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Usability Study of the Taverna Scientific Workflow Workbench

Progress Report

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ABSTRACT

Workflow management systems facilitate the execution of experiments which are usually complex in nature. The Taverna scientific workflow workbench represents such a system that has been widely adopted and successfully used. The user audience is broad, ranging from experienced programmers to people with a pure scientific background. The Taverna workbench is a sophisticated tool and people who do not have sufficient computer experience may encounter problems using it. Therefore the issue of the User Experience of this tool needs to be addressed. This project attempts to measure and improve the user experience of the Taverna Scientific Workflow Workbench.

In order to achieve this aim a systematic usability study is conducted with access to users of the Taverna workbench. The methodology for this study is analysed and developed. The intended results of the work are a usability study design, the usability study and usability recommendations to the development team of Taverna workbench based on the usability study results. This paper provides background information on the project, a detailed description of the proposed methodology and the progress made on the project to date.

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INTRODUCTION

Taverna is an open source workflow management system developed by the myGrid team. It is an environment which enables setting up, executing and monitoring scientific workflows. A scientific workflow can be defined as a means for managing and sharing complex scientific analyses which is constructed by chaining together different services or codes [1].

The Taverna Scientific Workflow Workbench is widely used by scientists from different domains, such as Astronomy, Bioinformatics, Chemistry, Data and text mining, Engineering, etc.. More than 350 organizations around the world are using Taverna for executing workflows and sharing them with others. Taverna is a sophisticated tool which provides broad functionality. As a result, the tool can be difficult to use for scientists who have a lack of computer experience, as this is not the main focus of their work [2]. In order to make the tool easier to use this project aims to identify and to catalogue the common problems users have when working with Taverna.

The main aim of the Usability Study of the Taverna Scientific Workflow Workbench project can be stated as follows: to understand and measure the user experience of the Taverna Scientific Workflow Workbench by conducting a systematic usability study of the tool.

In order to achieve this aim the following objectives must be met:

- Conduct the usability study
- Produce the usability design
- Report the observations to the Taverna team
- Make recommendations

User Experience is the field which investigates the user's attitude to the particular (software) product, how users perceive various aspects of the tool, such as the ease of use and efficiency. After investigating existing techniques user testing was chosen as the main method in studying usability of the Taverna workbench. As Jakob Nielsen states [3]:

"User testing with real users is the most fundamental usability method and is in some sense irreplaceable, since it provides direct information about how people use computers and what their exact problems are with the concrete interface being tested "

As opposed to the other popular methods of studying usability - questionnaires and focus groups - user testing involves actual observation of the users. The former implies listening to what people say, while in the latter case a researcher has an opportunity to directly observe the interaction and draw conclusions.

The users are recruited and continuously observed while they are interacting with the tool. People, who are going to be observed during the study, are represented as three groups of users: novices, intermediate users and expert users of the Taverna workbench. They are scientists from different domains with the difference in computing experience and programming background. The qualitative rather than quantitative approach was chosen, where 3-4 users in each group are presented. In qualitative studies, the data is usually gathered by directly observing how people use technology to meet their needs. The reason for conducting qualitative research is that a small number of participants in user testing is adequate for finding the majority of the main usability issues as it was claimed by Nielsen [4], Virzi [5] and Lewis [6].

The process of work on the project is the following:

- Study usability evaluation methods, user experience measurement tools and techniques to develop a methodology for the study
- Design a methodology for measuring the user experience of the tool based on the findings
- Run a pilot usability study in order to ensure the effectiveness of suggested techniques within the methodology
- Examine the results, enhance and modify the methodology based on the pilot study outcomes
- Recruit the users, set up the environment for the actual usability study
- Perform a usability study applying developed methodology
- Observe the final results and report them to the Taverna software development team
- Based on the obtained information make recommendations to the Taverna development team.

The rest of the report is organized as follows. The next chapter discusses project background including the information regarding scientific workflows in general as well as the detailed description of the Taverna scientific workflow workbench. A brief discussion of the current scientific workflow management systems is provided. The relevant material on the User Experience background is also presented. The first chapter is concluded by the User Experience methods description and comparison. Chapter 2 reports the progress up to date, including the pilot methodology description, the details of the developed methodology for the actual usability study and the participants' recruitment procedure. The chapter is finished by giving the information on the project mechanics, obstacles overcome and identified risks. Lastly, a Project Plan in the form of Gantt chart is presented, providing information on how the objectives will be achieved.

CHAPTER 1. BACKGROUND

This chapter discusses the relevant background material to the project with the purpose of covering the environment where this project is situated, defining the specific terms and providing the reader with necessary information for further understanding. As the current project seeks to resolve the problem of measuring and improving the user experience of the Taverna Scientific Workflow Workbench, the information related to the Scientific Workflows Management Systems as well as the User experience field will be given. The chapter also aims to justify the need for the project.

1.1 Scientific Workflows

Workflow as a notion emerged about three decades ago and it was defined in 1996 by the Workflow Management Coalition as an automated process where data is passed for further actions from step to step. The accent is made on the process, as a flow of action, from one phase to another, chaining required services for achieving a desired result [1]. Firstly, workflows were used in a business context, but later they found their application in science as well. Mainly this is due to the spread of *in silico* experimentations which make use of computers/computer simulations. Workflows which are used in these experimentations are called scientific workflows [2]. Scientific Workflows are also can be defined as useful paradigm for describing, managing, and sharing complex scientific analyses [7].

Scientific and business workflows have similarities in terms of possibility to apply control flow modeling techniques used in business workflow management systems to scientific workflow management systems [8]. However, workflows in a scientific environment go beyond the initial notion of workflows in a business perspective. Scientific workflows support not only the management and transactions between resources within one domain, but also enable the automation of the data analysis through heterogeneous data resources [9].

There are several motivations for scientific workflows [8]:

- To be able to build a collaborative workflow for complex e-science applications
- To be able to carry out a low-level expertise for using the underlying computing infrastructure such as Grid toolkits
- To be able to reuse, modify and share the analysis

Scientific workflow is a composition of different remote local services in a linked components manner in order to produce results for further analysis. Each component performs a particular task which is a fragment of the overall work, which workflow is composed to accomplish. The output of the previous component should fit to the input requirements imposed by the next node of the workflow. Often it might be the case of data formats incompatibility, when the input type of one workflow node is different from the output format of previous component which is going to be fed. Tasks within the workflow are different steps which present a particular computational process. Examples can be: executing a program, querying a database or invoking a service to use a remote resource. The output from one stage serves as an input to the next creating the flow of data [11]. This process of chaining workflow components is called *workflow composition*. The result is a graph-like structure (Figure 1.1).

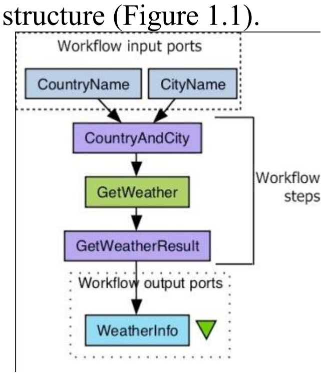

Figure 1.1 Example of a simple Taverna workflow that retrieves weather forecast for the specified city *Adapted from [12].*

Scientific workflows help scientists offering an abstract view, concealing at least some of the complexities and details of how the experiment process will be executed. Instead, scientific workflows allow a clear view of what the task is aiming to achieve. Scientific workflows make available sufficient computational resources for the researchers and allow access to necessary services and data. Scientists also have an opportunity to share and reuse workflows in a simple way. In addition, they can track the process of the workflow creation and execution. Scientific workflows acquire more importance as science is becoming more computation-intensive. It is also difficult for researchers to handle the complexity of the growing experiments and scientific workflows come to help [10].

1.2 Scientific Workflows Management Systems

A Scientific Workflow Management System (SfMS) is a software package which enables the setting up and executing of scientific workflows by providing an environment for running of *in silico* experiments [13]. These systems are used by scientists for the assembly and management of complex distributed computations. Figure 1.2 presents an example of the Taverna scientific workflow performing such computation.

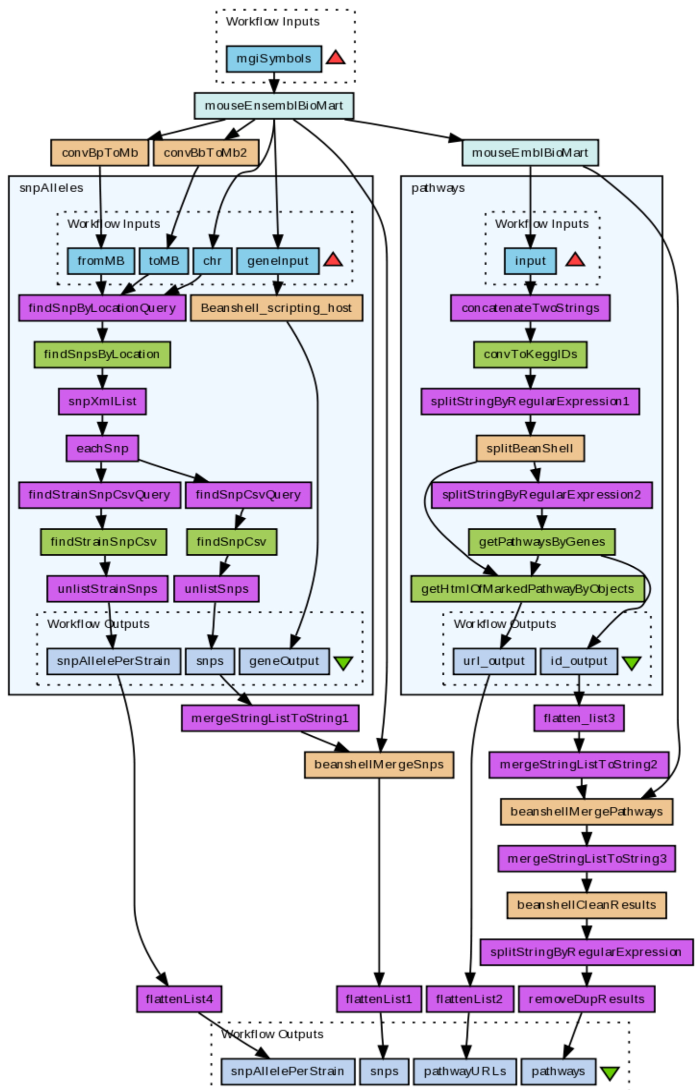

Figure 1.2 Example of a Taverna scientific workflow for mouse functional genomics from the CASIMIR consortium

Adapted from [14]

SfMSs aim to help an average researcher whose knowledge might be not sufficient for configuring the system to perform the desired actions. Lack of computing experience which is typical for researchers as it is not the main focus of their everyday activities becomes a significant obstacle in exploiting scientific applications and causes these applications remain inaccessible for the most researchers [9]. Workflows systems operations can be described as follows. The user indicates the subsequent steps in the workflow and the system performs particular tasks within those steps such as getting the required data from a database, calling different web services or other software applications, and allocating tasks on a grid [15].

Scientific Workflow Management Systems try to [16]:

- Deal with the complexity of data analysis in a scientific domain
- Provide an easy-to-use way of conducting in silico experiment
- Hide at least some of the technical details of workflow execution allowing scientist to concentrate on the data analysis
- Provide a graphical user interface so that users could compose web services into workflows
- Enable scientists reusing and sharing workflows between them. It can be done through web sites, such as myExperiment
- Help to deal with data incompatibility and allow workflow creators to avoid developing these tasks themselves

The increasing popularity of scientific workflow management systems can be accounted for by the growing number of scientists relying on these systems for conducting complex distributed computations.

1.3 Taverna Scientific Workflow Workbench

Taverna is a Workflow Management System which is created to support the construction of workflows to perform different analyses and the automation of complex, service-based and data-intensive processes. It allows the employment and integration of the variety of different tools which are offered on the web [17]. Taverna is broadly used in diverse domains such as bioinformatics, arts, chemistry, medical research, astronomy, and the social sciences. The widest application it found in the domain of the Life Sciences where it is exploited for experimental investigations.

Taverna Workflow Management System consists of the Taverna Workbench desktop application and the Taverna Server which serves for remote execution of workflows. Both of them are powered by the Taverna Engine. It is also available as a Command Line Tool which allows a quick execution of workflows. The current usability study is conducted on the Taverna workbench, therefore in the rest of the paper the term “Taverna” refers to the Taverna Workbench which provides the main user interface. Taverna Scientific Workflow Workbench allows creating, visualization, editing and running workflows as a desktop application on a computer. Taverna Workbench has a graphical workflow designer where users can drag and drop workflow components. The main features of Taverna are its free availability, domain independence and wide range of services offered. It also allows finding workflows created by others and share yours through myExperiment website. The workflows discovered through myExperiment can be downloaded, edited and run within the Taverna Workbench. Another important feature of Taverna is that the set of available services is not limited and new services can be imported into the Taverna Workbench [18].

Graphical user interface of the Taverna workbench is used for workflows construction, execution and results browsing which are generated from workflow runs. There are three perspectives in the Taverna workbench which serve for accomplishing particular tasks in the different stages of workflow composition [18]:

- Design Perspective is the main perspective of the workbench which offers a means for workflows building.
- Result Perspective provides functionality for monitoring workflow runs and viewing intermediate and final workflow results
- MyExperiment Perspective is a way to access and query myExperiment website from within the Taverna Workbench

All the Taverna menus, toolbars and panels are organised into abovementioned perspectives.

Let me describe the Design Perspective (Figure 1.2) - the main working view of Taverna which provides functionality for building workflows. It consists of three main areas: Workflow Explorer, Service Panel and Workflow diagram [18].

- Workflow Explorer is located at the bottom left of the screen. It offers a hierarchical view of the current workflow units, such as services, workflow inputs and outputs, data connections and coordination links and annotations associated with them
- Service Panel at the top left provides the functionality for managing the tools for building workflows. These tools are displayed as a hierarchy and they can be searched by regular expression. The user can also add services to the existing list of services offered in Taverna
- Workflow Diagram, which occupies the right hand-side of the displayed area, provides a graphical view of the current workflow. The diagram can be used to create, edit and modify workflows. Inputs, outputs and processors are presented as boxes of different colours and data and control links are presented as arrows between them

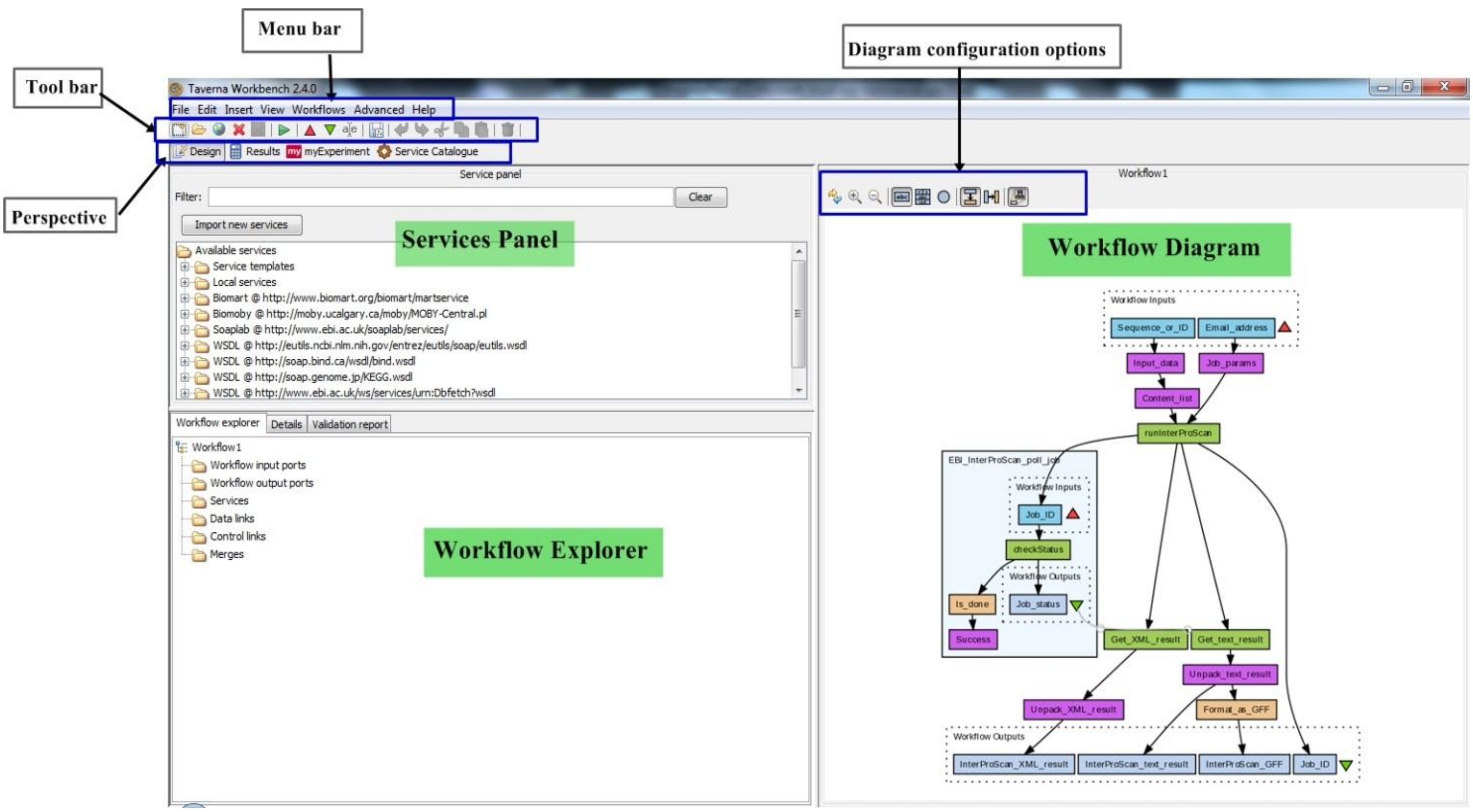

Figure 1.3 Taverna Workbench – Design Perspective

In order to perform analysis several analytical tools and databases usually need to be used in a sequential order. Connecting the tasks together is typically accomplished either by copy-pasting manually between web pages or by writing a complex scripts. While the first one is simply cumbersome and inconvenient, the second requires good programming skills which most scientist do not have. In Taverna the workflow construction is accomplished through a graphical user interface, by combining different web services into automatic workflows and no programming background is required. It seems like a simple and natural procedure to a programmer, but to the scientific end-user "visual programming" methods offered in workflow systems can be unusual and complicated. Particular difficulties can arise when workflow construction passes over into an actual programming such as repeating iterations over workflow parts and defining parallel workflows. Another problem might be that the systems require users' knowledge about the necessary workflow components for performing their experiment, as well as the data location which is requested by these components. In addition, the systems also assume that a researcher knows in advance which experiment they are describing [19].

The strengths of the Taverna workbench are its capability to combine a significant range of autonomous services and to reproduce of scientific analyses and processes [20]. The weakness is that the software can be complicated and difficult to use for the ordinary scientists.

One of the Taverna main goals is to provide a powerful instrument with a broad functionality at the same time preserving the ease of using the tool. Taverna also aims to support users, who have limited computing experience, giving them the ability to assemble complex workflows [21].

1.4 Other Scientific Workflow Management Systems

There are various Scientific Workflow Management Systems based on dataflow languages, which provide a graphical interface for users for constructing applications as a visual directed graph by linking the components together. As the most widely used examples of the current Scientific Workflow Management Systems can be named Taverna [1], Kepler [22], VisTrails [23], Triana [24], Pipeline Pilot [25] and KNIME [26].

Kepler [22] is an open-source scientific workflow system which is created to help scientists by providing the tool for sharing and reusing data and workflows. Kepler includes a graphical user interface for building workflows in a desktop environment, a runtime engine for executing workflows separately from a command-line within the graphical user interface, and a distributed computing option provides the ability to distribute workflow tasks between several of components in a computer cluster. Kepler makes an emphasis on actor-oriented design where actors are re-usable computational units, such as web services. Data is fed to the actors from inports and it is written to outports. Then actors can be combined by mapping from outports to inports [19]. Other features of Kepler are: first, workflows and components can be saved, reused, and shared with other researches with the means of the Kepler archive format (KAR). Next, Kepler allows nested workflows. The software also includes a library with around 350 prepared for use processing elements, which can be searched, modified and linked in an easy way. They also can be executed from a desktop for carrying out an analysis, automating data management, and integrating applications efficiently.

VisTrails [23] is a scientific workflow and provenance management system which delivers data exploration and visualization services. VisTrails is an open-source software package which main feature is a comprehensive provenance infrastructure with history information about the steps taken and data obtained during running an exploratory task. This information is given either as XML files or in database and users can intuitively operate between workflow versions, to undo actions without losing results, match workflows and their results, and analyse the actions which produced a result. In VisTrails sequence operations and user interfaces are presented which make the design and management of workflow easier, providing the ability to create, enhance and query workflows by example.

Triana [23] is an open-source simulation system and problem-solving environment developed at Cardiff University. It is used by researchers for a variety of tasks, such as simulation, signal, text and image processing. Triana offers an intuitive visual interface along with data analysis tools for creating, modifying, managing and running workflows. Triana enables users to build workflows by dragging units or tools onto a working area and joining them together by connecting components using data and control links. Triana has a big library of pre-defined tools for data analysis and users can also easily add their own tools. Various workflow readers/writers can be integrated, for example, Web Services Flow Language (WSFL), Directed Acyclic Graph (DAG), Business Process Execution Language (BPEL), etc. [20]. Triana serves as a powerful toolkit for automating repetitive tasks, such as find-and-replace on all the text files in a specific directory, or continuously observing the data coming from long-lasting experiments.

Pipeline Pilot [25] is a data pipelining framework and a platform which is used for integrating, accessing, handling and analysing large amounts of scientific data in domains such as chemistry, cheminformatics, bioinformatics, etc.. The tool provides an environment for managing service-oriented workflows throughout its life cycle. In order to create service-oriented workflows two components are used: a custom manipulator component and a set of SOAP components. Within the custom manipulator component the PilotScript language (functional expression language) is used for specifying the operations performed on the service's input and output. In the SOAP component the Web service can be defined by indicating the path in the WSDL file. In the Pipeline Pilot command line, Web browser, or application can be used for enacting the workflow. The main benefit of Pipeline Pilot is the lightweight of the client graphical environment. Another advantage is the reliability of the tool. Lastly, Pipeline Pilot offers great capabilities for supporting service-oriented workflow management. One of Pipeline Pilot's major disadvantages is that workflows can't be used in BPEL-compliant workflow platforms. Also, the current version of Pipeline Pilot's client graphical environment works only with Microsoft Windows, imposing restrictions for Linux and Macintosh users [25].

KNIME (Konstanz Information Miner) [26] is an open-source analytics platform which allows data integration, processing, analysis, and exploration. It allows a data pipeline simple visual construction and interactive execution. KNIME is created for education, research and collaboration purposes. It allows easy integration of new algorithms and provides methods for managing data. One of the attractive features of KNIME is its built-in modular approach, which records and keeps the process of analyses in the order they were conducted, at the same time providing intermediate results availability. The main features of KNIME are its scalability through sophisticated data handling, simple extensibility and intuitive user interface. In KNIME workflows are presented as graphs with linked nodes, which call direct acyclic graph (DAG). New nodes and connections between them can be added using the WorkflowManager. The status of nodes can also be tracked and a pool of executable nodes can returned on demand [26].

Let us briefly examine some differences between the first three systems described [21]:

- ✓ The initial focus of Taverna was creating an environment for building and running bioinformatics workflows while Triana initially was designed as software for signal processing analysis. Now both systems have a similar focus of delivering a general tool to build workflows across a variety of scientific fields.
- ✓ If we compare Taverna, Triana and Kepler systems, it can be noted that they have taken different approaches. For instance, Taverna and Triana offer a single dataflow execution model of workflows while Kepler allows many execution models. However, there are fundamental similarities in the way workflows composition and execution is conducted: first, user chooses the workflow components, then he specifies the appropriate properties for the chosen units and finally he defines the connection of components into a flow of operations
- ✓ The process of implementing a workflow and reviewing the produced results is also different between the systems. While in Taverna a unified result viewer is exploited enabling the user to browse through produced results with appropriate results visualisation, Triana and Kepler provide just the final component of the workflow to show the result. This method gives the suitable output from the workflow, but it does not assists the researcher in further workflow development or experimentation with other concepts in the workflow. This ability to use a workflow for further explorations offers benefit through managing a history of executed workflows
- ✓ The capability of a component to have several ports that produce different output types exists Taverna and Kepler, but not in Triana

The number of scientific workflow systems is growing every year. These systems aim to provide scientists with necessary functionality for conducting compute and resource-intensive analyses. While these systems have common goals and characteristics, they differ in a set of requirements they impose and different languages and workflow execution engines implementation.

1.5 User experience overview

The "user experience" (UX) is a new concept which was first used in 1995 by User Experience Architect Donald Norman [27]. The term "User experience" is difficult to define because a common agreed understanding of UX is not reached yet. ISO FDIS 9241-210 defines User Experience as "a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service" [28]. UX is closely related to the Usability term. Both of them are central terms in the Human-Computer

Interaction discipline. Let us examine the difference and relationship between these terms. According to J. Nielsen, Usability considers five basic components [3]:

- Learnability
- Efficiency
- Memorability
- Error tolerance and prevention
- Satisfaction

Usability can be presented as the user's ability to complete a task successfully using the tool, while user experience goes beyond that and takes into account the entire process of the user's interaction with the product, including the user's feelings which result from this interaction. The user experience measurements are important, but they are based on usability dimensions [29].

Next, usability is considered to be a prerequisite for user experience [30]. User experience aims to design not only usable software, but pleasurable as well. Figures 1.4 and 1.5 illustrate this relationship between the two terms.

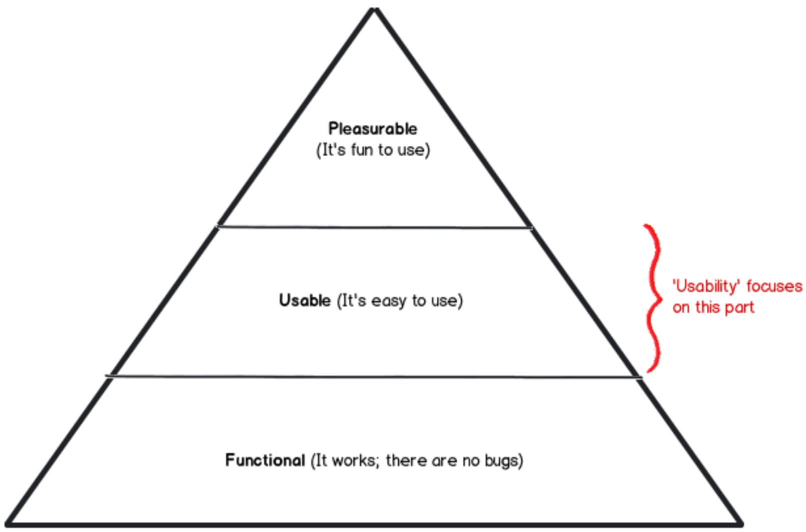

Figure 1.4 Usability in the user's hierarchy of needs.
Adapted from [31]

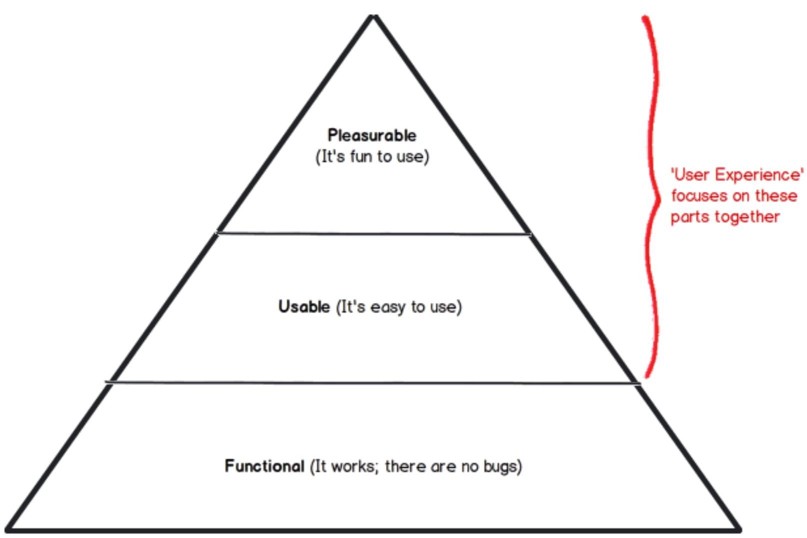

Figure 1.5 User Experience in the user's hierarchy of needs.
Adapted from [31]

It can be assumed that the user has three hierarchical categories of needs [31]:

1. Functional – the most basic need. The software must work. It is a prerequisite to usability and UX
2. Usable. The software should be easy to use. It is a prerequisite to UX
3. Pleasurable. The software should be enjoyable to use.

A difference between usability and user experience can also be made in terms of methods they apply. The goal of the former is to enhance human performance while the latter aims to improve user satisfaction with achieving both pragmatic and hedonic goals. Sometimes the term "user experience" is used to refer to both approaches [32].

The reason of the growing popularity of the User Experience field in both academia and industry can be the fact that the limitations of the traditional usability framework have been understood. The usability framework concentrates mainly on performance of a user in the process of human-computer interactions, while user experience takes into account all the aspects of how people use the system [33].

1.6 Usability Evaluation methods overview

Usability evaluation aims to assess the functionality of the tool, to identify the effect it has on users, and to detect any application problems [34]. There are numerous methods for usability evaluation which are divided into three main types such as testing, inspection, and inquiry. A brief description of each type and related methods is presented below.

- *User testing* is a type of usability evaluation methods, where representatives of real users are observed. It involves users performing a set of tasks interacting with the system, while their behaviours are observed and the information related to the way participants accomplish the tasks is collected. This method is viewed as one of the most effective methods since the exact information on users' problems can be obtained with the actual interface being tested [3]. Commonly used usability testing methods are Think aloud protocol and Remote Usability Testing [35].
- *Usability inspection* represents a set of usability evaluation methods for finding usability problems and examining usability-related aspects of the interface [35]. In contrast with usability testing, in Usability inspection user interface is assessed by the inspector (researcher). Commonly deployed usability inspection techniques are Cognitive Walkthroughs, Heuristic Evaluation and Pluralistic Walkthrough
- In *Usability inquiry* information related to users' preferences, requirements and understanding of the tool is collected through verbal communications or asking them to response to given questions in a written form. Commonly used usability inquiry methods are Focus Groups, Interviews, Questionnaires

Let us examine each of the abovementioned methods highlighting the main issues related to them.

- ✓ *Thinking-aloud* is a method, where a user interacts with the software continuously thinking out loud, reporting his thoughts and feelings. It helps to understand how the users see the observed product, how he feels about it, and this helps to detect the users' main problems they have while interacting with the tool [35].
- ✓ *Remote usability* testing is a method which is used when the participants are located in a distance from usability evaluator. In this method the network acts as a link between evaluators and users, where evaluation is performed with users connected via this bridge and working in their natural work settings [36].
- ✓ *Heuristic evaluation* is an inspection technique which is conducted by having several usability evaluators assessing an interface design. They check whether the interface conforms to usability design requirements [37].
- ✓ In *Cognitive walkthrough* the system's interface is evaluated by a group of inspectors. The tool is assessed in terms of ease of understanding and learning, particularly by an exploration. The reason for this is that it was noticed that usually users prefer learning how to use the tool by exploration [38].

- ✓ *Pluralistic walkthrough* is a method where developers, users and human factors engineers gather to pass step by step through a scenario, considering and assessing the product usability [39].
- ✓ *Focus groups* method is an informal technique for evaluating user needs and feelings. In a focus group, about six to nine users discuss new concepts and identify issues related to the software usability for approximately two hours [36].
- ✓ *Interviews* is a usability inquiry method, which concentrates not on the user interface itself but only users' views about it. It is a verbal method where the information related to the usability of the product is obtained by directly asking users, which features they particularly like or dislike [37].
- ✓ *Questionnaires* usability inquiry method refers to indirect techniques, as it does not study the user interface, but obtains users' opinions about it. Questionnaire consists of a series of questions which are designed with the purpose of learning the way users use the tool and what is their attitude [3].

1.7 Techniques Comparison

Evaluation Method	Evaluation Method Type	Applicable Stages	Description	Advantages	Disadvantages
Think aloud protocol	Testing	Design, coding, testing and release of application	In this method participants report their thoughts on the system while performing set of tasks	- Less expensive - Results are close to what is experienced by users	- The Environment is not natural to the user
Remote Usability testing	Testing	Design, coding, testing and release of application	The researcher does not directly observe the users while they interact the product, but activity may be recorded for subsequent viewing	- Efficiency, effectiveness and satisfaction - the three usability issues - are covered	- Additional Software is necessary to observe the participants in a distance
Focus groups	Inquiry	Testing and release of application	A moderator guides a discussion with a group of users of the software being evaluated	- If done before prototypes are developed, can save money - Produces a lot of useful ideas from the users themselves - Can improve customer relations	- The environment is not natural to the user and may provide inaccurate results. - The data collected tends to have low validity due to the unstructured nature of the discussion
Interviews	Inquiry	Design, coding, testing and release of application	The test participants are interviewed to learn about their experience and expectations	- Good at obtaining detailed information - Few participants are needed - Can improve customer relations	- Cannot be conducted remotely - Does not address the usability issue of efficiency
Cognitive walkthrough	Inspection	Design, coding, testing and release of application	A team of evaluators walks through the system discussing usability issues through the use of a paper or a working prototype	- Good at refining requirements - Does not require a fully functional prototype	- Does not address user satisfaction or efficiency - The designer may not behave as the average user when using the application
Pluralistic walkthrough	Inspection	Design	A team of users, usability engineers and product developers review the usability of the paper prototype of the application	- Usability issues are resolved faster - Greater number of usability problems can be found at one time	- Does not address the usability issue of efficiency

Table 1.2 Usability Evaluation Techniques Comparison
Adapted from [40]

1.8 Summary

Scientific workflows came to help solving the problem of the scientific applications complexity. The environment for running these workflows is provided by the Scientific Workflow Management Systems, one of which is the Taverna Workflow System. The Taverna Workbench is a desktop application that provides a means for exploiting the range of features that the system offers. Users can face the problems during the process of their work with the tool, as it sometimes involves actions, which can be difficult for Taverna users, who are ordinary scientist. The user experience aims to identify and address these problems using various techniques and methods. The participants recruited for the usability study are located remotely. For this reason the Remote user testing technique is applied for the study. User diaries and Think aloud methods, which are used in the methodology, also fit in imposed limitations and requirements.

CHAPTER 2. PROGRESS UP TO DATE

The chapter reports the contribution towards the usability study, that was set out to design and produce in the project. The progress made so far includes the pilot usability study and the developed methodology for the actual usability study. The process of setting the environment for conducting the usability study is also described, which includes recruiting the participants for the study and sorting out the mechanics.

2.1 Pilot study and adjustments

Purpose. The main purpose of the pilot usability study is to verify that the methodology is feasible. It also aims to identify the weaknesses of the developed methodology and redesign the methodology according to findings before running the actual study.

Procedure.

1. Design initial methodology based on investigated user experience methods and techniques.
2. Recruit participants for the pilot usability study
3. Meet users and explain the details
4. Continuously during three weeks:
    a. Collect the data from the users using suggested techniques
    b. Analyse the data
    c. Obtain the results
    d. Conversation with purpose after each analysed recording
5. Classify the issues
6. Refine the methodology based upon results

Duration. The duration of the pilot usability study is three weeks. One more week is devoted to analysis of the findings and modification of the methodology.

Methodology.

After investigating existing techniques user testing was chosen as the main technique for the initial methodology. There are three main methods have been suggested for the pilot usability study:

1. *Remote usability testing with Thinking aloud protocol*. The benefit of this method is having an additional source of information from the Thinking aloud protocol. The process is the following:
    a. Users record their work with Taverna using Camtasia screen recorder.
    b. They also think aloud while working, commenting on their actions
    c. Afterwards video is analysed by the researcher to identify the user experience issues.
    d. Make a Conversation with purpose after analysing each video recording. Conversation with purpose is an interview with the user which purpose is to verify the issues revealed after the analysis of the recording.
2. *Remote usability testing*. In this method Remote usability testing is used without Thinking aloud protocol. The procedure of this method is the same as described above except users do not make any comments on their work while recording. The benefit of this technique is natural behavior of users, because they are more likely to forget about recording and work as usual.
3. *Usability testing.* This method may be beneficial in a way that it gives to researcher space to log notes or observe. However this method is intrusive, which might cause users feeling uncomfortable and the process of user working with the system can also be affected.
    a. Sit next to the user in the lab and observe him interacting with the tool
    b. Make notes about the behaviour of the users, problems he has or any other observed issues
    c. Interview user afterwards discussing the assumed problems.

The method which was assumed to be used as an additional source of information at the beginning is Archival analysis. Archival analysis is an observational method, where the researcher examines the collected documents or archives. For the initial methodology the following techniques have been suggested:

1. Examine training material of the Taverna Workbench, looking at the parts which are actually trained, understand why these parts are included and what the problems might be.

2. Examine Taverna Issue tracker (JIRA) and email archives looking for the usability issues reports.

Findings and Methodology Refinements

After analysing the results of the pilot usability study the following refinements to the methodology have been suggested:

- *Use only remote usability testing with Think aloud protocol.* It has been identified that Usability testing conducted sitting next to the user influences the results and also results in unnatural behaviour of the user. Thinking aloud protocol has been proved to be useful as an additional source of information.
- *Do not categorize identified issues*. By categorizing obtained results researches affects the results as categorization is subjective. Instead, emergent behaviour should appear, i.e. patterns arise as data is collected.
- *Exclude archival analysis*, because the researcher does not have control over how data was collected and previous issues may be outdated. Using the user's diary technique as an additional source of information instead.

2.2 Actual Usability Study Methodology

The methodology for the actual usability study of the Taverna Scientific Workflow Workbench has been developed after careful examining and analysing usability methods and user experience techniques. It has been modified based on the findings from the Pilot Usability Study. The initial methodology of the Pilot Study was described previously. The qualitative approach for conducting the study has been chosen, which help understand how people feel and why they feel as they work with the system. The aim of the Qualitative research is to gain the understanding of human behavior and the motives for that behavior. For the Qualitative research, smaller but focused samples are needed rather than large samples.

The current methodology includes several usability evaluation methods, which were selected after careful investigation of the existing techniques and methods. The reasons for choosing them are the following. Firstly, these methods are considered to be very efficient. Next, they fit to the requirements and limitations imposed, such as remote locations of the users (remote usability testing).

These <u>methods</u> are:

1. Usability testing
2. Think-aloud protocol
3. Users diaries

The description of the forenamed techniques, the way they are applied for the project and explanation of the reasons for selecting them are presented below.

- *Usability testing*

Usability testing is the activity which involves observing users interacting with a product, performing particular tasks. Usability testing allows us to see what people actually do, not what we guess they would do or what they assume they would do if they were using your product. The knowledge obtained from the usability testing about users' experience covers all the sides of design and development [41].

The main benefit of User testing is that it deals with real behaviours of users' representatives, which means that feedback is obtained directly from the target audience. Usability testing focuses on the detailed analysis of the process of users' interaction with the product for accomplishing tasks [42].

There are a number of types of usability testing. As it was mentioned previously, Taverna Workbench is used all around the world, so most of the Taverna users are in a remote location. Therefore, remote usability testing is going to be applied for the current project. Remote usability testing is usability evaluation technique where usability inspector is in a remote location from users. Most of the time, audio/video recording is used for conducting usability testing. The recordings are systematically analysed in order to detect usability related issues experienced by the participant [43]. For the current project the video recording using Camtasia screen recorder [44] will be applied. The collected recordings will be coded and analysed using Aquad software package [45].

- *Think-aloud protocol*

This technique involves is a technique where an observed participant uses the product while continuously thinking out. It gives to the researcher an understanding how the user views the software, his feelings and real thoughts. Moreover, the information about which particular sections of the tool result in the most problems is obtained, as this technique demonstrates users view each interface item [3]. In the think-aloud protocol, users explain their actions while working with the system. The protocol helps to identify why users act the particular way, especially when users' behaviour is unexpected. However, it is more obtrusive in comparison to observation and thus can change the process of performing the task [46].

"Although thinking out loud seems not "normal" for most people, the added dimensions of having users share their thoughts, reactions, pleasure, pain, and so forth helps you understand so much more about their experience. Not only you see the actions users take, but also you benefit from hearing why users are taking an action and what they think about the process—good and bad. When users think out loud, you don't have to guess what they're thinking. They tell you"[41].

For the Taverna Workbench usability study thinking aloud is applied the following way. Users are invited to share their thought while they are working with the Workbench, which is video recorded. Thus, the protocol serves as an additional source of information to User testing.

- *Users diaries*

Diary study is a method where users are asked to keep a diary as they use a product. Using this method different information can be tracked. For example, which mistakes users make, what they learn, and what they find inconvenient or appealing in the tool (or anything which can be interesting to researchers). Afterwards, the diaries are coded and analysed in order to find usage patterns and common issues. The main benefit of this technique is that diaries can reveal information which would be difficult to identify otherwise. Diaries are also one of the only geographically distributed qualitative research methods which allows perform research with users in remote locations [47].

For the usability study this technique is used for building additional data set. After information from the diaries is coded and analysed, the data set will be built separately from data obtained from other methods. At the end the results of two data sets will be compared and thus the final results will be ensured.

The developed methodology for the actual usability study uses three main user experience techniques described above. A major "strength" of the approach is that results are obtained both from remote usability testing and thinking aloud protocol, enhanced with users' feedback in the form of the "diary".

The following <u>steps</u> have been identified for performing usability study (after conducting pilot usability study and modifying methodology based on the findings from the pilot study):

1. Obtain Ethical approval. Perform Users recruitment. Details of the Users Recruitment process are given later in this chapter.
2. Conduct users testing using suggested techniques:
    a. Collect relevant data. Record users interacting using Camtasia screen recorder.
    b. Build data set. Code the data using Aquad coding tool. Coding is an activity, where user's speech is converted into analysable units. There categories and concepts are defined, which are concluded from the initial data [49]
    c. Analyse information obtained after coding. Look for repeated patterns, revealed usability problems, emerging categories.
3. Examine Users diaries. Build data set and compare it to the results of coding users' recordings.
4. Summarise all the results
5. Give formative recommendations

2.3 Participants Recruitment

Before recruiting the users the following questions need to be thought out [50]:

1. Which kind of users do I need?
2. How many of them are required for the study?
3. How many groups of users are necessary?

For participating in the study the following three main types of users have been identified in terms of experience with the Taverna Workbench:

- Novices. People in this category have no or little experience of using the tool.
- Intermediate users. They have some experience and can build decent workflows
- Experts. Users have been used the tool for a long period of time and they build complex workflows using advanced capabilities of Taverna Scientific Workflow Workbench

The number of participants in the usability study is about 10-12, with 3-4 representatives in each group. It is assumed that large sample of participants is required for collecting trustworthy usability results. However, nowadays in formative usability testing 5-7 participants are observed. It was identified that this number of representative users is generally sufficient in order to find about 80% of the usability issues. The idea of using less number of participants for user testing for finding the majority of the problems has been widely supported [4], [5], [6].

Taverna users' profile:

Average Taverna user is a scientist with experience in their particular domain, such as chemistry, biology, astronomy, etc., but with understandably limited background in IT technology [55].

Participants for usability study of Taverna Scientific Workbench have been recruited via emails explaining all the details. The reason for this is that most Taverna users are in remote locations. It is difficult to establish trust with a participant when they are in a remote distance. Therefore relationship establishment, with a researcher introducing himself, and continuous communication at the beginning is crucial.

2.4 Mechanics

Ethical approval

As the project involves human research the ethical approval for the project has been obtained. The ethical approval main purpose is to confirm that the study meets the requirements of general ethical values and standards.

Software used

Software used for the video recordings is the Camtasia screen recorder [44]. It has a free trial which was used for the pilot usability study. The Camtasia license for performing actual usability study has been purchased. Camtasia was chosen because it is not difficult to learn how to use this software, which is important as users may have limited computing background and it meets all the requirements for conducting usability testing.

Aquad qualitative data analysis software [45] is used for data coding. It allows performing data content analysis in qualitative research in different domains. Aquad has a straightforward interface and adequately functional.

2.5 Obstacles overcome and identified risks

There are several obstacles and risks to the project which has been identified and overcome:

1. Participants are not recruited for the study or they are not representative users. Usability study participants have been recruited in advance. In order to ensure that they are real representative users of Taverna Workbench one of the members of Taverna software development, who deals with users issues within Taverna team, was consulted.
2. Remote location of the users. Remote usability testing technique was proposed to solve this problem, which makes use of particular software to record users' actions.
3. Infeasible methodology techniques. In order to prove that proposed methods and techniques are achievable and refine the initial methodology Pilot usability study was conducted.
4. Researcher affects the process and results of the study. During the pilot study possible effects on the study process and results from the researcher have been identified and addressed.
5. Unrealistic results. For ensuring the outcomes of the study several techniques are used, where results of the one method are compared to the results of the other. For example, two datasets will be built, one of them from usability testing and the other from user's diaries. The obtained results of both methods will be compared.

2.6 Summary

The work on the dissertation started with examining the relevant material for the project. Based on the findings, preliminary methodology was developed which was applied for the pilot usability study. After conducting the pilot study, the results were analysed and refinements were applied to the methodology. Finally, the environment for the actual usability study was set up. It includes participants' recruitment for the study, obtaining ethical approval and choosing the appropriate software for conducting the usability study. The next step on the process of work on the dissertation is the actual usability study as indicated in the Project Plan.

PROJECT PLAN

Figure 2.1 represents the Project Plan in the form of Gantt chart. The stages are listed on the left hand-side with their Start Date, Finish Date and Duration. The duration of each stage is indicated in days. On the right hand side the time line with project performance can be viewed.

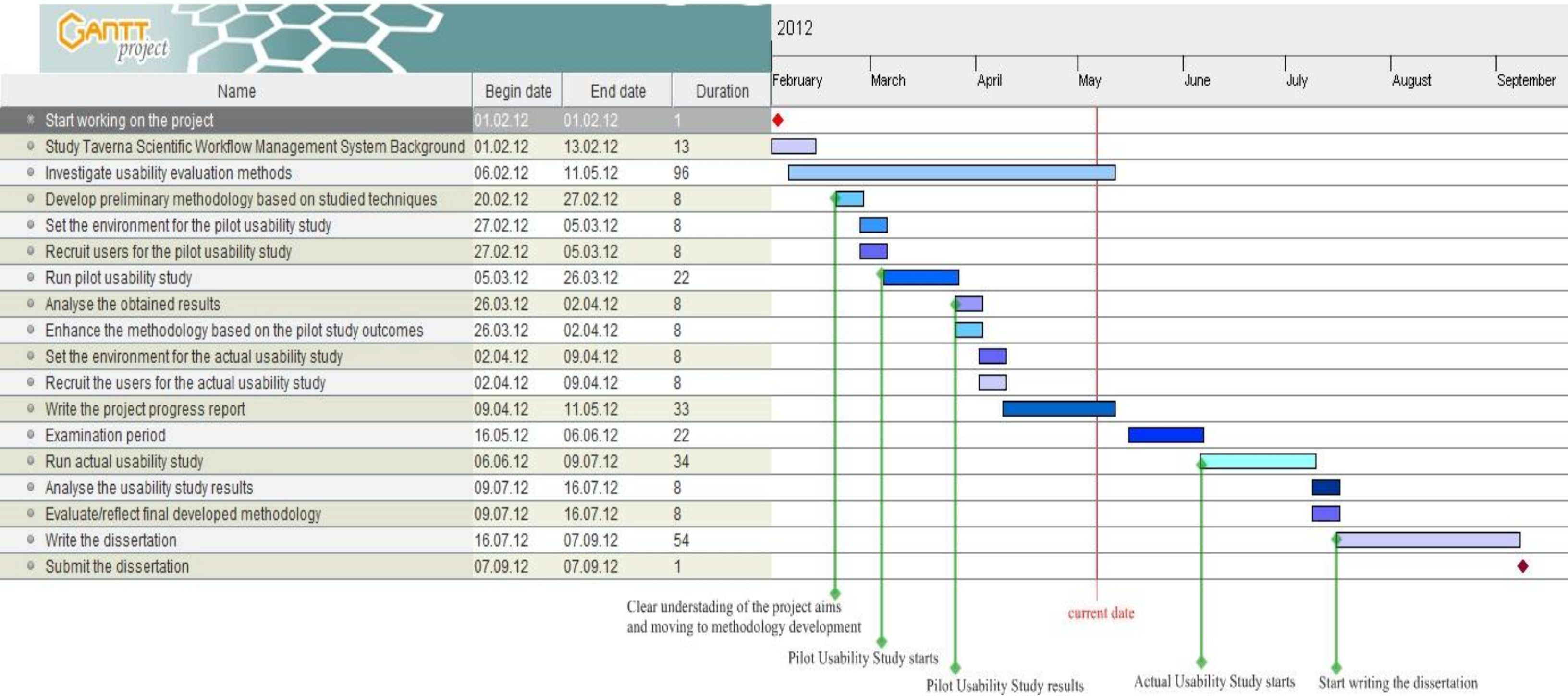

Figure 2. 1 Project plan

The process of work on the project can be divided into two main parts: before the examination period and after it. During the first part the background research on the dissertation is performed. Usability evaluation methods and user experience techniques are studied. Next, preliminary methodology is evolved and applied to the pilot usability study. The pilot usability study is performed and after that its results will be examined and exploited for the methodology enhancement. The second part starts after the examination period and it includes the actual usability study, methodology evaluation, analysis of final results and writing the dissertation.

Deliverables

Artifact, which is going to be delivered as a result of the project, consists of the following elements:

1. Evolved methodology (design) for conducting usability study.
2. Usability study results
3. Analysis/recommendations to the Taverna team

These three components are linked in the following way: First, methodology needs to be developed for performing usability investigation. Next, actual systematic usability study will be conducted and its results will be produced. Finally, based on the first two components, Taverna scientific workflow workbench analysis and recommendations are going to be designed.

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