D4.2.3 – The Dicode Decision Making Support Services (final version)

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The Dicode Consortium

Computer Technology Institute & Press “Diophantus” (CTI) (coordinator), Greece

University of Leeds (UOL), UK

Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V. (FHG), Germany

Universidad Politécnica De Madrid (UPM), Spain

Neofonie GmbH (NEO), Germany

Image Analysis Limited (IMA), UK

Biomedical Research Foundation, Academy of Athens (BRF), Greece

Publicis Frankfurt Zweigniederlassung der PWW GmbH (PUB), Germany
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Deliverable manager
- Spyros Christodoulou, CTI

List of Contributors
- Nikos Karacapilidis, CTI
- Manolis Tzagarakis, CTI
- Spyros Christodoulou, CTI
- Fan Yang-Turner, UOL
- Vania Dimitrova, UOL

List of Evaluators
- Lydia Lau, UOL
- Max Jakob, NEO

Summary
This deliverable is a progress report on the final version of the Dicode decision making support services, which are designed and implemented in the context of WP4. Decision making support services developed in Dicode concern the building of machine-interpretable knowledge in order to actively support various decision making tasks. In this deliverable, the technical specifications of the decision making support services being developed in the context of Tasks 4.3 and 4.5 are presented. The intended audience of this document are designers and developers of the Dicode project. The document informs them on which decision making support services have been developed or updated (with respect to the enhanced version of the decision making support services that have been described in deliverable D4.2.2) and how they can be used. The final versions of the decision making support services are presented using a formalized and project-wide adopted service description template.
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1 Introduction

1.1 Context

This deliverable presents the final version of the decision making support services that have been designed and developed in the context of WP4 (“Data-Intensive Collaboration & Decision Support Services”) of the Dicode project. Specifically, it reports on the progress of work being carried out in Tasks 4.3 and 4.5, by describing the current (final) version of the associated services.

Deliverable D4.2.3 is the third of a series of three deliverables reporting on the progress of work related to the development of decision making support services in the context of WP4. While the focus of D4.2.1 and D4.2.2 was on the initial and the enhanced version of these services, respectively, this deliverable reports on their final version.

1.2 Objectives

The purpose of this document is to present the final version of the developed decision making support services, as they originated from the functional specifications outlined in deliverable D2.2 (“The Dicode Approach – User requirements, conceptual integrative architecture, agile methodology and functional specifications”) and the updated Dicode approach described in deliverable D2.3 (“The Dicode Approach Revisited”). In addition, the development process carried out in the third year of the project put much emphasis on the improvement of usability issues, as this has been also recommended by the Project Officer and Experts during the 2nd Review Meeting of the project.

As in the previous deliverables of this series (D4.2.1 and D4.2.2), the developed services are presented from a technical perspective, broken down to the level of individual operations, in order to make clear their role and use and facilitate their assessment with respect to the derived functional specifications. The operations presented are those which are available to clients to be invoked and executed without going into detail about how exactly these can be invoked or executed. In particular, the presented operations can be executed by various technologies such as REST (Fielding, 2000) or Web Services (W3C - Web Services Architecture, 2004), but such issues are not the focus of their description. The description of services takes an operation-oriented approach, which lists the available operations and details their aim and purpose.

The final versions of the services are presented using the service description template, called the Abstract Service Description, which has been derived and used in the context of deliverables D3.1.1 (“The Dicode Data Mining Framework”), D4.2.1 (“The Dicode Decision Making Support Services (initial version)”) and D4.2.2 (“The Dicode Decision Making Support Services (enhanced version)”). The Abstract Service Description template provides a technical specification of services by providing an overview of the supported interfaces and the relevant operations. For each operation, a description together with major input and output information is presented. Only services that have been updated or added, in comparison to the enhanced version of the decision making support services (described in deliverable D4.2.2), are presented.
2 Dicode Decision Making Support Services

As described in detail in D4.2.1 and D4.2.2, the aim of the Decision Making Support services is to make information and knowledge machine interpretable, thus allowing the active participation of the system in collaborative activities, and ultimately aiding the overall decision making process.

This document reports on the final version of the services that have been developed in the context of the following tasks:

- Task 4.3: Semantics-driven collaboration monitoring mechanism, which will derive a semantics-driven model of collaborative processes in a community;
- Task 4.5: Decision making support services, which are concerned with the formalization of collaborative decision making issues to intelligently support stakeholders in such activities.

2.1 Overview of changes in the final version of the collaboration services

The following table gives an overview of changes made in the final version of the decision making support services, which will be presented in detail in the rest of this deliverable. The value “Updated” in the “Status” column means that the data type, interface or operation has been updated (compared to the enhanced version of the services reported in D4.2.2), while the value “New” means that a data type, interface or operation has been newly introduced in the enhanced version of the decision making support services.

<table>
<thead>
<tr>
<th>Dicode Service</th>
<th>Interface</th>
<th>Method</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Collaboration Service</td>
<td>MultiCriteriaDecisionMaking</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>calcWSMScores</td>
<td>Updated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>showWSMPlot</td>
<td>Updated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>setAHPParameters</td>
<td>Updated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>calcAHPScores</td>
<td>Updated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>showAHPPlot</td>
<td>Updated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>setLexicographicParameters</td>
<td>Updated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>calcLexicographicScores</td>
<td>Updated</td>
</tr>
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<td></td>
<td></td>
<td>showLexicographicPlot</td>
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<td>FormalCollaboration</td>
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<td></td>
<td>Updated</td>
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<tr>
<td></td>
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<td></td>
<td>setReasoningEngine</td>
<td></td>
<td>Updated</td>
</tr>
<tr>
<td></td>
<td>generateReport</td>
<td></td>
<td>New</td>
</tr>
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</table>
2.2 Semantic-driven collaboration monitoring mechanism

In the third year of the project, a semantic approach was devised to interpret log data from sensemaking tools such as Semantic Data Browser and Collaborative Workspace. Empirical studies were conducted to obtain datasets which enabled a deeper understanding on how the log data could be used for analysis of user/group behaviour during sensemaking. The ultimate aim is to derive patterns of collaborative decision making behaviour, which can be used to develop alerts to indicate when intervention and/or attention may be required from the collaboration and decision support services.

More specifically, since last deliverable (D4.2.2), two studies have been conducted on the topic of semantic-driven collaboration monitoring mechanism:

- Profiling Exploratory Browsing Behaviour with a Semantic Data Browser (Yang-Turner et al., 2013), which takes the first step in profiling browsing behaviour of users in a semantic space and compares the outcome against their task performance.
- Modelling Collaborative Sensemaking Behaviour with Dicode Collaborative Workspace, which identifies the activities that need to be monitored to support sensemaking and decision making.

In this deliverable, we report the progress of these two studies and the design implications for the Dicode Decision Support services.

2.2.1 Profiling Exploratory Browsing Behaviour

Introduction

Semantic Web technologies are increasingly being adopted for aggregating Web data. Tools such as Semantic Data Browsers (SDB) have been proposed to assist users to access and make sense of the vast semantic space. A SDB provides an interface for browsing through several linked semantic datasets. By following the links in a SDB, a user can browse through concepts (or entities) in the domain and the relevant content based on semantic data. However, further investigations are needed to understand how users make use of the additional semantic features provided by these new breed of browsers and their effectiveness in supporting exploration of a domain. Measurements of browsing behaviour in a semantic space are also needed. Using the log data from a semantic browser, namely MusicPinta (Thakker et al., 2013), for the music domain, this study takes the first step in profiling browsing behaviour of users in a semantic space and compares the outcome against their task performance.

Two exploratory search tasks were designed for the experiment (Dimitrova et al., 2013). Movements in terms of users traversing the provided semantic links in the browser were captured and the patterns of clicks between abstract and concrete concepts were analysed. In this study, we aimed to answer two research questions:

- “Can we model exploratory browsing behaviour in terms of semantic features of hyperlinks?”
- “Can we relate the possible browsing behaviour in a SDB with performance in exploratory tasks?”
Design of Exploratory Tasks

Motivated by Dicode Use Case 3, we designed two exploratory search tasks of marketing analysts. An advertising scenario for a hypothetical music shop was used as the context. Participants were asked to explore the information on musical instruments within MusicPinta. Task 1 was analytical, which requires exploring, comparing, finding similarities and differences within a pool of knowledge items. Task 2 was more creative with open-ended outcomes. An advertising scenario for a hypothetical music shop was used as the context. Participants were asked to explore the information on musical instruments within MusicPinta. In both tasks, the participants were given an entry point to the browser and a form to fill in their answers. The details of the tasks are shown below.

**Task 1:**

The music shop is extending its collection of instruments with international musical instruments. You work in an advertising agency which has been asked to prepare an advertisement script for some of the new instruments that will appear in the shop. A key part of the preparation of the advertisement script is the research of the product.

You have been asked to conduct a research on one of the new instruments, called bouzouki, using the information available in MusicPinta. You have to identify:

- The main characteristics of bouzouki;
- Up to five similar instruments to bouzouki;
- Features that make bouzouki distinctive from the similar ones you have chosen.

Go to ‘Semantic Search’ in MusicPinta and type bouzouki. Browse the content and follow links. Complete the provided form.

**Task 2:**

The music shop wants to increase the sales of its traditional musical instruments, such as electric guitars. It intends to do this by adding links to album recordings with electric guitars which are available in creative commons, together with some interesting information about these albums to inspire customers to play/buy electric guitars or any other musical instruments.

Furthermore, when displaying its electric guitar items, the shop wants to highlight key features people look for when purchasing electric guitars.

You are asked to conduct a research to address the above requirements by using information provided in MusicPinta. You have to review the information about electric guitar and identify:

- Three interesting album recordings that include electric guitars and specify what is interesting;
- Key features that people look for when purchasing an electric guitar.

Go to ‘Semantic Search’ in MusicPinta and type electric guitar. Browse the content and follow links. Complete the provided form.

**Methodology**

A methodology is proposed for using log data to profile browsing behaviour. MusicPinta, a SDB which accesses Linked Open Data in the music domain, has been developed to capture user browsing behaviour by monitoring the clicks and their context.

Our approach for profiling exploratory browsing behaviour with a SDB is shown in Table 1, with MusicPinta case study as an example. There are three stages: preparation, analysis and profiling.
General Approach | MusicPinta Case Study
---|---
**Preparation** | Extend semantic data browser with logging features
Encode log data with semantic annotations | MusicPinta was programmed with the ability to capture user interaction with a user id, timestamp and the entity that a user clicked.
Choose one or more human factors to profile | Hyperlinks with different levels of “abstract concept” or “concrete concept” were encoded for the study.

**Analysis** | Count the total number of links user clicked
Examine the number of links based on semantic coding | User performance for each task was chosen to be profiled.
The number of links encoded “abstract concept” and “concrete concept” of each user was examined.

**Profiling** | Profile browsing behaviour in terms of human factors and semantic features
The relationships amongst number of clicks, links of abstract/concrete concepts and task performance were examined.

Table 1: Methodology of profiling browsing behaviour with semantic data browser

This proposed approach provides a method for profiling browsing behaviour with interaction log data and externalising the behaviour in an explicit form. With the profile in an explicit form, we can conduct comparison of user behaviour across different versions of SDB, which may provide useful insight while experimenting new ways of using semantics.

**Analysis**

To understand the semantic relationship among the links that users browsed, we coded ontology entity into four levels based on the abstraction levels in the ontology. This coding is defined in Table 2. With this coding, a snippet of log data on one participant (p01) after pre-processing is shown in Table 3.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Abstraction level</th>
<th>Code</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract concepts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classification – upper level</td>
<td>L5</td>
<td>Entity as an upper level concept e.g. instrument, performance, artists</td>
<td></td>
</tr>
<tr>
<td>Classification – middle level</td>
<td>L4</td>
<td>Entity as a middle level concept e.g. string instrument, drums</td>
<td></td>
</tr>
<tr>
<td>Classification – lower level</td>
<td>L3</td>
<td>Entity as a lower level concept e.g. plucked string instruments, hand drums</td>
<td></td>
</tr>
<tr>
<td><strong>Concrete concepts</strong></td>
<td>Concrete concepts</td>
<td>L2</td>
<td>Entity as a concrete item e.g. violin, electric guitar</td>
</tr>
</tbody>
</table>

Table 2: Semantic coding of entities of MusicPinta

<table>
<thead>
<tr>
<th>User Id</th>
<th>Ontology entity of the link</th>
<th>Abstraction Level</th>
<th>Timestamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>p01</td>
<td>dbpedia:Ukulele</td>
<td>L2</td>
<td>2012-12-08 22:03:24</td>
</tr>
<tr>
<td>p01</td>
<td>dbtune_instrument:plucked_string_instruments</td>
<td>L3</td>
<td>2012-12-08 22:03:30</td>
</tr>
<tr>
<td>p01</td>
<td>dbtune_instrument:balalaika</td>
<td>L2</td>
<td>2012-12-08 22:04:18</td>
</tr>
<tr>
<td>p01</td>
<td>dbtune_instrument:plucked_string_instruments</td>
<td>L3</td>
<td>2012-12-08 22:05:04</td>
</tr>
</tbody>
</table>

Table 3: Example of log data with semantic coding for participant p01
One of the important factors of evaluating an exploratory search system was task success. As the first step, we chose “user performance” as a human factor for behaviour profiling. We aimed to profile users’ browsing behaviour and compare that against their task performance. The summary of user performance (Table 4) is ordered by average performance of Task1 and Task2 with top and bottom performers identified. As our study was to profile browsing behaviour against task performance, the extreme cases in terms of task success rate can allow us to separate clearly “successful behaviour” from clearly “unsuccessful behaviour”.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Task1</th>
<th>Task2</th>
<th>Average of Task1 &amp; Task2</th>
<th>Top and bottom Performers</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01</td>
<td>81%</td>
<td>66%</td>
<td>73.5%</td>
<td>3rd highest performer in Task1; 3rd highest performer in Task2.</td>
</tr>
<tr>
<td>P05</td>
<td>97%</td>
<td>50%</td>
<td>73.5%</td>
<td>Highest performer in Task1</td>
</tr>
<tr>
<td>P04</td>
<td>71%</td>
<td>75%</td>
<td>73.0%</td>
<td>Highest performer in Task2</td>
</tr>
<tr>
<td>P07</td>
<td>67%</td>
<td>67%</td>
<td>67.0%</td>
<td></td>
</tr>
<tr>
<td>P03</td>
<td>74%</td>
<td>50%</td>
<td>62.0%</td>
<td></td>
</tr>
<tr>
<td>P06</td>
<td>73%</td>
<td>58%</td>
<td>65.5%</td>
<td></td>
</tr>
<tr>
<td>P10</td>
<td>82%</td>
<td>50%</td>
<td>66.0%</td>
<td></td>
</tr>
<tr>
<td>P08</td>
<td>64%</td>
<td>8%</td>
<td>36.0%</td>
<td>Lowest performer in Task2</td>
</tr>
<tr>
<td>P09</td>
<td>44%</td>
<td>17%</td>
<td>30.5%</td>
<td>Lowest performer in Task1</td>
</tr>
<tr>
<td>P02</td>
<td>53%</td>
<td>42%</td>
<td>47.5%</td>
<td>2nd lowest performer in Task1; 4th lowest performer in Task2.</td>
</tr>
<tr>
<td>P12</td>
<td>69%</td>
<td>50%</td>
<td>59.5%</td>
<td></td>
</tr>
<tr>
<td>P11</td>
<td>71%</td>
<td>41%</td>
<td>56.0%</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Top and bottom performers in the experiment study ordered by average performance of Task1 and Task2

Figure 1 shows the number of links browsed by each user in Task1 and Task2, sorted from the top clickers (who browsed the most number of links) to the bottom clickers (who browsed the least number of links). The top and bottom performers are marked in the figure.

Figure 1: Number of links browsed by users in two tasks
Based on the semantic coding, two types of links are classified - abstract (L3, L4 and L5) and concrete (L2). To compare the browsing behaviour against users’ overall performance (which is the average of Task1 and Task2), numbers of abstract and concrete concept links browsed by users in the two tasks are visualized in Figure 2. The user list is ordered by the total number of links browsed by users. On the left and middle part of Figure, the abstract concept links and concrete concept links are presented separately; while on the right the abstract concept links and concrete concept links are presented together to show the proportion of the two.

![Figure 2: Number of abstract and concrete concept links browsed by users in the two tasks](image)

**Profiling**

Browsing behaviour (number of links and the proportion of the concrete and abstract links) with overall task performance is visualized in Figure 3.

![Figure 3: Browsing behaviour with overall task performance](image)
With this figure, we are able to examine if there is any correlation between performance, the number of clicks and the level of abstract/concrete browsing. The participants are represented by different sizes of square, proportional to the number of links they clicked. Each square is filled with two colours: black for the number of clicks on abstract concepts and grey for the number of clicks on concrete concepts. As seen in the figure, there is no obvious pattern detected amongst the top performers (p01, p04, p05) and amongst the bottom performers (p02, p08, p09). However, we can profile the users with an explicit form shown in Table 5. Although there is no strong correlation between the profile and the performance, this explicit form has established a way to externalise the user behaviour according to the semantics.

<table>
<thead>
<tr>
<th>Type of clickers</th>
<th>Description</th>
<th>Examples of top performers</th>
<th>Examples of bottom performers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top clickers</td>
<td>Ranking top 3 in 2 tasks based on the numbers of clicks</td>
<td>p01 and p05</td>
<td></td>
</tr>
<tr>
<td>Bottom clickers</td>
<td>Ranking bottom 3 in 2 tasks based on the numbers of clicks</td>
<td>p04</td>
<td>p09</td>
</tr>
<tr>
<td>Concrete clickers</td>
<td>About 90% clicks were concrete concepts</td>
<td>p04 and p05</td>
<td>p08</td>
</tr>
<tr>
<td>Mix clickers</td>
<td>About 25% clicks were abstract concepts and 75% clicks were concrete concepts.</td>
<td>p01</td>
<td>p02</td>
</tr>
</tbody>
</table>

Table 5: Profile of browsing behaviour of MusicPinta

Discussion

In this study, we examined users’ interaction with semantic links and their task performance in order to understand users’ behaviour with semantic data browsers. We reached an answer to our first research question: “can we model exploratory browsing behaviour in terms of semantic features of hyperlinks?” in two steps. Firstly, we proposed a methodology to profile browsing behaviour with log data and user performance; and secondly, conducted a study with a Semantic Data Browser (SDB), MusicPinta. In addition to the number of clicks as a measure of browsing behaviour, the semantic links in the log were annotated to gauge the level of zooming in and out of abstraction – a feature of ontological structure. The analysis was conducted by visualising the proportion of abstract and concrete level browsing. There is certainly potential to exploit further the semantic relationships of the hyperlinks for deeper insight. In the future, more detailed semantic coding can be added, for example the type of content such as “descriptions” or “images” at the concrete level browsing.

The answer to our second research question “Can we relate the possible browsing behaviour in a SDB with performance in exploratory tasks?” was mixed. On one hand, the results clearly showed the power of visualising browsing behaviour against task performance. On the other hand, no conclusive patterns were found from this study which indicated that either a larger sample of users would be needed or the parameters chosen for analysis might have no impact on task performance. For the latter, new tasks with new parameters could be designed for a repeat study, for example, more human factors (such as user learning style, knowledge and skills, curiosity index etc.) can be selected for the profiling.

This study established a methodology in profiling user behaviour, benefiting from the semantic features of log data, and compared the outcome against their task performance.
2.2.2 Modelling Collaborative Sensemaking Behaviour

Dicode presents an approach to support collaboration which exploits a range of semantic types to enable an incremental formalization of argumentative discourses, as well as the integration of argumentation support systems with data mining services (Tzagarakis and Karacapilidis, 2013). The overall aim of this approach is to semantically augment argumentative discourses, while also exploiting the synergy between tools supporting machine and human intelligence.

Following the methodology we established in the first study, we believe the extra semantic types enabled by the Dicode workspace can provide us a way to model collaborative sensemaking behaviour. To gain insight about how users perform with these semantic features of collaborative argumentation spaces, we conducted our research in 3 steps:

- Designed a user study inspired by Use Case 1 (Scientific research) to collect log data of users completing a collaborative decision making task;
- Developed a Community Behavior Analytics Tool (CommBAT) to gain insight of log data of users behavior, and
- Analysed the data supported by CommBAT.

User Trial Study

In this study, we recruited three researchers at University of Leeds, who were working on a research project. Before the study, they attended a demo session to learn the main functions of the Dicode collaborative workspace:

- Switch between communities and access workspaces
- Add/update/delete objects
- Work on different views of workspaces:
  - Desktop-view, where objects (ideas, comments or notes) or links between objects can be added and organize in a spatial space.
  - List view, where all objects are listed in a table format, where you can sort the items by object title, type, user, time etc. List view provides the history of all the activities in the collaboration workspace.
  - Formal-view, where the ideas and relations are transformed to a tree view. Formal-view presents the structure of the arguments in the collaboration workspace.
  - Time-ordered view, where you can view/post objects in a chronological order. This view shows the title and content of the objects.

The team were using three types of objects to represent a knowledge item in the Dicode Collaborative Workspace.

- An idea is a thought or suggestion as to a possible course of action. Use ideas to propose a possible solution to the issue under consideration. Ideas have to be related to the decision being sought.

- A comment is a remark expressing an opinion or reaction. Comments can be linked to an idea, a comment or a note. Comments can provide explanation or point to useful information.
A note is a statement expressing one’s knowledge about the issue under consideration. Notes can be linked to ideas, comments or notes.

The task for the team participating in the study was to formulate research questions and design a user study to tackle the specific research questions. The team used the Dicode Collaborative Workspace to discuss and come to some consensus on a design of an experimental study. Two collaborative workspaces were set up for the team:

- Research Questions (RQ)
- Participants & Procedure (PP)

The team worked on this task for one week and we collected log data of two collaborative workspaces.

CommBAT

We developed CommBAT, a standalone Windows application (Figure 4), that provides an interactive way to explore the log data of Dicode Collaborative Workspace and supports the analysis of community behaviour.

![CommBAT, a standalone Windows application](image)

**Figure 4**: CommBAT, a standalone Windows application

The main functions of CommBAT are

- Read a log file, which is produced by Dicode Collaborative Workspace.
- Pre-processing log data in different facets with total numbers of records:
  - Users (list of users and number of records of different users)
  - Activities (list of activities and number of records of different activities)
  - Objects (list of objects and number of records of different objects)
  - Object semantic types (list of semantic types and number of records of different semantic types)
Object content types (list of content types and number of records of different semantic types)

- Interactive facets filtering with number of records
  - Users: to filter the logs and number of records based on a selected user
  - Activities: to filter the logs and number of records based on a selected activity
  - Objects: to filter the logs and number of records based on a selected object
  - Object types: to filter the object types and number of records based on selected object types.
- Explore the Link type object: the links that connect two objects
- Explore the Idea type object: the Ideas that are connected with other objects

Results of the log data analysis using CommBAT are the following:

**Top Activities of Two Workspaces (Figure 5)**

On further analysis, the top three activities of two workspaces appear to be the same. They are activities of “MoveObject”, “LoadMindmap” and “ViewContent”. The activity of “MoveObject” in the Desktop (Mindmap) view contributed almost half of the log entries. This shows that a further study is needed to investigate:

1. Why users need to move the objects?
2. How does user move the object?
3. Does the spatial relationship of objects have impact on sensemaking of the topic?
4. Does this moving contribute to sensemaking of the objects?

![Figure 5: Top activities of two workspaces](image)

(Top: research questions workspace; bottom: participants & procedures workspace)
Different users’ top activities of two workspaces (Figure 6)

Not only the top three activities of the two workspaces appear to be the same; looking into the distributions of different users’ activities, it shows a similar pattern of how they contributed to the top three activities. Only two participants (p01 and p03) contributed to the 3rd top activity (“ViewContent”) and p02 contributed most of the 2nd top activity (“LoadMindmap”). This result led us to investigate how differently three users contribute to the workspaces from a semantic type point of view (next section).

Figure 6: Different users on top activities of two workspaces
(Top: research questions workspace; bottom: participants & procedures workspace)
Different users’ contribution of new objects (Figure 7)

With the semantic types recorded in the logs, we can look into how different users contributed to the workspaces based on those types. From the previous result, we noticed that only p01 and p03 contributed to the activity of “ViewContent”. In terms of the contribution of new objects to the first workspace (“Research Questions”), p02 contributed most of the ideas, comments and notes, while p01 and p03 contributed on comments and notes. This could be explained that to provide comments and notes, p01 and p03 had to read the content produced by p02.

![Bar chart showing contribution of new objects]

Figure 7: Different users’ contribution of new objects
(Top: research questions workspace; bottom: participants & procedures workspace)

Interactions among users detected through links

The CommBAT has a function to show a list of all links and information of their start object and end object, which includes
- Object ID;
- The creator of the object; and
- The type of the object.

Currently, we use a simple Interaction Index to present whether the link involves multiple users (Figure 8). It shows out of 33 links, there were 10 links with Interaction Index as 1, which means the link, the start object and the end object were created by one user; there were 23 links with Interaction Index as 2, which means two users were involved with the link and the linked objects. This information can be used to detect the interaction level among the objects.

![Figure 8: List of Links in Workspace: Research Questions](image)

**Connected Objects (Figure 9)**

The CommBAT explores the objects of Ideas that are connected with other objects. Specifically, it counts the inbound links and outbound links to identify the maturity level of an idea.

![Figure 9: Linked Ideas in Workspace: Research Questions](image)

As shown in Figure 9, Idea 29970 had 7 inbound links and 1 outbound link, ranging from comments, notes and ideas, while Idea 30125 only had one outbound link. This information could be used to calculate the maturity of an idea in order to inform the participants to take actions.
Discussion

The log analysis supported by CommBAT has helped us to identify some important factors of community modelling, such as activities, object types and interactions of objects to model user and community behaviour of Dicode Collaborative Workspace. An initial analysis has shown that top activities of users in both workspaces were “MoveObject”, “LoadMindmap” and “ViewContent”. Different users showed consistent pattern of contribution to the workspace in terms of activity and semantic types of objects. More than two-thirds of the links between objects were created by two users. A larger sample of users would be needed to gain deeper insight of the user and community behaviour in order to develop alerts to indicate when intervention or attention are required from the collaboration and decision support services.

2.3 Decision making support services

Dicode’s decision making support services are the focus of Task 4.5. They aim towards a meaningful formalization of collaboration to intelligently support stakeholders in decision making activities by enabling the use and exploitation of various reasoning mechanisms.

Based on the functional specifications outlined in deliverable D2.2, a set of operations supporting collaboration within Dicode have been designed and developed. In particular, in the initial version of the decision making support services, the “formal view” of collaboration workspaces has been implemented as outlined in deliverable D4.2.1. In the enhanced version of the decision making support services, apart from the “formal view” of the Collaboration Service, the support for the decision making process has been augmented with algorithms coming from the field of Multi-Criteria Decision Making (MCDM; also called Multi-Attribute Decision Making - Triantaphyllou et al., 1999). In the final version of the decision making support services, based on the results of the 2nd review of the Dicode project, development efforts put a more explicit focus on usability issues.

2.3.1 Decision making support

The final version of the decision making support services, apart from providing the necessary operations to implement the “formal view” and the “multi-criteria decision making view” of the collaboration workspaces, deals with a series of usability issues such as the layout of the HTML pages implementing the services, as well as the styling and the efficient (from a user perspective) positioning of elements on the respective web forms.

As already stated in D4.2.1, the “formal view” of a collaboration workspace permits only a limited set of discourse moves for a limited set of message types whose semantics is fixed and system defined. In addition, this view can be associated with reasoning algorithms that are able to calculate which proposed solution is currently prevailing or which position has been defeated.

The “multi-criteria decision making view” of the collaboration workspaces is the fourth option (the other three are the “forum view”, the “mind-map view” and the “formal view”) in which collaboration workspaces can be operated. Three multi-criteria decision making algorithms have been implemented, namely: (i) the Weighted Sum Model – WSM, (ii) the Analytical Hierarchy Processing – AHP, and (iii) the Lexicographic Decision Making rule
(LEXIC) (the reader should refer to D42.2 for details on these algorithms and their implementation in the “multi-criteria decision making view” of Dicode workspaces).

Since all the abovementioned views constitute an integral part of the collaboration workspace concept, the decision making support operations have been implemented within the Collaboration Service. Two different interfaces provide the relevant decision making operations, when the workspace is operated in the “formal view” and the “multi-criteria decision making view”.

In the table below, we present the associated changes in the final version of the Collaboration Service. We annotate each change with “New” or “Updated” to indicate the type of change that occurred in the final version (compared to the enhanced one).

<table>
<thead>
<tr>
<th>Name</th>
<th>Collaboration Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standards</td>
<td>REST (Fielding, 2000)</td>
</tr>
</tbody>
</table>
| Description           | As already described in deliverables D4.1.2 and D4.2.2, the Collaboration Service provides operations that enable users to conduct formal argumentative discourses and multi-criteria decision making analysis. Formal argumentative discourse is provided by the “formal view” of collaboration workspaces. The service provides operations to allow users configure the “formal view” and use them to engage into collaborative activities towards decision making. The “multi-criteria decision making view” incorporates a set of three algorithms to further augment the decision making process. The Collaboration Service provides functionality for supporting the “formal view” and the “multi-criteria decision making view” of collaboration workspaces through the following interfaces:

- **FormalCollaboration Interface**: Its purpose is to provide all operations related to the configuration and use of the “formal view” of workspaces.
- **MultiCriteriaDecisionMaking Interface**: Its purpose is to provide multi-criteria decision making algorithms to augment the decision making process.

The **FormalCollaboration** and the **MultiCriteria-DecisionMaking Interface** do not provide operations for creating and managing collaboration workspaces, as such tasks are handled through the **Workspace Interface** that has been described in deliverables D4.1.1 and D4.1.2. |
**Interface** | *FormalCollaboration (Updated)*
--- | ---
postIssue (Updated) | Updated the corresponding HTML form according to a uniformly applied CSS styling (concerning the form labels, the allocation of buttons on the form, the font styles used for the data labels and text fields, etc.)

| **Interface** | *MultiCriteriaDecisionMaking (Updated)*
--- | ---
setWSMWeights (Updated) | Updated the corresponding HTML form according to a uniformly applied CSS styling (concerning the form labels, the allocation of buttons on the form, the font styles used for the data labels and text fields, etc.)

calcWSMScores (Updated) | As above

| **Example usage (Updated)** | A web application will provide the necessary user interface through which the previously mentioned operations can be executed by end users. In general, all Dicode use cases that require support for decision-making will be able to use the above
operations. In particular, users of the Dicode use cases can use the operations provided by the workspace interface (presented in deliverables D4.1.1 and D4.1.2) to create and configure new workspaces where the collaboration will take place. Depending on their needs, they may deploy the workspace either in “forum view” or “mind-map view”, where they are able to upload and process the available collaboration items via the respective interfaces. If decision making functionalities are required, users may transform a workspace into the “formal view” or use the “multi-criteria decision making view” to assist decision making through the execution of multi-criteria decision making algorithms.

<table>
<thead>
<tr>
<th>Comments</th>
</tr>
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<tbody>
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<td></td>
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<th>Conformance classes</th>
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<table>
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<tr>
<th>Implementation status</th>
<th>Prototypical version implemented. The source code of the final version of the collaboration service, implementing the above operations, can be found at the following Subversion repository: <a href="https://devel.dek.cti.gr/svn/ftel/dicode/trunk/src/dll">https://devel.dek.cti.gr/svn/ftel/dicode/trunk/src/dll</a></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>UML model</th>
<th>Not available.</th>
</tr>
</thead>
</table>

Appendix A includes some representative screenshots of the final version of the Decision making support service to illustrate some of the modifications performed (with respect to the enhanced version of the service, as described in D4.2.2).

3 Conclusions

The final version of the previously described services have been developed using the guidelines outlined in deliverables D5.1.1: “Standards and guidelines for development” and D5.1.2: “Standards and guidelines for development (enhanced version)”. The changes introduced were motivated by findings that came out during the evaluation of the Dicode services, as well as by issues raised during the project’s 2nd Review Meeting.

Future work will concentrate on thoroughly testing the functionalities of the final version. Moreover, the final version of the decision making support services will be used in diverse collaboration settings in order to further assess their usefulness and ease-of-use.
4 References

Dicode Deliverable D2.2. (2012) – The Dicode Approach

Dicode Deliverable D2.3. (2012) – The Dicode Approach Revisited


Dicode Deliverable D4.2.2. (2012). The Dicode Decision Making Support Services (enhanced version)


Appendix A – Usability improvements

Appendix A includes representative screenshots of the final version of the Decision making support service illustrating some of the user-interface modifications performed (the reader should refer to the Appendix of deliverable D4.2.2 to spot the user-interface changes performed).

**Figure 1**: The Multi-Criteria decision making view with the results list, one for each algorithm. Number of alternatives shown (without scrolling) on each list has be restricted to 5 to enable users easily get an overview (on the same screen) of the differences/commonalities among the results coming from the three different MCDM algorithms.
Figure 2: The WSM alternatives list, the top three alternatives are displayed in green background. A vertical scrollbar has been added to the corresponding list in order to avoid uncontrolled height enlargement (when alternatives’ number becomes relatively large).

Figure 3: The form for setting the relative weights in AHP, an example of the performed usability improvements concerning the uniformly applied CSS styling (the form labels, the allocation of buttons on the form, the font styles used for the data labels and text fields, etc.). Similar changes have been applied in a number of forms including forms for setting the required inputs for the decision making algorithms and displaying the detailed algorithm results and the corresponding graphs.
Figure 4: Part of a report (in DOC format), generated from the formal view of a collaboration space, containing the alternatives and the positions in favour/against alternatives or positions. Alternatives are displayed in orange font color and the positions in favour/against in green/red font color.
Figure 5: Sorting attributes/factors with respect to their importance in the Lexicographic DM rule (LEXIC). Tooltips have been added (when moving the mouse over each one of the four HTML elements corresponding to each attribute/factor) to urge user dragging for factor reordering.