Comparison between Web Engineering Methods to Develop Multi Web Applications

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Abstract: Web applications act as a source of strength for business growth over the internet and have become the backbone of the e-commerce. With the evolution of these type of applications, numerous features have been added to overcome the issues of complexities of the processes development web engineering methods. These methods are intended for specific purposes, and there has been some lack of the development of web applications, especially concerning the new types of web applications. The problem is that web engineering methods cannot support new features of web applications, furthermore no single method to support all types of web applications. In an attempt to solve this problem, a significant amount of work has been undertaken to improve or extend these methods to develop new types of web applications. In this paper, we make a comparison between web engineering methods (including IFML) to support the features of modern web applications. The result of our comparison will show the capability of the methods to support modern and multi web applications, and help the developers in the process development web applications.

Key words: Web engineering methods, web applications, IFML, comparison study.

1. Introduction

With the swift web evolution during the period past 1990, web engineering methods were implemented to create web applications. Numerous methods, like Hypermedia Design Model (HDM) [1], as well as Object-Oriented Hypermedia Design Method (OOHDM) [2], facilitated novel approaches, notations plus models ini – ‹ ƒ Ž Ž › Š ƒ • † Ž ‹ • ‰ ò Š › ’ ‡ ” • ‡ † ‹ ƒ ó • › • – ‡ • • ‰ ‡ • ‡ ” ƒ Ž Ž › á-based systems precisely Ž › Š ‹ ‰ S The growth of this research line, Web engineering, is examined in Several comparative studies and surveys [3]-[10]. Regardless of a range of uncertainties put forth concerning the need for specialized Web development ƒ ’ ’ ” ‘ ƒ … Š ‡ • … ‘ • – ” ƒ ” › – ‘ ò … ‘ • ˜ ‡ • – ‹ ‘ • ƒ Ž ó [11]. ò – ” ƒ † ‹ – ‹ ‘ • ƒ Ž ó • ‡ – Š ‘ † •

Web engineering methods for progressing web applications, tend to engage a range of notations and suggest some development procedures, hence employing a standard metamodel as based approaches for the Web domain. Equally enough, the metamodel is the best delineation of the modeling models. The association between metamodels and their aspects, with aptly-formedness guidelines, continues requirements for designing a semantic web. Web engineering methods founded on this metamodels as part of the design facilitated by the metamodels. The common metamodels ought to be a union of the modeling design of renowned web engineering methods allowing for their excellent evaluation and assimilation [12]. Founded on evolution aspects and intricacy, there exist diverse classifications for webs and webs application.

In their study, Aghaeiet al. [13] categorized four Web generations founded on the growth of web design and

includes web 4.0, web 3.0, web 2.0, and web 1.0. A"þ•‡•–ƒ–‹ƒ•ƒ†…‘•'ƒ"‹•'•‘^–Š‡•‡™‡„%
features have equally signified achieved. It was evident that as of 1989, information space or the Web has had tremendous development and it is adapting towards Artificial Intelligent methods and is seen as a large Web of sophisticated, intelligent communications shortly.

The primary problem facing businesses is that single web engineering methods cannot support all web applications, since each method has been designed for a special aspect. Moreover, a designer needs specific information about approaches to develop web applications. In this paper, we make a comparison between web engineering methods to develop multi web applications. Comparison study best way to find weaknesses and strengths of the methods in the process development web applications, also comparison explains the similarity and differences between methods.

This paper is organized as follows: Section 2 demonstrates related works. Section 3 explains modern web applications. Section 4 explains MDWE methods by which to develop multi web applications. In Section 5, we make a comparison between existing web engineering methods used to develop multi web applications. The last section consists of the conclusion of the comparison and suggestions for future research.

2. Background

Within the study area of web methods, there exists comparatively limited literature on such web methods [12], [14]-[17]. While acting as a basis for process improvement and improved product dominance, a vast level of literature in Web engineering has centered on the proposal of tools and methodologies. In their study, Lee et al. [14] assessed the measurements of some particular aspects of Web approaches, such as stages, predominant •‘†‡Ž‹•‰ƒ'’"‘ƒ…Š‡•á•ƒ˜‹‰ƒ–‹•‘•'—"…‡á†‘…—•‡•–ƒ–‹•á–‡…Š•‹"—‡•–‘‹
quality. Nonetheless, the outcomes authenticity may have suffered ambiguity as a result of subjectivity by the researchers hence causing demarcation in the study outcomes. For instance, Koch [8] compares the phases ran through by some given web approaches by engaging a differentiation technique that obscured some key aspects. There exists an apparent deviation in the infiltration where an approach describes a stage. For example, some web approaches tend to propose some textual approaches for various growth phases with others facilitating support tools for the identical phases.

Nonetheless, Montero et al. [16] design a requirement configuration, with the intent of examining web ‡•‰‹‡"‹•‰•‡–Š‘†•ˆ"•›•–‡•Š›'‡"•‡†‹ƒä‘•‡…‘†‹–‹‘••ƒ"‡‘„–ƒ‹•†
engineering as well as web engineering. These conditions are employed in the configuration of methodologies to assess their benefits and demerits. To exemplify the elements of web applications, as well as where the present methods fail in conforming to these conditions, Gu et al. [15] assesses the prerequisites of web approaches. In some key areas, present limitations appear highly significant, such as, the affiliation between operational and information aspects need for support within its dynamic modeling. This study by Gu et al. can be regarded being less biased and vague compared to that by Lee et al, Koch and Montero et al., regardless of the meager methods offered while some extensions were not taken into consideration. Furthermore, Wakil and Jawawi made a comparison between UWE, OOH and WebML through the metamodels and elements [9]. Furthermore, they perform a new comparison between UWE and WebML [18] to show weaknesses and strengths of the methods, these comparisons showed the ability of methods to develop web applications, but not highlighted the type of applications.

Baresi and Morasca [17] carried on three empirical studies focusing the effort needed on designing web applications. The empirical studies were based on the use of W2000, but the hypotheses and results may apply to other methods. By differentiating between web engineering methods in previous works, there were drawbacks and strengths. But certain investigators endeavored to enhance web engineering techniques and metamodels, however until now is not ideal yet for the development of web application. However a number comparison exists but not enough to show capability the methods, for this reason in this paper, we will try to find the best method among web engineering methods to develop multi web applications including new features from

modern web applications.

3. Modern Web Applications

Based on the continuing evolution of features and complexity, there are different categorizations for webs and web applications. An outline, based on the evolution of the web given by Aghaei et al., classified four generations which are: web 1.0, web 2.0, web 3.0 and web 4.0. The features of the generations are presented and contrasted. It came to the point that, since 1989, information space or the web has undergone tremendous development. It is increasingly adapting artificial intelligent methods and is seen as becoming a huge web of sophisticated intelligent communications in the near future[13].

Web applications have differing degrees of complexity. They may be strictly informational or manage full-size and fully-fledged 24/7 e-commerce applications, based on their progress history and their level of difficulty [18] Wakil and Jawawi [19] decided that the latest web applications are ubiquitous web applications, semantic web applications and intelligent web applications. In addition, there is the Rich Internet Application (RIA) that focuses on the client and server user interface as highlighted in Fig. 3.

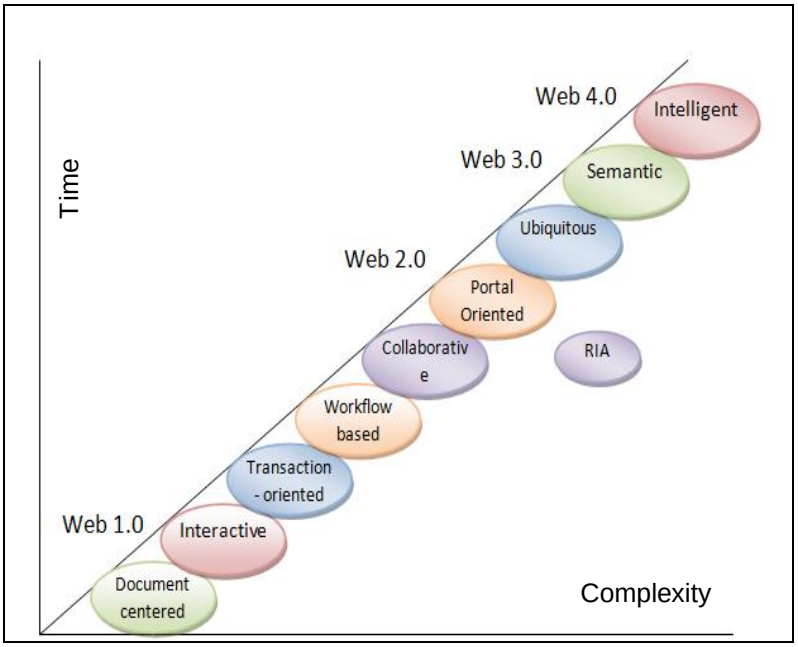

Fig. 1. Web applications complexity history with respect to web evolution[19].

After web 2.0 until web 4.0, the progress of new web applications is based on the outcome above. The latest and most popular web applications centered on complexity and history are: RIA, UWA, SWA, and IWA. Table 1 shows the features of web applications that need to be supported by web engineering methods.

Table 1. Features of Newest web Applications [19]

Features	Web applications
Client/Server, Rich UI, Rich Client	RIA
Anywhere, Anytime, Anyplace, Anymedia, Anydevice, Adaptation, Context-aware	UWA
Ontology, Rich UI, RDF, Semantic hyperlink, behavior	SWA
Web Personalization, Web Mining, Semantic Web, Intelligent Agents	IWA

The client/server feature is a feature that helps the software working on the client and server as the same interface through the rich UI. Furthermore, Rich client is a new feature that users mostly utilize through new smart phones, ipads and new electronic devices. The features from UWA possess extraordinary characteristics to present web applications on any device, anywhere or via any media, ensuring high adaptability for the web

software.

A new feature from semantic web is ontology. The semantic web is mostly used by developers for web site development, especially in Google, and other search engines. This feature is very important to enable users to search easily in order to find information by using semantic hyperlinks. The future feature of web applications from IWA is that of web mining. It is expected that this will help web users to utilize web applications in a smart way.

4. Web Engineering Methods for Developing Web Applications

There are a number of web engineering methods which have been proposed for developing web applications. These are shown as follows:

4.1. Web Modeling Language (WebML)

Web Modeling Language (WebML) [20] is normally a model-driven method for the design and creation of data-intensive application of webs via waterfall software procedure. The method entails seven phases whereby the software developer conceptualizes diverse web application qualities. This approach is founded on three models [19] which include presentation model, Data model as well as Enhanced Hypertext Model. Within the last 10 years, there has been an improvement of the inventive WebML methodology by engaging primitives in creating diverse web applications aspects as well as fresh application types [21]. Different scholars have ’‹‘•‡‡”‡† ƒ• ‡•Š ƒ•…‡•‡•– ‘ˆ –Š‹• ƒ’’”‘ƒ…Š ‹• Š ƒ•†Ž‹‰ –Š‡ [22]. Bozzon et al. [23], Toffetti [24] and Fraternali et al. [25]). Precisely, the researchers developed an enhanced such Data model to promote the depiction of temporary and distributed data objects, as well as the Stretch Text model, inclusive of novel primitives to handle the new model for delineating the dynamic aspect of the elements of an RIA user interface, that is, the RIA dynamic model, identical to UML activity diagrams. This method is sustained by a CASE tool identified as WebRatio [26].. In their study, Brambilla and Facca [27] exemplified the key features ƒ•†”‡“—‹”‡•‡•– ‘ˆ î•‡•ƒ•…‡ ™‡„ ’”–ƒŽ ‹• Š‡…‡••ƒ”› ƒ• ‡•Š ƒ•…‡•‡† ‡ these applications type. While creating social web applications, Fraternali et al. [28] described and examined a set of software models utilized in prevailing community-based Web applications. In addition, the researchers introduced a collection of models illustrative of the way of implementing them by engaging WebRatio and WebML.

4.2. UML-Based Web Engineering (UWE)

As initially proposed by Koch and Kraus [29], [30], UML-based Web Engineering (UWE) entails a model-driven development method for Web applications founded on the utility of UML models. Exclusively, the approach engages a UML profile for the specification of the use conditions plus the design qualities. UWE creation method is facilitated by a five-model design plus the transition among them: Presentation model, Navigation model, Process model, Content model as well as the Requirements model. Additionally, ArgoUWE is a CASE tool [31] highly facilitates the UWE by instigating the UML pattern as well as the model transformations. Over the last 10 years, UWE has been employed in Web applications as far as business setting is concerned to customize Rich Internet Applications as well as business Web applications, founded on the use of BPMN (Business Process Modeling Notation) standard. There exist two UWE diversifications in creating Web applications: one suggested by the inventive researchers while the second proposed by some modern researchers.

In their study, Koch et al. [32] devised a method founded on pattern in creating Rich Internet Applications by using UWE. The researchers invented the description of UWE’s ‡Ž•ï ‡š–‡••‹‘• ’‹‹•• ˆ‘” ‹•–‡‰”‡ƒ–‡† to RIA development. These patterns are described as UML state models and are incorporated into UW models by using model-to-model transitions or to the eventual Web application code through model-to-text transitions. The other method, suggested by Machado et al. [33], , enhanced the UWE UML profile integrating the aspects needed in modeling the definite RIA aspects. The resulting methodological extension was identified s UWE-R. The authors offered a description of the RIA design inclusive of novel aspects in the process, navigation and

presentation models, inherent of the design and behavior of UWE profile elements.

4.3. RUX Method

Rich User eXperience (RUX) method [34]-[36] is another model-compelled approach centered on the creation of rich user interfaces, that is, the user-client RIA modules. For the purpose of coming up with the eventual user interface, this method suggests a 3-phase method compelled by the design of three models: the Abstract, Concrete and Final interfaces. The RUX-method is incapable of facilitating the design and creation of RIA server modules as it is centered on RIA client modules and user interface. For the creation of the RIA server, the researchers at first suggested reusing the WebML Data and Hypertext models [37]. So as to minimize the RUX-WebML interdependence and confirm the method flexibility, the researchers equally suggested another adjustment for the UWE models engagement [36]. RUX-Tool CASE tool highly facilitates the RUX method [38].

In their study, Linaje et al. [39] described the modifications and conditions required for the integration of semantic annotations within AJAX user interfaces by utilizing the universal Web Consortium WAI-ARIA proposal [40], which highlights the convenience of Web user interface through ontology collection. The suggested solution is integrated, and therefore enhanced, courtesy of EditSAW tool, typically a CASE tool for the creation of accessible Websites by engaging its personal causal approach. In another methodology, Linaje et al. [41] offered a solution by using onto RUX,, that is, an enhancement of the WAI-ARIA ontology

4.4. Object Oriented Hypermedia Design Method (OOHDM)

The Object Oriented Hypermedia Design Method (OOHDM) [42] was equally enhanced to handle the establishment of RIA [43]. The suggested method enhances the OOHDM interface model to highlight the creation of the rich user interfaces by engaging ADVs (Abstract Data Views), which delineates all the structural aspects of the rich interface besides being hierarchically presented. As a measure of delineating the interface behavior, the researchers considered the use of ADV-charts, typically some state tools facilitating expressing interface transformations caused by user interactions.

4.5. Object Oriented Web Solutions (OOWS)

The object oriented web solutions (OOWS) methodology [44] is a model-compelled method centered on the development Web (2.0) applications and founded on OO-Approach. Another proposal was offered by Valverde and Pastor [45] in their research to address creation of Rich Interfaces, by suggesting an enhancement of this method. In this study, the researchers offered a novel model, that is, the model of Interaction, to identify the RUI components as well as their dynamic behavior. They equally delineated a set of typical interaction models capable of taking place between the users and the RIA interface. An inclusive categorization of all the prevailing methods and a concise explanation of all the methods can be established in the assessment conducted by Toffetti et al. [46].

4.6. Semantic Hypermedia Design Method (SHDM)

Semantic Hypermedia Design Method (SHDM) [47] is an ontology-compelled design approach for creating Web applications on Semantic Web. From a 3-ontology set, that is, navigation (describing the application configuration plus the navigational paths), domain (delineating the application data) as well as presentation •–‹’—Žƒ–‹•‰ –Š‡ ‡„•‹–‡•ï …‘•…‡’––ƒŽ‹œƒ–‹‘• –Š‡ ƒ’’”‘ƒ…Š …”‡ƒ–‡• ƒŽ studies [48-49], researchers enhanced SHDM with a set of primitives in designing RIAs. This enhancement augmented the total presentation ontology elements increased the Web creator functionalities. In this final adaptation, the researchers managed to prevail over the shortage of annotation in their initial Web applications by using RDFa [50]. It is important to argue that the inventive SHDM proposal focuses at creating textual annotations on browser-focused RIAs, founded on JavaScript and HTML. This clearly restricts the forms of technology capable of being employed in the RIAs creation. Of late, de Souza and Schwabe (2011) have revised the methodology so as to create web applications capable of functioning with data from Data Web, which is,

achieving the Lincked data standards. This method is executed using synth proposal, which enhances the design and creation of Data Web applications.

4.7. Hera Methodology

HERA[51] is a method used in the configuration of SWISs (semantic web information systems), described as WIS (Web information) that utilize semantic web methods. In particular, the method employs ontology in the † ‡ ’ ‹ … – ‹ ‘ • ‘ ^ – Š ‡ ƒ ’ ’ Ž ‹ … ƒ – ‹ ‘ • ï • † ‘ • ƒ ‹ • • ‘ ™ Ž ‡ † ‰ ‡ á ^ ƒ … ‹ Ž ‹ – ƒ – ‹ • ‰ – Š ‡ ” ‡ — • ‡ the researchers introduce a method for having the generated websites annotated. Using the Hera point of view, the SWIS structural design can be categorized into 3 classes: Semantic, Application and Presentation Layers. There exist two key events in the procedure described within the Hera methodology: data collection and presentation [52] [53], where data generated from various sources is integrated while the designer creates a hypermedia data presentation of the data acquired from the initial phase, respectively. Additionally, Vander Suijs et al [54] suggested a methodology enhancement, identified as Hera-S, in order to promote the … ‘ • ^ ‹ ‰ — ” ƒ – ‹ ‘ • ‘ ^ - ö ‘ • . ƒ ˜ ‹ ‰ ‡ ƒ † – ‹ ‡ • „ • – ” — … – — ” ‡ • ‘ ˜ ‡ ” ‡ • ƒ - S facilitates the creation of ‡ ” ƒ Semantic Web applications that, engaging the Sesame RDF framework[55] for the organization and storage of RDF triples, permi– ‘ – Š ‡ ” ƒ ’ ’ Ž ‹ … ƒ – ‹ ‘ • • – ‘ ‘ ’ ‡ • Ž › ƒ … … ‡ • • ƒ • † ƒ † ƒ ’ – – Š ‡ † ƒ – ƒ — – ‹ Ž ‹ [56].

4.8. Web Requirements Engineering (WebRE)

WebRE is an approach concerning the handling of Web prerequisites founded on W2000, Navigational Development Method (NDT), OOHDM, and UWE. The concepts of modeling presented in the present study for Web prerequisites specifications are delineated founded on the correspondences of the assessed methods. They are signified as UML metaclasses and make up our WebRE model. The metaclasses delineate the notions without any knowledge concerning its demonstration. They are categorized into two groups, in adherence to the design of UML metamodel: the WebRE behavior package and WebRE structure. The behavior package entails Web Process, Metaclasses Navigation, Web User, Search and User Transaction as illustrated in figure 2 [57].

4.9. Interaction Flow Modeling Language (IFML)

IFML [58] endorses the platform-independent account on GUI for applications accessed on installed on systems like laptops, desktop computers, tablets, mobile phones and PDAs. The predominant concentration is on – Š ‡ ƒ ’ ’ Ž ‹ … ƒ – ‹ ‘ • ï • † ‡ • ‹ ‰ • ƒ • † „ ‡ Š ƒ ˜ ‹ ‘ ” ƒ • ” ‡ … ‘ ‰ • ‹ œ ‡ † ƒ • – Š ‡ ‡ • † — • ‡ ” ä integrates data references and business logic affecting the experience of the user. This is attained accordingly by having the domain model objects referenced by facilitating the data exhibited in the interface and the deeds to be activated through interface interaction. Wakil and jawawi,2017 [59] ƒ † † ‡ † – ‘ ™ ‡ „ ‡ • ‰ ‹ • ‡ ‡ ” ‹ • ‰ Ž ‹ map, they explained IFML one of the good methods to cover lifecycle, this work help the researcher to follow IFML to solve other web application issues. Moreover they created a framework for combining IFML with other methods[60], this combine provide more ability to IFML for developing web applications. IFML extended for developing mobile applications by [61]. IFML will be one of the best methods because created after ten year experience of WebML.

5. Comparison between Web Engineering Methods to Develop Multi Web Applications

In this section, we make a comparison between the existing web engineering methods used to develop multi-web applications. In this comparison, we use the web application features that are presented in Table 1.

The main features of RIA are Client/Server, rich user interface, Generate browser and Generate Plug-in Oriented rich client. Most web engineering methods originally cannot support RIA features, but after improvement or extension was supported, among them IFML originally supported RIA features. Another type of web applications is Semantic Web, this type more popular and more usable type in developing web applications, many applications focused on Semantic web, the Semantic web features related to ontology such as; design

ontology, import ontology, generate ontology instance, General semantically annotate UIs, and Generate a service Ontology. As shown in Table 2 some web engineering methods can support semantic web and some of them after improvement supported. WebML, OOHDM, OOWS are best methods to support semantic web applications; however other methods can support or have an ability to extend to support semantic web features.

Another type of web applications is Ubiquitous Web application, this type of application not popular type just defined by some researcher in web engineering methods, but very adaptive type especially in their features (anytime/anywhere/anymedia). WebML and SDHM are methods that can support this type of web applications. the latest modern web application in intelligent web application, this type starting at 2016 and will become base of modern and smart web application in the future, the main features are; Web mining, Intelligent Agent and web personalization, this type not applicable by web engineering methods, so we cannot decide which one is the best method to develop this type of web applications. Based on features we can describe each method can support features of intelligent web applications also can support this type of web application.

Table 2. Comparison between Web Engineering Methods to Develop Multi Web Applications

Area		Features	Methodologies								
			WebML	UWE	WebRE	OOHDM	OOWS	SHDM	Rux-Method	Hera	IFML
Multi Web Applications	RIA	Design RIA Server	●	●	●	●	●	●	⊘	◐	●
		Design the structure of Rich user Interface	◐	◐	●	◐	◐	◐	◐	◐	●
		Generate browser oriented Rich client	●	●	●	●	●	●	◐	◐	●
		Generate Plugin Oriented rich client	●	⊘	●	⊘	⊘	●	●	◐	●
	Semantic WebApp.	Design ontology	◐	○	○	●	●	◐	⊘	◐	◐
		Import Ontology	●	○	○	●	●	◐	◐	●	◐
		Generate Ontology instance	●	○	○	●	●	●	●	●	◐
		General semantically annotate UIs	●	○	○	●	◐	●	●	◐	◐
		Generate a service Ontology	◐	○	○	◐	◐	⊘	⊘	◐	◐
	Ubiquitous WebApp.	anytime	●	●	◐	⊘	⊘	●	○	⊘	○
		Anywhare	⊘	⊘	◐	⊘	⊘	⊘	○	⊘	○
		anymedia	●	⊘	⊘	⊘	⊘	●	○	⊘	○
	Intelligent WebApp.	Web Mining	○	○	○	○	○	○	○	○	○
		Intelligent Agent	○	○	○	○	○	○	○	○	○
		Web personalization	○	○	○	○	○	○	○	○	○

● Fully Support ◐ Partially Support ○ Not Applicable ⊘ Not Support

Table 2 above shows a detailed comparison between web engineering methods used for developing multi-web applications. The current methods are already extended to support RIA, especially UWE, WebML, OOHDM, OOWS, and so on. Most methods have been extended to support the semantic web but some of them are not applicable (such as UWE). Even though the methods can support UWA, it still seems that all is not perfect. Moreover, existing web engineering methods do not qualify for intelligent web applications. However, IFML is a new method which supports rich interface RIA but cannot support web applications. However, we can say that it is still the best method for practice.

Finally, we can conclude about web engineering methods cannot fully support all modern types of web applications, because each method designed for the special task and different concern, so we need to define a new method to support all types of web applications especially modern web applications. however IFML is new but designed after the ten-year experience of WebML and WebRatio, so IFML one of the web engineering methods have an ability to the extension to develop all types of modern web applications.

There are many challenges to extension web engineering methods, for example, the architecture of the method, models, metamodels. The methods have a different type of models and a different number of models; moreover, number and type of elements are different. Another challenge is process development web applications, each method focused on a phase of web engineering life cycle. Another challenge is tool support to design models and metamodels.

6. Conclusion and Future Work

In this paper, we have made a comparison between web engineering methods, through their respective capability to support different web applications. This comparison showed that current methods cannot support all types of web applications. However, IFML is still the best method with which to practice. It can support RIA perfectly, but also needs to improve. It is anticipated that this comparison will be able to help designers with choices as to which method in web engineering is the best for the development of web applications. However a number of challenges do not allow enhancing web engineering methods but with using a different mechanism and new technologies we can solve that problem, we recommend for researchers to improve the methods by using new mechanism and new technologies to develop multi web applications through the adaptive concept for models and metamodels.

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