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Sourcing and automation decisions in financial value chains

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TOWARDS A REFERENCE MODEL FOR ONLINE RESEARCH MAPS

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Abstract

Online research maps are websites that present information about certain research activities in a structured manner. Institutions like universities, states, or individual researchers use them as knowledge base to identify and communicate "who knows what" and "where can the respective information be found". Furthermore, these items are used as a research marketing measure, stressing the importance of this kind of portal. However, research maps differ in their range of functionalities, their respective naming, their target audience and so on. Thus, it is an exhausting task identifying and choosing the right set of functionalities. Our goal is to offer a template for the creation of common practice online research maps. For this purpose, we present a reference model and describe its development process. As preliminary measure, 66 research maps have been carefully analysed with respect to the formerly mentioned aspects. Derived from the results of our analysis, common practice was identified and used as basis for developing a reference model for online research maps. For development purposes, an existing language for describing internet portals was chosen and adapted to suite the requirements of describing research maps. The reference model presented in this article was then evaluated in a multi-methodical procedure.

Keywords: Web Site Analysis, Reference Modelling, Conceptual Modelling, Knowledge Transfer.

1 MOTIVATION

These days, main deficiencies in information supply are no longer caused by lacking availability of information but rather by information overflow and high complexity in information processing (Porter & Millar 1985). This problem is addressed by the research area of knowledge management, which elaborates on how to identify, gain, generate, disseminate, utilise, and retain knowledge (Probst & Raub & Romhardt 1999). Knowledge management is not only a success factor in business but it is also of highest importance for researchers and research networks. This paper addresses the above stated deficiencies by supporting the development of online research maps.

Online research maps are Internet-based knowledge management instruments, which present research activities through answering different questions, like (a) "who is conducting the research?", (b) "what is being researched?", (c) "what results have been achieved?", and (d) "who is paying for the research?". Research maps give a general overview of the involved parties, research topics, and achieved results, trying to emphasise existing mutual relationships. These relationships can be, for example, of geographical, organisational, financial, or causal nature. Online research maps can significantly reduce the effort put in the search for knowledge assets and the respective experts due to structured – often visual – representation (Eppler 2001). Thus, online research maps facilitate getting familiar with an unacquainted research area. Furthermore, the database of the research map can be quantitatively analysed to identify research gaps. By giving an insight into the research activities of an organisational unit, research maps are not only a knowledge management instrument but can also be used as a marketing instrument to make own research results available for public. For instance, the U.S. National Cancer Institute uses an online research map (http://www.cancermap.org) to "connect the dots between all researchers involved in pancreatic cancer research to speed the development of national strategies and to leverage resources for pancreatic cancer research".

While using and hosting an online research map yields certain advantages, their development can be an exhausting undertaking when conducted manually in a try-and-error manner. As organisations conceive their individual solutions independently, much work is carried out redundantly. In many cases, research organisations' budgets limit the effort that can be brought into the development of a research map. Especially in this case it is important for those organisations to get support designing the functionality and structure of their internet portal.

Reference modelling has been proven a successful means of knowledge transfer through capturing common-practise solutions for information systems development (for detailed information about the advantages of reference models see e.g. vom Brocke 2007; Frank & Strecker 2007; Fettke & Loos 2007). Our goal is to develop a reference model for online research maps, which can support constructors during the conceptual phase of a development project of an online research map.

Hence, there are two major research questions we address with our paper.

(1) What functionalities and structures should be included in the reference model for online research maps to capture common practise?

(2) How can this common practice be graphically represented by a modelling language?

Our development process of the reference model includes the collection and analysis of existing websites, the choice and adaptation of an appropriate modelling language, data-driven reference model construction, and finally the evaluation (cf. Figure 1). The remainder of this paper proceeds correspondingly. In Section 2, we present our explorative analysis of existing online research maps. It consists of an online-based search for websites, their analysis, and identification of implemented functionalities. Furthermore, as the naming of these functionalities varies from website to website, we establish a common vocabulary for the used functionalities. In Section 3, a modelling language appropriate for online research maps is chosen, adapted, and specified by a language-based meta-model. Section 4 covers the creation of our reference model, which is conducted in an iterative way. In the following section the evaluation of our reference model is discussed. On the one hand, the model is validated against randomly selected websites. On the other hand, we evaluate the applicability of our model to a concrete real-life situation of research map construction. In Section 6, we conclude with an outlook for further application and evaluation activities as well as for important contributions of the reference model to other research questions.

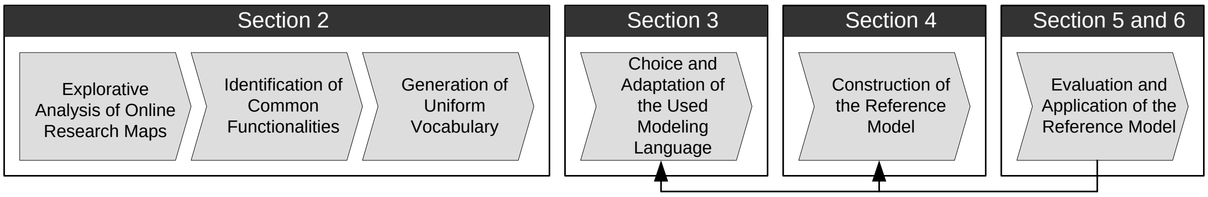

Figure 1: Development Process of the Reference Model

2 EXPLORATIVE ANALYSIS OF RESEARCH MAPS

As a preliminary step, typical functionalities of research maps had to be identified. These functionalities should serve as basis for the selection of an appropriate modelling language. Thus, from July to August 2008, an analysis of existing research maps was conducted. For this, the search engine Google (http://www.google.com) was used to retrieve results for keywords like “research map” (and other corresponding English terms) and “Forschungslandkarte” (and other corresponding German terms). For each term, the first 250 results were analysed whether or not they belong to a research map. Besides many links leading to pages just providing information about research maps or solely providing links to them, 76 research maps were identified as being adequate for our analysis at the first moment. However, 9 of them were offered as print media and one of the web based research maps did not deliver the required login information in time. This led to a total of 66 research maps analysed, originating from eight different countries. Most of them (42) originate from Germany, another 10 from the United States. The remaining 14 maps originate from several European countries. Each of the 66 research maps was scanned for functionalities it provides. As the namig of the research maps’ functionalities differ, coding them with common terms was required. Once functionalities for a certain research map were identified, they were recorded in a contingency table. This enabled us to identify common expressions and aggregate them thematically (cf. Table 1). For this, every term found on a certain online research map and identified as being relevant was assigned to one of the 52 defined functionalities. Those again were aggregated to another set of 12 classes, characterising them in a more general manner. Furthermore, for common understanding we defined the meaning of each of the functionalities and counted their absolute occurrences (#Freq.) and their percentage share (%).

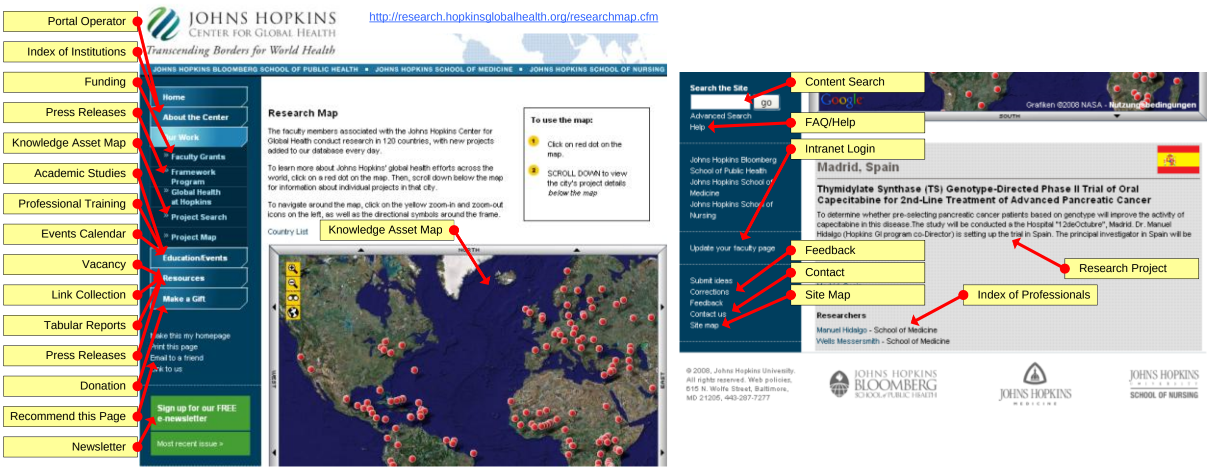

Figure 2: Screenshot of an Exemplary Research Map (Johns Hopkins Center for Global Health)

Class	ID	Functionality	RM	Characterisation	#Freq.	%	Common expressions
Knowledge representation	01	Index of institutions	X	A list which offers information about organisations, institutions and enterprises.	42	63,6	Organisations; Institutions; Research Centers
	02	Index of professionals	X	A list which offers information about people.	19	28,8	Researcher; Staff; Investigators; Accounts; People
	03	Knowledge Structure Map	X	A visual representation of a knowledge domains structure and its relations.	10	15,2	Map of Science; Mapping Science; Research Map
	04	Knowledge Asset Map	X	A map which visually qualifies the existing stock of knowledge of an individual, a unit or an organization.	40	60,6	Map; Science Map; Project Map
Searching	05	Content search	X	A full-text search on the content of the website.	49	74,2	Search; Project search; Search for text
	06	Institution search	X	A search limited on information about insitutions, organisations and enterprises, which are part of the website.	26	39,4	Search; Institution search
	07	Person search	X	A search limited on information about persons like researchers or members of staff.	13	19,7	Search; Contact name search; Employee Locator
	08	Cooperation search	%	A search for enterprises requesting cooperations.	2	3,0	Cooperation search*
	09	Special equipment search	%	A search for the existence of special equipment or methods in a company´s profile.	1	1,5	Special equipment search*
Content	10	Area of research	X	An introduction to the area of research of the website.	27	40,9	“Name of the area of research“
	11	Research methods	X	An explanation of methods used to create the research map.	5	7,6	Methods; “Name of the research method“
	12	Research project	X	The existence of a page containing research projects.	27	40,9	Projects; Activities
	13	Research results	X	The existence of a page containing research results.	35	53,0	Publications; “Name of the research project“; Reports
	14	Publications	X	A list of articles, proceedings and reports published.	18	27,3	Publications; Papers; Proceedings*
	15	References	X	The existence of references to pages of the website to bring evidence to statements and reports.	11	16,7	References; Papers; Key documents
	16	Literature database		The existence of a database containing a list of textbooks or scientific journals related to the research map.	4	6,1	Library; Journals
Research funding	17	Funding	X	Information about scientific grants and funding opportunities.	8	12,1	Funding; Funding Opportunities
	18	Awards	%	Information about science awards gained by the portal operator.	3	4,5	Awards
Analysis	19	Link to external Websites	%	A link to an external Website which contains statistical data and analysis of an area of research.	2	3,0	Statistics*
	20	Tabular reports	X	Analysis as tabular reports.	9	13,6	Statistics; Analysis*
	21	Chart reports	X	Analysis as chart reports.	10	15,2	Overview of…; Quick view of…; Analysis*
Participation	22	Apply for membership	X	Gives an user or an institution the opportunity to become a member of the research map.	12	18,2	Apply to join; Join the researchmap
	23	Intranet login	X	Entrance to a password protected area of the website.	19	28,8	Login
Legal information	24	Imprint	X	General and legal information about the company, responsible for the webpage.	43	65,2	Imprint; Terms of use
	25	Privacy Policy	X	Legal document dealing with the information related to customers and merchants private profiles.	14	21,2	Privacy Policy; Privacy and Cockies Policy
	26	Disclaimer	X	Statement intended to define or delimit the scope of rights.	5	7,6	Disclaimer
Common components	27	Site map	X	A representation of the structure of a website.	24	36,4	Site map
	28	Language	X	Opportunity to change a websites used language.	28	42,4	“Text“; “Icon“
	29	Contact	X	A page containing the portal operators contact details.	57	86,4	Contact; Contact us; Main Contacts
	30	FAQ/ Help	X	A list of frequently asked questions.	9	13,6	FAQ
Portal components	31	Latest news	X	A page containing information about the latest research results and news of the area of research or the portal.	19	28,8	News; What´s new?
	32	Portal operator	X	Information about the portal operator like the history, company organisation and directions.	37	56,1	“Name of the operator“; About …; About us
	33	Events calender	X	A list of events related to the research map in chronological order.	25	37,9	Events; Events Calender; Conferences*
	34	Objectives	X	Information about the ambition and purpose of the research portal.	15	22,7	“Welcome page“; Mission; Purpose; Vision; Objectives*
	35	Sponsors	X	Pages or links containing companies’ names or logos supporting the website financially.	12	18,2	“Banner ad“; Funding Partners; Funders
	36	Link collection	X	A list of links related to the website.	25	37,9	Links; Related links; Useful websites
Media	37	Press release	X	A page listing press releases chronologically.	37	56,1	News; News Center; Press release*
	38	Newsletter	X	Gives an user the opportunity to subscripe to newsletters.	13	19,7	Newsletter; Mailing Service; Subscription Service
	39	Podcast	X	Gives an user the opportunity to watch or subscribe to podcasts.	4	6,1	Podcasts; Video Gallery
	40	RSS-Feed	%	Gives an user the opportunity to subscripe to RSS-Feed.	2	3,0	RSS
Career	41	Vacancy	X	A page containing job advertisements.	9	13,6	Jobs; Vacancy*; Job exchange*
	42	Further education	X	A page containing information about advanced training opportunities.	7	10,6	Further education*; Advanced training*
	43	Internship	%	A page containing trainee and internship offerings	2	3,0	Trainee; Internship*
	44	Professional training	%	A page containing information about professional training opportunities.	3	4,5	Professional training*
	45	Degree dissertation		A page containing diploma theses.	5	7,6	Diploma Thesis*; Diploma*; Dissertation*
	46	Academic studies	X	A page containing information about academic studies related to the area of research.	9	13,6	Education; Academic studies*
Miscellaneous	47	Recommend this page	X	Opportunity to email the URL of a page to a friend.	5	7,6	Email to a friend; Share an article; Send it to a friend
	48	Feedback	X	Opportunity to submit ideas and corrections to the portal operator.	4	6,1	Feedback; Submit ideas; Corrections
	49	Shopping cart for papers		Opportunity to put papers and brochures into a shopping cart befor ordering.	11	16,7	Shopping cart*
	50	Visitor counter	%	A function whichs counts the amount of visitor of a page.	2	3,0	Hits; You are the x visitor to the site
	51	Keyword index	%	A list containing domain related keywords.	1	1,5	Index
	52	Donation	%	A call for donation to support the research portal.	1	1,5	Make a gift

RM: Reference Model X : in RM % : not in RM due to 5% rule [grey box] : not in RM due to specialisation “...“: Placeholder representing specific terms *: translated literally

Table 1: Common Expressions, Their Relation to Functionalities and Their Definitions

For this article, common German expressions were translated to English (marked with *). Terms in quotation marks serve as placeholders (e.g. “Text” stands for “English” or “German” (ID 28), “Icon” stands for the respective flag symbols). After having built the overview, we created a screenshot of each research map and tagged it with the respective term (cf. Figure 2). Thus, documentation of the assignment results is available. As an example for the assignment, the research map of the “Johns Hopkins Center for Global Health” (http://research.hopkinsglobalhealth.org/researchmap.cfm) provides the functionality *Project Map*, which was coded with the respective term *Knowledge Asset Map* (ID 04). As another example, *About the Center* was coded with the term *Portal Operator* (ID 32).

3 ADAPTATION OF A MODELLING LANGUAGE

A necessary task during the reference modelling process is the selection and – if necessary – adaptation of an adequate modelling language (Becker et al. 2008). For websites, various approaches towards modelling requirements definition are proposed, which can be differentiated into three branches of development (cf. Figure 3). One group of approaches originates from data modelling and is based on Entity-Relationship Models (Chen 1976). Other approaches primarily derive from Hypertext Modelling (Garzotto & Poalini & Schwabe 1991; Halasz & Schwartz 1994). A further branch of development comprises object-oriented approaches (Rumbaugh et al. 1991; Rumbaugh & Jacobson & Booch 1998).

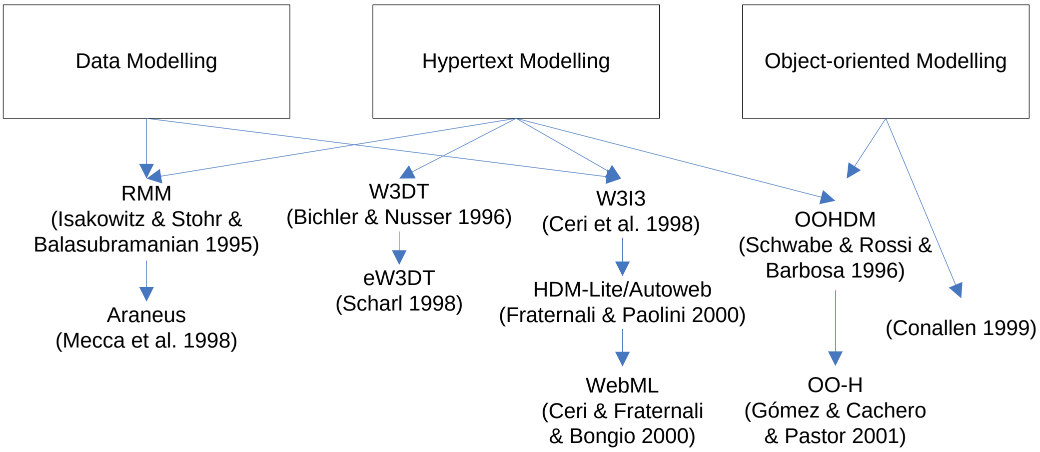

Figure 3: Modelling Approaches for Web Applications (Brelage 2006)

The extended World Wide Web Design Technique (eW3DT) by Scharl (1998) was chosen for the construction of the reference model for research maps. The crucial advantage of eW3DT was the fact that reference models for internet portals have already been constructed using this modelling language (Scharl 1997). Thus, this modelling language is intended to be partly reused in the context of this paper. Furthermore, this modelling language incorporates all required elementary model constructs provided by the other modelling languages. eW3DT distinguishes the five website element types *page*, *interaction*, *index*, *menu* and *file*, which can be either static or dynamic. In contrast to static web elements, the content of dynamic web elements may vary depending on the time being accessed. A website structure is modelled by establishing relations between website elements using different connection types. The contents of single website elements can be refined in sub-models. The analysis as presented in Section 2 revealed requirements that made it necessary to adapt eW3DT. The meta-model in Figure 4, for which we used an extended version of the ERM data modelling language (Chen 1979), illustrates the project-specific extensions to eW3DT. Derived from the functionalities of the class *analysis* (cf. Table 1, IDs 19-21), the reference model is required to be able to describe the content-related structure of reports that should be available in the research portal. Thus, the new element type Web-OLAP represents a quantitative report that is available on the research map and may also be manipulated through the OLAP operations: *rotate*, *slice*, *dice* and *drill-down* respectively *roll-up*.

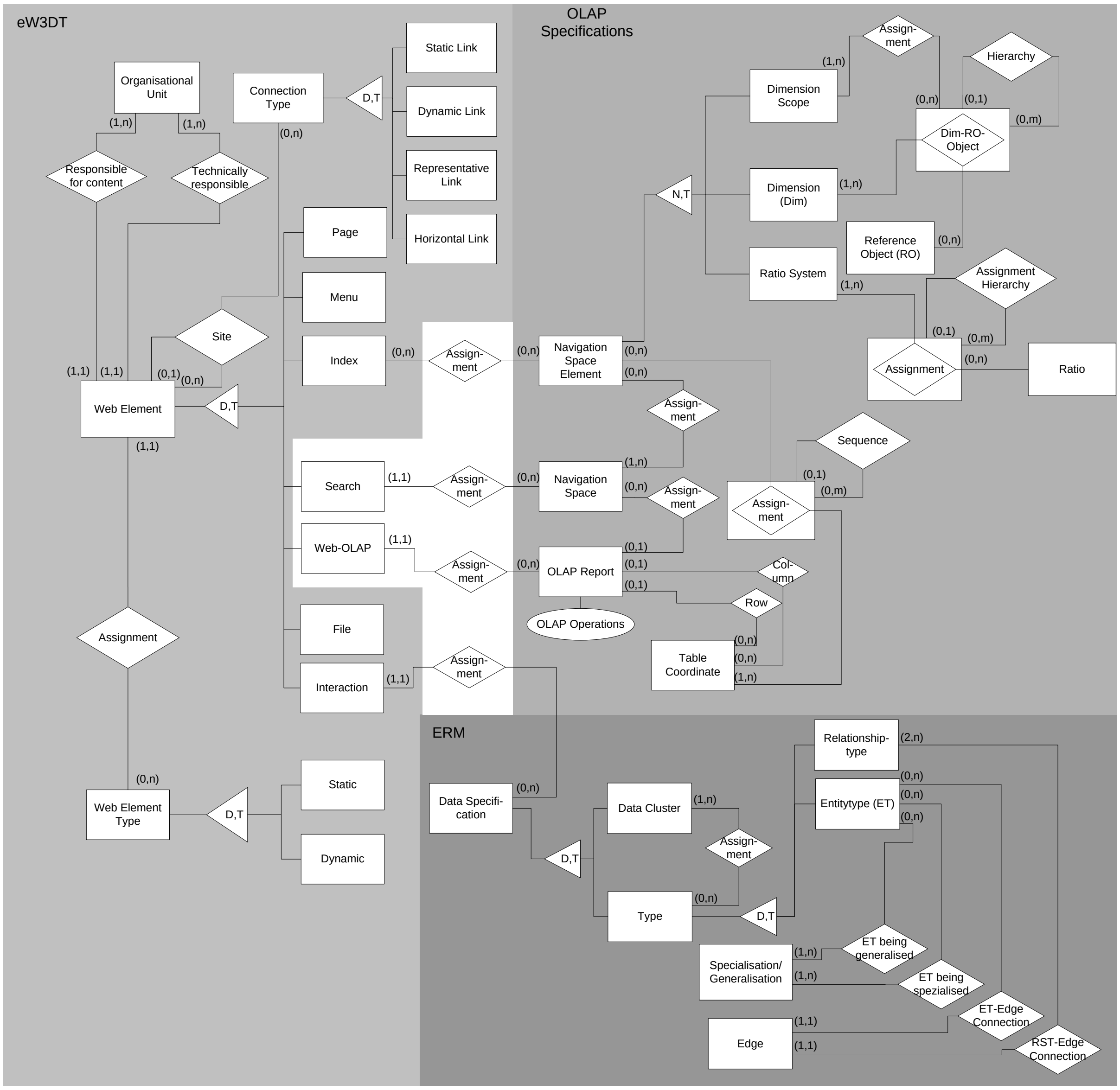

Figure 4: Model of the Modelling Language Used for the Reference Model

Concerning the extension of the meta-model for the specification of analysis reports, the model constructs that are commonly used in modelling languages for the functional specification of OLAP systems have been adopted (Bulos 1998; Golfarelli & Maio & Rizzi 1998; Holten 2003). The content-related specification of OLAP reports is defined by values of columns and rows which determine a two-dimensional projection of a navigation space. Navigation spaces are made up of dimensions and dimension scopes (e.g. date defined by year, institution defined by country and research theme defined by theme group) and systems of metrics (e.g. number of research results). Thereby, the navigation space clarifies which metrics should be analysable according to which structure of dimensions. The design relying on rows and columns determines the tabular structure of the report. If the element type Web-OLAP-Report is being marked as dynamic, the report is generated from the data base on demand and thus can contain different metric values at different access times. If the report is static, however, its contents remain the same regardless the time the web portal is accessed. By specifying additional attributes of the Web-OLAP element, the available OLAP operations can be chosen. Further information functionalities were identified empirically, some of which pointed out that indices are frequently used in research portals to give an overview of various entities, like *institutes*, *people*, and *topics*. Within the extension of the meta-model, the element type *index* is intended to be assigned to different dimensions – respectively dimension scopes – which can also be used within the context of report-based analysis. For example, by using this meta-model extension it is possible to express that the index *directory of institutions* is presented in different ways, e.g. ordered *alphabetically/geographically* or by *Institution Type/Area of Research* (cf. Figure 6). Besides the hierarchically structured index navigation, it should be possible to search throughout thematically separated areas, e.g. via full-text search. For this purpose, the additional element type *search* has been included. By defining a navigation space, the content-related restriction of a supported search can be specified.

Another extension to the meta-model was motivated by the fact that in eW3DT database symbols are assigned to the element type *interaction* in order to specify that data is collected or provided during this interaction. As decisions are to be made concerning the naming and structure of databases, we used data clusters to specify this data in our adapted eW3DT variant. The data clusters are excerpts of an Entity-Relationship Model (ERM). The ERM excerpts describe the data addressed in the interaction from the requirements definition point of view. Thereby, a consistent application of reference modelling in requirements definition is guaranteed. However, this abstracts from the way the data is physically structured in the database and from the database itself.

4 A REFERENCE MODEL FOR RESEARCH MAPS

With the functionalities identified in Section 2 and the modelling language as prerequisite for the creation of the reference model at hand, we chose an iterative process for building its structure. During the first initiation step, a set of five research maps, which provided a considerable amount of functionalities, was analysed regarding their structure (cf. Table 2). For each functionality the respective web element type (*Page*, *Menu*, *Index*, *Search*, *Web-OLAP*, *File* and *Interaction*) as *Static* or *Dynamic*, and the links between them (*Dynamic*, *Static*, *Including*, or *Representing*) were chosen. If necessary, additional functionalities were included and placed at an appropriate position.

Step	Research Map
Initiation	Forschungslandkarte zur hybriden Wertschöpfung (Ec); Kompetenznetzwerk Stammzellforschung NRW (Me); Forschungsportal Sachen-Anhalt (Ec); Forschungsportal der Universität für Bodenkultur Wien (Env); FIDES der Wirtschaftsuniversität Wien (Sc)
Iteration 1	Forschungslandkarte Asklepios Kliniken (Me); Forschungslandkarte zur Exzellence Initiative des BMBF (Ed); Forschungslandkarte zu Bundeseinrichtungen des BMBF (PA); Fachportal Pädagogik (Ed); Forschungslandkarte Windenergie (Ene); Duke University (Me); Knowledge Base Social Science Eastern Europe der GESIS (CS); Kunststoffland NRW e.V. (Ch); Landesinitiative Projekt Zukunft Berlin (Sc); Alaska Science Portal des USGS (Env)
Iteration 2	Forschungslandkarte zur Helmholtz-Gemeinschaft des BMBF (RC); Security Research Map des BMBF (SE); Kompetenznetzwerk Katalyse von DECHEMA (Ch); Forschungsportal der Deutschen Rentenversicherung (IF); eigenfactor.org (Sc); Research Map des John Hopkins Center for Global Health (Me); Kompetenznetzwerk Neuro NRW (Me); Sandia National Laboratories (Sc); Kompetenzcluster des VDI (Ec); Forschungslandschaft Sachsen der VEMAS (In)
Iteration 3	Forschungslandkarte der Hochschulen des BMBF (Ed); Kompetenznetzwerk dezentrale Energietechnologien e.V. (Ene); Informations- und Wissensplattform Chem.de (Ch); Holzcluster Steiermark (Ti); Forschungskarte der Deutschen Massivumformung e.V. (In); Cancermap des National Cancer Institute (Me); Bundesumweltamt (Env); Forschungsatlas QPT der Universität Zürich (Ps); Forschungslandkarte des Deutschen Instituts für Erwachsenenbildung (Ed); Science Map der University of Saskatchewan (Sc);
Legend of research areas: Ch = Chemistry; CS = Culture und Social Affairs; Ec = Economics; Ed = Education; Ene = Energy; Env = Environment; IF = Insurance and Finance; In = Industries; Me = Medicin; PA = Public Administration; Ps = Psychology; RC = Research Centre; Sc = Science (multi disciplinary); SE = Safety Engineering; TI = Timber Industries;	

Table 2: Iteration Steps for Building the Reference Model

The first iteration step consisted of ten research maps being compared to the model originating from the initiation step. Ten functionalities had to be additionally included and placed in an appropriate position in the model. Others had to be repositioned. During the second iteration, only three more elements had to be included.

During the third iteration, no more additional elements were required and no repositioning had to take place. Thus, we defined the result as our reference models first version (cf. Figure 5). The greyed out elements in Table 1 express, which functionalities of the initial list were left out in the reference model either because not more than five percent of the analysed research maps included them, or because they were very domain-specific and not of any value for research maps belonging to different domains.

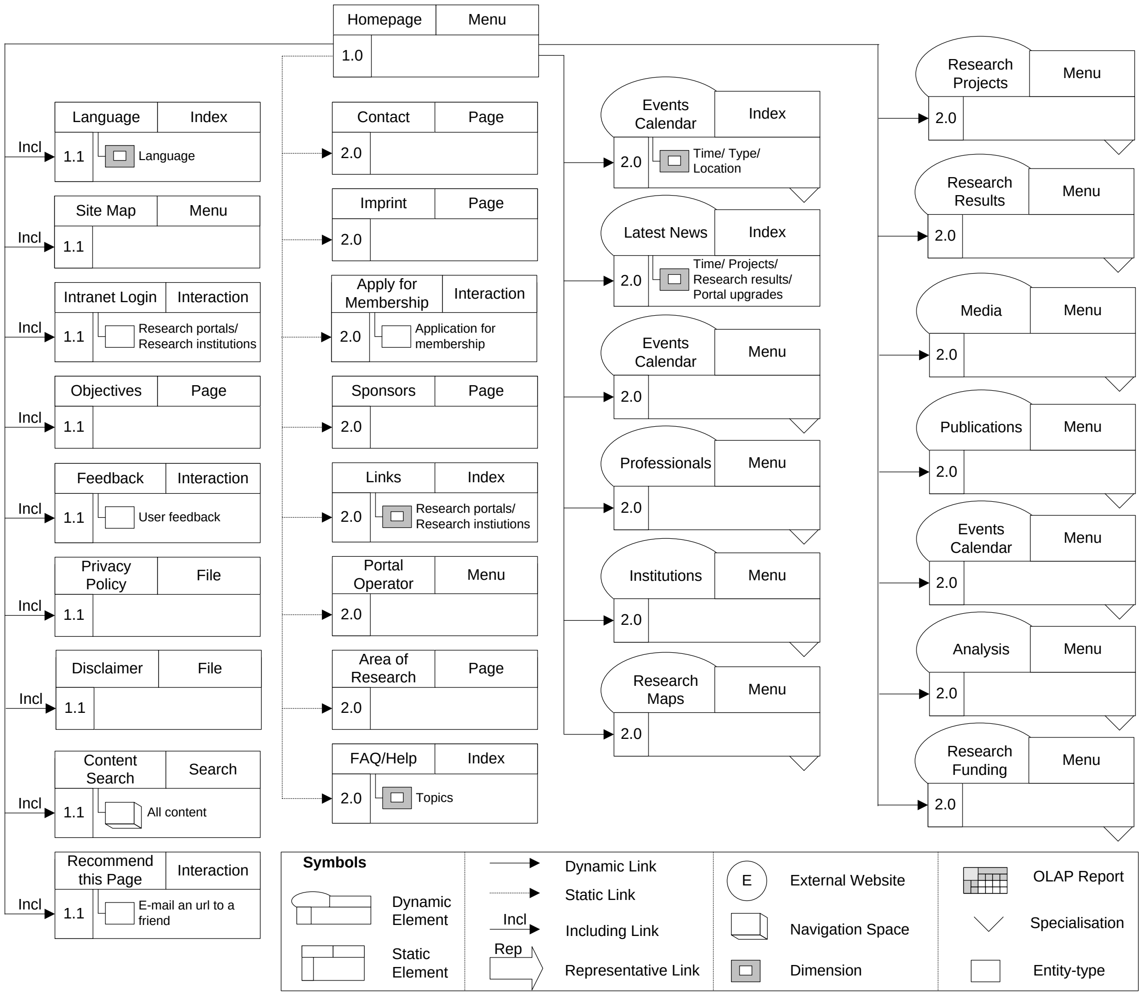

Figure 5: Reference Model Proposal after Three Iteration Steps

The reference model all in all consists of 148 elements and is divided into 14 sub-models, describing subordinate contents. If not accessing the research map via a deep link, e.g. by using a link provided by a search engine, the user enters the research map via the *Homepage* (level 1.0). There, elements of level 1.1 are included and immediately presented. For maximum impact, on this level the user should be enabled to choose his preferred *Language*. Furthermore, the *Objectives* of the map should be presented to give a quick overview about what the site is about. The interactions *Intranet Login* and *Feedback* communicate the possibility to get in contact with the operators by sending annotations or proposals for corrections. By entering a secured area, the (active, thus not visiting) user gets the possibility to contribute to the research map, a necessity e.g. for research networks or communities. A file *Privacy Policy* generates trust and informs about how the operator deals with members data and their profiles. *Content Search* enables the user to search the content of the research map by keywords. To send the URL of one of the page to interested third parties, the interaction *Recommend this Page* can be used. The *Site Map* gives an overview of the structure of the web portal whereas the *Disclaimer* is a serves as legal insurance.

Web site elements on level 2.0 can be accessed from the homepages navigation menu. Figure 6 illustrates this for the menu *Institution*, which consists of a dynamic element *Directory of Institutions* and an element *Institution Search*.

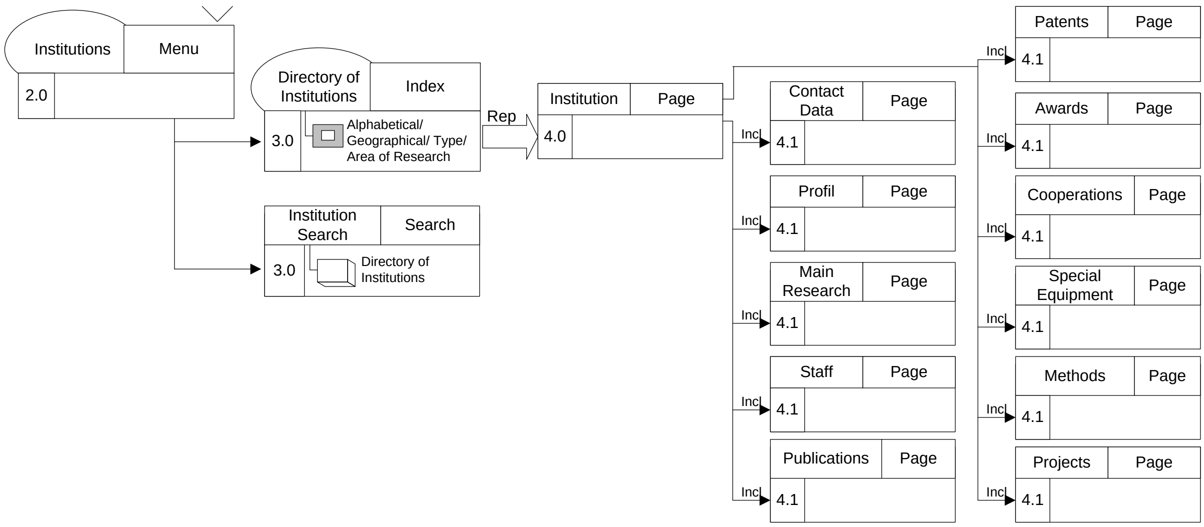

Figure 6: Sub-Model of the "Institutions" Menu

Similar to the menu *Institutions*, 14 more sub-models were created. A condensed description of all available sub-models is listed in Table 3:

Sub-model	Description
Analysis	This sub-model contains four dynamic Web-OLAP-Applications. Each application is configured to its special scope. The Web-OLAP-Applications *Project Analysis*, *Area of Research Analysis*, *Institution Analysis,* and *Publication Analysis* will generate significant reports.
Career Center	Four dynamic indices in the sub model *Career Center* exist. Each index contains domain-specific information, external links for further information, e.g.*Vacancy*, *Further Education*, *Academic Studies,* and *Professional Training.*
Events Calendar	The dynamic index *Events Calendar* announces events, exhibitions, workshops, and advanced trainings related to the area of research. An external link to an organisers website lets users sign up for an event.
Institutions	This sub-model lists research institutions alphabetically, geographically or by type of institute. One institute is characterised by its *Contact Data*, *Profile*, *Main Research Area*, involved *Members of Staff*, *Publications*, *Projects*, *Patents*, *Awards*, *Cooperations*, *Special Equipment* and handled *Methods*. For large numbers of registered institutions, an *Institution Search* should be implemented.
Intranet login	This sub-model contains a menu *Intranet* linking to two interactions: One interaction manages the administration of user data, the other interaction manages the administration of content data like *Projects*, *Research Results*, *Publications*, and *Events Calendar*.
Links	The static or dynamic index *Links* is a link collection to external websites related to the research portal.
Media	The dynamic menu *Media* contains three dynamic indices and one static page. The page *Press Contact* keeps contact data for press only. The index *Press Release* lists press reports chronologically. Older reports will be stored in the index *Press Archive*. The third index *Podcasts* enables users to play audio and video documents related to the portal. Additionally, there is a possibility to subscribe to the *Newsletter*.
Portal Operator	This sub-model consists of five static pages. A *Profile* discribes the portal operator with his core competences, the service offering and philosophy. The *History* of a firm will be presented as well as its *Organisation*. Pages with *Contact data* and *Directions* are in this sub-model, too.
Professionals	The sub-model *Professionals* consists of a *Person Search* and an *Index of Professionals*. One professional is characterised by his *Contact Data*, membership to an *Institution*, *Profile*, *Main Area of Research*, *Publications*, *Projects*, *Patents,* and *Awards*.
Publications	A publication is characterised by its *Pblication Status*, *Type of Publication*, *Title*, *Location*, *Publisher*, *Year*, *Authors*, *Project*, *Research Area*, *Institution* and *URL*. The index *Publications* lists data sets sorted by time, type or author. Categorial filters in a *Publication Search* could be used to specify database requests.
Research Funding	This sub-model includes an index with information about *Funding* opportunities.
Research Maps	Maps facilitate the search process in an area of research. *Knowledge Asset Maps* and *Knowledge Structure Maps* are modelled as Web-OLAP-Reports. Web-OLAP-Reports are being real-time-generated from the database, so they will be up-to-date permanently.
Research Projects	This sub-model contains the index of *Research Projects* which will be described by a *Title*, a realising *Institution*, *Participants*, a *Description*, its *Duration*, *Keywords*, used *Methods*, *Research Results*, *Cooperations*, *Financial Supporters* and its *Project Status*. A powerful *Project Search* helps to control the project data sets.
Research Results	One or more research results could originate form one research project, so research results are outsourced in its own sub-model. The index of *Research Results* lists all data sets alphabetically. Using *Search Research Results*, the output could be limited and sorted by categories. One result will be described by its *Title*, its publishing *Institution*, *Contact Person*, *Description*, *Classification*, *Keywords*, *URL*, its mapping to a *Research Project*, its situation of *Patent Registration*, *Financial Supporters*, its *Status,* and *Publications*.

Table 3: Descriptions of the Sub-Models' Contents

5 EVALUATION OF THE REFERENCE MODEL

Having built the reference model, we chose a multi-methodical approach for our evaluation, initially starting off with testing the abilities of the reference model against a random sample of ten of the remaining research maps. During this, we found out that no more website elements had to be added to the reference model to completely describe the sample. This can be interpreted as an indicator for the reference model completeness. Subsequently, we used the reference model as accompanying measure for the creation of a research map from scratch. By doing so, we wanted to evaluate its usefulness in day-to-day business. The map that was to be set up was on order of an international research network, settled in the domain of information systems. It can be accessed via the URL http://www.forschungslandkarte-hybridewertschoepfung.de. The research map generally required the ability to present information about research artefacts created by the members of the network. It was also required to describe the artefacts with different dimensions, list the respective contact person and additional downloads, if available. For reporting purposes, the dimensions should be analysable by an OLAP system.

The reference model successfully served as a guide for the discussion on and the choice of functionalities implemented for the portal. The artefacts of the research maps are analysable with the OLAP system IBM Cognos by their dimensions. During the next step, we called the users of the research map for participation by filling in a paper-based questionnaire about the applicability and usefulness of the elements provided. No negative comments regarding the content of the portal were given, however the naming of the website was questioned, which, however, was not subject to the application of the reference model anyway.

Furthermore, we conducted semi-structured interviews with seven users. All in all, they too found the research portal to be complete in regards to the requirements. Besides successfully describing the required content, the reference model turned out to be helpful during the creation process of the research map. For a detailed description of how this process can be evaluated, see Frank (2007). However, up to this point, all personnel except third party users of the research map developed are known to the authors and therefore – although leading to very good results – their judgement has to be questioned. Thus, in the next step, the reference model will be used during the development process of a research map for clients personally not known to the authors.

6 OUTLOOK

The reference model in its as-is state seems to be able to completely describe most of the research maps, which are available online. However, as motivated in Section 5, the fourth step of the evaluation phase still has to be taken, which will be done in a larger scale project with participants that are not acquainted or connected to the authors in any way. For this, the reference model will be handed over to the research map development team. The authors will accompany the whole process and observe the reference models applicability for both the choice of elements and the process of developing the research map. The result of this analysis should provide the means for a further adaptation of the modelling language and an even more suitable definition of functionalities. By doing this, another iterative process will be started, improving the reference model's significance (cf. Figure 1). The reference model serves as basis for a larger scale empirical analysis, encompassing more online research maps. As prerequisite for such an empirical analysis, it is important to define adequate criteria for coding the objects of investigation. Here, the reference model for research maps comes into play by offering criteria in terms of functionalities and common expressions. Once collected, further results should be expected from this data pool:

(1) By being able to work with a larger number of results, we should be able to identify different types of research maps. Concluding from the sample analysed in Section 2, it seems that there are different purposes for which research maps are set up. Firstly, single researchers use the maps as online documentation of their own work. These kinds of maps are very limited in their number of functionalities,

the number of research domains covered and the number of people accessing the site and contributing to it. Secondly, organisations like universities or sponsors set up research maps to either present their own research results or those of the supported projects. The amount of users accessing and contributing to this kind of map is naturally considerably larger. Furthermore, the research map might cover more than one research domain. Due to the larger amount of stakeholders, the demand for functionalities, too, will be higher. Thirdly, research networks use research maps for sharing their results among each other similar to organisations. In opposite to them, there is no need for a central institution managing the research map. Once empirically identified, these different types of research maps might lead to clusters of functionalities connected to them. If this should succeed, the reference model could be enriched with meta-data, specifying for which type of research map the respective functionalities are relevant. This would greatly simplify the choice of functionalities for a certain kind of map, as the adequate set could be derived from the selection of a certain configuration parameter (Becker & Delfmann & Knackstedt 2007).

(2) Another application scenario of the empirical data collected is the construction of a maturity model (Nolan 1979; de Bruin et al. 2005) for research maps. A similar approach addressing portals in general was proposed by Baroni de Carvalho & Ferreira & Choo (2005). A quantitative analysis can show which functionalities are typical for different degrees of maturity. Assuming that the maturity model consists of five – as widely used – stages, it is our expectation that our reference model corresponds with level three, implying a medium level of maturity. While research maps can be considered as knowledge management instruments, such a maturity model is a specific kind of a knowledge management maturity model as e.g. proposed by Freeze & Kulkarni (2005).

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