Leveraging Mashups Approaches to Address Research Evaluation Challenges

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***Abstract*—The evaluation of research, i.e the assessment of productivity or measuring and comparing impact, is an instrument to select and promote personnel, assign research grants and measure the results of research projects. However, there is little consensus today on how research evaluation should be done, and it is commonly acknowledged that the quantitative metrics available today are largely unsatisfactory. The process is very often highly subjective and there are no universally accepted criteria. Computing reliable and useful evaluation criteria typically requires solving complex data integration problems and expressing custom evaluation metrics. In our current research work we show that leveraging mashups approaches we can address domain specific evaluation challenges. We aim at providing a mashup platform which will support the research evaluation domain. Finally we will explore what we can learn from this development in order to generalize our finding and tackle other domain specific mashup applications.**

I. Introduction

The concept of scientometrics (i.e. the science of measuring and analyzing science and informetrics (i.e. the science of the quantitative aspects of information in any form)) is increasingly popular. In fact, recently research impact evaluation has received tremendous interest as the amount of contribution to science is increasing heavily and the competition is getting tough among researcher and at large extent among research groups, department and academic institutions. As the research landscape evolves, assessing the impact of researchers and publications is in high demand for a variety of reasons, such as the self-assessment of researchers, evaluation of faculties or universities, faculty recruitment and promotion, funding, awards [1] as well as to support the search for interesting content within an ocean of scientific knowledge.

Another important dimension in the research impact evaluation domain lies in the exponential growth of the amount of available scientific/scholarly digital content. The information sources (e.g. Web of Science (WoS), Scopus, Google Scholar etc.) as well as information production sources (IPS) (e.g. authors, journals, books, articles etc.) are growing day by day. Information fusion is an important aspect in informetrics, that is to collect data from different sources and to apply merging techniques. For example several authors (i.e. IPS) can be merged in many ways, like (1) taking author's papers information from one source and getting citation information from another (2) comparing two authors from data coming from different sources (3) using own private data source in comparison with other sources and so on.

Moreover, the very problem of finding experts or high-profile people in some specific area or to search for the best paper in some topic across different communities, is still a challenging endeavor. Scientific research is heavily funded by governments and institutions around the world, that want to be able to have some enriched metrics to monitor both the productivity of their public money and the quality/impact of research, in order to establish the policies for future investments. These metrics should be able to provide properties such as *reliability*, *personalization* and *flexibility*.

This leads to the need to have *reliable*, *fast* and as much as possible *automated* tools to support the query and successive ranking of interesting scientific contributions and researchers. The availability of personalized and flexible metrics based on the potentially available digital sources could support scientists both in their evaluation tasks and in their search for high impact scientific artifacts (not only papers, but also shared experimental data and procedures, influential blog entries and interesting discussions). In order to achieve such broad objectives it is needed to pay attention on software technologies which would provide such flexible development environment.

The recent advances on mashups and open APIs for data access are driving towards new, quick and better solutions in software and system development based on services-oriented architecture (SOA). In recent past large number of functionalities have been made available online as web services. These services are easily used as stand-alone services as well as in service compositions. A mashup is a web application that uses and combines data, or functionality from two or more sources to create new added value services. Mashups are meant to achieve this composition of heterogeneous services to accomplish certain tasks. Currently these tasks are simple like RSS, ATOM feed fetching, making location based maps and so on. These services are composed in various ways usually unanticipated by their authors. Web mashups are the composition of data and services from different sources. Mashup composition of such heterogeneous sources available as services represents an useful approach that can complement the traditional control-driven coordination and orchestration illustrated for example by Web Services Business Process Execution Language (WS-BPEL).

The rest of this paper is organized as follows. In section II we report on what is currently being used in research evaluation and how different communities personalize various metrics according to their needs. We also review exiting mashup tools and other supportive technologies used in service composition. In section III we formally present the problem statement. Section IV presents preliminary results and future research outline is presented in V.

II. State of the Art

In this section we first review the current status in research evaluation and analyze the existing approaches which are currently being used by Research Executives and Managers to perform such evaluations. Then we present a detailed review of the state-of-the-art related to the main concepts in mashup methodologies and tools, dataflow languages and ETL (Extract, transform, and load) processes in order to ground our research proposal on the use of a mashup framework for research evaluation.

A. Research Evaluation

Bibliometrics indicators have become a standard and popular way to assess research impact in the last few years. All significant indicators heavily rely on publication and citation statistics and other, more sophisticated bibliometric techniques. In particular, the concept of citation [2], [3] became a widely used measure of the impact for scientific publications, although problems with citation analysis as a reliable method of measurement and evaluation have been acknowledged throughout the literature [4]. Indeed, not always a paper is cited because of its merits, but also for some other reasons, as flaws, drawbacks or mistakes. A number of other indices have been proposed to balance the shortcomings of citations count and to "tune" it so that it could reflect the real impact of a research work in a more reliable way. Scientometrics was then introduced as a science for analyzing and measuring quantitatively science itself [5].

In the last decade a number of new metrics were introduced. Although these metrics are also based on citation analysis but they gained popularity over simple citation indexes. For instance *h-index* [6] was proposed by Jorge Hirsch, as a more comprehensive metric to access the scientific productivity and the scientific impact of an individual researcher. This is the recent and most successful indicator so far because it is simple to compute and also it takes into account both the quantity and the impact of the researcher's contributions. That is why some of the most significant journals [7] take interests into it. The original definition of the h-index by Hirsch (2005), was:

"A scientist has index h if h of his or her N_p papers have at least h citations each and the other $(N_p - h)$ papers have $\leq h$ citations each."

H-index has been widely acknowledged because of its good properties, for instance in [8] authors say it is an objective indicator and hence it plays significant role when allocating funds, making decisions about personnel, awarding prizes. In [9] another advantage of *h-index* is mentioned. Author says that *h-index* does not care much about low cited papers, and it is a fact that the great majority of the errors in citation resources tend to occur in the lower part of the citation portion.

However, some flaws and drawbacks of h-index have been identified over time and often different authors have tried to solve those errors by introducing new indicators or variations of it. Hirsche himself mentioned that due to differences in the productivity of different fields, there are differences in h values. It is not proper to compare h-indexes of two researchers from two different research domain. Another disadvantage of h-index is that, it is used to compare researchers which are at different level of their career, since h-index depends on scientist's whole career, but publications and citations increases over time [10]. Focusing on a indicator which should indicate quality of a researcher, should consider the performance of top cited paper. Such indicator *g-index* is proposed by Egghe. The definition of *g-index* is:

"A set of papers has a g-index g if g is the highest rank such that the top g papers have, together, at least g^2 citations. This also means that the top g + 1 papers have less than $(g+1)^2$ cites."

Egghe's concern with h-index was that, once h-index is computed, it is then unimportant for the highly cited paper to receive further citations. In fact this means highly cited researchers may have h-index similar or equal to moderate researchers. However g-index also suffer from problems. For instance, if a scientist receives a high number of citations in one paper, but for other papers he gets average citations. The scientist's g-index would be higher as compared to other scientists with higher average citations in their papers [11]. To overcome some limitations of both the h-index and the g-index, a new index has been proposed in [11] with the aim to combine the good properties of both indices and to minimize the disadvantages: the hg-index is defined as $hg = \sqrt{h.g}$, which is the geometric mean of the h and g-index. It is easily understandable that $h \leq hg \leq g$ and that $hg - h \leq g - hg$. Indeed this index is very simple to compute once both h and g-index have been obtained. It has more granularity, which makes is even easier to compare researchers with similar h or g-indices.

The present literature review on research impact evaluation emphasizes how there are so many different criteria, proposals and thoughts for conducting the evaluation and there are different opinions on which criteria are more effective than other (depending on the reason why they are conducting the evaluation).

B. Research Evaluation Tools

Until recently researchers had essentially only one source for looking bibliometric type of information: the *Web of Science*[1] an on-line commercial database from Thomson Scientific. The commonly used indexes provided by *web of science* includes: P-index (number of articles of author), CC-index (number of citations excluding self-citations), CPP (average number of citations per article), Productivity (quantity of

[1] http://scientific.thomson.com/products/wos/

papers per time-unit). Starting from the late 90's, many other competitors emerged like Citeseer[2], Scopus[3], Google Scholar[4] and Microsoft Academic[5], with the purpose of giving users a simple way to broadly search the scholarly literature.

Based on the existing sources, new tools are beginning to be available to support people in the research impact analysis. A useful tool is Publish or Perish[6], a desktop based software program that uses only Google Scholar to retrieves the citation data, and then analyzes it to generate the citations based metrics. Current weakness of this tool are: (i) they reliance on only one information source (Google Scholar); (ii) the need for manual cleaning of the obtained data (for example for author disambiguation and self-citations among others) and (iii) the lack of Application Programming Interface (API) over which other applications or web services could use the offered functionalities.

Information sources and tools based on these sources are becoming available but they still have many shortcomings. For example they differ in data coverage, data quality. Moreover, these tools are data-source specific and can not be extended to use other data-source. Moreover personalization of metrics is still missing.

C. Mashups Related Work

In parallel to the continuous development of the web, we notice the rapid emergence of the web data sources. These data sources provides data in various forms such as API's, textual, meta-data, usage data etc. Besides the general mashup concepts, the analysis of existing mashup tools may help to identify critical points and to make decisions about the architectural design, the functionalities our platform should offer. Furthermore, since mashups are about the integration of data, knowledge about the ETL data manipulation process is also required. The work in [12] helps to understand how ETL activities can be executed within a control flow model. This paper introduces a proposal called BPEL4ETL, an extended BPEL framework that allows the user to intermix data warehousing processing, such as ETL tasks, with control activities in a BPEL flow. Akkaoui et al. [13] propose a platform-independent conceptual model of ETL processes based on BPMN and give a brief explanation of the mapping between BPMN and BPEL, with the aim of pointing out a possible implementation of this kind of processes.

The work in [14] may constitute a starting point to learn how to develop a mashup tool or what features it can have. The authors here describe five existing mashup tools and assess them in terms of their component and composition models and their development environment. The need of middleware for the UI integration is also argued in this paper. These integration issues are being investigated in a framework called Mixed [15]. Different evaluation criteria is used by Grammel et al. [16], who present six mashup makers and classify them according to features such as the kind of information they manage, their level of abstraction, the user support they provide and the level of customization of their UI's.

The visual dataflow object-oriented language POL (Picture Object Language) is introduced in [17]. It is a general purpose language that supports four levels of abstraction, three of which are domain-specific oriented, e.g. level 2 can be used for developing domain-oriented POLs and level 3 is a domain-specific POL for constructing domain applications. IBM has also developed a visual dataflow language called RBlocks (Relational Blocks) [18]. This language has been implemented in the WebRB tool, which follows the Software as a Service (SaaS) paradigm and runs in Firefox. It aims at writing interactive applications that manipulate data in a GUI for a Web application environment. WebRB lets users (mainly developers) build non-trivial web pages using only RBlocks syntax.

III. Problem Statement

As we have seen in the previous sections, at present there is a big number of different bibliometric methods for evaluating the research work of a single researcher or group of researchers. We have also reported the lack of a common consensus on a universally accepted index (or family of indices). This is quite obvious since too many subjective factors may reflect scientific productivity and creativity. Moreover, stakeholders(i.e. university management, department heads, employers etc.) are more an more interested in being supported in their evaluation/hiring tasks with personalized metrics and methods tailored for the specific task they have to perform. For instance, in some hiring cases, the panel could be interested in measuring the "autonomy" of a specific researcher, which means how the productivity of the researcher is connected with the productivity of his group or past supervisors. In other cases, the panel could be interested in the "diversity" or "complementarity) of the researcher with respect to the institution who is offering the specific position.

We believe that this kind of personalization of the evaluation processes (as well as many other personalization of the evaluation process, like for instance the need of normalizing for a specific community the traditional impact indices) is a key element for the correct use and practical success of the various evaluation indices. Moreover, people involved in such evaluation process most of the time are not IT experts, capable of building proper software for crawling data sources, automatically parsing relevant information, merging data and computing the needed personalized metrics. Therefore, in order to empower the interested persons an appropriate and possibly easy-to-use IT platform need to be designed, implemented and tested. Indeed, supporting custom metrics for research evaluation is a non-trivial issue and requires addressing interesting research questions like:

- What is the set of key features that may enable a user to express its own evaluation metrics, i.e., what is the expressive power needed to do so? For instance, assessing

[2]http://citeseer.ist.psu.edu/
[3]http://www.scopus.com/home.url
[4]http://scholar.google.com/
[5]http://academic.research.microsoft.com/
[6]http://www.harzing.com/pop.htm

the independence of a set of young researchers requires fetching all publications by the researchers, cleaning out papers that have been co-authored by the researchers' PhD supervisor, computing their h-index metrics, and ranking them according to their h-index.

- How to enable non-expert end-users to perform both simple and more complex data integration tasks ? We have seen that being able to access an evaluation body (e.g., a set of papers) that is as complete as possible is at least as important as expressing custom metrics over the evaluation body. For example, fetching all publications of the young researchers may imply fetching data from Google Scholar, DBLP, and Scopus as well as fusing the obtained data and cleaning it.
- Which is the best paradigm or formalism that may allow users to model/express their custom evaluation metrics? A metric may, for example, be expressed in text form via a dedicated domain-specific language, modeled visually by means of suitable graphical modeling constructs, composed with the help from a guided wizard, and so on.
- What type of software support does the computation of custom evaluation metrics need? Depending on the logic needed, the actual computation of a metric may be achieved via generated code, a dedicated evaluation engine, a query engine, or similar.

Providing effective answers to these research challenges may lead to a more flexible and, at the same time, widespread use of systematic research evaluation practices, significantly advancing the current spectrum of available, simple metrics.

A. Challenges

In order to evolve and support better the current status of research evaluation, a number of research challenges has to be addressed in this thesis work, namely:

1) Find the appropriate starting set of commonly accepted *indices* among communities. As we noticed that every community has its own way to evaluate the scientists, thus it is crucial to take into account this kind of diversities. A good starting point is to study the literature throughly for different communities.
2) Define a *conceptual model* for scientific evaluation domain, covering all relevant concepts. The model should be flexible enough to adopt to newly emerging concepts in research evaluation domain. In order to facilitate the different scientific communities, this model should include the essential concepts belonging to them.
3) Design the proper *domain specific language* (DSL) aiming at capturing and expressing the domain terminology needed in the composition models, in order to give constructs the needed domain specific expressive power. In some fields, such as database design, domain-specific languages are a consolidated practice: declarative visual languages like the ER model are well accepted in the field. We believe that DSL is one of the key ingredients in the proposed platform development.
4) Define the needed *model transformation* rules. In our case the domain model has to be transformed into mashup based meta-model and this transformation needs to be performed by satisfying domain related rules, constraints, and itself model checking syntactic checking. Meta-models allow a syntactically precise definition of modeling languages. Moreover it provides other benefits like model parsing (syntactic) checking.
5) Implement the abstraction for accessing, querying and integration of heterogeneous data sources available online. The web is an emerging source for such data, as the day passes new types of scientific content interesting for the research evaluation prospective become available. This means that, the model should be able to go beyond the traditional data sources, by accessing distributed, heterogeneous and evolving repositories for scientific contributions.

B. Expected Benefits

We see the expected benefits of this research work in multiple direction. Below we provide some important aspects.

Platform Specific Benefits:

1) It allows end-user (e.g., researchers, researcher groups, institutes, funding bodies etc) to develop tailored and personalized research evaluation metrics.
2) Platform provides easy to develop compositions using ready to use components. These components ranging from simple to complex ones including predefined as well as user-defined components.
3) It exploits the community based normalization factors which would provide filtering facilities on top of standard metrics.
4) It allows to select multiple data sources at a time in order to perform complex evaluation or to compare research results from different data sources.
5) It allows end-users to generate output of a certain composition in various forms e.g. web service, XML, Excel etc.

Benefits From a Broader Prospective:

1) It allows institutes to develop strategic research partnership with other institutes by accessing own and others strengths and weakness.
2) Support and improve hiring processes.
3) Identify key performance metrics, measure and access the performance of individual researchers and staff members.
4) It allows funding bodies to compare research groups to plan for funds allocation.
5) It helps young researcher and students to identify key publications in particular research areas.

IV. Hints for the solution

Enabling end users to develop their own applications or compose simple mashups or queries means simplifying current development practices. Some mashup approaches heavily rely on connections between components (this is the case of Yahoo!

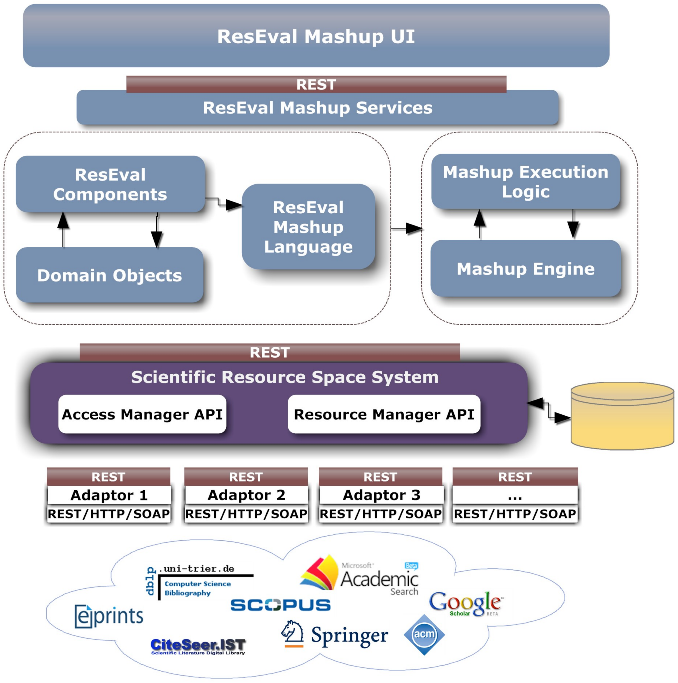

Fig. 1. ResEval Mashup Architecture

Pipes[7] and IBM Damia, for instance), and therefore are inherently imperative; other solutions completely disregard this aspect and only focus on the components and their pre- and post-conditions for automatically matching them, according to a declarative philosophy.

We aim at providing a mashup platform taking advantages of both approaches in combination with service-oriented computing (SOC) framework. For this purpose we have developed mockup and real services and a user-interface for the sake of early validation. ResEval[8] is a preliminary research evaluation platform that is currently being developed. ResEval is based on a service-oriented platform. The preliminary architecture of the platform is shown in Figure 1.

One of the main component of this architecture is the *Scientific Resource Space System* (SRS). All the underlaying adapters which are used to fetch data from real sources as well as to persist this data into database are implemented into this component. *ResEval Components* presents implementation of all the components this platform exposes. *ResEval Mashup Language* is the domain language is used in composition as well as by *Mashup Execution Language* in order to interpret compositions into executions understandable by *Mashup Engine*. Execution and working of all components are controlled by *Mashup Engine*. We have successfully presented our preliminary ideas about ResEval mashups in [19].

A. ResEval Mashup Model & Language

Domain-Specific Languages (DSLs), (i.e. design and/or development languages that are designed to address the needs of a specific application domain) are important to provide the end user with familiar concepts, terminology and metaphors. DSL's empowers the grounds for domain specific mashups approaches which we are targeting at. The first and the most important ingredient in domain specific mashups is the *domain* itself along with its domain model. It is a conceptual model of the domain which describes the various object/entities involved in that domain and their relationships. Domain vocabulary, important methods and attributes are the key concepts of the system being modeled. Important elements in the definition of a conceptual models are the constraints which comes with conceptual model, which are then effectively used to validate the system itself. The aim of this model is to express the concepts used by domain experts and the relationship between concepts, however it attempts to clarify the meaning of ambiguous terms which ensures that the different interpretations of the concepts cannot occur. Figure 2 presents a first attempt to model the scientific evaluation domain.

Model transformation comes at next step, where we take source model and generates target model which is used in our engine. The transformation is the automatic generation of the target model according to transformation rules. These set of rules tell that how one or more constructs in source model are transformed into one or more constructs of the target model. For supporting automated transformation, this model needs to be expressed in an appropriate modeling language (e.g., UML).

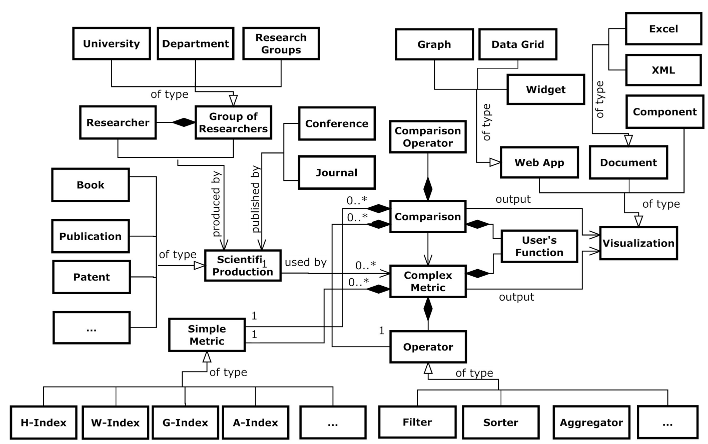

Fig. 2. Domain Conceptual Model

B. Model Mappings

At the time of mappings from source to meta-model, the separation of the concepts which exist in source model is a central issue. That's how the mashup engine knows how to deal with some particular component and at what level. To tackle this problem, We propose a generic mashup meta model (MMM) as shown in figure 3, which has the core generic components. The advantage of MMM is to provide a simple and abstract level of specifications for the mashup engine so that a engine knows that what it needs to support. In this model we define the generic categories of the components

[7]http://pipes.yahoo.com/pipes/
[8]http://open.reseval.org/

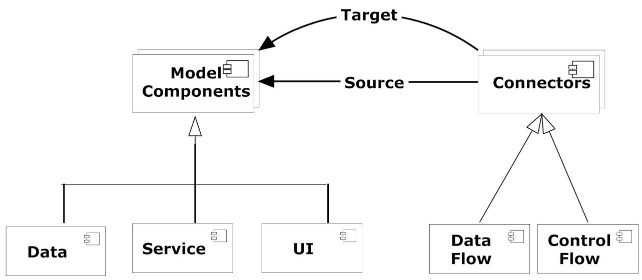

Fig. 3. Meta-Model Architecture

and their relationships, we say how a component connects to other components through a connector. The MMM is then used to map domain specific components to the categories defined in MMM, for example the components which are data sources mapped to the data component category and so on. The MMM elements are divided into two main categories 1) Model components 2) Connectors.

The model components represent the data, logic, and visualization concepts in the domain. All the concepts in domain model which presents information or data such as in bibliography domain (e.g. a researcher, data Source etc) belongs to data components. These are the information sources components which produce data. The elements which are used to perform computation or process data such as metric, filters, aggregators belongs to service components. These components are information sink components which consume data and perform some processings. The third sub-category is UI components which perform the visualization tasks (e.g. charts, tables, maps, widgets etc). The UI components can be generic and can be used in multiple domains as mainly these are only used to present data in different ways. The second category in MMM is connectors components. Connectors are of two types 1) data flow 2) control flow. To control the flow of data and to transfer control to a specific component for further execution we use Data flow technique. Data flow ensures the availability of data required for the execution of a component before it starts execution or scheduled for the execution. Whereas control flow transfer the control, based on some decision. For this particular domain, we have identified that sspecific domain we use data flow connector, mainly pipes, which simply takes data from one component to other component and ensures the availability of data before component been executed.

V. Conclusion & Research Plan

In this research work we deeply study the domain of scientific research evaluation and we describe the various ways which are used to evaluate research performance. New considerations for measuring the impact, demand new and better solutions and this is so far rapidly changing the world of research. In this paper we present an introduction to the problem of research evaluation and we show leveraging mashups power how we can address these challenges. Applying our ideas to this domain would give us a chance to generilize a domain specific requirements, and hence we will be able to apply the same ideas to other similar domains. For this particular domain, in future work we need to tackle a couple of aspects such as, the definition and evolution of domain-specific language, elaboration of mockups for early validation, and the definition of model transformation rules. Model transformation in model-driven engineering takes source model (i.e research evaluation conceptual model) and generate an output model conforming to a given mashup meta-model as described in above sections. Finally we need to implement a whole mashup platform which will facilitate to the end users to compose own research evaluation procedures easily and intuitively.

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