Journal of
open research software

Graziotin, D and Abrahamsson, P 2013 A Web-based modeling tool for the SEMAT Essence theory of software engineering. *Journal of Open Research Software* 1:e4, DOI: http://dx.doi.org/10.5334/jors.ad

SOFTWARE METAPAPER

A Web-based modeling tool for the SEMAT Essence theory of software engineering

Daniel Graziotin[1] and Pekka Abrahamsson[1]

[1] Free University of Bozen-Bolzano, Bolzano, Italy

As opposed to more mature subjects, software engineering lacks general theories that establish its foundations as a discipline. The Essence Theory of software engineering (Essence) has been proposed by the Software Engineering Methods and Theory (SEMAT) initiative. The goal of Essence is to develop a theoretically sound basis for software engineering practice and its wide adoption. However, Essence is far from reaching academic- and industry-wide adoption. The reasons for this include a struggle to foresee its utilization potential and a lack of tools for implementation. SEMAT Accelerator (SematAcc) is a Web-positioning tool for a software engineering endeavor, which implements the SEMAT's Essence kernel. SematAcc permits the use of Essence, thus helping to understand it. The tool enables the teaching, adoption, and research of Essence in controlled experiments and case studies.

Keywords: software engineering, general theory, web positioning system, SEMAT Essence Theory, project management

Funding statement
This project is financially supported by the PhD grant of Free University of Bozen Bolzano.

(1) Overview

Introduction

Well-established academic disciplines emerged from practices without focusing on the underlying theory[1]. In time, however, general and advanced scientific theories have been developed as they are essential for the advancement of scientific fields[2]. Software engineering is notably a young discipline[3]. As such, it is not yet overly concerned with a core, general theory; thus, the risk is to be limited to trial-and-error practices[4]. A lack of theoretical foundation inhibits the growth of a research tradition. A research tradition is essential to secure scientific beliefs but also to cause paradigm shifts[2]. Software engineering is missing such tradition. Software engineering suffers from gaps in the knowledge for understanding software development processes and their impact on each other[5].

The SEMAT initiative was born in order to "support a process to refound software engineering based on a solid theory, proven principles and best practices. […][What will enable this is a] kernel of widely-agreed elements […] supported by industry, academia, researchers and users"[6]. The outcome of the SEMAT initiative is the Essence Theory of Software Engineering[7, 8]. Strictly speaking, Essence documents the "things to work with" in software engineering[8], the relationship they have with each other, and the actions that involve such "things".

Essence is claimed to provide a common basis for defining software development practices, by using widely agreed elements that are present in every software engineering endeavor[8]. These elements are called Alphas. As of today, the core Alphas of Essence kernel are Opportunity, Stakeholders, Requirements, Software System, Work, Team, and Way-of-working. Alphas change in their States, thus enabling a representation of the progress and health of the endeavor. For example, the Requirements can be Conceived, Bounded, Coherent, Acceptable, Addressed, or Fulfilled. Finally, Essence Alphas are organized in three areas of Concern. Each Concern focuses on a single aspect of software engineering. They are called Customer, Solution, and Endeavor. As opposed to other attempts to create a general theory of software engineering – e.g. the Software Engineering Body of Knowledge[9] – Essence aims to generalize software engineering by identifying its universal elements and actions, and to develop a universal language to describe them. The theory was submitted to the Object Management Group (OMG) and is currently undergoing the necessary steps to become an OMG standard [8]. A simple introduction to Essence is available in the material of a special lecture held at the Free University of Bozen-Bolzano by one of the authors of this paper[10].

As of today, there is a lack of consensus of Essence as an accepted model. For example, notable practitioners and researchers of Agile methodologies expressed negative comments on the SEMAT initiative (e.g.,[11, 12, 13]). Reasons include a difficulty to see Essence's utilization potential and a lack of tools for implementation. It is challenging to understand Essence before even evaluating it. As software engineering heavily relies on empirical research[14], there is the need to produce the empirical data when applying Essence, in order to understand its theoretical and practical implications and to evaluate it scientifically.

This paper describes the SEMAT Accelerator (SematAcc), which is a Web-based modeling system for software engineering processes as depicted by the SEMAT's Essence kernel. SematAcc has been developed as a way to produce such needed empirical data for evaluating Essence. It helps in using and understanding the Essence theory under a practical viewpoint. SematAcc lets users model a software development process with Essence elements. A software engineering endeavor (called project in SematAcc) has an associated Essence kernel. The kernel has been implemented using the OMG submission of Essence[8] as a reference. A software engineering endeavor is represented using graphs of the Concerns' and Alphas' completions.

SematAcc is developed in JavaScript both on the client side and on the server side, on top of the recently born Meteor[15]. Meteor is an open-source platform to build JavaScript-based Web applications. By providing a nearly identical API for the development of the server and the client, Meteor target is to deliver almost real-time data transfer through latency compensation techniques and reactive programming.

SematAcc can be employed in empirical experiments and case studies on Essence theory because it registers the events triggered by its usage. The events can be easily downloaded as a CSV string. Thus, they are directly employable in statistical software.

The rest of this paper is organized as follows. The next section - Implementation and Architecture - provides a brief introduction to Meteor, an illustrated guide on how to use SematAcc main functionality, and more technical details on the architecture of the system and the source-code organization. It is followed by a section regarding the Quality Control of the system, where the tests and the techniques in order to ensure a high quality of the delivered software are provided. In the Availability section, details on SematAcc system requirements and dependencies are given, as well as the information on how to obtain the software. The last section - Reuse Potential - provides an overview on how to configure and run SematAcc on a local computer and on a remote server and suggestions on how to employ the software for research purposes.

Implementation/architecture

SematAcc was implemented using the recent Meteor project[15]. Meteor is an open-source platform and framework to build JavaScript-based Web applications. It is built upon the server-side JavaScript enabling technology Node.js[16] and the NoSQL document-oriented MongoDB database[17]. As a programming framework, Meteor permits developers to write both client- and server-side applications using almost the same JavaScript APIs. Its aim is to achieve nearly real-time performance by providing latency compensation for data transfers between the server and clients (and vice versa). Data is the central point of Meteor. It is organized in data structure named collections. Meteor collections are convenient wrappers around MongoDB documents; they provide the basic create, read, update, and delete operations needed for the functionality of a Web application.

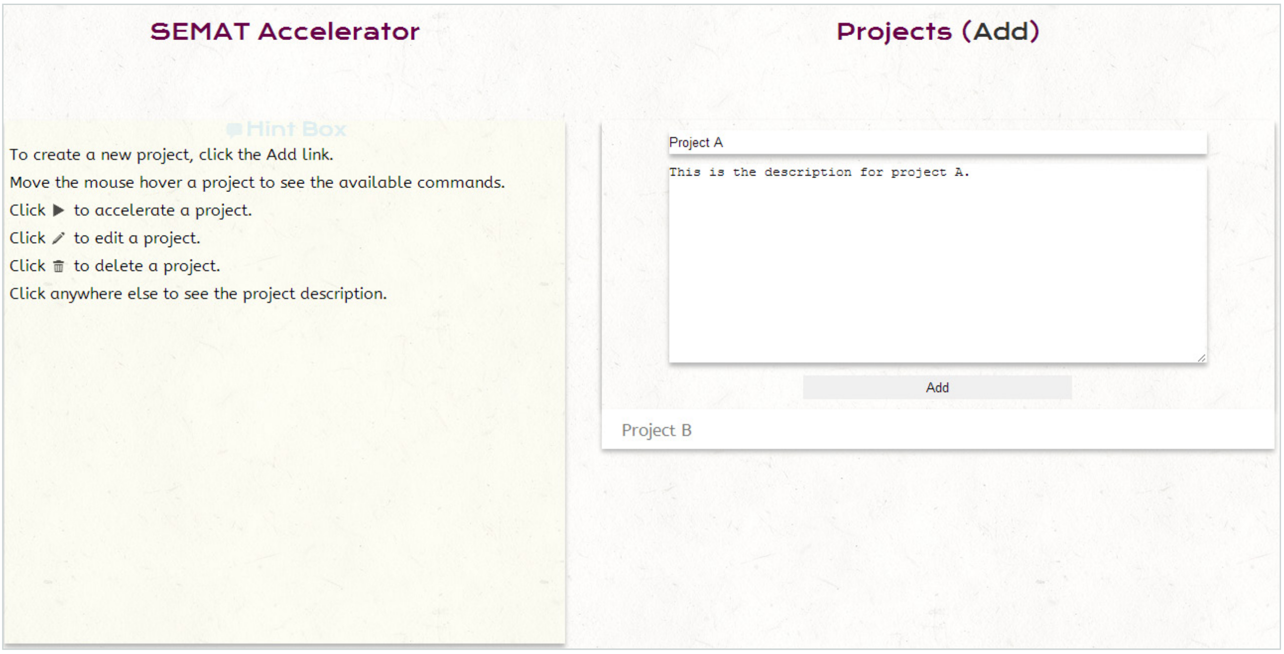
Meteor has been inspired by the reactive programming paradigm[18]: nearly all of its layers, from database access to graphical user interface (GUI), provide an event-driven interface whose operations run whenever the underlying data-dependencies change. For example, a hypothetical Meteor Web application is developed to manage a library. A template of the GUI of the application is responsible to render a list of books. A user observes a Web page with a list of books. Meanwhile, an editor inserts a new book in the database, from the application backend. The change in the data is detected by Meteor components, which automatically trigger a re-render of the GUI element interested by this operation. The user simply sees a new element added to the list, without a Web page refresh.

As an infrastructure, Meteor covers development, testing, and production phases to run the implemented source-code. For development, Meteor provides a local server, built on top of Node.js[16], to run the developed Website and perform tests. For testing and production, Meteor provides a freely available infrastructure of servers. More information on Meteor can be obtained on the official Website[15], in the introductory screencast[19], and on the documentation Website[20].

Before illustrating some details regarding SematAcc architecture, a brief introduction on using SematAcc is provided. Upon login, the user manages the projects (Fig. 1). The Hint Box on the left side of the screen contains suggestions, which help the user to manage the projects. The central box lists the available projects. After the user creates a project, putting the mouse over it, it will activate the available commands. A click on the arrow icon will accelerate a project with SematAcc (that is, it will start the modeling activity with Essence kernel). The other two commands are for editing a project and for deleting it.

When the user decides to accelerate a project with SematAcc, the Essence kernel is loaded with the chosen project (Fig. 2). This is the main functionality of SematAcc. The user interface is divided in three parts. The first part, on the left, is the already mentioned Hint Box, which reports information on an Alpha or a State, depending on the position of the mouse. The second part, on the center, is Essence kernel. It shows the Alphas. If the user clicks on an Alpha, the Kernel expands and shows the corresponding States. The third part, on the right, is the project status. It displays a rose graph and a horizontal bar chart. The rose graph represents the project status in terms of Alphas' completions, whereas the horizontal bar chart provides an overview of the Concerns' completion.

When a user clicks on a State, thus expressing a change of State of an Alpha, the graphs are immediately updated. For example, in Fig. 3), the user chooses that Requirements Alpha is now in the Conceived State. The rose graphs and the horizontal bar chart on the right side of


SEMAT Accelerator

Hint Box

To create a new project, click the Add link.
Move the mouse hover a project to see the available commands.
Click ▶ to accelerate a project.
Click ✎ to edit a project.
Click 🗑 to delete a project.
Click anywhere else to see the project description.

Projects (Add)

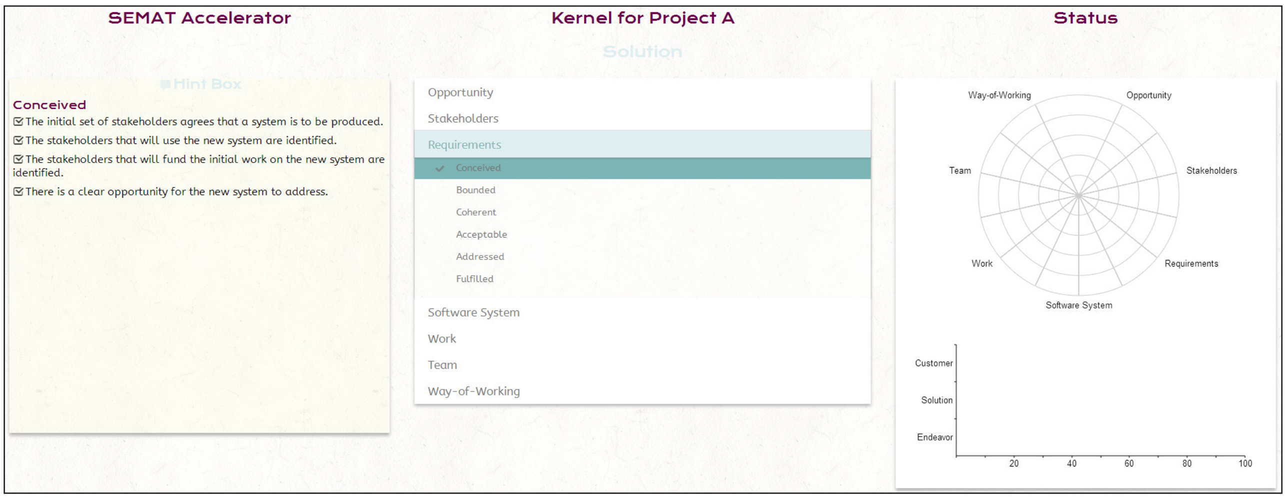
Project A

This is the description for project A.

Add

Project B

Fig. 1: Project Management in SematAcc.


SEMAT Accelerator

Hint Box

Conceived
☑ The initial set of stakeholders agrees that a system is to be produced.
☑ The stakeholders that will use the new system are identified.
☑ The stakeholders that will fund the initial work on the new system are identified.
☑ There is a clear opportunity for the new system to address.

Kernel for Project A

Solution

Opportunity
Stakeholders
Requirements
✓ Conceived
Bounded
Coherent
Acceptable
Addressed
Fulfilled
Software System
Work
Team
Way-of-Working

Status

Fig. 2: SematAcc Main Window: the Hint Box, the Essence kernel, and the graphs.

Fig. 3 represent the change in the State of an Alpha, and the completion of the project is shown.

The models of SematAcc derive from an analysis of the Essence theory. They are represented in the class diagram of Fig.4.

A user of the system possesses one-to-many projects. Each project has an associated Essence kernel. In SematAcc, the kernel is a graphical conceptualization and does not have a corresponding database collection. Although a kernel may have one-to-many Concerns, the current OMG standard proposal suggests three of them: “Customer”, “Solution”, and “Endeavor”. The three Concerns contain the corresponding Alphas. Alphas have several associated States but may be in zero or one-and-only-one State.

Each Concern, Alpha, and State has a corresponding name and description taken from Essence OMG submission. In order to speed-up the Essence learning process, the descriptions of kernel elements appear in SematAcc as soon as the user hovers with the mouse over them.

Concerns and Alphas also possess a completion, represented as a JavaScript Number. This number represents the percentage of completion of such kernel elements. For an Alphas completion, the order of the current Alpha State is employed. Then, the completion of the Alphas determines the progress of the project in terms of Concerns completion.

Finally, each project possesses events, which are employed by SematAcc to log and generate data for research purposes.

A high-level view of the most important functionality of SematAcc is represented in Fig. 5.

In the example provided in Fig. 3, the user decides that the “Requirements” are now “conceived”. A mouse click on the “conceived” State in the user interface triggers an update to the server’s Alpha collection. Upon a successful update in the database, the completion ratios for the Concerns and the Alphas are recalculated in order to keep the data consistent. Then, the client component of SematAcc

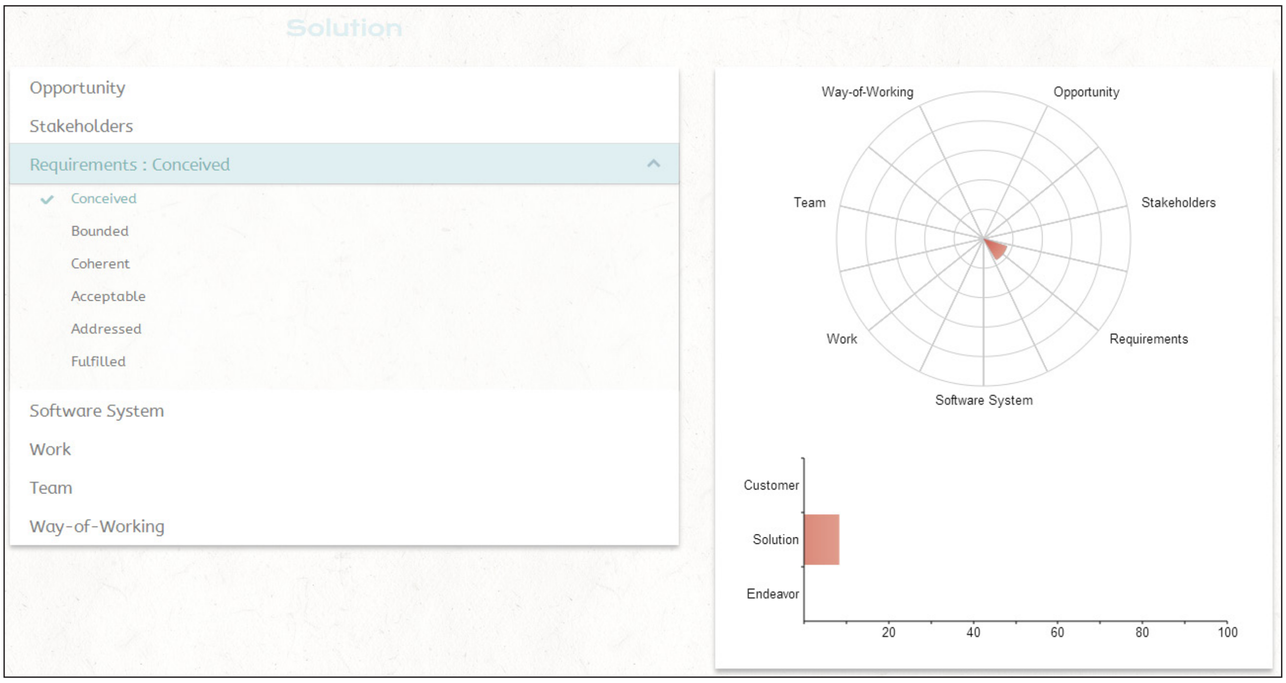


Fig. 3: Change of State in SematAcc.

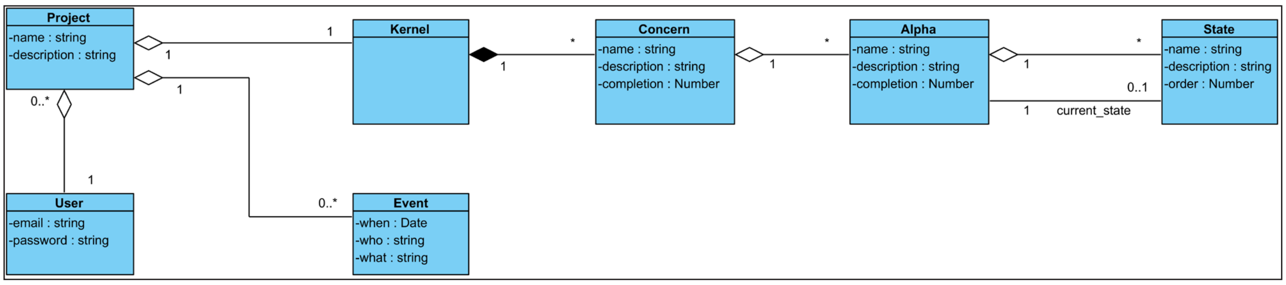


Fig. 4: SematAcc Models.

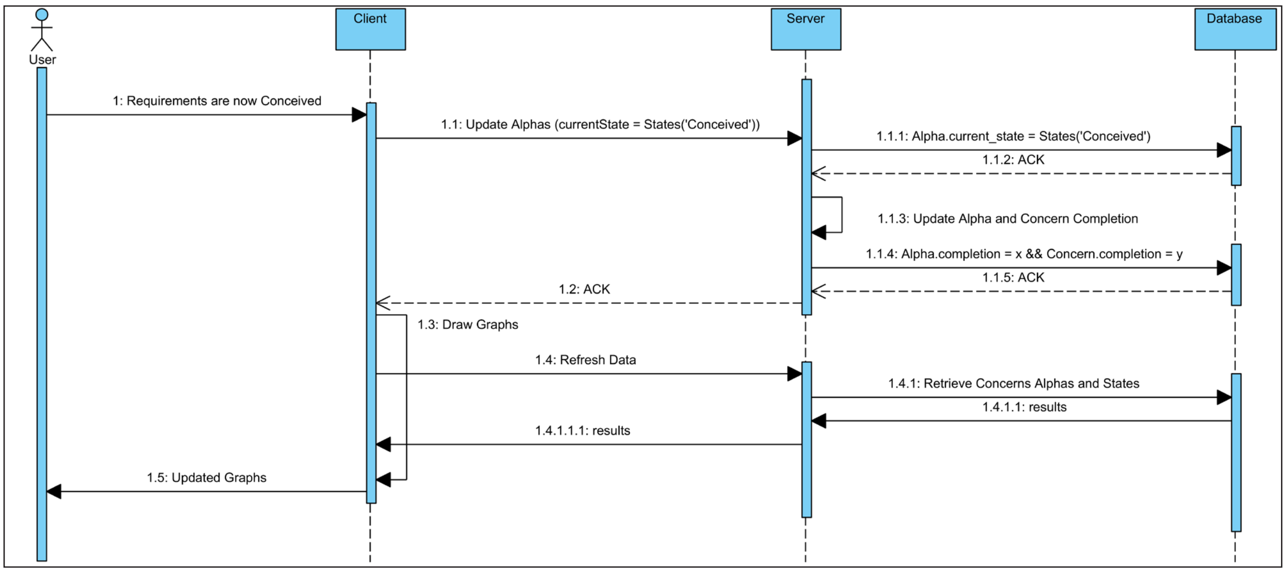

User
Client
Server
Database
1: Requirements are now Conceived
1.1: Update Alphas (currentState = States('Conceived'))
1.1.1: Alpha.current_state = States('Conceived')
1.1.2: ACK
1.1.3: Update Alpha and Concern Completion
1.1.4: Alpha.completion = x && Concern.completion = y
1.1.5: ACK
1.2: ACK
1.3: Draw Graphs
1.4: Refresh Data
1.4.1: Retrieve Concerns Alphas and States
1.4.1.1: results
1.4.1.1.1: results
1.5: Updated Graphs

Fig. 5: High-level view of a change in Alpha State.

is notified of the successful change of State operation. A relevant event is generated and stored. Finally, the graphs are updated to represent the new data. At this stage, SematAcc GUI shows what is represented in Fig. 3.

The project source-code is organized by separation of concerns. The project's root directory contains three main parts, according to Meteor conventions. In the client folder, there is the code executed by the client (the Web browser). In the server folder lives the source-code, which is purely executed on the server side. The tests folder hosts the automated tests written with the Laika framework[21]. The public folder stores all the binary files publicly accessible – e.g., pictures. All the source-code files are commented. For more information regarding the project structure, we advise to read the README file in SematAcc source-code. The file also contains instructions on how to run SematAcc on a development machine and how to have an own private instance of SematAcc on Meteor's free servers.

Quality Control

Different levels of testing have been performed. Eight volunteers were involved to perform user-acceptance tests of the software. Three of them are experts of Essence. The remaining five are experts in the field of software engineering but needed an introduction to Essence theory. Their involvement persisted up to the first public release of SematAcc. Their feedback influenced the development of Essence, especially of its GUI.

Before a public release, SematAcc is manually tested with the latest versions of the leading browsers (i.e., Mozilla Firefox, Google Chrome, Microsoft Internet Explorer, and Apple Safari).

An official automated testing method does not exist for Meteor yet[22]. However, community-based tools are under active development. SematAcc employs the recently born Laika[21], a feature rich testing framework for Meteor, which simulates the interaction between the server and clients. The tests are run before each commit to the version control system. In order to run the tests, the Laika framework has to be installed on the system. More information on how to run the test cases can be found in the TESTING.md file in SematAcc root directory.

Lastly, each SematAcc function has been carefully debugged. Formal inspections of the database content revealed consistent data values after the software trials. The JavaScript code adheres to standard coding conventions and passes all JS Hint tests[23].

(2) Availability

Operating system

Server-side: SematAcc works wherever Meteor works. Official support[24] is offered for:

- Mac OS X 10.6 and above
- GNU/Linux x86 and x86_64

Microsoft Windows is non-officially supported and not immediately updated[25].

Client-side: any operating system, which runs a recent Web-browser.

Programming Language

HTML, CSS, and JavaScript over Meteor framework v0.6.4.

Additional system requirements

A minimum resource requirement is the ability to run the Meteor framework, i.e. Node.js[16] and MongoDB[17].

In a GNU/Linux development machine, the memory map of the processes, gathered with the pmapcommand, was of 295.02Mb.

SematAcc source code occupies about 1Mb of disk space.

Dependencies

Meteor v0.6.4[15].

List of contributors

- Daniel Graziotin (Project Development)
- Pekka Abrahamsson (Project Manager)

Archive

Name

figshare

Persistent identifier

http://dx.doi.org/10.6084/m9.figshare.664127

License

3-clause BSD license

Publisher

Daniel Graziotin

Date published

20/04/2013

Code repository

Name

Github

Identifier

https://github.com/s4fs/sematacc

License

3-clause BSD license

Date published

09/10/2013

Language

English

(3) Reuse potential

Before describing the reuse potential of SematAcc, the instructions on how to obtain and run SematAcc are provided.

For demonstration purposes, an example instance of SematAcc is available (http://sematacc.meteor.com). Users need to register to the system in order to employ it. However, a demo project is ready to be used (http://sematacc.meteor.com/demo) without requiring registration. The demo project is not owned by any user and is shared between all users of the system. Changes made to the demo project are immediately pushed to any client that is visualizing the demo project. It must be noted that the example instance is for testing the software, and not for production environment. While attempts are made to preserve the data at each new version deployment, this cannot be guaranteed.

Preferably, SematAcc should run on a local machine or on Meteor's freely available servers. In the following paragraphs, we describe both cases.

SematAcc needs Meteor as unique dependency. Any other dependency has been included in SematAcc source-code. Meteor is officially available for GNU/Linux and Mac OS X, while official support for Microsoft Windows is under development[24]. The installation of Meteor is straightforward for the supported platform as it is reduced to a single line to be input in a terminal. Please see the Quick start section in Meteor Documentation[20]. For Microsoft Windows, non-official support is provided. The instructions and an installer for Microsoft Windows are provided in Meteor for Windows[25].

After the installation of Meteor, the command meteor has to be issued in a terminal, within the root folder of SematAcc. A Meteor instance will run and serve the project. SematAcc will be accessible from a Web browser at http://localhost:3000. In order to test-deploy SematAcc on Meteor's free servers, the command meteor deploy –P chosenname.meteor.com has to be issued from the root folder of SematAcc. After choosing a password, SematAcc will automatically be deployed and will be available at http://chosenname.meteor.com, given that the chosen name is available. These instructions are valid for all operating systems.

Support requests for SematAcc are accepted and welcomed through the issue tracker of the project (https://github.com/s4fs/sematacc/issues). Bug reports and feature requests should be entered in the issue tracker. Other enquiries can be made via e-mail to the authors of this project.

Regarding the reuse potential, SematAcc serves for multiple purposes in research activities on Essence theory. The tool has been developed specifically for producing empirical data on Essence and it is currently suitable only for this purpose. SematAcc may be employed as a tool for setting up case studies in the adoption of the Essence theory. How practitioners can learn the Essence theory can be studied. SematAcc can also be employed in empirical experiments and case studies when a software development progression is measured in terms of State transitions and Concern visualization.

Each change in an Alpha State is recorded and can be exported as a CSV string. The example of Figure 3 would generate an event of the form <"2013-04-03T14:01:27.007Z","Requirements.State", "Conceived">. The events are directly exportable as a CSV string from the graphical user interface. Other events can be easily recorded by modifying the source-code of SematAcc, as a single line of code is required to record an Event. See the README file of the project source-code for more information.

Acknowledgements
We kindly acknowledge Dr. Ivar Jacobson, who provided his constructive feedback for SematAcc while discussing the Essence theory with us. We would like to thank all the anonymous users who tried the system and provided user-acceptance data for it. We are grateful for the insightful feedback received by two anonymous reviewers, which helped us to improve the paper significantly. Last but not least, we are thankful to Elena Borgogno for her tireless help in improving this article.

References

1. **Ralph P, Johnson P, Jordan H.** 2013 Report on the first SEMAT workshop on general theory of software engineering (GTSE 2012). *ACM SIGSOFT Software Engineering Notes,* 38(2): 26–28. DOI: http://dx.doi.org/10.1145/2439976.2439999
2. **Kuhn T S.** 1996 *The Structure of Scientific Revolutions.* London: University of Chicago Press;
3. **Naur P, Randell, B.** 1969 Report on a conference sponsored by the NATO Science Committee. Available at: http://homepages.cs.ncl.ac.uk/brian.randell/NATO/nato1968.pdf [accessed 19th July 2013]
4. **Johnson P, Ekstedt M, Jacobson I.** 2012 Where's the Theory for Software Engineering? *IEEE Software,* 29(5) DOI: http://dx.doi.org/10.1109/MS.2012.127
5. **Kajko-Mattsson M.** 2013 Software engineering suffers from the beehive syndrome. Information Science and Digital Content Technology (ICIDT), 2012 8th International Conference on Computing Technology and Information Management, 1: 49–52.
6. **Software Engineering Method and Theory, SEMAT.** 2009. Available at: http://semat.org/?page_id=2 [accessed 2 April 2013]
7. **Jacobson I, Ng P-W, McMahon P E, Spence I, Lidman S.** 2012. *The Essence of Software Engineering: Applying the SEMAT Kernel.* Indiana: Addison-Wesley Professional;
8. **SEMAT.** 2013. Essence – Kernel and Language for Software Engineering Methods. Available at: http://www.omg.org/spec/Essence/1.0/Beta1/ [accessed August 19 2013]
9. **IEEE Computer Society.** 2004. Guide to the Software Engineering Body of Knowledge (SWEBOK). Available at: http://www.computer.org/portal/web/swebok/overview [accessed 19th August 2013]
10. **Graziotin D.** 2012 Special Lecture on Semat Essence of Software Engineering. Introduction to Management Engineering. Free University of Bozen-Bolzano Avaialble at: http://task3.cc/1328/special-lecture-on-semat-essence-of-software-engineering/. [accessed 2nd April 2013]
11. **Fowler M.** 2010 SEMAT. Available at: http://martinfowler.com/bliki/Semat.html [Accessed 19th July 2013]
12. **Cockburn A.** 2007 A Detailed Critique of the SEMAT Initiative. Humans and Technology, inc. Available at: http://alistair.cockburn.us/A+Detailed+Critique+of+the+SEMAT+Initiative[accessed 19th July 2013]
13. **Aranda J.** 2009 Against SEMAT. Available at: http://catenary.wordpress.com/2009/11/29/against-semat/ [accessed 19th July 2013]
14. **Wohlin C, Runeson P, Höst M, Ohlsson M C, Regnell B,** et al. 2000 *Experimentation in software engineering: an introduction.* Dordecht: Kluwer Academic Publishers.
15. **Schmidt G, DeBergalis M, Martina N, Greenspan D, Oliver A,** et al. 2013 Meteor. Available at: http://meteor.com [accessed 25th July, 2013]

16. **Hafner U, Potter J, Fettig A, van Zonneveld K, Carter M,** et al. 2009 Node.js. Available at: http://nodejs.org/ [accessed 3rd April 2013]
17. **Ryan K P, Merriman D, Horowitz E.** 2007 MongoDB. Available at: http://www.mongodb.org/ [accessed 25th July 2013]
18. **Pucella R R.** 1998 Reactive programming in Standard ML. *Proceedings of the 1998 International Conference on Computer Languages.* Pp. 48–57. DOI: http://dx.doi.org/10.1109/ICCL.1998.674156
19. **Schmidt G, DeBergalis M, Martina N, Greenspan D, Oliver A,** et al. 2013 Meteor Introductory Screencast. Available at: http://www.meteor.com/screencast [accessed 25th July, 2013]
20. **Schmidt G, DeBergalis M, Martina N, Greenspan D, Oliver A,** et al. 2013 Documentation - Meteor. Available at: http://docs.meteor.com/ [accessed 25th July, 2013]
21. **Susiripala A.** 2013 Laika: Testing Framework for Meteor. Available at: http://arunoda.github.io/laika/ [accessed 22nd July 2013]
22. **Schmidt G, DeBergalis M, Martina N, Greenspan D, Oliver A,** et al. 2013 Official testing framework on Meteor Roadmap. Available at: https://trello.com/c/BQ3gu0no/12-official-testing-framework [accessed 25th July, 2013]
23. **Kovalyov A, Kluge W, Perez J.** 2010 JSHint, a JavaScript Code Quality Tool. Available at: http://www.jshint.com/ [accessed 2nd April 2013]
24. **Schmidt G, DeBergalis M, Martina N, Greenspan D, Oliver A,** et al. 2013 Supported Platforms. meteor/meteor Wiki. Available at: https://github.com/meteor/meteor/wiki/Supported-Platforms [accessed 2nd April, 2013]
25. **Wijsman T.** 2013 Meteor for Windows. Available at: http://win.meteor.com/ [accessed 2nd April, 2013]

How to cite this article: Graziotin, D and Abrahamsson, P 2013 A Web-based modeling tool for the SEMAT Essence theory of software engineering. *Journal of Open Research Software* 1:e4, DOI: http://dx.doi.org/10.5334/jors.ad

Published: 2 September 2013