

# A Modelling Language for Interactive Web Applications

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**Abstract**—Web applications are increasingly becoming the most important platform for software applications in industry, with many modelling languages proposed to handle the complexity of developing, documenting and deploying these applications. New technology has allowed for development of Rich Internet Applications (RIAs) which increase usability and reliability; however, existing modelling languages fall short of modelling many of these new concepts. The research in this Ph.D. seeks to identify these new modelling challenges, and develop an approach that is suitable for modelling RIAs.

**Index Terms**—rich internet applications, modelling languages, model-driven architecture

## I. INTRODUCTION

Since the introduction of the Internet, the development of software applications is significantly moving away from single-computer applications, to distributed *web applications* published online and accessible by web browsers. The rise of web applications has been accompanied with a number of proposed modelling approaches to describe these applications in platform-independent ways, such as the WebML [1] and UWE [2] modelling languages.

Software application development has arguably been improved by the development of standard modelling languages such as UML [3], providing a clear, consistent way to document and model software systems. As web applications can be considered a form of software, it is clear that web application development should have a similar level of support [4].

Web development tends to focus solely on the low-level implementation [5] using a diverse range of technologies [4], but at the same time must be accessible to a diverse range of platforms and devices [4]. It is this *conceptual gap* between application requirements and the implementation that needs to be addressed. Some researchers argue that some level of abstraction in the form of models and tools will bridge this gap [6], [7], and many different types of modelling approaches have been proposed in literature [2], [8], [1], [9].

The recent introduction of client-side scripting to web browsers, along with AJAX functionality and new rich media types, has evolved web applications into *Rich Internet Applications* (RIAs) which increase the usability and reliability of web applications [10], [11]. Unfortunately, this recent development has not been met with the same standard of modelling support as conventional web applications, and RIAs cannot be modelled with existing approaches [12], [13], [14]. It

is the task of modelling this increasing conceptual gap between requirements and implementation details that is the focus of this Ph.D. project.

This short paper briefly covers the research problems tackled by this Ph.D. and discusses preliminary ideas and approaches used to answer those questions. We also discuss the progress of both the modelling language and its accompanying CASE tool, and concludes with an overview of future work anticipated for this research.

## II. RESEARCH QUESTION

This research in this Ph.D. can be broken down into answering five key questions:

- 1) What are the implementation challenges that interactive web applications provide?
- 2) What issues exist with existing web application modelling languages?
- 3) Can we develop a modelling language to handle these challenges?
- 4) How do we prove that such a modelling language provides web application developers with greater reliability, usability and security?
- 5) Similarly, how do we prove that such a modelling language improves the development process, in terms of speed, simplicity and consistency?

We have satisfactorily answered the first two of these questions by defining the requirements of RIAs in our WISE 08 paper [15]. We are currently focused on answering the third question, through the development of a new modelling language. The development of a CASE tool, along with the benchmarking application discussed in this paper, implementing this language will assist us in answering the final two questions.

## III. RELATED WORK

The definition of a RIA has been covered regularly in literature [10], [13], and is generally defined as a web application which approaches the interactivity of desktop applications, while still being accessible by a range of different devices. The definition of a RIA does not specify specific technologies, and can be implemented through the likes of HTML, Javascript, Flash or Java.

The major existing academic work that seeks to address this conceptual gap with a modelling language is the WebML language [1]. WebML is supported by the Eclipse-based CASE tool WebRatio [16]. We have previously shown that WebML is inadequate to model existing RIAs [14], as have others [13]. Recent language modifications to support RIA concepts [10], [11], proposed after the start of this research, appear to have improved the support of RIAs within WebML, but still appear to fall short as they do not address the core problem – a RIA modelling language needs to have first-class modelling support for RIA concepts, not simply the addition of new visual elements to model existing RIA components.

UML-based Web Engineering approaches the modelling of web applications with a Model-Driven Engineering (MDE) approach [17], and separates the modelling into a series of conceptual models, which can be integrated together to form a final deployable web application. Unfortunately UWE also lacks support for RIA concepts [14], [13], although the recent combination of UWE and the RUX-method [18] adds RIA-style interactivity to the static UWE approach. We argue that RIA concepts are deeper than simply user interfaces, so UWE itself is inappropriate.

Many other existing web modelling languages have been proposed in academia, such as W2000 [19] and WUML [8], but these appear to have been abandoned and lack any kind of support for RIA modelling. Indeed, many of the older languages still struggle with modelling of database-driven web applications, itself a fundamental requirement.

Existing commercial RIA development tools are generally focused on a particular technology, and cannot support platform-independent modeling [10]. The most similar commercial tool attempting to address the research questions in this Ph.D. is the open source *Skyway Builder* [20], although the models used in this application are not platform-independent.

An obvious candidate to modelling web applications is to use UML, either directly or through a custom UML profile. While we acknowledge this is definitely possible, a serious issue is that UML is not precisely defined, and its operational semantics depend on the tools implementing it. As we want a platform-independent modelling language that can reliably generate deployable web applications, we have instead chosen to focus on designing a domain-specific language (DSL). Interested researchers will note that a DSL could be implemented in UML through a profile. Notwithstanding this choice, we are using UML as an inspiration and reference for different modelling aspects.

The *Model-Driven Architecture* (MDA) is an ongoing software engineering approach to define modelling languages [21]. It defines three layers of models (CIM, PIM, PSM), and advocates simple transformations and integrations with other modelling languages. This can be combined with its four-layer metamodelling architecture, which complements existing OMG standards such as the *Meta-Object Facility* (MOF) [22] and UML. As MDA is an architecture and not a process, it does not define the technical details of modelling languages, but rather covers the big picture of system modelling. UWE

is an existing web application modelling technique that uses the entire MDA architecture [17].

#### IV. APPROACH

As we mentioned above, many existing modelling approaches have been attempted in the past, but these still fail to model the core requirements of RIAs. We suggest this is due to some key issues:

- 1) Commonly, modelling approaches are aimed at an older version of web technology, and cannot express client-side user interactivity. A modelling language for RIAs should use RIA concepts as fundamental building blocks.
- 2) Most approaches are not easily extensible, which prevents developers from adding support for new technologies.
- 3) Many approaches have no CASE tool support or are proprietary, hindering industry adoption, and making it unclear if such a model is expressive enough to model RIAs.

After investigating existing modelling approaches [14] and defining a list of core requirements of RIA [15], we have decided to develop a new modelling language for RIAs, rather than through the extension of an existing approach. As a result, we can directly address the fundamental requirements discussed in the first point above. We also will integrate existing modelling languages where possible, such as using UML for activity and domain modelling; however a key goal of the language is to remain platform-independent.

This approach is made realistic by the excellent modelling and tooling support provided by the Eclipse project [23], in particular the *Eclipse Modelling Framework* (EMF) [24] and the *Graphical Modelling Framework* (GMF). The use of Eclipse also satisfies the second point above, as Eclipse is fundamentally designed around the extensibility of plugins, simplifying the work necessary to support model extensibility.

The modelling language being developed satisfies the architectural goals of MDA. The technical details of this achievement are beyond the scope of this paper, but generally the work we have done so far covers the definition of an M2 meta-model for instances of M1 meta-models, in the platform-independent model (PIM) aspect of MDA. Significantly, this suggests that the integration and interoperability of our modelling languages with others will be achieved easily.

Along with the development of a new modelling language, we are simultaneously developing a CASE tool that allows for the graphical creation of new model instances in this language, and can be used to generate and deploy a web application from this model. We expect that having this environment available will maximise the benefit of using models to describe RIAs, and satisfies the third issue mentioned above. It will also benefit in the evaluation of the modelling language in terms of usability, conciseness, and requirement satisfaction.

The major risk in the development of a modelling language for RIAs is the fact that RIAs are evolving rapidly; new technologies such as offline application support [25] and

HTML 5 [26] had not been published before the start of this research. As such, the modelling language and software tool are being developed in an iterative fashion [27], allowing us to evolve the model gradually and identify new requirements as they are discovered.

## V. CONTRIBUTIONS

Our modelling language, named the *Internet Application Modelling Language* (IAML), already supports the definition of some aspects of Rich Internet Applications. We are currently in the development of the fourth iteration of model development, which has support for:

- 1) Operational modelling (using UML activity diagrams).
- 2) Database modelling (based on UML class diagrams).
- 3) Event and condition modelling (based on ECA rules [8]).
- 4) Database querying and instancing.
- 5) Limited navigation and user interface modelling.
- 6) Role-based access control [28].
- 7) Some higher-level components, such as element synchronisation and user security.

This modelling language has been implemented in an Eclipse-based CASE tool, using the EMF and GMF technologies as a graphical model editors which serialises model instances to XML. We currently support basic model validation through an OCL-like syntax, and use the *OpenArchitectureWare* framework [29] to generate deployable web applications using PHP, HTML and Javascript. An alternative implementation in Java using JSP is forthcoming, allowing us to demonstrate platform independence.

Once this fourth iteration is complete, we will re-evaluate our modelling priorities to identify important aspects for the fifth iteration. An evaluation of our third iteration against our benchmark requirements highlighted serious deficiencies in access control and user security, allowing us to focus on these areas in our current work. Future work in the modelling language includes expanding its user interface modelling; explicit and implicit type systems; and messaging and concurrency modelling.

To reduce the burden on the model designer, we have designed the modelling language to work with the concept of *model inference*. Generally a model designer will have to specify their intended model completely, and this is the approach taken in WebML. We instead use a commercial rule engine to infer missing knowledge of the model based on default conventions, which can be overridden if necessary. This is similar to the approach taken by Ruby on Rails, and is also similar to the series of model transformations used by UWE. In an upcoming work, we define this inference technique formally, illustrating the accessibility and usefulness of model inference.

Academically, we have published two major papers; our first paper published in 2008 is a thorough investigation into how suitably existing academic modelling languages can express RIA concepts [14]. Our second paper published in 2008 thoroughly discusses the requirements of RIAs and covers the definition of a RIA benchmark application called *Ticket*

2.0, which can be used to evaluate new modelling and tool approaches to their suitability of modelling RIAs [15].

Evaluation of this modelling language against this benchmarking application is a critical aspect of the language verification. In particular, if we can design a model that fully meets the requirements of this benchmark, and can be transformed automatically into a deployable web application, then we can argue this modelling language successfully expresses RIA requirements. This is key to answering our third research question on model expressibility.

We have not yet adequately addressed the final key research questions mentioned in Section II. Our current work into model validation will provide us with an opportunity to highlight the reliability, usability and security of a modelling language. Combining this work with our approach of model inference will allow us to investigate model consistency. Finally, an evaluation of model speed and simplicity may be achieved through the comparison of modelling metrics with existing languages and conventional approaches. Both of these research questions remain as important future work.

The final goals of this research will be the definition, publication, implementation and evaluation of a modelling language suitable for modelling RIAs. Industry participation and adoption are ambitious goals that would obviously benefit the evaluation and usability of the modelling language. Ideally it will provide rich interoperability and extensibility opportunities for further research, and advance the field of web engineering itself.

A preliminary version of the modelling language and its accompanying CASE tool can be reviewed and downloaded from the website <http://openiaml.org>.

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## REFERENCES

- [1] S. Ceri, P. Fraternali, and A. Bongio, "Web Modeling Language (WebML): A Modeling Language for Designing Web Sites," in *Proceedings of the 9th international World Wide Web conference on Computer networks*. Amsterdam, The Netherlands, The Netherlands: North-Holland Publishing Co., 2000, pp. 137–157.
- [2] N. Koch and A. Kraus, "The Expressive Power of UML-based Web Engineering," in *IWWOST'02*, 2002, pp. 105–119.
- [3] Linda Heaton, "Unified Modeling Language (UML): Superstructure Specification, v2.0," Object Management Group, Tech. Rep., 2005. [Online]. Available: <http://www.omg.org/cgi-bin/doc?formal/05-07-04>
- [4] J. Offutt, "Quality Attributes of Web Software Applications," *IEEE Software*, vol. 19, no. 2, pp. 25–32, 2002.
- [5] R. Gitzel, A. Korthaus, and M. Schader, "Using established Web Engineering knowledge in model-driven approaches," *Sci. Comput. Program.*, vol. 66, no. 2, pp. 105–124, 2007.
- [6] C. Belletini, A. Marchetto, and A. Trentini, "WebUml: reverse engineering of web applications," in *SAC '04: Proceedings of the 2004 ACM symposium on Applied computing*. New York, NY, USA: ACM, 2004, pp. 1662–1669.
- [7] H.-W. Gellersen and M. Gaedke, "Object-Oriented Web Application Development," *IEEE Internet Computing*, vol. 3, no. 1, pp. 60–68, 1999.
- [8] G. Kappel, W. Retschitzegger, and W. Schwinger, "Modeling Ubiquitous Web Applications: The WUML approach," in *International Workshop on Data Semantics in Web Information Systems (DASWIS-2001)*, Yokohama, Japan, 2001.
- [9] G. Rossi and D. Schwabe, "Model-Based Web Application Development," in *Web Engineering*, E. Mendes and N. Mosley, Eds. Springer, 2006, pp. 303–333.

- [10] A. Bozzon, S. Comai, P. Fraternali, and G. T. Carughi, "Conceptual Modeling and Code Generation for Rich Internet Applications," in *ICWE '06: Proceedings of the 6th international conference on Web engineering*. New York, NY, USA: ACM Press, 2006, pp. 353–360.
- [11] J. Preciado, M. Linaje, S. Comai, and F. Sanchez-Figueroa, "Designing rich internet applications with web engineering methodologies," in *Web Site Evolution, 2007. WSE 2007. 9th IEEE International Workshop on*, October 2007, pp. 23–30.
- [12] S. P. Christodoulou, G. D. Styliaras, and T. S. Papatheodrou, "Evaluation of Hypermedia Application Development and Management Systems," in *HYPertext '98: Proceedings of the ninth ACM conference on Hypertext and hypermedia*. New York, NY, USA: ACM, 1998, pp. 1–10.
- [13] J. C. Preciado, M. Linaje, F. Sanchez, and S. Comai, "Necessity of Methodologies to Model Rich Internet Applications," in *WSE '05: Proceedings of the Seventh IEEE International Symposium on Web Site Evolution*. Washington, DC, USA: IEEE Computer Society, 2005, pp. 7–13.
- [14] J. Wright and J. Dietrich, "Survey of Existing Languages to Model Interactive Web Applications," in *Proceedings of the Fifth Asia-Pacific Conference on Conceptual Modelling (APCCM 2008)*, Wollongong, NSW, Australia, 2008.
- [15] J. Wright and J. Dietrich, "Requirements for Rich Internet Application Design Methodologies," in *Proceedings of the Ninth International Conference on Web Information Systems Engineering (WISE 2008)*, Auckland, New Zealand, 2008.
- [16] R. Acerbis, A. Bongio, M. Brambilla, and S. Butti, "WebRatio 5: An Eclipse-Based CASE Tool for Engineering Web Applications," in *ICWE, 2007*, pp. 501–505.
- [17] N. Koch, "Classification of Model Transformation Techniques Used in UML-based Web Engineering," *Software, IET*, vol. 1, no. 3, pp. 98–111, 2007.
- [18] J. C. Preciado, M. Linaje, R. Morales-Chaparro, F. Sanchez-Figueroa, G. Zhang, C. Kroi, and N. Koch, "Designing Rich Internet Applications Combining UWE and RUX-Method," in *ICWE '08: Proceedings of the 2008 Eighth International Conference on Web Engineering*. Washington, DC, USA: IEEE Computer Society, 2008, pp. 148–154.
- [19] L. Baresi, S. Colazzo, L. Mainetti, and S. Morasca, "W2000: A Modelling Notation for Complex Web Applications," in *Web Engineering*, E. Mendes and N. Mosley, Eds. Springer, 2006, pp. 335–364.
- [20] Skyway Software, "SkywayPerspectives.org," 2009. [Online]. Available: <http://www.skywayperspectives.org/>
- [21] D. Djuric, D. Gasevic, and V. Devedzic, "The Tao of Modeling Spaces," *Object Technology*, vol. 5, no. 8, 2006.
- [22] Linda Heaton, "Meta Object Facility (MOF) Core Specification, v2.0," Object Management Group, Tech. Rep., 2006. [Online]. Available: <http://www.omg.org/cgi-bin/doc?formal/2006-01-01>
- [23] Eclipse Foundation, "Eclipse.org Home," 2007. [Online]. Available: <http://www.eclipse.org>
- [24] Steinberg, David and Budinsky, Frank and Paternostro, Marcelo and Merks, Ed, *EMF: Eclipse Modeling Framework*, 2nd ed. Addison-Wesley Longman, Amsterdam, January 2009.
- [25] Google Inc., "Google Gears," 2007. [Online]. Available: <http://gears.google.com>
- [26] W3C Group, "HTML 5: A vocabulary and associated APIs for HTML and XHTML," W3C Working Draft 26 February 2008, Tech. Rep., 2008. [Online]. Available: <http://www.w3.org/html/wg/html5/>
- [27] Eric Lopes Cardozo, "The seven habits of effective iterative development," IBM, Tech. Rep., 2002. [Online]. Available: <http://www-128.ibm.com/developerworks/rational/library/1742.html>
- [28] R. S. Sandhu, E. J. Coyne, H. L. Feinstein, and C. E. Youman, "Role-Based Access Control Models," *Computer*, vol. 29, no. 2, pp. 38–47, 1996.
- [29] S. Efttinge, P. Friese, A. Haase, D. Hbner, C. Kadura, B. Kolb, J. Khnlein, D. Moroff, K. Thoms, M. Vlter, P. Schnbach, M. Eysholdt, D. Hbner, and S. Reinisch, "openArchitectureWare Documentation," openArchitectureWare, Tech. Rep., 2008. [Online]. Available: <http://www.openarchitectureware.org/pub/documentation/4.3.1/html/contents/>