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Model Driven Web Engineering: A Systematic Mapping Study

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Abstract

Background: Model Driven Web Engineering (MDWE) is the application of the model driven paradigm to the domain of Web software development, where it is particularly helpful because of the continuous evolution of Web technologies and platforms. Objective: In this paper, we prepare a survey of primary studies on MDWE to explore current work and identify needs for future research. Method: Systematic mapping study uses for finding the most relevant studies and classification. In this study, we found 289 papers and a classification scheme divided them depending on their research focus, contribution type and research type. Results: The papers of solution proposal (20%) research type are majority. The most focused areas of MDWE appear to be: Web Applicability (31%), Molding and Notation (19%), and Services and Oriented (18%). The majority of contributions are methods (33%). Moreover, this shows MDWE as a wide, new, and active area to publications. Conclusions: Whilst additional analysis is warranted within the MDWE scope, in literature, composition mechanisms have been thoroughly discoursed. Furthermore, we have witnessed that the recurrent recommendation for Validation Research, Solution Proposal and Philosophical Papers has been done through earlier analysis.

Keywords: Model Driven Web Engineering, MDWE, Web engineering, systematic mapping study

1. Introduction

MDWE is the application of the model driven paradigm in the Web domain [1–5]. The advent of a new area of software engineering, focusing on the special features of the Web environment, was undertaken by the research community at the beginning of the 1990s. At the beginning, this research focused on new methods, models and notations which were used in hypermedia systems. However, later the target were Web-based systems that were presented through some approaches which included the Hypermedia Design Model (HDM) [6] and the Object-Oriented Hypermedia Design Method (OOHDM) [7]. There are a number of comparative studies and surveys which investigate the evolution of this area and have drawn attention to areas where further research is needed to address a number of clearly-identified gaps and shortcomings. Within the Web engineering community, a number of research groups are working towards suitable resolutions to these gaps, which can be broadly classified within three areas: 1) There is a wide variety of Web development methodologies, using a multiplicity of different notations, models and techniques. 2) No single Web development approach provides coverage for the whole life cycle. 3) There still remains a lack of tool supports for Web development methodologies [8–12]. Instead of traditional or conventional methods, specialized Web development methods were used [13].

The application of the Model Driven Architecture (MDA) initiative has been applied

to numerous domains since 2001. In general, it works better than those areas controlled by functional requirements, well-structured models, and accurate separation of concerns and standard platforms. MDA has created potent advantages in which Web engineering has essentially been shown to be an application domain. As new platforms emerge and changes in technologies occur continuously in this area, MDA mainly permits successful highlighting of interoperability, model evolution and adaptation issues of Web systems [14]. Due to the rapid evolution of Web technologies and platforms, MDWE was also developed by applying independent models, such as the content, navigation, process, and presentation issues possessing various issues of Web applications. Moreover, these models are unified and changed to codes, conversely. These codes consist of Web pages, configuration data for Web frameworks, and also traditional program codes [1].

For the design and advancement of many types of Web applications, MDWE approaches already offer outstanding methodologies and tools. By applying independent models (including navigation, presentation, data and others), these approaches reveal diverse issues, and are sustained by model compilers that generate a vast majority of the application's Web pages and the logic centered on these models [15].

The specification of the application is built up step by step by alternating automatic generation and manual elaboration steps, from the Computational Independent Model (CIM), to a Platform Independent Model (PIM), to a Platform Specific Model (PSM), to code. Today, most approaches based on MDA are 'elaboration' approaches, which have to deal with the problems of model and code synchronization. Some tools support the regeneration of the higher-level models from the lower-level models [1].

A systematic mapping study is a way of identifying and classifying research related to the topic, it has been adapted from other disciplines to software engineering by Kitchenham and Charters [16]. When used for a specific research area, it categorizes different types of research reports in various dimensions and often provides a map of its results. Systematic mapping studies have been recommended mostly when little relevant evidence is found during the initial study of the domain, or if the topic to be investigated is very broad [16]. In contrast to systematic literature reviews, systematic mapping studies are conducted at a coarse-grained level. They aim only to find and identify evidence relating to research questions, and to identify research gaps in order to direct future research. In this context, we believed it would be appropriate to conduct a systematic mapping study, since model driven Web engineering appears to be a broader concept with multiple research focus areas. In this paper, a Systematic Mapping Study for MDWE is presented from the perspective of the guidelines extracted from the reports published by Kitchenham and Charters [16] and Biolchini et al. [17].

There are a great number of journals, conferences and workshops within the Web engineering area and MDWE fields that were published. These included the Journal of Web Engineering (JWE) [18], the International Journal of Web Engineering (IJWE) [19], and the International Conference on Web Engineering (ICWE) [20]. Wherever this topic is mentioned, it is hard to get a comprehensive overview of the state of the research. For controlling the review papers and understanding the subjects of the papers, we need a systematic mapping study in MDWE.

Following this introduction, this paper has been structured as follows: In Section 2, we present a short overview of the context in which the current study has been conducted, and we justify its needs. Section 3 describes how the systematic mapping methodology has been applied. The classification schemes and their various dimensions are discussed in Section 4. Section 5 is dedicated to presenting the results of mapping the selected primary studies, and the discussion of research questions. We discuss the overall results and identify the potential limitations of our study in Section 6. Section 7 consists of a conclusion and suggestions for future work.

2. Background and Motivation

There already exist literature surveys and systematic review works in this field resulting from the swift progressed in Web engineering and MDWE. Some investigators completed going through MDWE methodologies [21], introducing a crucial assessment of earlier studies of traditional Web methodologies and highlighting the capability of the MDWE paradigm [2] as well as systematic review of Web engineering research [22].

Several of the MDWE methods that have been suggested are presented by Jesús and John, 2012 [21], who consider and investigate the strengths and weaknesses of such methods associated with the present trends and best practices on Model Driven Engineering (MDE). Introducing every approach and investigating the models, they suggest signifying Web applications, the architectural factors in the changes, and the application of present Web user interface technologies in the code outcome are their aim. This is accomplished for the purpose of creating potential research strategies for upcoming works on the MDWE area [21].

A crucial review of the earlier studies of classical Web methodologies is presented by Aragón et al. 2012 [2], who highlights the capability of the MDWE paradigm to highlight lengthy overdue issues of Web development, encompassing research and enterprise. With respect to the terms extracted from the literature, the chosen key MDWE development approaches are investigated and matched. The paper argues that certain classical gaps can be enhanced with MDWE and shows that this new tendency introduces a stimulating as well as novel method to create Web systems inside practical projects. However, this paper presents a general assessment of the situation and investigates how MDE can overcome the classical issues identified in Web development in the past years [2], as can be concluded from this introduction.

For the purposes of investigating the rigor of claims ascending from Web engineering research, Mendes, 2005, applies a systematic literature review. The rigor is measured by applying a standard spooled from software engineering research. The outcomes have indicated that just 5% of 173 papers reviewed by them could be considered methodologically rigorous. On top of showing their outcomes, they offer proposals for the betterment of Web engineering research founded on lessons picked up by the software engineering fraternity [22].

In many areas, systematic review has achieved great attention amongst researchers these days. In the application investigating statistical sciences, psychology sciences, industrial-organizational psychological sciences, education, medicine, health sciences domain, and software engineering, it is extensively used. The idea of Evidence-Based Software Engineering founded on medical practice by applying systematic review was assessed by [23], and presents a guideline for a systematic review that is conducive for software engineering investigators [17]. As a result, numerous systematic reviews were carried out in software engineering after words and several article were published in the Web engineering domain, such as: Mendes reviewed 173 papers, only 5% of all papers reviewed were designed properly, were based on a real scenario [22], Alfonso at al. to create a comprehensive review and synthesis of the current state of the art in the literature related to the engineering requirements in the Web domain. To do this, a total of 3059 papers published in the literature and extracted from the most relevant scientific sources were considered, of which 43 were eventually analyzed in depth in accordance with the adopted systematic review process [24]. Insfran and Fernandez presented a systematic review of usability evaluation methods for Web development; total of 51 research papers have been reviewed from an initial set of 410 papers; the results show that 45% of the reviewed papers reported the use of evaluation methods [25].

Where continued investigation is required to highlight a number of visibly recognized gaps, and weaknesses, a few comparative studies and reviews of Web development methodologies have gained attention in these areas. Several investigative groups within the Web engineering fra-

ternity are pushing towards appropriate solutions to these gaps which, already laid out in the previous section, can be categorized into three parts [2]:

- Applying a diversity of dissimilar notations, models and techniques, there is a vast range of Web development methodologies.
- The non-presence of a single all-in-one answer because no single Web development approach offers coverage for the entire life cycle, which means that Web developers need to mix-and-match factors from diverse approaches.
- Web development methodologies remain inadequately supported via tool support. On the contrary, there are inadequate methodical investigation and design components by way of the majority of development tools.

By implementing a Model Driven Development (MDD) paradigm, for instance MDWE, these problems can be highlighted to a certain degree. Investigating approaches adapted to the model driven paradigm is the chief focus which makes an innovative input from the review paper. Concepts play the utmost significance in MDWE, free of their representations. MDWE suggests applying metamodels that are platform-independent together with the representation of ideas. A set of transformations and relations among ideas that facilitate active development and guarantees uniformity between models supports the development process. In some regions of software engineering and development, the model driven paradigm is being applied with outstanding outcomes. This indicates it could also be adapted for Web engineering. For example, MDE offers an appropriate way to guarantee traceability and product derivation in software product's lines [2, 26, 27]. Several articles on the secondary study in the area of Web engineering, readied by the earlier reviewer, with different sides of Web engineering methodologies and MDWE, presented certain problems and methods for the development of Web applications. At times, they did not present a systematic mapping for MDWE as it seemed a concrete work for MDWE.

Systematic mapping studies belong to the Evidence-Based Software Engineering (EBSE) paradigm [28]. They provide new, empirical and systematic methods of research. Although several studies have been reported in the broader MDWE (e.g. [2, 14, 15, 21]), we are not aware of any systematic mapping study that has been conducted in this field. Given the fact that various types of research have appeared addressing varying focus areas at different levels of granularity related to a broader topic of MDWE, there is a need for a more systematic investigation of the topic. Therefore, the current study is intended to contribute to MDWE through a systematic and evidence-based approach. This study may help researchers in the field of MDWE through providing an overview of the current research in the area. Furthermore, it may serve as the first step towards more thorough examination of the topics addressed in it with the help of systematic literature reviews.

3. Research Method

The process of continuing a systematic mapping study in software engineering was expounded by Petersen et al. [29]. By taking into account their guidelines, we carried out the present study. Referring to our subject matter, we discovered demarcating certain explicit schemes apart from utilizing the classification schemes suggested in their task for some areas. As highlighted in Figure 1, it is based on the crucial process steps of (1) Defining research questions. (2) Defining search strategy. (3) Screening of primary studies. (4) Defining classification schemes. (5) Mapping of studies.

3.1. Research Questions

In Web engineering, acquiring a general idea of the present analysis within the scope of the model driven is the objective of this study. To clarify this aim, we demarcated three research questions:

- RQ1: What MDWE subject matters are the most analyzed ones and how far have these

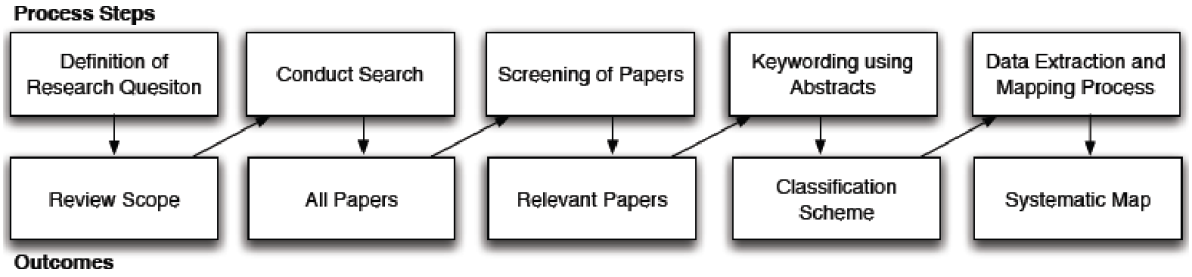

Figure 1. The systematic mapping process [29]

subject matters been explored? In addition, until now what kinds benefits have been highlighted? At the design stage, by utilizing various modeling illustrations, MDWE can be supported in different ways. Which modelling illustration has constructed MDWE forms, the demarcation of our question. The probability of recognizing complementary research requirements would be the solution to this question. Besides, based explicitly explicitly on the kind of contributions, this question is meant to observe how far theseapproaches provide for the overall goals at present.

– RQ2: To publish research on MDWE, which methods are normally utilized? Early analysis revealed that Web engineering was the subject matter of certain meetings devoted to cpecificities and international journals whilst MDWE was a workshop topic. By our intention to observe through the question demarcation, we seek other forums that are utilized to publish the investigation in this field.
– RQ3: What diverse kinds of investigation in this literature has been highlighted and how far has it gone? As explained in SWEBOK and MDWE workshop guides [30, 31], to heighten the integrity of the investigation, the utilization of empirical studies and enhanced proven approaches is encouraged [32]. In this perspective, with regards to the particular scope of MDWE, we want to categorize various research types available.

3.2. Search Strategy

With the purpose of ascertaining the largest number of significant chief studies, we created a definite pursuit approach. We label it from three viewpoints: search scope, search method, and search strings utilized.

As far as the scope is concerned, to identify the highest quantity of the associated investigative tasks, we did not limit the scope of our search to any specific research locations. But, the investigative outcomes are narrowed to publications dated between January 2000 and January 2014. We selected this commencement date because the highest publication regarding this area commenced post-end 1999. Conversely, the search scope for manual search (highlighted below) is restricted to the periods indicated for each location as follows.

In view of search techniques, manual as well as automatic searches were carried out. The search carried out by manually going through journals or meeting events is our idea of a manual search. At the same time, through the amalgamation of pre-demarcated search strings to locate the prime electronic dates is an automatic search. As the manual search for certain journals and meeting events published on those areas was forecasted to be immensely time consuming, we carried out automatic search for the bulk of locations.

Based on Table 2, we chose a number of journals and meetings for the manual tasking majority of the studies were MDWE, discovered there during preliminary investigative searches. We utilized the search string highlighted in Table 1 for the automatic searches, being the former which is characteristic of four rudimentary ideas connected to MDWE. By conducting a number of initial searches on chosen electronic data sources, the concluding string was created. ACM Digital Library, IEEEXplorer, Science Direct, Springer Link, Scopus, Engineering Village, ProQuest, and Google scholar, as per Table 3,

Table 1. Search string used for automatic searches

Concept	Alternative Used
Model Driven Web Engineering	(model driven OR model driven OR model driven development OR MDD OR MD OR modeling OR meta model OR meta-model OR model transformation) AND (web engineering OR web engineering methods OR web-based OR web application)

Table 2. Overview of publication forums for selected studies

Sources	Name	No.
Journals	Journal of Web Engineering	7
	International Journal of Web Engineering and Technology	3
	International Journal of Information Technology and Web Engineering	2
	ACM Transactions on Internet Technology journal	3
	international journal of Web information system	5
	Global Journal on Technology	1
Conferences	International conferences Web engineering	58
	International Conference Web information system engineering	8
	International Conference On Web Information Systems And Technologies (WEBIST)	14
	International World Wide Web Conferences	14
	International Conference Model Driven Engineering Languages and Systems	3
	The Unified Modelling Language Conference	8
	Proceedings edition of the Educators' Symposium	3
	International Conference on Information Integration and Web-based Applications Services	14
	International Conference on Software and Data Technologies	7
	Hawaii International Conference on System Sciences (HICSS)	5
	Symposium on User Interface Software and Technology (UIST)	1
	IEEE International Symposium on Web Systems Evolution	4
	International Journal of Computer Information Systems and Industrial Management Applications	1
Workshops	Model Driven Web engineering workshop	69
	international workshop Model Driven Security	1

were the primary digital sources that were utilized to carry out automatic searches.

The string provided in Table 1, utilized to structure an accordingly equivalent string explicit to each source based on the point that since the tools furnished by different sources, including the precise syntax of search strings to be used differ between each source. For the application of the search string for safeguarding uniformity, a duplicate set of metadata values (i.e. title, abstract and keywords) covering all sources was chosen.

3.3. Selection of Primary Studies

As mentioned earlier, we utilized an amalgamation of manual and automatic searches. The system of choosing chief studies is highlighted in Figure 2. To ascertain a preliminary set of publications, we started by conducting a number of investigative searches on digital libraries provided earlier. In addition, we utilized six previously known papers [11, 21, 234, 258, 289] as the initial point and according to the references and citing publications. As a result, this step produced 14 publications [1, 4, 15, 34, 35, 38, 46, 56, 67, 71, 139, 204, 245, 253]. To aid us in ascertaining certain journals and meeting events pertinent to our study; we utilized this preliminary set of publications. Hence, since they were acknowledged to be famous among Web engineering investigators and publications associated with our study and probably were to be located

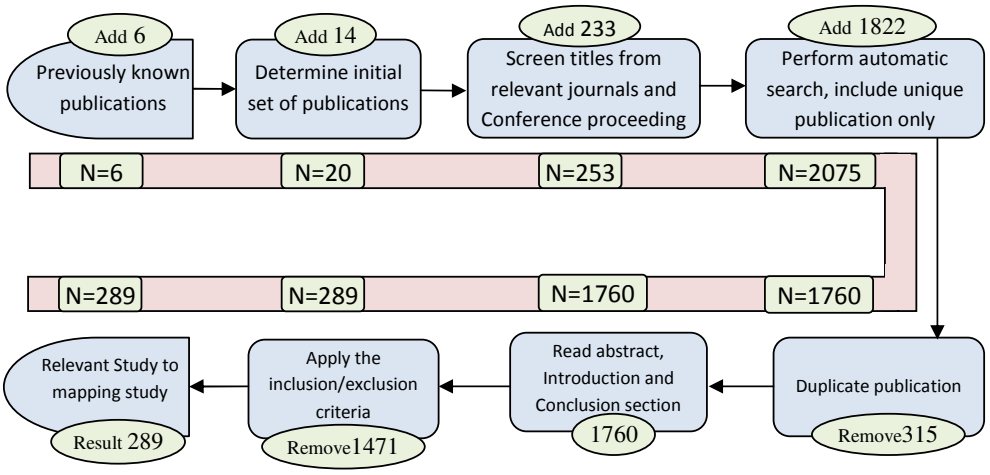

Figure 2. Study selection process

there as highlighted in Table 2, we made up our minds to manually search for transactions on Model Driven in Web Development, events of the annual conference models and metamodels, events of the transformation model conference and MDWE workshop. We acquired additional significant studies by screening titles in these areas, and the overall number of studies was 233. For the purposes of obtaining a general view of the area and to demarcate initial classification plans, these publications were screened.

We discovered 253 publications, six from previous known papers that very relevant papers in this area also any person can find it easily, 14 from references of six papers, 233 from journals, conferences and workshops through the manual step in total as shown in Figure 2.

Utilizing the search engines of electronic data sources i.e. IEEEXplore, Science Direct, ACM Digital Library, and Springer Link, we conducted automatic searches in the following phase. The search string provided in Table 1 was utilized by us. Table 4 represents a general view of outcomes taken from the manual and automatic searches. In addition, we performed the search string to Google Scholar. As a result, as shown in Table 3, we acquired additional significant studies, and the overall number of studies is 1822.

Eventually, we discovered 2075 papers: 253 from manuals, 1822 from the automatic search after merging manual search and automatic search.

Table 3. Digital libraries used in automatic search

Library	No.
ACM Digital Library	77
IEEE Xplorer	646
Science Direct	72
Springer Link	347
Scopus	115
Engineering Village	214
Google scholar	120
ProQuest	231
Total	1822

After conducting manual and automatic searches, we did not include the duplicate publications. By matching results acquired in this step, we discovered 315 papers were duplicated. Hence, the remaining papers total 1760.

To resolve about its inclusion or exclusion, the authors took into account the Abstract, Keywords, Introduction and Conclusion of each of these 1760 studies acknowledged to this stage, for the second time. Because of their shortfall in significance or fulfilling one of the other exclusion conditions, a total of 1471 studies were not included either. Based on our selection criteria, which are utilized for the mapping study, we discovered that the the remaining number of papers that were ready for systematic mapping is 289 papers. A general view of outcomes acquired from manual and automatic searches is presented in Table 4.

Table 4. Presents overview of results obtained from manual and automatic searches

Sources	Study retrieved	Duplicate	Exclusion	Inclusion	Ready to mapping
Manual Search:					
Previously known publications	6				
Determine initial set of publications	14				
Journals, Conferences and Workshops	233				
Online Search:					
ACM Digital Library	77				
IEEE Xplorer	646	315	1471	289	289
Science Direct	72				
Springer Link	347				
Scopus Link	115				
Engineering Village Link	214				
Google scholar Link	118				
ProQuest Link	231				
Total	2075	1760	289	289	289

A listing of all criteria on the foundation of which studies were included or excluded is given below.

- Inclusion: We highlight some points to inclusion of the papers that answer our research questions.
  - Studies that clearly present an MDWE, demarcating new structures into UML or by utilizing its extension mechanisms.
  - Papers that demonstrate a distinctive answer to certain metamodeling or model transformation problem, or MDD, or MDA.
  - Papers that create a current MDWE in practice and assess it.
  - Studies that suggest methods to mapping MDWE.
  - Studies that merged the model driven in Web application's scope.
  - Papers that suggest rudimentary outlines such as typical case studies for demonstration or substantiation of MDWE.
- Exclusion: We highlight some points to exclude the papers that do not answer our research questions.
  - Based on abstract, papers which mentioned MDWE. This was needed because in spite of the studies indicating MDWE in their introductory sentences as a chief concept, we found that these studies fell short of highlighting it. Other concepts such as MDD, MDA and MDSD were also subjected to the same criterion.
  - Papers that address only recommendations, guidelines or principles, rather than highlighting a useful approach to MDWE.
  - Initial papers for books.
  - Editorials, keynotes, tutorial outlines, tool demonstrations and panel deliberations, books, technical reports and other non-peer-reviewed publications.
  - Identical reports of the same study discovered in various sources.
  - Papers from industrial meetings, posters, and non-English publications.
  - Papers unable to solve our research questions.

A general view of studies acquired by way of manual and automatic searches is presented in Table 4. The number of studies that were chosen in accordance to the inclusion criteria highlighted in Figure 2 is shown as well.

3.4. Defining a Classification Scheme

The classification schemes suggested by Petersen et al. [29] were utilized by us (Fig. 3), and we classified the publications into categories from three viewpoints: (1) focus area, (2) type of contribution and (3) research type. But, these categories were altered to match the details

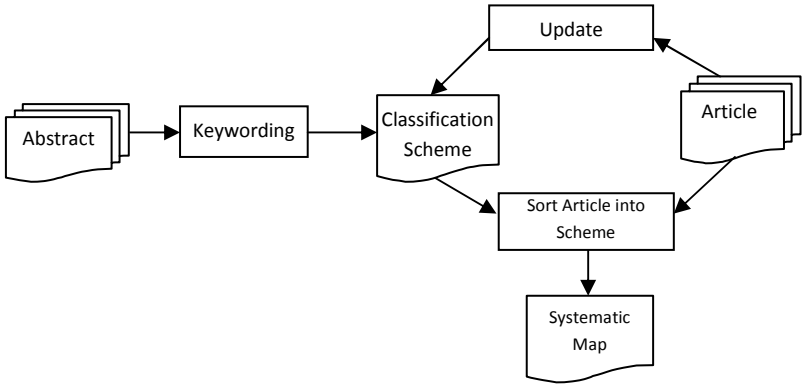

Figure 3. Building classification scheme [29]

of our mapping study. We utilized an iterative strategy while categorizing and mapping the studies into classification schemes. The concluded classification schemes are shown in Section 4.

Techniques to lessen the time required in creating a classification scheme and making sure that the scheme takes the current studies into consideration is key wording. Key wording is completed in two steps. At the beginning, the reviewers go through abridgements and search for keywords and ideas that showcase the input paper. In the process, the reviewer confirms the framework of the research. Following this, a comprehensive grasp about the nature and input into research is created through a set of keywords from various papers merged together. This aids the reviewers in demarcating a set of categories that is characteristic of the core population. In addition, reviewers can choose to study the opening or closing segments of the paper when abridgments are found to be of terrible quality to permit important keywords to be selected. When an absolute set of keywords has been selected, they can be gathered and utilized to create the categories for the map [29].

3.5. Mapping of Studies

As demarcated in Section 4, the real mapping was undertaken by mapping each involved study to a specific intersection set in the classification schemes. Section 5 shows the resultant mapping.

4. Classification Schemes

As deliberated earlier in Section 3, publications are categorized from three diverse approaches: focus scope, contribution and research type as shown in Figures 4, 7 and 8.

4.1. Focus Area

Chosen studies were separated into five research focus scopes based on specific research subjects, they addressed based on a broader outlook. Identifying these research focus areas was achieved through the key wording method shown in [29]. The eight categories of research focus areas are concisely described below and as well as in Figure 4.

Web Applicability: This category includes studies that present software applications that run in a Web browser and Rich Internet applications (RIA). Furthermore it presents articles when related to the Web Information System (WIS), Search engine, Semantic Web and cloud application. Furthermore, represent any articles that are related to MDWE with Web applications.

Testing and quality: This category reflects papers that present Web system qualities, such as QoS, testing Web software and Web security. It also shows the papers that are related to the quality of Websites.

Service and oriented: One of the most popular fields in Web software is Web service. This category includes studies that present Web services with Model driven Web services or partially

related to MDWE ones, such as Web services with UML, Metamodel, and workflow in the Web domain. It also represents studies related to Service Oriented Architecture (SOA) with Model Driven in the Web engineering.

Requirements and design: Requirements and design are the software engineering steps; this category presents studies that are related to UML design and some steps in the design process; also, report studies that are related to functional and non-functional requirements.

Web economics: This Category presents studies of software economics; moreover it includes articles focused on e-commerce, e-business, social Web and social mashup Websites.

Modeling and notation: This category includes studies that present a modeling and a notation on its own, or in some way, contribute to the modeling process which uses some existing notation. This category reflects papers in the fields: Metamodels (presentation model, navigation model and user interface), model transformation (CIM, PIM models), code generation and adaptively, or other studies with the same concept as MDWE.

Methodologies and development process: While some studies focused on the methodologies or Web development process, this category reflects papers that study the Web engineering methodologies or the concepts of methodologies. On the other hand, it represents papers that focus on the Web development process such a business process or an agile process.

Web Management: Studies present a novel method of weaving models, or present some solutions related to management of the model for Websites. In the future, they will include more papers that work on Content Management System (CMS) or data management in the Websites.

The following figure (Fig. 4) shows the topics of focus areas for MDWE with the percentage value of each of them. In this classification of finding topics, we use the SWEBOK guideline and the guide call paper at the workshop of the model driven Web engineering [30, 31].

Figure 4 shows the classification 289 papers of MDWE for eight topics of research focus; we found most of the papers in Web Applicability

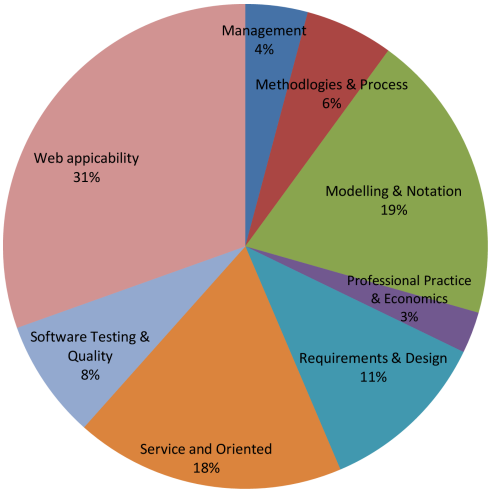

Figure 4. Distribution of research focus

(31%), followed by modeling and notation (19%) and service & oriented (18%). However, some categories were very important in software design, but we could not find more of them, such as: Requirements & Design (11%), Testing & quality (8%) whereas development processes covered only (6%) and some categories have few publications, such as Web management (4%), and Web economics (3%). However, we classified our research focus on eight topics, but it was not easy to select the research focus because the eight topics were very general; so we classified each topic into several subtopics by using SWEBOK and MDWE workshop guides [30, 31], as shown in Figure 5.

Figure 5 classifies 8 topics of research focus into 26 subtopics: (1) Web applicability subtopics (Web Application, RIA, Semantic Web, WIS, Search Engine, and Cloud Application), (2) Testing & Quality has three subtopics (Security, QoS, Testing), (3) Service & Oriented that has only two subtopics (Web Service and SOA), (4) Requirements & Design subtopics are (Functional & non-functional requirements, UML & Design), (5) Web Economics subtopics (business, social Web, evolution) (6) Modeling & Notation subtopics (Model transformation, metamodel, adaptivity, code generation), (7) Methodologies & Development Process subtopics (Methodology, agile, Development Process), (8) Management sub topics (CMS, Weaving, data-intensive). Figure 6 shows the 26 sub

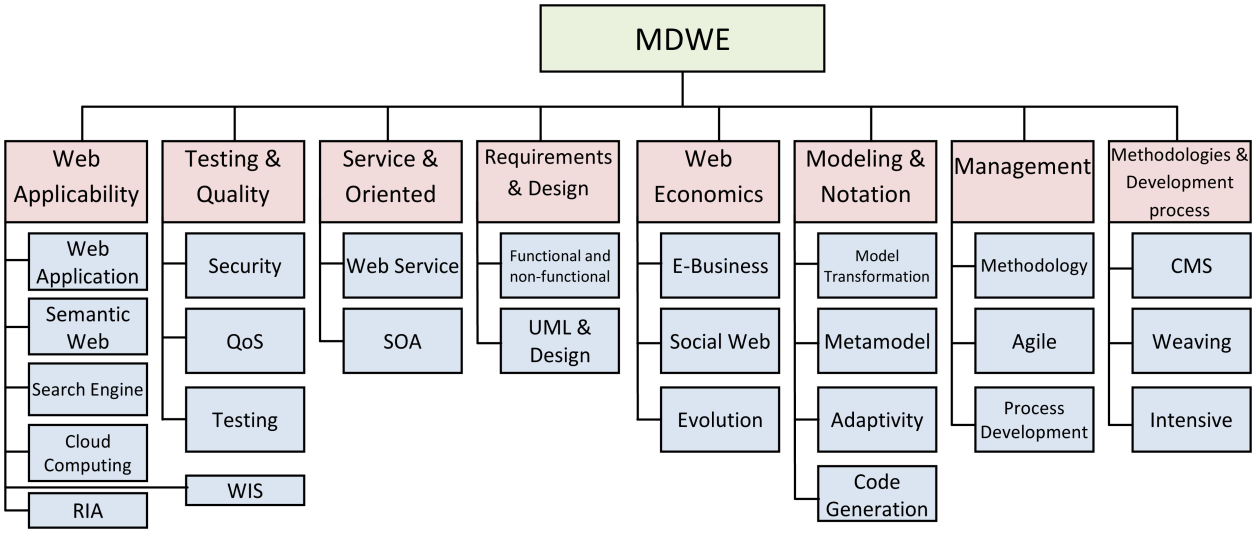

Figure 5. Classification of the research related to MDWE

topics with a number of publications and references.

Figure 6 explains the number of publications per subtopics. The figure shows the majority of publications in Web Applications (15.9%), Web Services (13.5%), Model Transformations (8.7%), minor publications in Cloud Application (0.3%), Evolution (0.3%), and Data-insensitive (0.3%). Other subtopics (between 0.7% to 6.6%) on the other side of this figure represent the reference of publications for e.g. RIA has 19 publications where the references are [77–95], CMS has 9 publications where the references are [304–312], but Cloud Application has only one publication where the reference is [118], and so on.

4.2. Contribution Type

The contribution type is divided into five categories (see Fig. 7) described below:

Metric: The suggestion or application of metrics to effectiveness of MDWE is emphasized through this contribution.

Tool: In the design of a prototype or a device which can be assimilated with current outlines is based on contributions that target on supplying tool support for MDWE.

Method: Modeling, approaches, model changes and model structure, which are provided explicitly through contributions.

Model Based on papers that theoretically deliberate or create contrasts, investigate associations, seek challenges, or create classifications, etc.

Process: The papers contribute to the process which is characterized through papers that explain the MDWE and furnish a depiction on their assimilation in the general software development process. Furthermore, certain specific issues which are settled through these contributions are associated with MDWE.

Figure 7 shows major publications in the contribution type which are are related to the Method (33%) which minor in Metric (2%), between minor and major there is Model (24%), Process (23%), and Tool (18%).

4.3. Research Type

The research strategy utilized in the main study is reflected through research type. For the classification of research types (RQ3), we have utilized a scheme suggested by Wieringa et al. [32]. A concise depiction of research kinds are as follows (see Fig. 8):

Evaluation research: Comparision with validation research, evaluation research focuses on analyzing the answer which has been essentially applied by now. It examines the practical application of the solution.

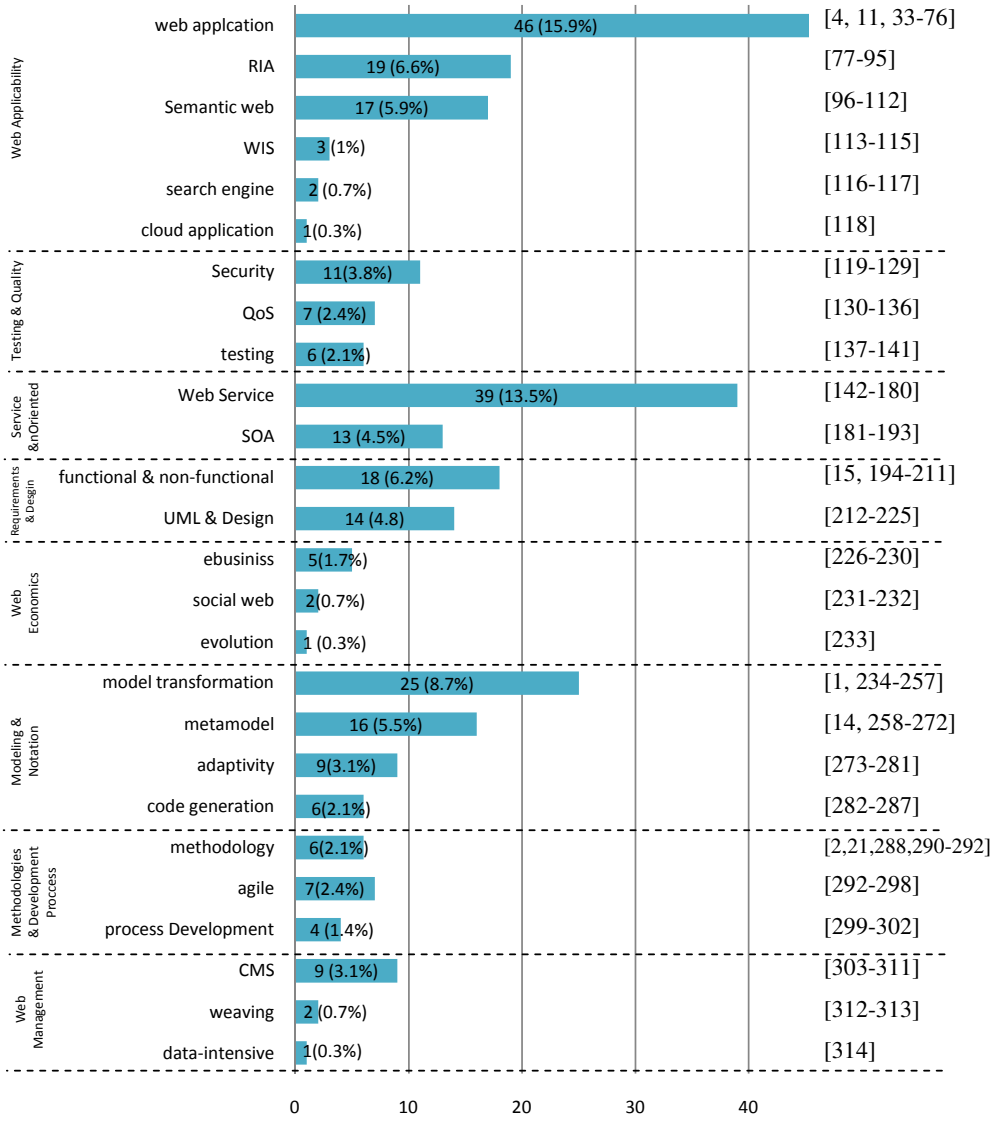

Figure 6. Number of papers per research topic and references

Experience paper: The personal experiences of the author from a single or more real life projects are reported through an experience paper. It normally explains what was achieved in the project and also how it was accomplished.

Opinion paper: The author's own ideas on the aptness or inaptness of a certain method or instrument are reported through these papers. Likewise, on the basis on explanations how certain methods or instruments should have been developed etc., these papers are sometimes used to share personal opinion.

Philosophical paper: To observe things that are already present in a novel way through an arrangement presented via theoretical suggestions. However, it does not accurately overcome a specific issue. Taxonomies, theoretical outlines, etc. will be maybe added to theoretical suggestions.

Solution proposal: By providing either an innovative answer or a significant extension of an existing technique, a solution proposal overcomes a problem. In addition, its advantages are highlighted by either a case in point or in-depth reasoning.

Validation research: The investigation of the solution proposal that has not been essentially put into use is the chief reason for validation research. By way of systematic manner, valida-

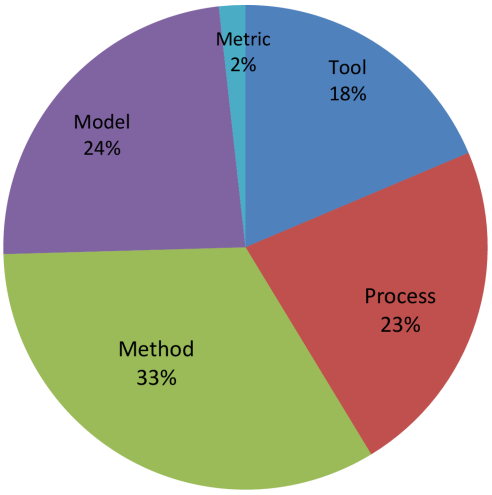

Figure 7. Distribution of contribution type

Figure 8. Distribution of research type

tion research is carried out and may pose any of these: experiments, prototypes, simulations, mathematical analysis, etc.

Chief and minor publications in the research type are Validation Research (24%) and Opinion Papers (7%) respectively; other publications are divided into Solution Proposal (20%), Philosophical Paper (19%), Experience Paper (17%), and Evaluation Research (13%).

4.4. Scheme Mapping Study

In this study, we have 289 papers that are ready for systematic mapping, after the extraction of papers to form categories of the Research Focus (Fig. 4), Contribution Type (Fig. 7), and Research Type (Fig. 8); we designed a mapping study with a number of publications, as shown in Figure 9.

The Map (Fig. 9) shows the classification mapping study of 289 papers; these papers show the number of applications with a focus on research type and contribution type. We will discuss this in Section 5. For more information about our papers, we designed a bar chart of publications per year as shown in Figure 10.

Figure 10 shows 289 papers per year between 2000 and 2014; the result of a bar chart is the publication of continual MDWE growth. In 2000, only one paper was found but in 2013, there were 29 papers, with most publications between 2007 and 2013. However, the result for 2013 was such because probably, our search in January 2014 found some unpublished papers. Hence, these results show this area is a new and active area, which means that in the last decade the researchers focused on this area in publications.

5. Mapping and Discussion of Research Questions

With regards to research type and contribution type, a map covering eight current research target scopes within the setting of MDWE was created in order to provide an overview of the field (see Fig. 9). The framework of the focus of the current investigation, together with a suggestion of investigative divisions in the area, is provided on the map. Most of the research papers are particularly devoted to furnishing model driven development, and clarifying the related processes as shown through mapping outcomes. A higher degree of investigation has been undertaken regarding the structure of Web engineering methods, model driven development and model driven architecture, within the scope of Web development. However, we highlight our findings in two divergent dimensions to the extent to which analysis of MDWE subjects in current research is concerned: (1) main subjects in the area together with the magnitude of their coverage and contribution types (RQ1) and research type (RQ3),

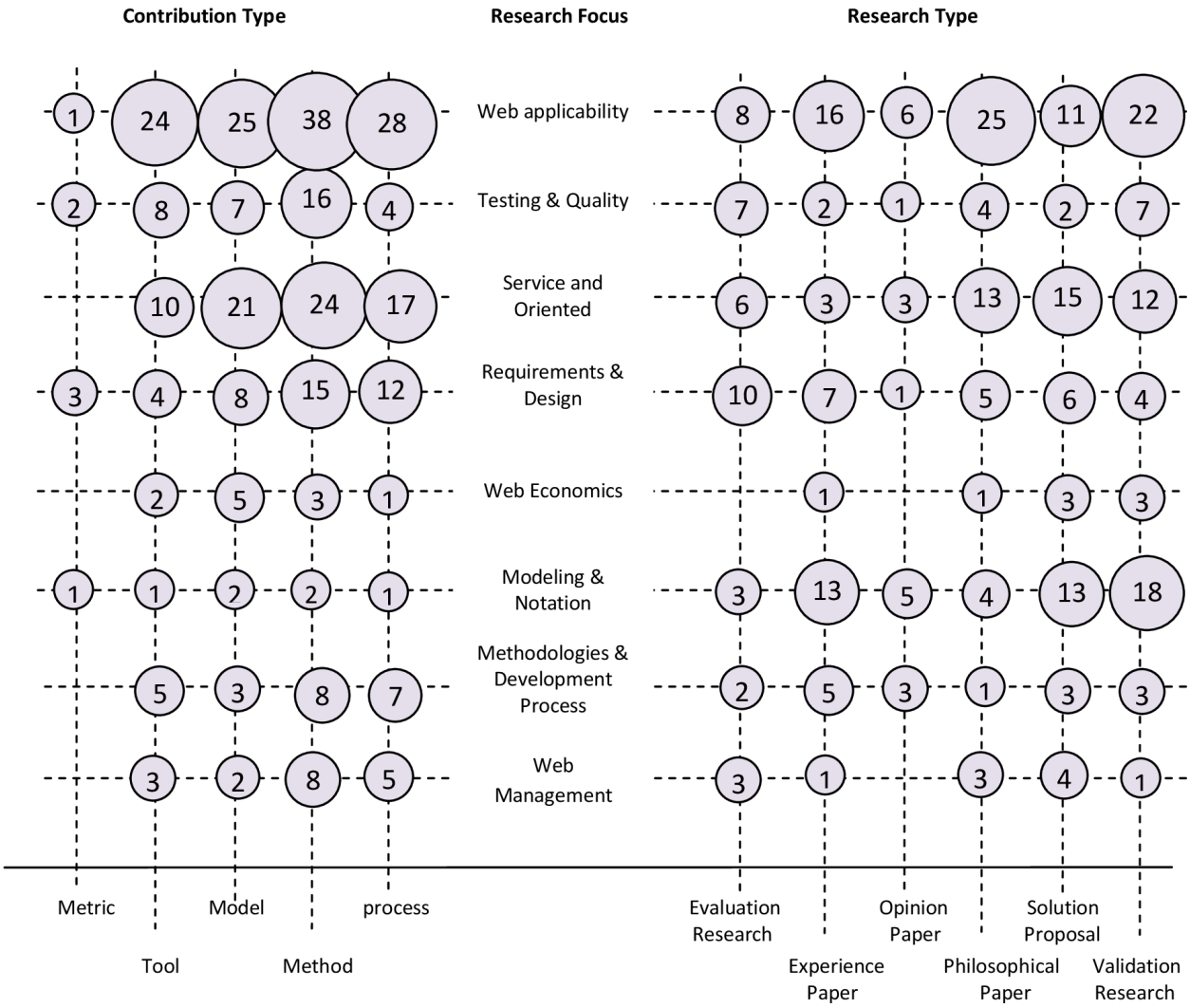

Figure 9. Map of research focus on MDWE

and (2) forums utilized for publishing the associated research (RQ2).

The first dimension of our results, including the major topics along with specifications of research types, has been covered in the Sections 5.1–5.8. We have organized each subsection in a way that briefly describes the studies selected for each topic, while highlighting the extent and nature of research. Furthermore, it identifies the types of contribution made by each selected study. The publications in this area can be divided into eight major focus areas (see Fig. 4), including Web Applicability, Service and Orientation, Modeling and Notation, Requirements and Design, Testing and quality, methodologies and process, management and Economics. Figure 5 also shows the major topics addressed by the existing research, divided into related subtopics where possible. Figure 6 shows a summary of groups of papers identified per research subtopic.

An overview of the volume of research selected by major research focus areas is shown in Figure 4. It shows that most publications are covered by Web Applicability, at 31%, followed by modeling and notation at 19% and Web services at 18%. Another level is software quality, which has a good coverage rate in the publications, but 11% of publications cover requirements and design, while 8% of publications cover software testing and quality, and 6% cover methodologies and processes. A very small number of publications cover management (4%) and economics (3%). Figure 7 shows the

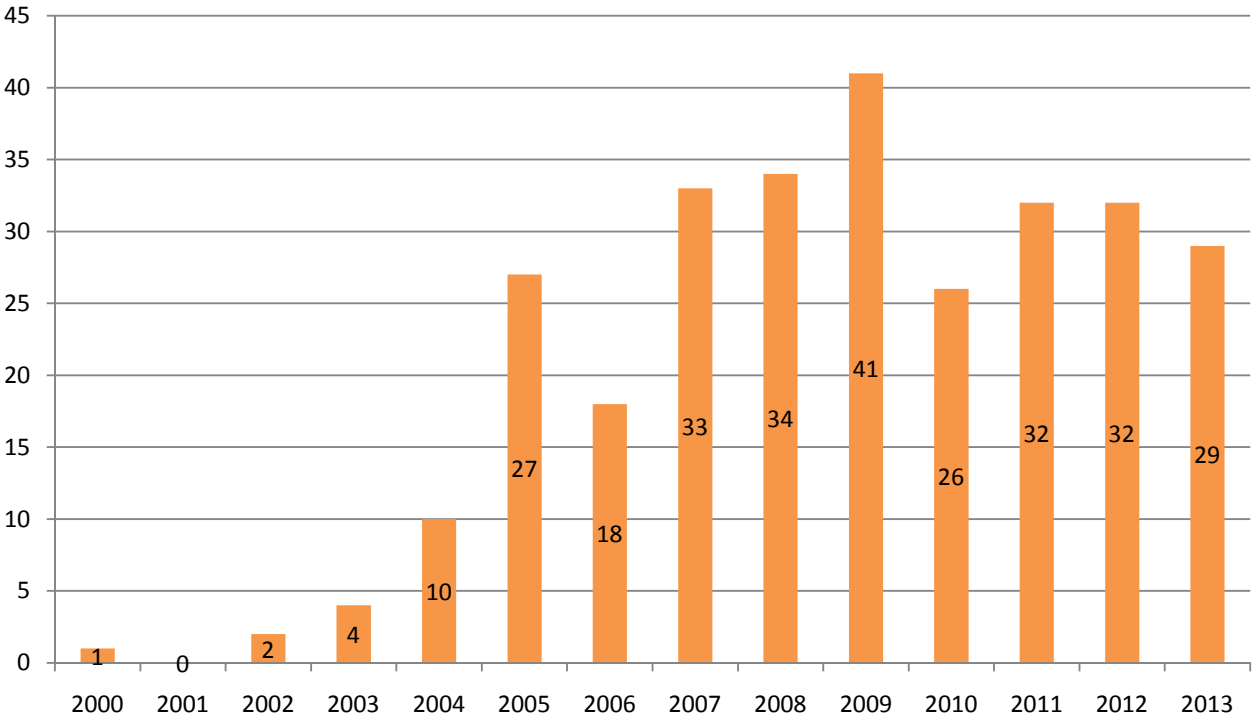

Figure 10. Publication per years

Table 5. Research and contribution types presented by 88 papers on Web applicability

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	[41, 48, 76]	[47, 48, 103, 117]	[47, 53, 85]	[103]	–
Experience Papers	[40, 55, 82]	[33, 40, 61, 66, 92, 100]	[11, 39, 57, 90, 92]	[33, 57, 59, 61, 71, 72, 105]	–
Opinion Papers	[93, 113]	[52, 83, 93]	[69]	[82]	–
Philosophical Paper	[4, 42, 43, 45, 46, 79, 80, 87–89, 99, 102, 106, 118]	[35, 45, 95, 96, 99, 110, 115]	[4, 56, 65, 80, 88, 89, 91, 98, 109, 115]	[4, 43, 56, 67]	[89]
Solution Proposal	[58, 75, 84, 97]	[36, 64, 78, 101]	[58, 64, 86]	[97, 104, 116]	–
Validation Research	[50, 73]	[34, 38, 44, 49, 50, 62, 63, 68, 70, 74, 108, 111, 112]	[60, 94, 107]	[37, 38, 51, 54, 63, 77, 107, 114]	–

contribution type of publications, where 33% contribute to method, but the model, process and tool, have near percentages, which are 24%, 23% and 18% respectively. A small percentage of publications returned to metrics, specifically 2% of publications. Figure 8 shows that, based on research type, only 7% of publications reported opinions, but 24% reported validation research, 19% reported philosophical content, 17% reported real-life experiences, and 13% reported evaluation research. Furthermore, Figure 10 shows the bar chart of publications per year, but with most publications released in 2009 starting with 2005 it is still an active field for publication.

5.1. Web Applicability

In this section, we briefly discuss different studies related to Web Applicability. Table 5 lists the papers that focus on this topic. This is an area where most research effort is spent. Also in this section we discuss the sub-topics which consist of Web applications, Rich Internet appli-

cations, semantic Web, search engine, and cloud computing.

In the MDWE Web applications there is an application program that is stored on a remote server and delivered over the Internet through a browser interface that is driven by software engineering methods. With the publications' growth in this field, Cheung [37] developed a Web application design framework through a tool and in [55] used a model driven process for the development of Web applications.

Rich Internet applications (RIAs) offer rich, engaging experience that improves user satisfaction and increases productivity. Using the broad reach of the Internet, RIAs can be deployed across browsers and desktops. In [80], RIA was defined as a new approach and was developed through model driven architecture, while [86] presents a RIA metamodel to deal with the new technological challenges that have arisen with Web 2.0 development [86].

Another type of Web application is the Semantic Web that is represented in [96–112], Web information system that is represented in [113–115] and search engine that is represented in [116, 117], while a new field is clouding, as shown in [118]. In this paper Kumar et al. used the Model Driven Approach for Developing Cloud Application. This paper was published in 2013.

5.2. Testing and Quality

This category includes papers related to Model Driven, with software testing, quality of service and security. Escott [141] focused on Model Driven in the development of testing Web applications, Ortiz in [134] presents a model-based approach to the implementation of QoS monitors, by describing them as platform-independent models. On the other hand, Nakamura [123] describes a tooling framework to generate Web services security configurations, using a model driven architecture (MDA) as shown in Table 6.

5.3. Services and Oriented

One of the most popular fields in MDWE are Web services, usually with some combination of programming and data, and possible inclusion of human resources as well. Table 7 shows the papers related to Web services and Service Oriented Architecture (SOA), for example, Achilleas et al. [151]. They propose a Model Driven Web Service oriented framework that combines MDE with Web Services, to automate the development of platform-specific Web-based applications. In another paper, Bajohr and Margaria [189] address the high availability of model driven SOAs for applications that are orchestrations of services and are defined by their (behavioral) models.

5.4. Requirements and Design

This category includes papers that explain functional and non-functional requirements that support Model Driven in the Web domain, and also papers that focus on the UML design in Web domains. Table 8 classifies requirements and design publications. Aguilar et al. [197] prepared an algorithm that has been defined in order to analyze dependencies among functional and non-functional requirements, and Guzman et al. [222] showed Web 2.0 patterns requirements in MDWE.

5.5. Web Economics

Software engineering economics is about making decisions related to software engineering in a business context. The success of a software product, service and solution depends on good business management. Yet, in many companies and organizations, software business relationships to software development and engineering remain vague. Table 9 has all the publications that were founded on MDWE. Guotao and Du [227] implemented e-commerce on the Web application.

Table 6. Research and contribution types presented by 23 papers on software testing and quality

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	[121, 135]	[121, 126, 130, 135]	[134, 136]	[126, 132, 134–136]	[135]
Experience Papers	–	[139]	–	[123]	–
Opinion Papers	–	[122]	–	–	–
Philosophical Paper	–	[128, 131, 140, 141]	[128, 131]	[131]	[141]
Solution Proposal	–	[120, 125]	[120]	–	–
Validation Research	[137, 138]	[127, 129, 133, 138]	[124, 137]	[119]	–

Table 7. Research and contribution types presented by 52 papers on services and oriented

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	[144, 182, 187]	[153, 187]	[155, 181]	[144, 182]	–
Experience Papers	–	[160, 176, 189]	[189]	–	–
Opinion Papers	[167]	[171]	[156, 167]	–	–
Philosophical Paper	[152, 159, 165, 193]	[142, 159, 185, 188, 190, 193]	[161, 164, 165, 174, 180]	[147, 188]	–
Solution Proposal	[145, 177, 178, 183, 186]	[146, 150, 157, 158, 169, 170, 172, 173, 175, 177]	[150, 170, 175, 178, 186, 191]	[145, 178]	–
Validation Research	[148, 166, 184, 192]	[143, 149]	[163, 166, 168, 179, 192]	[18, 151, 154–162]	–

Table 8. Research and contribution types presented by 33 papers on requirements and design

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	[195, 198, 200, 201, 212]	[195, 200, 206, 211]	[206, 211, 218]	–	[201, 209, 210]
Experience Papers	[194, 199, 208, 222]	[222, 225]	–	[202, 204, 208]	–
Opinion Papers	[197]	–	–	–	–
Philosophical Paper	–	[205, 216, 224]	[203, 220]	–	–
Solution Proposal	[213, 214]	[217, 219, 221]	[221, 223]	–	–
Validation Research	[207]	[15, 196, 215]	[207]	[196]	–

Table 9. Research and contribution types presented by 8 papers on economics

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	–	–	–	–	–
Experience Papers	–	[230]	–	–	–
Opinion Papers	–	–	–	–	–
Philosophical Paper	–	[232]	[232]	–	–
Solution Proposal	–	[231]	[226, 233]	[231]	–
Validation Research	[227]	–	[227, 229]	[228]	–

5.6. Modeling and Notations

In this section, we briefly discuss different studies related to modeling notations and the associated notations. Table 4 lists the papers that focus on this topic. This topic consists of metamodels, model transformations, adaptive and code generation. Jiang et al. [273] propose MAWA, a method for model driven development of adaptive Web applications. Koch and Kraus [268] present a first step towards such a common metamodel by defining first a metamodel for the UML-based Web Engineering (UWE) approach. [235, 236, 257] are papers that focused on model transformation, but [282–287] are papers that focused on code generation in MDWE, as shown in Table 10.

5.7. Methodologies and Process

This topic includes papers related to Web engineering methodologies and processing, a list of which can be seen in Table 11. Andrés and Duitama [21] present some Web engineering methodologies. In Rivero et al. [296] proposed an agile approach to MDWE methodologies (called Mockup-Driven Development, or MockupDD) by inverting the development process. This can be seen in Table 11.

5.8. Web Management

The last topic under MDWE is management Websites through different models. This topic covers papers that are related to CMS, weaving and data management in this area. Table 12 lists management papers in MDWE. Joao and Alberto in [306] proposed the creation of a model driven approach for the development of Web-applications, based on Content Management Systems.

6. Discussion

In this part, based on findings on future examination, we provide a summary of the legitimacy of threats, related to the crucial findings of this systematic mapping study, and deliberate regarding certain consequences of these findings. We also highlight the limitations of this mapping study that may represent threats to its validity.

In this paper we propose a systematic mapping study for MDWE, the primary studies on MDWE to explore current work, and we identify needs for future research. A systematic mapping study is used for finding the most relevant studies and classification. In this study, we found 289 papers and classification schemes divided them into classification schemes on the basis of research focus, contribution type and research type. The majority of 20% of the papers were on the solution proposal type of research. The most common areas in MDWE appear to be: Web Applicability at 31%, Molding and Notation at 19%, and Services and Oriented at 18%. The majority of contributions are methods, at 33%. Moreover, this shows the MDWE as a wide, new, and active area for publications. Whilst additional analysis is warranted within the MDWE scope, in literature composition mechanisms have been thoroughly discussed. Furthermore, we have observed that a recurrent recommendation for validation research, solution proposals and philosophical papers has been presented through earlier analysis.

6.1. Threats to Legitimacy

The outcomes of a systematic mapping study may be affected by diverse factors, for example, the researchers who conducted the study, the databases and the search string developed, as well as the time limits chosen. As it will be shown in the following paragraphs, when these threats to legitimacy are taken into account, the outcomes become more satisfactory and precise.

We conducted a systematic mapping study and every stage was explicitly defined. The other investigators were permitted to reprise the mapping study, since each step was shown explicitly. However, it is probable that certain articles that were omitted would be counted in, and vice versa, as a result of choosing articles which have been conducted by diverse investigators, because the decision about the exclusion or inclusion of

Table 10. Research and contribution types presented by 56 papers on modeling and notations

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	[259]	–	–	[259, 275]	[238]
Experience Papers	[14,239,244,285]	[254, 260, 287]	[244, 255, 266, 284]	[14,243,249,254, 256, 260, 287]	–
Opinion Papers	–	[241, 277]	[1, 267, 270]	[270]	–
Philosophical Paper	[236, 257]	[250, 252, 257]	[250, 252]	–	–
Solution Proposal	[273]	[248, 258, 268, 269, 276]	[235, 247, 268, 269, 278, 279, 281, 286]	[263, 279]	–
Validation Research	[234, 237, 246, 265, 274, 280, 282, 283]	[240, 242, 251, 253, 262, 271, 272]	[245, 246, 251, 264, 271, 280]	[240, 253, 261, 262, 264, 282]	–

Table 11. Research and contribution types presented by 17 papers on methodologies and process

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	[2]	[289]	–	[289]	–
Experience Papers	[290, 294]	[297]	[290]	[291, 294, 302]	–
Opinion Papers	–	[21, 293, 300]	–	–	–
Philosophical Paper	[292]	[292]	–	–	–
Solution Proposal	[295, 296]	[296]	[299]	–	–
Validation Research	[298]	[301]	[301]	[287]	–

Table 12. Research and contribution types presented by 12 papers on management

Contribution Type	Research Type				
	Process	Method	Model	Tool	Metric
Evaluation Research	[314]	[310]	–	[309]	–
Experience Papers	[311]	–	–	[311]	–
Opinion Papers	–	–	–	–	–
Philosophical Paper	[306]	[303, 306, 313]	[313]	–	–
Solution Proposal	[304, 312]	[304, 305, 312]	[307]	–	–
Validation Research	–	[308]	–	[308]	–

a specific article is based on the investigators who conducted the mapping study. Yet, it is highly improbable that the main conclusions derived from the recognized set of articles would be altered by these diversities, based on personal assessments, which is a general categorization of approaches.

Acquiring a set of significant articles encompassing the said research subject was the target of the conducted mapping study. The outcome set should be completed as soon as possible. Based on this motive, we derived the search string in a systematic fashion. Because of the number of significant articles discovered utilizing a search string, not all appropriate words are used whilst creating a search string. For instance, the word 'Model Driven' was added in the search string, and 'Web Engineering' was not included in the papers which have model driven in software engineering only, including model driven in Web engineering. Moreover, some terms, for instance 'Web Application', are used incongruously in literature. At times, MDWE is not the only factor in 'Web Application'. In conclusion, a diverse set of final articles might have been the outcome of diverse or added terms utilized in the search string, but this would only pose a negligible effect on the general classification obtained, and added articles could be easily categorized based on the given classification.

6.2. General Findings

MDWE, as the main target in modern software development, is endorsed by results of the systematic mapping study, as there are many publications on this subject. As was proven by the number of new publications, the topic has received greater attention in recent years.

The advent of several suggestions, as a result of recent suggestions in the sphere of MDWE has focused mainly on the development of Web applications. Nevertheless, there is still a relevant task to be undertaken if we look at the overall issues related to amalgamating MDWE into an MDE setting. Models are the main aim for envisaging an operable outlook of the system in an MDE framework, and essentially acquiring working software systemically, in an automated manner. Therefore, the scope of modeling precise and comprehensive behaviors of factors requires more care, along with resolutions to identification models so as to amalgamate factors into this broader context. Up till now, minimal tasks have been described in the literature (e.g. [21]) that have highlighted methodologies substantiation, but even these substantiation methods pose a restricted infrastructure to substantiating methodologies, through execution only. Notwithstanding the fact that a systematic substantiation system cannot be replaced via verification undertaken in this manner, it can cause other issues. For example, it necessitates designers to be aware of the exact details of advice transformations, hence leading to usability issues.

6.3. Limitations of Review

It has to be mentioned that this review has certain restrictions. These restrictions are comparable to those of other systematic reviews. There is some probability that certain significant materials were not added to the review, for example dissertations, related books or white papers, and some significant papers might not have been discovered in the digital databases, by means of our search and selection protocol. The latter is more of an issue regarding how investigators write their abridgments, and how digital databases categorize and locate published work. The former is a restriction of our review, and could be highlighted the following works. There is actually no reason why a keyword search would not return the entire published significant material, if abridgments were prudently written and keywords were inserted. Sometimes, categorization schemes in the literature are already present, which can preferably be used again or enhanced. Nevertheless this seldom happens, and worst still, a sound categorization scheme may often not be the case. On top of that, for the currently published material, a thoroughly planned categorization scheme might not be the best option. Slowly developing the categorization scheme when running through the abridg-

ments of all the papers was the approach taken in this review. One direct issue with this strategy is that it might fall short of discovering some breaks in the field. For instance, in a certain categorization scheme there could be a missing category. Had the category been inserted, the significant breaks would clearly be noticed. Investigators are encouraged to be very conversant with the scope under assessment, creating the categorization schemes that diminish the threat of legitimacy from this restriction.

7. Conclusion and Future Work

A relevant progression in the development of Web software systems that are more maintainable, extensible and reusable is an outcome of the investigation in the area of MDWE. We demarcated some research questions and launched a systematic mapping study, in order to acquire an overall view of the present investigation in this field. To satisfy the goals of the study, we discovered 289 publications that retained highest significance.

The chosen papers appeared between 2000 and 2014. The findings of this study show that MDWE is a somewhat underdeveloped area. In 2001, the preliminary relevant contributions to this area were shown (i.e. [63]). Most papers come out in workshops and meetings, while some have come out in journals.

As far as the answer to our first research question is concerned, the main research topics identified are: (1) Web Applicability, (2) Service and Oriented, (3) Modeling and Notation, (4) Requirements and Design, (5) Testing and quality, (6) methodologies and process, (7) management, and (8) Economics of MDWE. To respond to our second research question, we have determined that most research has appeared at conferences (63%) and workshops (32%). Relatively fewer publications (9%) have appeared in journals so far. As far as an answer to our third question is concerned, most of the research (24%) is validation research, while 7% are opinion papers, 20% of publications focus on solution proposal, and 19% of papers are philosophical. 17% of the papers are experience papers, and 13% are evaluation papers.

Finally, the result shows that MDWE is a wide, new and active area for publication. Also, some fields need to be improved, and this is a good area for publication. This paper helps the Web engineering researcher to find weaknesses and strengths in this area, and to understand which point or which side of this area needs to be enhanced. With regards to future work based on resulting maps in systematic mapping, researchers can make systematic mapping one of the research focuses, for example modeling and notation in MDWE, Web management, Web applicability, requirements, designs and Web services in MDWE. Furthermore, the researcher can utilize the subtopics, including Semantic Web in MDWE, CMS, social Web, and SOA in MDWE. These can be potential areas for future work. Furthermore, some ideas in the Web domain have not appeared, or there can be be articles not yet published, such as those related to Crawling in MDWE. Also researchers can look for new Web domains to be added to MDWE. There is also a need for better empirical research, like the use of application/validation methods used for evaluation and validation research. Solutions proposed within the solution proposal need to be empirically validated, in order to strengthen the empirical research. Furthermore, researchers can use another method for classification and evaluation in order to find the best result, for instance for heuristic evaluations.

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