story": Basic requirements in relation to the "My Museum Guide" mobile application
- The application should offer recommendations to users, based on user profile and time/space constraints.
- The user (if she has a Facebook account) can upload messages through the application on her wall.
- The user can leave messages for friends in specific locations of the museums. In this case the friend will receive a notification (but not the actual message).

6.2.2. **Gameplay design requirements**
Apart from the basic application requirements, the gameplay itself has certain prerequisites, mostly related to the need to extract the cognitive and visiting style of the player, by mapping different gaming concepts to cognitive style dimensions and to visiting style types. For all the following requirements, series of small experiments are either already performed or will be performed in the near future, to check the validity of the hypotheses. The existing requirements are the following:
**General gameplay requirements**

- The basic gameplay target is the user to build her own museum and populate it with items.

  The game is defined as a role playing game. The purpose for the user is to “build their personal museum”.

- The gameplay comprises two phases: i) a preparatory one to extract basic cognitive and visiting profile aspects and ii) the main one to extract content preferences, extract and validate cognitive profiles aspects.

**Phase 1 requirements (preparatory gameplay)**

- The user can select her character in the game from a set of different avatars, all representing different ends of the cognitive style dimensions.

  The choice of avatars could not only provide information about the Extraversion-Introversion dimension but for all the cognitive style dimensions. Examples: A mad scientist avatar uses the stereotypical view of an introvert individual, lost in his own studies. A TV persona represents extraverts. A Judge is for people that view justice very important (Thinkers). A Diplomat is for people that wish to avoid conflicts and find a middle solution (Feelers). An Engineer is for people that prefer clear instructions and create practical solutions (Sensors). An Artist is for individuals that have vivid imagination and increased creativity (Intuition). An Old wise is for individuals that like to plan things in advance and like routines (Judgers). A Rapper is for individuals that like to mix work and fun, question rules and like action (Perceiver). Finally, an Alien is for people that feel different from the rest of the world (Introverts).

- Similarly the user can select her pet.

  The choice of pets is related to different aspects of the cognitive profile (Intuition-Sensing, Extraversion-Introversion, Judging) and of the personality of the user. Examples: A dog as pet implies high Intuition and can plan for the future. A cat implies high Sensing, since it will eat its food immediately and lives in the present. The monkey implies high Extraversion, since monkeys like interacting with others and live in groups. The gold fish implies high Introversion and the owl implies Judgers, since it is associated with wisdom.

- Similarly the user can select her favourite tool to use during the game.

  The choice of tools is related to the cognitive profile aspects of Thinking-Feeling and Judging-Perceiving. Examples: A book represents Thinkers since it is associated with the search for facts and logic. The heart represents Feelers, since it is associated with sensitivity to people’s needs and feelings. The clock indicates a preference for punctuality (Judgers) and the disco-ball can represent both extraversion and need for fun (Perceivers).

- Visiting style will be extracted by asking users to select how they want their museum to be organized from different floor plans.
Museum organization templates (floor plans) will be used to extract the player's visiting style, with each template corresponding to a different visiting style. All templates will have a small, and the same number of rooms, to follow short term memory capacity requirements [7]. Template examples: i) Open view museum, with easy to see rooms and exhibits. Possibly best for fish visitors that want to have a quick overview of the museum space, exhibitions and exhibits, ii) Museum of linear development, which is possibly best for ant visitors that need to follow a clear-linear path during their visit and iii) Free arrangement museums, possibly best for butterfly visitors that prefer a non-linear movement.

- *The player can choose the decoration style of the selected museum template, to extract further cognitive style aspects.*

The player can customize the game space to match her decorative preferences. Example: Perceivers like pop style more than Judgers. A series of initial experiments run, which will be presented in the next BLUE deliverable project D4.8.2, indicate that certain cognitive traits correlate to particular decoration styles.

- *The player can choose favourite background music, to map to the Judging-Perceiving cognitive profile aspect.*

The player can change the background game music by choosing a radio station from a provided list. There are at least two different choices available, one classical and one contemporary. This choice might reflect Judging vs. Perceiving characteristics.

- *The player will be given the ability to adjust extracted cognitive profile aspects before entering phase 2 (main game), to fine-grain the extracted cognitive profile*

After building her character the player is presented with an interactive diagram, e.g. in the format of a spider web like the following:

![Interactive Diagram Example](image)

The axes of the diagram represent the main characteristics of the character (e.g. prefers to talk a lot with people or not so much, prefers to use logic or intuition, etc). The player can fast and easily adapt it to match her desired characteristics.
1.1.1. Phase 2 requirements (main gameplay)

- Exhibits are won by playing mini-games. Different games will be available. Game preference will be used to elicit cognitive style aspects

Players can win items for their museum through mini-games. A variety of games will exist like arcade, knowledge, risk, memory, skill, puzzles, etc. Game preference will be used to elicit cognitive style aspects. Examples: multitasking vs. single tasking game, preference or not for collaborative games (or tasks in one game) or for games (or tasks) that require communication. For example, in one game and for the same purpose (e.g. to collect extra points), the player could chose to either play a game on her own or to send messages for points to her friends. The level of single or collaborative activities preferred by the player could provide an indication of the different levels of Extraversion-Introversion. In addition, the type of game chosen, not only the number of players, also indicates certain personality aspects. For example a person that decides to take risks and play adventure games, more than knowledge and brain games is more of a Perceiver than a Judger (data already collected in a small study and results will be available soon). Finally, brain games indicate different cognitive styles that risk games etc.

- Exhibits given as rewards for mini-games will be categorized in categories. Players can choose their exhibit reward from these categories, to identify content-preferences

Once a mini-game is completed successfully, the player can choose between object categories. These categories will be related to the museum exhibition themes and will provide a possible insight into the player's personal interests. For example, a person that decides to collect ancient statues instead of old machines and tools might prefer the exhibition on ancient cities and civilizations to the exhibition of old machinery and tools. Therefore, the items that the user finally chooses for their museum, should give us an idea of their “content based” interests, i.e. what they would expect to see in the real museum visit.

6.3. Mobile Application's role and operations

The mobile application will run on an Android operation system with a target version of at least 4 (API 11). Examples of mobile devices, fulfilling this requirement, which are considered for ordering include the Samsung Galaxy S2, the Samsung Galaxy Pad family, or the Google Nexus 4 to just name a few.

The mobile application will integrate the SN component of the SCC to enable the application to easily interact with the Facebook API. These operations include user login and logout, posting of content, and viewing of content. The latter two are depicted by the generic Post… and Get… operations as there are many different, relevant API calls to consider. The application will also integrate the ECC client, comprising the EM client as well as a definition of the metric model in use. The client will interact directly with the ECC installed server-side. The interaction will consist of the initial establishment of a connection to initiate the experiment as well as the commitment of data. It is yet unknown if both, pull and push modes, will be supported which is why the design accounts for both.
The Geolocalisation service run as part of the mobile application is in need of a predefined and well established map of the wireless environment in the target venue. When the service is started, this map is retrieved from a server if it was not previously cached. Hence, the operation to retrieve the access point (AP) map. Depending on the mode of the Geolocalisation service, the device might also update the map with new measurements and commit the updated version to the server. It will depend on the performance of the device and the service if this is needed.

An important aspect of the project is the ability to profile users and to recommend an exhibition itinerary based on said profile. The computations required to satisfy those requirements will likely be too intensive for the mobile device. Therefore, a separate architecture element, the Recommender will take care of these matters. See the next section for a brief introduction. The mobile application will be able to request the retrieval or update of a user's profile. Moreover, the Recommender will be able to push a profile update if, based on the available data, the profile of a user changed. Recommendations are handled in a similar fashion. The mobile application can request a recommendation or they can be pushed by the Recommender.

6.4. The Profile Manager’s role and operations
The Profile Manager will receive and treat requests for the generation of profiles. The data necessary to generate profiles will be retrieved from a database. The profile is then published and ready to be used. The Profile Manager will also keep profiles up to date should new data become available, notifying devices of the change. This is necessary as mobile devices, lacking the resources to do intensive computation, will not be able to detect the profile change of a user and, hence, actively request the profile be recomputed. Therefore, and to avoid periodical checks, we chose to have the Profile Manager take an active role.

6.5. The Recommender's role and operations
The Recommender system will be deployed as a server-side application. It will be connected to a database containing exhibitions and item descriptions, which will be compared to the user profile when a request for recommendation is issued (dynamic mode), or in batch mode to answer quickly requests for recommendation that will not be subjects to changes during a visit. As is detailed in the followings, not only the user profile will be exploited in the recommendation matchmaking process, but also contextual elements like, e.g., location (obvious as we recommend also paths) and environmental constraints in the Museum (e.g. crowded exhibitions).

The Recommender will receive requests from the mobile application to generate a number of recommendations based on a visitor’s profile. The profile will be retrieved from a database using the visitor’s ID. The same database will be used to store the recommendations issued by visitor, so that they can be accessed by the mobile application when needed.

6.5.1. User profiling
Providing the visitor with accurate and succinct recommendations is one of the major goals of the experiment. To reach this goal, the visitor’s profile needs to be known by the recommendation system to a degree that will let it use relevant personality traits, the cognitive profile, behavioural patterns, visiting styles, and personal preferences as well as interests, to compute a useful recommendation. These five dimensions will be considered in the gathering of
data to build the profiles, either explicitly by asking the user (e.g. for interests) or implicitly by analysis of her/his behaviour. Such implicit profiling is done through the social application (“My Museum Story”) to determine the cognitive profile and its components as well as some of the visitor’s interests (see previous section), while the visitor will also be tracked by the mobile application during the visit to gather any data useful for building accurate and timely recommendations.

Generally, visitor interests are determined by two main indicators. First, the dressing of the cognitive profile has as a side-effect that some of the visitor’s interests can be deduced. However, these are broad categories and may be wrong as they lack direct input by the visitor for the most part. The second indication to the visitor’s interests stems directly from his Facebook profile. Should the visitor have allowed us to use the data, it is possible to analyse the groups and interests he has pencilled down in his profile. The advantage is that these have been set directly by the user which means that he thinks that they accurately reflect his interests.

6.5.2. Recommendations
Generating recommendations requires data. However, in project setup, it was foreseen that not all visitors may have given access to, or simply given, enough, or any, data to compute a succinct recommendation. Therefore, the recommender can work in two modes. In the first mode, called full, it was stipulated that the recommender has enough data to provide an accurate recommendation. This mode is directly related to a group of visitors, notably visitors having played the Facebook game and wanting to use our mobile device for the visit. Note that it may be possible for visitors not having played the game but wanting to use the mobile application to enter this mode once enough data has been assembled to generate an on-the-fly visitor profile. In a similar manner, the degraded recommendation mode can be defined to provide very basic, untailored recommendations. Those recommendations are based on statistical or random predictions of the average visitor. This mode is enabled for visitors wanting to participate in the experiment but not having previously played the Facebook game and may change during the visit.

Initial recommender design
Initially, the recommender was thought to use the visitor’s profile to generate custom exhibit level recommendations. However, we came to realise that it is not possible to generate these recommendations as the FHW is not designed and set up like a regular museum. While there are themed exhibitions, these usually encompass one to a handful of exhibits which are tightly integrated into the exhibition itself. Therefore, it is not only hard to find any concrete difference between exhibit and exhibition that would allow the recommender to base any recommendation on this difference, it is also not possible to use the exhibit dispersion inside the exhibition to any concrete mean. Therefore, it was decided to approach the experiment from a related but different angle. This allowed us to keep some of the approaches that were thought to be used and had already been researched. In the following we not only detail the new approach, we also detail all the strategies for establishing recommendations.
Reworked recommender design

The reworked design was to operate not at an exhibit level. To avoid the problem of not having enough fine grained exhibits, it was decided to work on the level of exhibitions. This would include venues such as gift shops, restaurants, and snack bars. This would allow us to still pursue the initial research questions with a minimum amount of redesign of already designed items. Most importantly, all previously researched items such as user profiles could be used as is.

While in the initial design recommendations would establish paths, either in segments or as complete paths from exhibit to the next one, the reworked design will provide these on an exhibit level. These recommendations can be either dynamically drafted during the visit or they can be statically predetermined on a per profile basis. The segment based recommendation having the advantage and disadvantage that it distributes the recommendations and, thereby computational strain, in time. Also, the type of recommendation might be tied to a visitor’s preference as it is possible that a type of visitors may prefer to know the full path/schedule ahead of time while another might prefer the dynamic visit generation.

A group of paths or one single path will be presented to the visitor, providing alternatives if possible. The path will not be taken as is but will be weighted as by the visitor's interest. That way, even predetermined paths can seem dynamic and adapted to the visitor by his personal input. This is thought to, with minimal user investment, prevent any drop in quality of user experience due to a forced recommendation. However, it must be taken care of not providing the user with a group of recommendations spanning most possibilities. This is especially true when working on the exhibition level.

A last bit of optimization will be applied to the path based on the load of the exhibit. The recommender may impose constraints on certain objects and usher visitors onto different paths than under normal circumstances. This will be done with the goal to improve the visitor’s quality of experience as it is thought that a less crowded environment might be preferable to a visitor's experience.

Finally, while it is not in the scope of the experimentation, future work could include the addition of time/calendar entries to the visitor profile. With the additional bit of scheduling information, the recommendation could be fine-tuned to fit best in the visitor's schedule. After all, there is no need to recommend a lengthy visit if the visitor has scheduled an event. While this is a very straight forward case, calendar information is usually quite sensitive and users are unlikely to share it. A different approach would be to ask the user to provide the amount of available time he has in his schedule.

6.6. Server's role and operations

The server will hold important architecture components. First, it will hold the ECC which will enable us to receive incoming connections from mobile devices and manage experiments. It also empowers us to use the ECC facilities to manage and make persistent data to a PostgreSQL database. Secondly, the server will be host to the server component of the Geolocalisation service. It will manage the access point map and distribute it upon request to mobile
applications. Finally, the server will hold the Social Integrator EXPERIMEDIA module. In detail, hosted items are:

- Server-side ECC
- Server-side Social Integrator (SCC component)
- PostgreSQL Database
  - Edm-metrics (Database structure required by the EDM)
  - Exhibit data
  - Facebook application data
  - Recommender data
- PHP Scripts for the localisation module

### 6.7. Database's role and operations

A PostgreSQL 9.1 database will be deployed as required by the ECC. It will be used to store any data as specified by EXPERIMEDIA. Moreover, the database will hold additional tables used to store user profiles and related data. While they are also stored using the ECC during the experiment, the use of a Facebook application is outside of the operational scope of the component and hence needs additional facilities to store data.

### 6.8. Database schema and stored data

The experiment will see three sets of data collected. The first set pertains to the training phase of the wireless localisation module and is as such not directly involved in the outcome of the experiment. The data is collected by a mobile device and a subject inside the museum. The wireless topology is mapped and its details stored in an XML file on the server.

The second set of data is collected during the experiment from users playing the Facebook game. Since the game is not using any EXPERIMEDIA component, it will not be able to store the data using the ECC's facilities. It will however be stored in the same database. The data stored in that database is a unique user identifier that will enable the identification of a Facebook user. This is needed to retrieve an existing profile for a user once he visits the museum after having played the game. It will enable us to skip the degraded recommendation mode that would need to run as long as the visitor's profile has not been fully determined. Moreover, the user's complete profile is stored. Furthermore, the profiler can attribute visiting styles and the corresponding certainty levels to the user which are stored as well. While it would also be feasible to compile the list once the user visits the museum, it is yet unknown how computationally taxing these computations are and therefore it is preferred to have them ready before a user visits.

The third set of data is collected during the experiment by the mobile application. The complete set is gathered by the use of the ECC's facilities to store data gathered directly by the application through the use of its localisation module and the user's interaction with the exhibition as well as the user's interaction with functionality exposed through the SCC's facilities. While the latter in turn uses the same component to store its data, they are logically disjoint in EXPERIMEDIA's data model. The data will be stored in the default database structure as proposed by EXPERIMEDIA.
The data set collected by the mobile device is tied to the visitor which becomes the observed entity. Its observed attributes are its unique identifier which will allow us to link the user to his profile and recommendations. His position is stored as well as a set of coordinates relevant to the exhibition's layout. This measure might be expanded later to include GPS coordinates if possible. A set of important attributes pertain to the visitor's profile. It includes, for example, attributes relating to each of the cognitive dimensions as noted above and the visiting style (for more details, see Sections 3.2.1 and 3.2.2). Another set of data is needed in the application. This data is not collected during the experiment but provided up front by the FHW and distilled to meet our needs. This dataset contains exhibit information to an extent that would allow us to provide accurate information to the visitor. This information will be stored in a separate table not managed by the ECC's sub-components. As of now, we are in the process of gathering and distilling information from the venue.
7. Use Cases

The following sections will briefly present four Use Cases, elaborated in Appendix A - Detailed Use Cases, that will present different perspectives of the system based on three different actors: the user of the mobile application, called visitor in the context of a museum visit; the Profiler, part of the Recommender taking part of drafting profiles; and the Recommender, issuing and updating recommendations. For all these scenarios, we refer to the exhibition, the collection of exhibits, inside the museum which the user visits. By doing so, he is considered synonym to the visitor. A visit, for the purpose of this exercise, considers only the exhibition observed by our system. While exhibit is sometimes used as synonym for an exhibition, in this document, it denotes one artefact or a collection of several smaller artefacts arranged as one thematic piece such as a collection of coins for example. Please note that while the Profiler and Recommender have been chosen to be depicted as separate entities for Use Cases due to their different objectives, they are one component in regard to system architecture.

The Use Case also differentiate between exhibits that a visitor has seen as part of his virtual visit, interacting with them through specialised tags (QR codes) to retrieve additional information and, possibly, comment or like these exhibits, and those he has seen as part of his path through the exhibition. The use cases use "scan" to denote the in depth interaction with an exhibit and "view" as the normal interaction which is characterised by spending some time at an exhibit but not scanning the specialised tag. When a Use Case refers to a user's visit, it always refers to his virtual visit, containing the path he travelled through the museum as well as all scanned exhibits and comments thereon.
7.1.1. **Use Case 1: A guided visit through a museum**

This Use Case, depicted in Figure 3, caters to the main scenario, using the "My Museum Guide" application to experience the exhibition of a museum from a visitor point of view. The Profiler, Recommender, and Geolocalisation service act as external actors. The visitor may log into his existing Facebook profile which will trigger a retrieval of a possible previously established profile. The visitor may also get additional information of an exhibit. He may then rate the exhibit and post a comment on the virtual object that represents the exhibit. These actions include the retrieval of, possibly tailored, information on the exhibit as well as the scanning of a code to identify the exhibit in question. The visitor may also update his virtual visit by adding a scanned exhibit to his visit.

Furthermore, the visitor can get target the next exhibit by following a recommendation, moving away from a just visited exhibit. Once he is done, the virtual visit can be shared using social media. Anytime during his visit, a visitor may exit the exhibition and end the Use Case.
7.1.2. **Use Case 2: Playfully discovering one's cognitive profile**

This Use Case, depicted in Figure 4, caters to scenario involving the Facebook game from a user perspective. The Profiler acts as external actors. The user can play the game with the gameplay requirements described in Section 6.2.2. Once the user has finished the game, he can choose to recommend the game to friends and view his results. Playing the game will require that the user be logged into Facebook. While the game is being played, the user’s profile is being established and, once finished, stored for being used in a possible future museum visit.
7.1.3. Use Case 3: Establish a visitor profile

This Use Case, depicted in Figure 5, shows, from the Profiler's point of view, how profiles are established and updated. While no profile has yet been established, the profiler will attempt to compile a profile based on available data. This procedure includes the storage of the profile for further use, the reporting of the profiling results and the retrieval of user data to establish the profile.

Once a profile has been established, the profiler will be notified of all profile retrievals. Once retrieved, a profile is actively being used to dress recommendations. In those cases, it is possible that a user’s profile changes during his visit. Therefore, the profiler monitors active profiles and compares the recommendations with the actual path of the users. In case of a too great a discrepancy, the profiler updates the profile by recompiling it using a dataset updated with the latest data. The update includes the retrieval of user data, the propagation of the new profile and its storage.

Figure 5: Use Case of managing user profiles
7.1.4. **Use Case 4: Recommend an exhibition object**

This Use Case, depicted in Figure 6, details how recommendations for exhibits, the path along which the visitor should ideally travel, are generated and kept up to date in case the profile changes. To ensure that goal, the recommender generates a reasonable number of recommendations for the user to choose from. This requires the retrieval of the user’s profile as well as the exhibit data. The recommendations are also communicated to the user and stored for analysis. In order to provide up-to-date and accurate recommendations, the recommender keeps taps on the user’s profile and updates all recommendations should the profile be updated.
8. Experiment evaluation

During the experiment we want to validate a hypothesis which has not yet been answered. Hence, the experiment is explorative in nature. To come to a succinct conclusion, the hypothesis needs to be validated (or invalidated) by concrete and objective measurements. The QoS, QoE and QoC, as defined in section 5.1, and the metrics they include, will be used to judge the experiment.

The QoE will be the basis for the final evaluation of the experiment. A preliminary evaluation will serve to gauge the quality of recommendations and the overall quality of the experiment. It will not capture, in a way that they could be used for the experiment, any QoE measurements.

The results obtained by evaluating the final QoE in regard of our hypothesis and the level of integration and use of existing EXPERIMEDIA facilities, including the venue, will determine the degree of success that is achieved.

8.1.1. Baseline success
Criterion: Be an EXPERIMEDIA test bed.

- The experiment can be executed. This entails having integrated every used EXPERIMEDIA module into the operational system architecture. Knowledge and expertise has been gathered. This refers to the gathering of knowledge regarding the EXPERIMEDIA goals and expertise related to the use of EXPERIMEDIA components.

8.1.2. Moderate success
Criterion: Explore suitability of BLUE technologies and techniques for augmenting visitor experience inside a museum.

- Establish a baseline for comparing the use of BLUE project effort with.
- Identify and quantify the difference between using and not using BLUE to measure the overall impact.
- Classify the impact on the testbed and correlate with the QoE metrics to see if the desired effects can be measured at all and in a scientifically valid manner.

8.1.3. Success
Criterion: Measure impact of BLUE technologies and techniques.

- Quantify and measure QoS, QoE, QoC.

8.1.4. Exceptional success
Criterion: Identify parameters that impact QoE.

- Correlate the measured increases or decreases to specific BLUE technologies or techniques.
• Rate each BLUE component in regard to their impact on QoE and identify eventual synergies, correlations, or dependencies.
## 9. Risks

Table 1: Foreseen Risks and mitigation plan.

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Probability</th>
<th>Impact</th>
<th>Proximity</th>
<th>Response</th>
<th>Mitigation action</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Mobile device damaged during the installation of the mobile application</td>
<td>Low</td>
<td>High</td>
<td>Execution phase</td>
<td>Avoid</td>
<td>Instead of using the participant’s own devices, the project will supply the mobile devices that will be used during the experiment.</td>
</tr>
<tr>
<td>P2</td>
<td>Mobile device not compatible with the EXPERIMEDIA software</td>
<td>High</td>
<td>High</td>
<td>Execution phase</td>
<td>Avoid</td>
<td>See point P1</td>
</tr>
<tr>
<td>P3</td>
<td>Malicious software installed on the mobile device</td>
<td>Low</td>
<td>High</td>
<td>Execution phase</td>
<td>Avoid</td>
<td>See point P1</td>
</tr>
<tr>
<td>P4</td>
<td>Participants feel pressured to participate in the experiment</td>
<td>Low</td>
<td>High</td>
<td>Preparatory phase</td>
<td>Avoid</td>
<td>While this may hold true for early experimenters recruited from the FHW or the UOP, regular visitors are informed that participation is not required.</td>
</tr>
<tr>
<td>P5</td>
<td>Wireless internet access unavailable during experiment</td>
<td>Low</td>
<td>High</td>
<td>Execution phase</td>
<td>Avoid</td>
<td>The FHW has committed to installing new access points to provide wireless access to lent devices.</td>
</tr>
<tr>
<td>P6</td>
<td>Database failure</td>
<td>Low</td>
<td>High</td>
<td>Execution phase</td>
<td>Backup/Data redundancy</td>
<td>Data from the database should be backed up regularly. In case of a failure, the impact will result in a minimal loss of data.</td>
</tr>
<tr>
<td>P7</td>
<td>Loss of device</td>
<td>Low</td>
<td>Medium</td>
<td>Execution phase</td>
<td>Redundancy</td>
<td>Any kind of loss of a device will be countered by having a multitude of devices. However, upon loss of all devices in a short period of time, the</td>
</tr>
<tr>
<td>ID</td>
<td>Description</td>
<td>Probability</td>
<td>Impact</td>
<td>Proximity</td>
<td>Response</td>
<td>Mitigation action</td>
</tr>
<tr>
<td>----</td>
<td>-------------------</td>
<td>-------------</td>
<td>--------</td>
<td>-------------</td>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>P8</td>
<td>Software failure</td>
<td>Medium</td>
<td>High</td>
<td>Execution phase</td>
<td>Software Testing</td>
<td>While a guarantee can never be given, proper testing and debugging of software can reduce the risk and impact.</td>
</tr>
<tr>
<td>P9</td>
<td>Venue unavailable</td>
<td>Low</td>
<td>High</td>
<td>All phases</td>
<td>Alternative usage scenarios</td>
<td>Should the FHW cease to be able to host the experiment by any means, alternate experiment scenarios with similar setups are possible but will require an adjustment to the time schedule.</td>
</tr>
</tbody>
</table>
10. Conclusion

The purpose of this document is to provide insight as to the problem and requirements of the BLUE experiment, which will be implemented as part of the EXPERIMEDIA project at the Foundation of the Hellenic World museum. The experiment has as an objective the improvement of user experience of the visitors inside the museum, by offering personalized exhibition descriptions and routing suggestions. It will use for this end, one custom-made application ("My Museum Experience"), comprising two parts: a web-based one ("My Museum Story") and an on-site one, running on a mobile device that the participants will borrow from the museum premises ("My Museum Guide").

Currently, as also described in the present document, the requirements of the BLUE experiment have been defined, after examining the current EXPERIMEDIA infrastructure and the policies of the FHW museum, and also, certain implementation steps have been made.

Specifically, the mobile application ("My Museum Guide") has been implemented for Android devices running on Ice Cream Sandwich. At the moment, the core of the application is usable but offers very little concrete functionality in regard to museum visits. The Social Integrator sub-component and the Geolocalisation functionality have been implemented and are working. Wrappers to show recommendations, content, and the visitor’s visit items are in place.

The next steps involve defining the interface with the recommender and the dataset that will be sent to the ECC for storage. The latter will depend on the revision of the component and the progress in hosting experiments with dynamically changing participants.

As for the web-based application, a working prototype of its first phase (preparatory game design) has been prepared to extract users' cognitive profiles. Initial tests have also been performed, on students of UOP, showing a confirmation of the researchers' hypotheses over the elicitation of cognitive profiles through gaming.

The next steps on this side include developing the second phase of the game (main gameplay) and examining it further (beta testing), to verify further its capabilities in cognitive, visiting and content-based interest extraction, before launching it to future museum visitors. The implementation and initial testing results will be included in the next project deliverable, dedicated to the experiment's implementation.
11. References


Appendix A. Detailed Use Cases

A.1. Use Case 1: A guided visit through a museum

Primary Actor: Museum visitor

Goal: The visitor would like to take an assisted tour through the museum and record his visit in order to share it on social media.

Scope: Global - The Use Case details the visitor's interaction with the system in its largest sense.

Level: User - The Use Case focuses on the visitor and his interaction with the system.

Stakeholders and Interests:

- Visitor - wants to take an assisted tour through the museum and save exhibits to post them later to a social medium.
- Profiler - wants to determine a visitor's profile. See [Cross-reference to segment about profiles] for more details.
- Recommender - wants to recommend exhibits to the visitor based on his profile and location as well as to provide tailored information about visited exhibits.
- Localisation Engine - wants to accurately track a visitor's position inside the museum.

Precondition:

- The visitor uses a mobile device with the "My Museum Story" application open and running.
- At least three wireless hotspots can be detected at all times.
- A file containing the wireless topology is available.
- The mobile device is connected (online) during the visit.
- The museum has been mapped and information on the exhibits is available.

Postcondition:

- The visitor's cognitive profile is known as well as any changes during the visit.
- The visitor's viewed exhibits are stored and may have been posted to a social medium (visitor's choice).
- The visitor's visit is stored.

Main success scenario:

1) The visitor receives the mobile device and starts the "My Museum Story" application.
2) The visitor acknowledges the notifications regarding data collection and privacy and grants permission to use the data.
3) The visitor logs into Facebook.
3.1) The application retrieves the visitor's profile.
3.2) The application queries the recommender for a list of recommended exhibits.
3.3) The Recommender returns a list of suited exhibits.

4) The visitor views his first exhibit.
   4.1) The Geolocalisation service tracks the visitor's movement towards the exhibit.
   4.2) The Profiler updates or establishes the profile based on the visitor's movements.

5) The visitor scans the exhibit's specialised tag.
   5.1) The application retrieves tailored information from the recommender.

6) The visitor rates the exhibit and may leave a comment.
7) The visitor adds the exhibit to his visit itinerary.
8) The visitor moves on to the next exhibit, resume Use Case at 3.1, or ends his visit.
9) The visitor posts his visit online.
10) The visitor recommends the exhibition to his friends.
11) The visitor is presented with the option to delete all of his data, anonymise it, or leave it as is.
   11.1) The system logs the user out of Facebook after he has confirmed his choice and closes the application. The Use Case ends in success.

Extensions:

2a) The visitor does not acknowledge having read the notification. The application cannot continue. The Use Case ends in failure.
2b) The visitor does not grant permission to the application to use his data. The application cannot load a profile or recommend any items and closes. The Use Case ends in failure.
3a) The user does not log into Facebook.3
   a) The visitor views his first exhibit.
      a.1) The localisation engine tracks the visitor's movement to the exhibit.
      a.2) The profiler updates or establishes the profile based on the visitor's movements.
   b) The visitor scans the exhibit.
      b.1) The application retrieves tailored information from the recommender.
   c) The visitor rates the exhibit and may leave a comment.
   d) The visitor adds the exhibit to his visit itinerary.
   e) The visitor moves on to the next exhibit, resume Use Case at 3a.a1, or ends his visit.
   f) The visitor may export his visit.
   g) The visitor recommends the exhibition to his friends.
   h) The visitor is presented with the option to delete all of his data, anonymise it, or leave it as is.

---

3 It was chosen not to include nested extensions as they should be clear from the main scenario's extensions.
i) The system closes the application after he has confirmed his choice. The Use Case ends in success with a degraded result.

3.1.a) No profile for the user is available.
   b) The application queries the recommender for a list of recommended exhibits.
   c) The recommender returns a list of exhibits. The Use Case resumes at 4.

4.a) The visitor does not visit any exhibit. The Use Case ends in failure.
5.a) The visitor does not scan an exhibit. Resume Use Case at 8.
5.1.a) The recommender cannot suggest tailored information due to a lack of cognitive profile.
   5.1.a.1) The recommender replies with untailored, general information.

6.a) The visitor does not rate or comment on the exhibit. Resume Use Case at 7.
7.a) The visitor does not add the exhibit to his itinerary. Resume Use Case at 8.
9.a) The visitor does not post his visit online.
   9.a.1) The application offers the visitor the option to export his visit. Resume at 10.

10.a) The visitor does not recommend the exhibition to his friends. Resume at 11.
11.a) The visitor does not make a choice. The Use Case cannot continue and ends in failure.
11.1.a) The visitor had no Facebook account. The system closes the application. The Use Case ends in success.

A.2. Use Case 2: Playfully discovering one's cognitive profile

Primary Actor: Facebook user

Goal: The user would like to play a game to assert his profile.

Scope: Global - The Use Case details the user's interaction with the Facebook application.

Level: User - The Use Case focuses on the user and his interaction with the game.

Stakeholders and Interests:

- User - wants to assert his cognitive profile by participating in a Facebook game.
- Profiler - wants to attribute a profile to the user. See [Cross-reference to segment about cognitive profiles and visiting styles] for more details.

Precondition:

- The user possesses a Facebook profile.
- The user allows the application to access his basic information (identity).
- The application can connect to the database to store the profile.

Postcondition:
• The user's cognitive profile is established and stored.

Main success scenario:

1) The user logs into Facebook.
2) The user launches the Facebook application.\textsuperscript{4}
3) The user plays the game.
   3.1) The profiler evaluates the user's game prowess and establishes a cognitive profile.
   3.2) The profiler compiles a list of visiting styles and likelihoods of them matching.
4) The user finishes the game.
   4.1) The profiler stores the profile of the user in the database.
5) The user shares his results on the social medium.
6) The user recommends the game using the social medium's platform.
7) The user closes the application or logs out of Facebook.

Extension:

[1-6a] The user logs out of Facebook, terminating the application and the game. The application stored his progress, enabling the user to resume where he left off. The Use Case resumes at the appropriate step.
3.a) The user does not play the game.
   3.a.1) The user may choose to establish the profile by taking a series of tests or pick his profile by using descriptions of existing profile categories. The Use Case resumes at 5.
4.a) The user does not finish the game. The Use Case ends in failure.
   4.1.a) A cognitive profile already exists. The old profile is overwritten.
5.a) The user does not share his results. The Use Case resumes at 6.
6.a) The user does not recommend the game. The Use Case resumes at 7.
7.a) The user does not close the application or log out. The state is preserved until the session cookie expires or the user logs out at a later date. Determine if a time out should be set or what we want to happen.

A.3. Use Case 3: Establish a user profile
Primary Actor: The profiler engine

Goal: The profiler evaluates data to determine a profile.

Scope: System - The profiler is an integral part of the system.

Level: Functional - The Use Case focuses on a facet of the system's function.

Stakeholders and Interests:

• User - wants to get an accurate profile.
• Recommender - needs a profile to recommend exhibits.
• Profiler - wants to attribute a profile to the user.

\textsuperscript{4} The user consented to the use of his data when installing the application.
Precondition:

- There is sufficient data to produce a profile.
- The user for which the profile is to be established exists.
- The profiler can connect to the database.
- A connection to the user's mobile device can be established.
- User data is not deleted during the operation.

Postcondition:

- The user's profile is established respectively updated and stored as well as communicated to the user (his mobile device).

Main success scenario:

1) The profiler receives a request to establish a profile for a given user.
   1.1) The profiler retrieves the user's data.
3) The profiler establishes the cognitive profile and visiting style for the user and compiles the complete profile.
4) The profiler stores the profile in the database.
5) The profiler fulfils the request by relaying the compiled profile.

Alternate success scenario:

1') The profiler monitors an existing profile.
   1'.1) The profiler concludes that the expectation and reality don't match.
2') The profiler retrieves the user's data.
3') The profiler establishes the cognitive profile and visiting style for the user and compiles the complete profile.
4') The profiler stores the profile in the database.
5') The profiler propagates the profile and overwrites the remote profile of the user.

Extension: None

**A.4. Use Case 4: Recommend an exhibition object**

Primary Actor: The recommender engine

Goal: The recommender evaluates data to determine possible recommendations.

Scope: System - The recommender is an integral part of the system.

Level: Functional - The Use Case focuses on a facet of the system's function.

Stakeholders and Interests:

- User - wants to get an accurate recommendation.
- Recommender - wants to establish possible recommendations.
Precondition:

- The user for which the recommendation is to be established exists.
- The recommender can connect to the database.
- A connection to the user's mobile device can be established.
- User data is not deleted during the operation, nor does the user terminate the application.

Postcondition:

- A list of recommendations is generated, establishing an itinerary through the exhibition, respectively updated and stored as well as communicated to the user (his mobile device).

Main success scenario:

1) The recommender receives a request to generate a recommended itinerary for a user.
   1.1) The recommender retrieves the user's profile.
2) The recommender establishes an itinerary.
3) The recommender relays the recommended itinerary to the user
   3.1) The recommender stores the itinerary in the database.

Alternate success scenario:

1') The recommender monitors an existing profile which changes.
2') The recommender computes a new path and exhibit information snippets.
   2'.1) The recommender retrieves the user's profile.
3') The recommender relays updated path and information to the user (his device).
   3'.1) The recommender stores the path and itinerary in the database.

Alternate success scenario:

1") The recommender receives a request to generate recommended exhibit info.
   1.1") The recommender retrieves the user's profile.
   1.2") The recommender retrieves the general exhibit data.
3") The recommender establishes a customised exhibit description.
4") The recommender relays the customised exhibit description to the user (his device).
   4".1) The recommender stores the description in the database.

Extension: None