ThinkFree: Using a Visual Wiki for IT Knowledge Management in a Tertiary Institution

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ABSTRACT

We describe *ThinkFree*, an industrial *Visual Wiki* application which provides a way for end users to better explore knowledge of IT Enterprise Architecture assets that is held within a large enterprise wiki. The application was motivated by the difficulty users were facing navigating and understanding enterprise architecture information in a large corporate wiki. ThinkFree provides a graph based interactive visualization of IT assets which are described using the Freebase semantic wiki. It is used to visualize relationships between those assets and navigate between them. We describe the motivation for the development of ThinkFree, its design and implementation. Our experiences in corporate rollout of the application are discussed, together with the strengths of weaknesses of the approach we have taken and lessons learned from ThinkFree's development and deployment.

Categories and Subject Descriptors

D.2 [**Software Engineering**]: Software Architectures; H.3 [**Information Storage and Retrieval**]: Information Search and Retrieval; H.5 [**Information Interfaces and Presentation**]: Hypertext/Hypermedia

General Terms

Design, Documentation, Human Factors

Keywords

Visual wiki, knowledge management, visualization

1. INTRODUCTION

Large distributed organizations, such as major Universities, typically operate a federated IT management structure with distributed governance and responsibilities. This means they have a corresponding need for strong coordination and communication mechanisms to ensure that the diverse stakeholders are aware of evolving corporate standards, architectural principles, and strategic and operational activities [17]. Information and knowledge management strategies, tactics and tools to support these communication and coordination needs are vital [18]. Such strategies need to take into account that more than 80% of corporate learning is informal where effective socialization mechanisms enhance efficiency [13]. It is not surprising, therefore, that wikis have been rapidly adopted within large organizations for managing, coordinating and communicating corporate knowledge of various sorts [9].

However, creation of a successful "wiki culture" within an organization can lead to scale issues. The lack of structuring mechanisms makes semantic search and reasoning difficult [16]. Buffa reports that "the main problem reported is the difficulty experienced by users in finding their way, in navigating and searching the wiki, especially when it becomes large" [2]. In developing a wiki-based knowledge management approach for corporate IT assets at the University of Auckland, we encountered similar issues. This paper describes ThinkFree, a *Visual Wiki* application we have developed to mitigate these issues. This supports the exploration and comprehension of enterprise IT assets and their inter-relationships by a broad range of corporate stakeholders. It alleviates navigation and search issues through a combination of visualization and semantic wiki techniques.

We begin by briefly introducing our previously developed *Visual Wiki* model. We then describe the motivation, design, implementation, corporate deployment, and evaluation of the ThinkFree application. Discussion of our experiences and lessons learned are followed by conclusions and future work plans.

2. VISUAL WIKIS

2.1 Concept

In our previous work [8] we have explored several approaches that integrate *wikis* and *visualizations* in the domain of knowledge management applications. Both of these concepts have proven suitable for knowledge intensive tasks. Wikis, are suitable for knowledge management (as summarized in [5]) due to their ability to support authoring of dynamic knowledge. Human knowledge often exists in flows and can be described as a real time assembly of multiple fragmented memories [5]. A system that supports this kind of loose and ad hoc creation of content is

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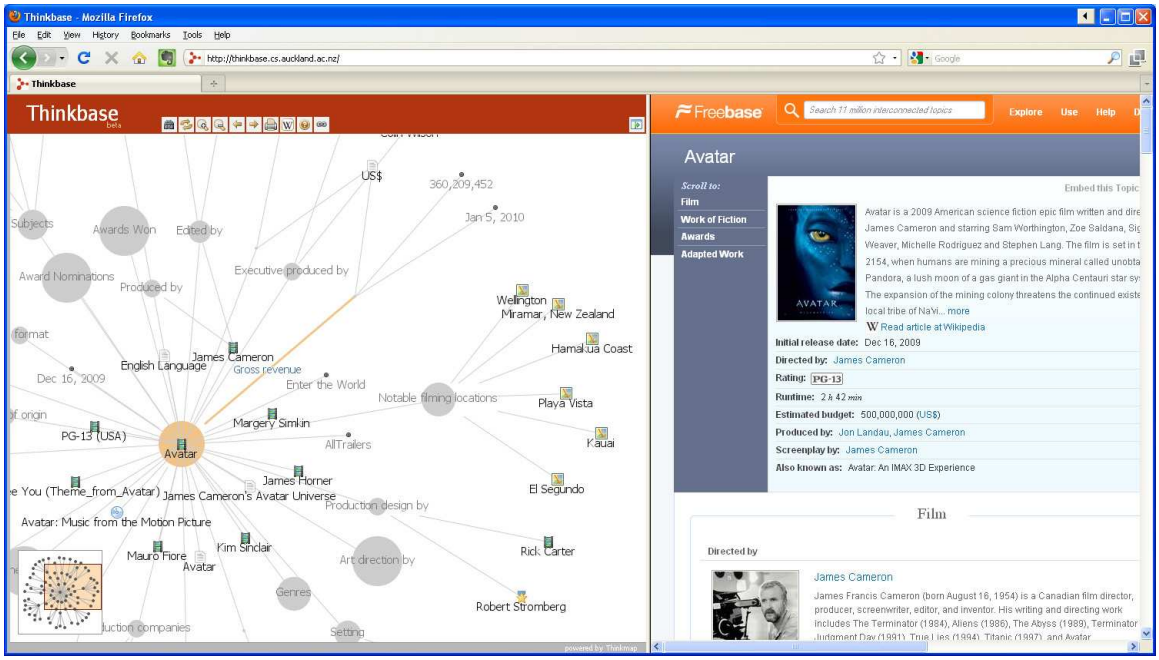

Figure 2. The Thinkbase user interface.

likely to capture knowledge adequately. Visualizations on the other hand contribute to knowledge management tasks by making use of the human cognitive processing system in order to create and convey content more efficiently. Visualizations are an alternative and very efficient way to represent and organize knowledge- and information-rich scenarios [4].

Combining these two approaches led us to a theoretical model describing what we call the *Visual Wiki* concept. A Visual Wiki is a web-application combining or integrating two representations (textual and visual) of the same underlying body of knowledge. Both or either of the representations may be editable in a shared, traditional wiki style. The purpose of a Visual Wiki is to increase the effectiveness of wikis as knowledge management tools, via visual enhancements. As shown in Figure 1, our Visual Wiki concept consists of four components: the underlying concept, the textual and visual representation, and a mapping between those two. Each component has a set of parameters.

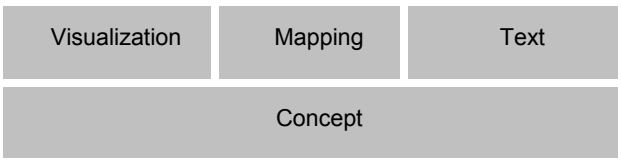

Figure 1. The four components of the Visual Wiki.

The *concept* component, which underlies all of the others, mainly describes the purpose and content of the Visual Wiki. The purpose could for example focus on tasks such as search and exploration, or creation of information. The content specifies the scope and type of information the application focuses on. The *text* and *visualization* components are similar. Both use a language to represent the content of the underlying knowledge base: a visual and a natural language. Our model e.g. describes those languages according to their complexity, their underlying model, and how they are manipulated. The *mapping* component determines how the two representations are linked together and how they influence each other. This includes e.g. the navigation behavior and how changes in one representation affect the other representation. A more thorough discussion of our Visual Wiki concept can be found in [8].

2.2 Visual Wiki examples

The purpose of our theoretical Visual Wiki concept is twofold. It can be used to analyze, compare, and discuss existing tools which fall under the category of the Visual Wiki. These range from applications which visualize specific properties of wikis (e.g. [14]), to applications which allow to collaboratively create and edit visualizations (e.g. [15]). More importantly it helps to design and implement new applications. We have developed a set of Visual Wiki prototypes which differ in some aspects of the theoretical model. In the following we will briefly discuss three of our prototypes to illustrate the Visual Wiki concept.

The first prototype, *Thinkbase*[1] [7, 8], is a visual navigation and exploration tool for Freebase[2], an open, shared semantic wiki of the world's knowledge [1]. Figure 2 shows the general user interface of Thinkbase (in this case displaying the movie "Avatar"). The application is divided into two frames. The right frame displays the current topic in Freebase. The left frame displays an automatically generated, interactive, force-directed layout graph of that same topic including all related topics. Each Freebase topic is represented as a node using an icon which corresponds to its type (e.g. person, movie, music). Edges between those nodes are annotated with the type of the relationship. These labels become visible when hovered by the mouse (eg "Gross Revenue"). Relationships with many particpants may be expanded (e.g. "Notable Filming Locations")

[1] http://thinkbase.cs.auckland.ac.nz

[2] http://www.freebase.com

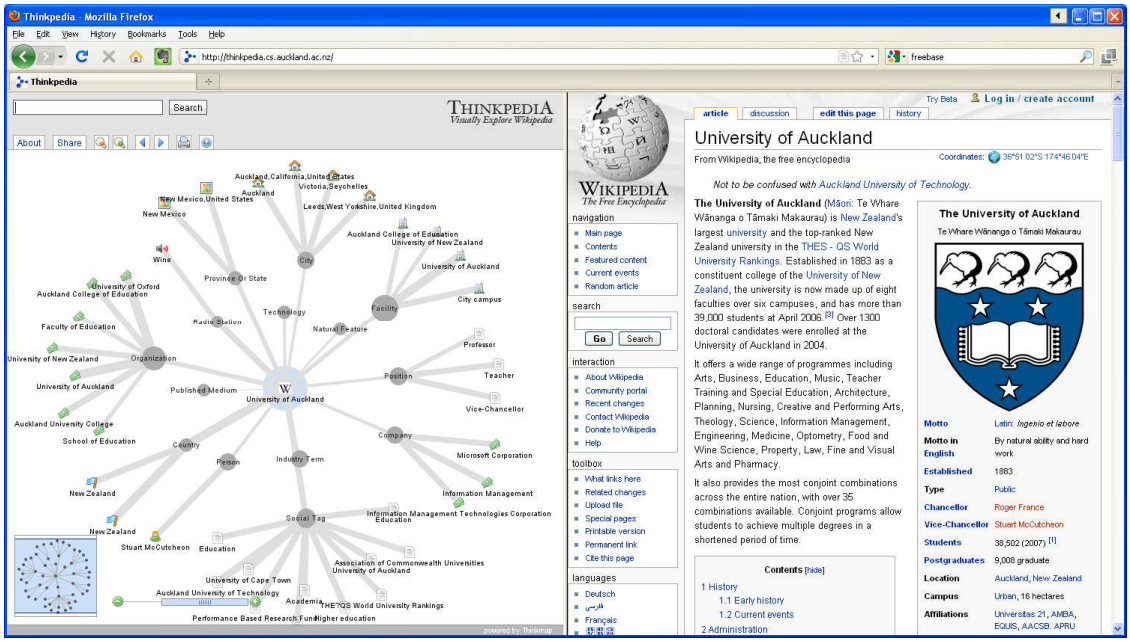

Figure 3. The Thinkpedia user interface.

or collapsed (eg "Art Direction By"). Clicking on a node causes that node's topic to be displayed in the Freebase frame and the force-directed graph is reconstructed from the perspective of that node. A variety of seach and filter mechanisms are also provided. The main purpose of Thinkbase is that of a navigation and exploration tool. Users can navigate along the graph, expand or collapse parts of it, and by doing so explore the vast content of Freebase. The "focus plus context" view, provided by integrating the two content representations into one interface, allows the user to focus on the details (in the Freebase view) while being able to keep track of the wider context and maintain a mental map (the graph view).

Our second prototype, *Thinkpedia*[3] [7], is a visual navigation and exploration tool for Wikipedia[4]. This application investigated creating a similar visual exploration tool as Thinkbase for a less structured knowledge space. This used the SemanticProxy[5] web service, which is part of the Calais initiative by Thomson Reuters, to add semantic features to the Wikipedia content. The SemanticProxy takes plain text or a URL as input, processes this, and returns the identified concepts and their relationships in a semantically enriched format. Figure 3 shows the user interface of Thinkpedia, which is similar in concept to Thinkbase, with graph visualization and Wikipedia frames. The width of the relationship lines provides an indication of the strength of the semantic mapping and an additional control allows filtering on this value.

The third prototype is *ProcessMapper* [8], a more domain specific visual navigation tool for business processes. This visualizes an interactive business process representation and maps it to a process documentation wiki. The visualized processes can be explored in a similar manner as the graphs in Thinkbase and Thinkpedia. However, they are based on BPEL and have a more refined model. Figure 4 shows the user interface of ProcessMapper with an example process on the left side (in this case a university enrolment process) and a search result within the wiki at right top and a linked webpage at bottom right. Web applications needed for process steps can directly be associated with nodes and opened in separate views. Thus, ProcessMapper allows for high level process exploration, while integrating detailed process documentation and process related applications.

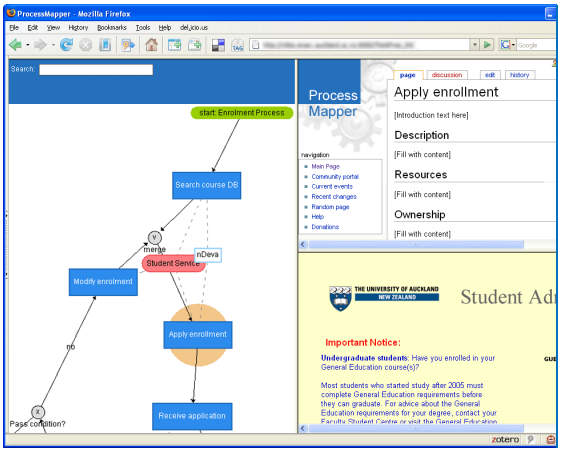

Figure 4. The ProcessMapper user interface.

As one can see the Visual Wiki concept can be implemented in many different variations. The variations are reflected in different design approaches (e.g. different visual languages, different types of mappings between the views), but also in different use cases and targeted user groups and settings. While Thinkbase and Thinkpedia target more general contents and user groups, ProcessMapper targets quite specific users and tasks.

[3] http://thinkpedia.cs.auckland.ac.nz

[4] http://www.en.wikipedia.org

[5] http://semanticproxy.com

3. THINKFREE

3.1 Motivation

The Enterprise Architecture (EA) Office at the University of Auckland governs the usage and communication of IT applications solutions and services used to satisfy business and educational needs of the University. The communications aspect of that role has been a challenging one, helping the enterprise understand the IT assets available and their inter-relationships.

The number and complexity of the latter mean that the Office has adopted an "EA as knowledge management" approach and trialed a variety of different approaches (e.g. wikis, various enterprise architecture visualization tools, and document management approaches) to managing and surfacing those knowledge assets. As with many large organizations, the development of a wiki culture (using Confluence[6]) has been predominant in achieving the office's aims.

The rapid adoption of this culture has, however, meant a large proliferation of wiki pages. The currently registered 1400 users (not counting a significant amount of unregistered users) have, since the introduction of Confluence about three years ago, created almost 90 wiki "spaces" and about 9000 individual wiki pages. In the last half year the wiki has grown the total number of pages by a factor of 1.25. While the number of spaces has increased by 1.31, the overall content grew by a factor of 1.51.

A number of shortcomings of the wiki solution have resulted. Due to the size and rapid evolution of the wiki knowledge base, it is becoming increasingly difficult for the casual University member to find information of relevance to them or appreciate its relationship to other important information, a result also noted by [2]. In addition, while a wiki culture has been rapidly adopted by the IT workers within the University, it is less popular with the more corporate members of the organization who are used to a more document repository based approach to knowledge management, as exemplified by SharePoint. Accordingly the EA Office was interested in complementary approaches that would provide the benefits of a wiki, but with features that appeal to other audiences.

3.2 Design

Looking at the shortcomings of the currently used approach for IT knowledge management at The University of Auckland, the decision was made to experiment with the Visual Wiki concept as a complementary approach. We designed *ThinkFree*, a visual exploration and authoring tool for high-level IT infrastructure documentation. ThinkFree aims to allow users to visually document, navigate, and explore IT assets and use this high-level visual information as a starting point to drill into more details in a textual view such as a wiki. From our experience with Thinkbase and Thinkpedia, we identified several key design features which seemed promising to overcome the shortcomings. These include:

- *Integration with existing tools*: As mentioned in our Motivation, one noticeable phenomenon while introducing the wiki for IT knowledge management was that not all users were willing to switch to a new platform. A crucial feature therefore was the ability to integrate ThinkFree with existing documentation tools, most notably the Confluence wiki, but also others such as Microsoft SharePoint. With this approach we hoped to overcome some of the problems inherent to the existing information silos, and make content more accessible and discoverable by providing a visually appealing and easy to use one-point-entry for much of the IT documentation.
- *High-level content visualization and navigation*: Another core design feature of ThinkFree is its high level of usability (e.g. responsiveness and self-explanatory used interface) as well as a sufficiently high level of content abstraction reflected in the visualization. As the intended audience is a mix of technical as well as more corporate members of the organization, the data model needs to strike the balance between useful but not too detailed content.
- *Focus-plus-context view*: As a fundamental design feature of our Visual Wiki concept, a focus-plus-context view is an important feature of ThinkFree. We aimed to achieve this by combining the previous two design features, high-level visualization abstractions and integration with existing tools. By doing this we aimed to permit a user (ideally *any* user) to navigate, explore and contextualize via the visual representation, while being able to drill into more details surfaced via the integrated applications such as the Confluence wiki. This feature should help users to better manage and explore large and growing information spaces.
- *Open collaboration mentality*: Similar to a wiki in general, we decided to provide open access (within the Intranet) as well as open editing functionality to our ThinkFree Visual Wiki. One of the main goals is to bring together several different collaborators and integrate their knowledge into one repository. Openness is therefore an important factor. The application's value will grow along with the number of contributors and the available content. Though we aimed to provide some structures for the data model, users would also be able to edit those. Lastly a transparent editing history and ownership is also part of the open collaboration approach.

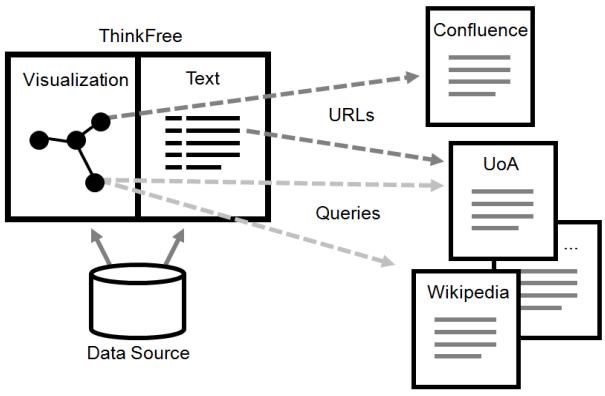

Figure 5. The ThinkFree architecture.

Figure 5 shows the basic design of ThinkFree. At its core it has similarities with our Thinkbase prototype but has a much more domain specific focus regarding the content as well as a set of integration features. We started with a fundamental data model, which allows users to describe high-level IT infrastructure entities and their relationships, such as "application", "database", "organizational unit", "business process", etc. This model was expressed in Freebase and instances of the model created as

[6] http:// http://www.atlassian.com

Freebase content. However, users are able to extend this data model to allow evolution of content and descriptions as corporate needs change. According to the Visual Wiki model this content is then made accessible in two different views: a visual and a textual one. The visual representation is purely based on the high-level content. The textual view integrates (as mentioned in our core design features) a set of web-based resources, such as the Confluence wiki, the university intranet and extranet, Microsoft SharePoint and other internally used applications, together with external services such as Wikipedia.

3.3 Implementation

One of the core components of ThinkFree is the interactive visual representation. We decided to use the Thinkmap visualization framework which we have also used for our Thinkbase and Thinkpedia prototypes. Thinkmap is a software platform for developing customized visualization interfaces. It consists of loosely coupled components which provide users the ability to retrieve a result set from data sources, and then visualize, navigate, and organize it. The Thinkmap Software Development Kit (SDK) provides ways to easily extend and adjust the suite as well as to integrate it with other web and database technologies [6].

Ideal for Thinkmap as well as our design requirements is a graph-based data model for the contents of ThinkFree. In an early version of ThinkFree (VBKE – the Visual Body of Knowledge Explorer) we used a relational data base inside which we created a graph-based data structure, as our data repository. However, there were several issues related to that approach, such as a high level of maintenance and low level of flexibility of the model. After realizing the advantages of using Freebase in the case of our Thinkbase application, we decided to switch to the Freebase semantic wiki as our data repository. Freebase provides a semantically enriched graph-based data structure, which can easily be set up, extended, and maintained. Being a freely available web-service, there are no high setup or maintenance efforts required. Using the different Freebase APIs we are able to easily read and write to the data source. Furthermore, Freebase allows setting up and modeling custom "domains" in which one has full control over the data model, its entities and relationships.

Figure 6 shows the default user interface of ThinkFree. As with our other Visual Wiki applications, it is divided into a graph view on the left side and a textual view on the right side. The graph view (implemented using Thinkmap) uses the Freebase API to access data in our custom data domain in Freebase and displays the entities and their relationships as an interactive force-directed

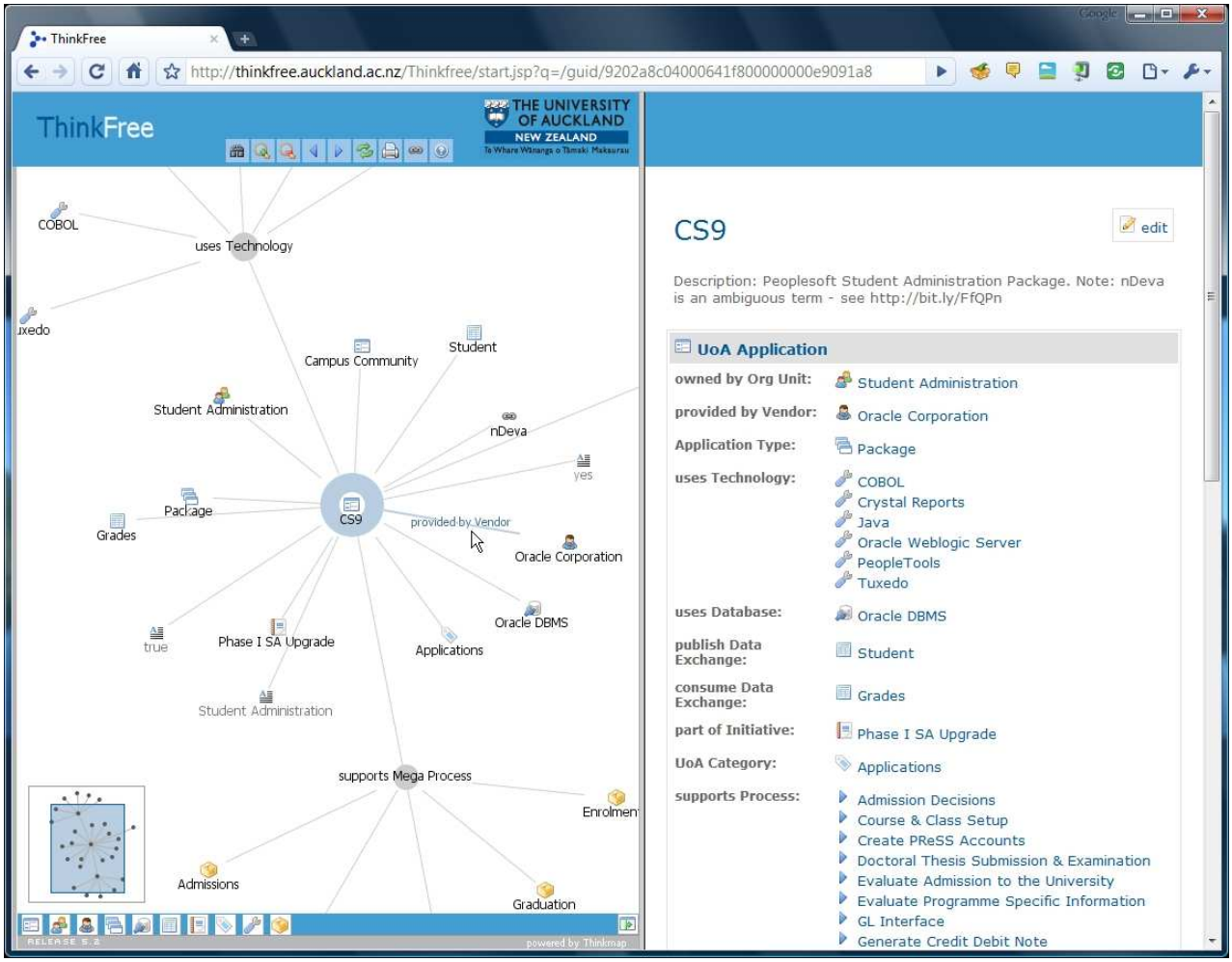

Figure 6. The default ThinkFree user interface.

graph. Our data model describes different IT Enterprise Architecture assets such as *applications*, *technologies*, *organizational units* as well as *process structures*, more abstract concepts such as *initiatives* and *objectives*, and many more. A subset of that model, shown as entities and relationships, can be seen in Figure 7. After retrieving relevant data from Freebase, the ThinkFree graph view (Figure 6) displays a selected entity as the center node and all related nodes in a graph around that center node. Nodes are displayed as icons (depending on their type, e.g. "database", "business process", etc.) and their title. If hovered over by the mouse, the edges display the type of relationship between nodes (e.g. "CS9 – *provided by Vendor* – Oracle Corporation"). Related nodes of the same type are grouped together using an aggregation node (e.g. the "uses Technology" connection in Figure 6). All nodes are interactive and can be clicked on in order to navigate and explore the contents. Navigation will result in a smooth transition and re-arranging of the graph.

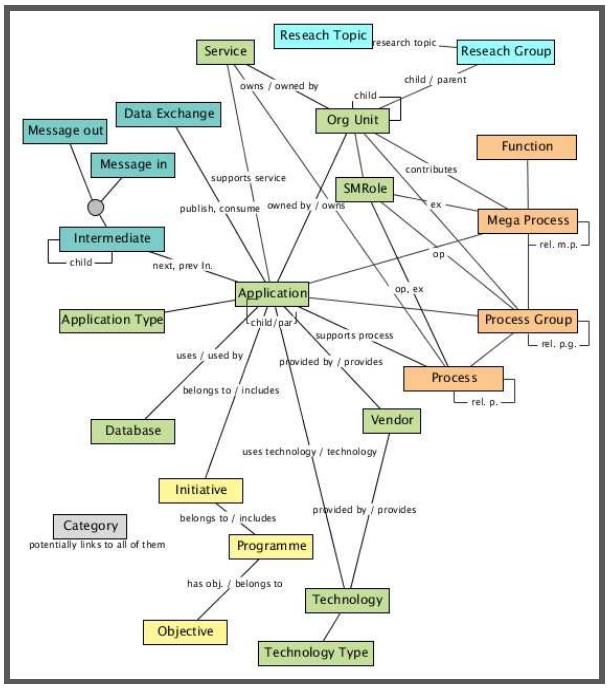

Figure 7. A subset of the ThinkFree data model.

By default, the text view on the right side displays a tabular version of the same contents as shown in the graph view, plus an optional short description of the current center node. If the user navigates using the graph, this text view will be updated as well. Likewise, the text view can be used to navigate along the related entities and will result in an update in the graph view. Once the data in our repository reaches a certain complexity, there are certain limitations to a graph representation. Thus, we have implemented several features to make the interactive graph visualization more useful and scalable to the growing amount of information captured in ThinkFree. Besides the already mentioned aggregation of nodes of the same type, the user can expand and collapse parts of the graph by using a context menu accessible from any node, and therefore is able to create customized and unique visualizations. We also provide different filtering mechanisms, e.g. nodes of certain types or nodes with a certain type of relationship can be filtered out. Filtering features are accessible either through a context menu or a menu bar at the bottom of the graph. Other features regarding the interaction with the graph view are: A collapsible search panel (as seen in Figure 8) which uses the Freebase Suggest plugin[7] and displays suggested topics while the user is typing; zooming and browsing history; a share function to share certain views of the graph (e.g. via Email); show and hide of labels; and a printing function.

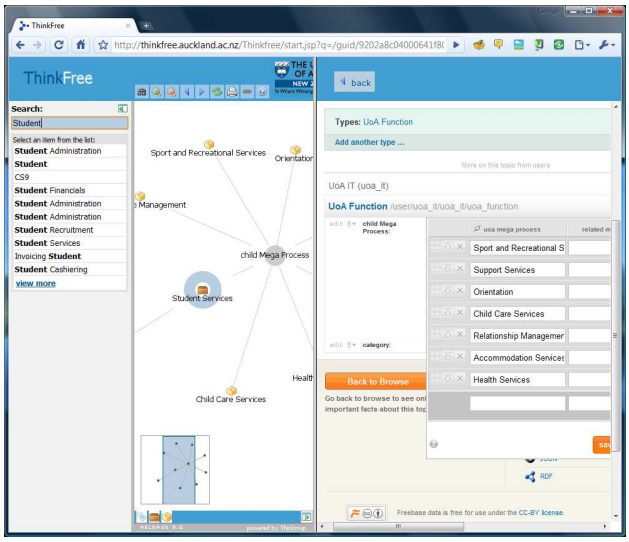

Figure 8. The Freebase editing interface.

Editing the contents can be done by clicking the "edit" button in any topic view. This will lead the user directly to an embedded Freebase interface, in which all the editing of existing and new entities can be taken care of. We are currently using the standard public Freebase interface for this. An example can be seen in Figure 8, which shows how the edit interface is displayed right inside the textual view. After logging in, users are able to edit and add new properties (relationships) to the active topic, they can add a descriptions of it, and create new topics. Once the changes have been made, they are immediately visible in the graph view.

An important design feature and one of the main motivations for ThinkFree is the ability to integrate the high-level visual representation of the EA assets with existing documentation tools which hold more detailed information. We implemented this with two different approaches: (1) Features to explicitly model URLs of the detailed resources and relate them to entities in the graph; and (2) features to implicitly trigger searches across several repositories and services from within the graph representation. These two methods are also shown in Figure 5. Explicit connections between high-level entities and low-level resources are made by modeling URLs directly in Freebase. An unlimited number of URLs can be associated with each topic (entity). In our ThinkFree application these URLs are converted to special nodes which can easily be identified by the user. The URL nodes can directly be selected which opens the respective wiki page, SharePoint page, website, or virtually any other web-accessible resource. Figure 9b shows an example in which an "organization unit" entity has been associated with a URL to a relevant wiki

[7] http://code.google.com/p/freebase-suggest/

page. A Confluence page, in this case about the Student Management Services division, is directly shown in the right frame. Using this as a starting point, users can now drill into the more detailed information shown in the textual view. As the context (represented in the graph view) of those details can now be better put into perspective, users are able to better preserve the "mental map" [12] of the knowledge space.

Implicit connection between the graph and low-level resources is achieved by providing different search mechanisms. Each node in the graph has a context menu. In addition to the previously mentioned filtering, collapse, and expand features, these menus allow the user to trigger a query with the title of the active node across a set of resources, such as the wiki, the University of Auckland website, as well as external services such as Wikipedia and Google. An example of a search across the University's website with the search results embedded in the text view can be seen in Figure 9a. In the current version of ThinkFree, most of the explicitly modeled connections are to the Confluence wiki, followed by connections to external websites and SharePoint sites. The implicit searches provide a further mean to explore and drill into related information. Together these features provide considerable value to our ThinkFree application.

In the current design and implementation of our application everything has to be modeled manually by the user. That is, none of the data for the graph is created automatically, e.g. automatically extracted from the Confluence wiki (an approach we have explored in our Thinkpedia prototype). We have deliberately chosen to not employ any automatic extraction techniques, as this would only reveal existing wiki structures. We have found our approach a good way to move away from the document metaphor (which is inherent to the wiki) to a metaphor of actual concepts (i.e. Enterprise Architecture assets).

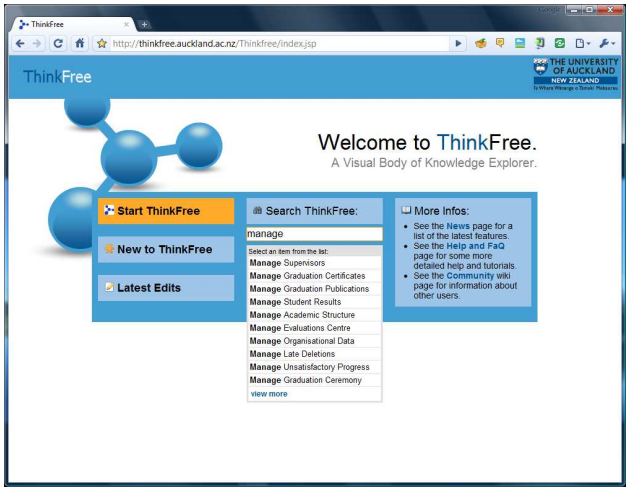

Figure 10. The ThinkFree start page.

In order to increase the usability of ThinkFree, and to foster a community of users, we have implemented several supportive functionalities. Some of them were inspired by feedback from our early users (as we will discuss later). The application's start page, as shown in Figure 10, provides new and novice users a good starting point. New users have easy access to introductions and tutorials of the tool. Novice users can dive right into the application or perform a search (which uses the Freebase Suggest plugin as well). Furthermore, users have direct access to other wiki resources, such as a News page reporting about the latest features and updates, a place to file bugs and feature request, and a community wiki page which lets users share their experience with ThinkFree, report what documentation they are working on, and see what other users are up to. Being able to see and trace back the activities of other users is an important part of the wiki approach. To provide this feature for our contents modeled in

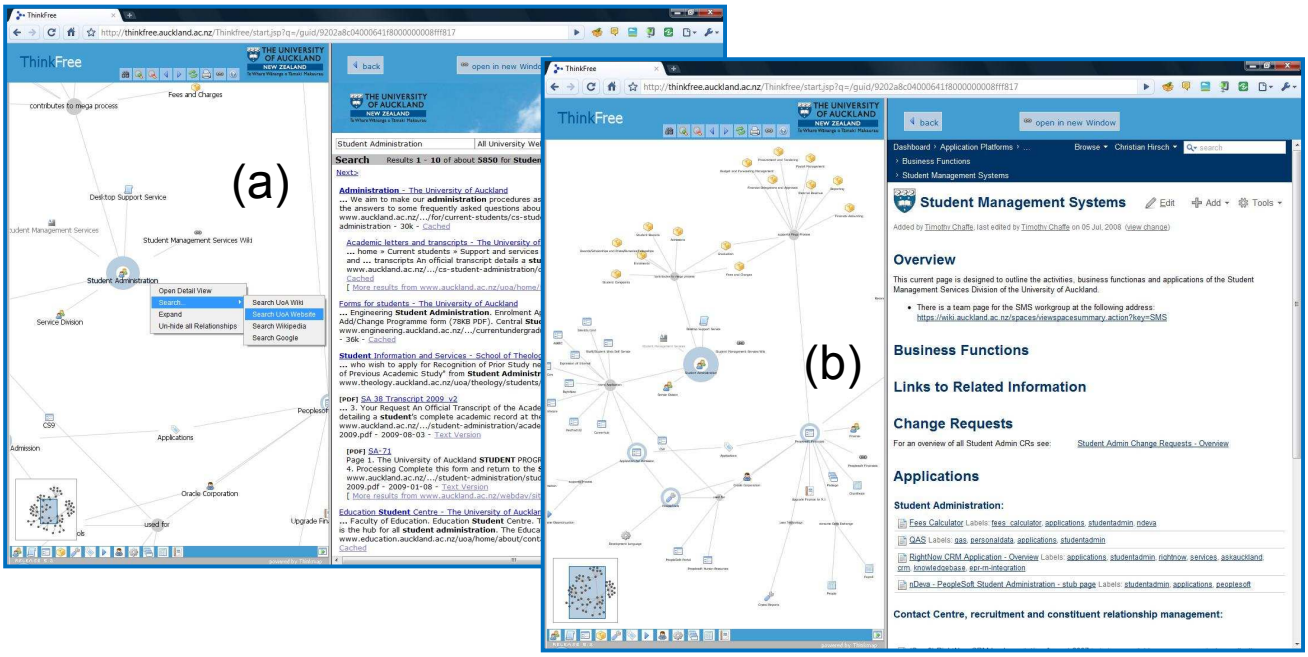

Figure 9: Integration of search results across the UoA website (a), and integration of the Confluence wiki (b).

Freebase, we have implemented an "edit history" view, which can be used to browse the latest edits, filter them according to type, and open the relevant entities directly in ThinkFree. The edit history view can be seen in Figure 11.

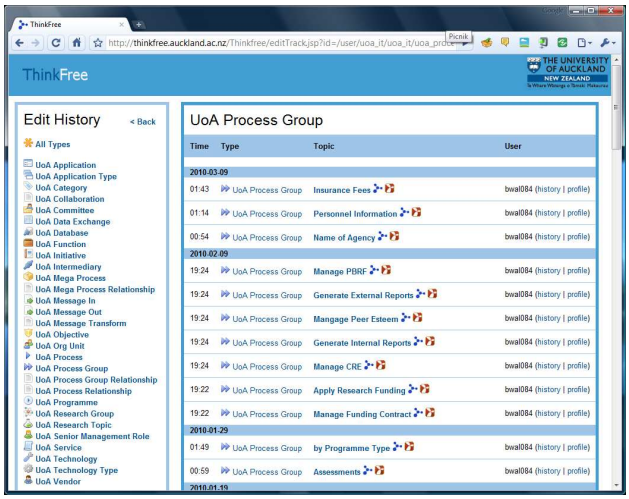

Figure 11. The ThinkFree edit history.

3.4 Roll-out

Most "Web 2.0" applications succeed on the basis of a bottom-up (or "grass root") approach. Once made available, social software such as a wiki or a social networking site will attract users or collaborators, and after reaching a tipping point the tool will become self-sustainable. This approach has been successfully replicated in many different applications (e.g. Wikipedia, Flickr, delicious). The somewhat counter-intuitive success of this approach, which relies on voluntary contributions, has been confirmed by several studies (e.g. [3]). It has been shown that amongst others the main motivations of the contributors are fame, fun, and sharing expertise with friends. None of the users' main motivations is financial rewards. The application of Web 2.0 tools in the enterprise setting ("Enterprise 2.0" [10]) poses some interesting challenges. No doubt there are similarities, e.g. the motivations for using Enterprise 2.0 tools, as pointed out in [3] are such as reputation building, team spirit, and community identification and not necessarily financial rewards either. However, there are quite considerable differences compared to public collaboration tools, most significantly scope and scale [9]. A different scope, e.g. more focused on certain business outcomes, might suggest using a more structured top-down approach. A much smaller scale, on the other hand, poses problems around reaching a critical mass of contributors. For example, only 2% of users in Wikipedia and Flickr contribute 60% and 95% of the contents [3]. A similar distribution in the enterprise setting would simply not be sustainable. As a result, in the Enterprise 2.0 much debate is around using a healthy mix between a top-down and a bottom-up approach (e.g. [11]).

During the roll-out of ThinkFree, we were facing a similar challenge of getting this mix right. In order to achieve a good balance we took the following approach. Our top-down approach plan was to first targeted specific key people (initially IT managers in the Services divisions) for training and education on the use of the application. The rationale was that by closely working together with those key users, we could (1) propagate ThinkFree with enough content to reach a critical mass, and (2) leverage the position and influence of those key users who would ideally spread the use of ThinkFree in their respective divisions. Our bottom-up plan was to develop several web resources, including tutorials and community wiki spaces, which would allow potential users to begin using the application by themselves.

ThinkFree was rolled out to a few selected users during the early stages of development (first half of 2009) in order to obtain early feedback, which we used to continuously improve the tool. After some initial tests, data modeling, feedback from early users, and subsequent improvements of the application, we rolled out a more mature version of ThinkFree and started promoting it to our target key users towards the end of 2009. Tutorials and workshops were carried out with IT managers (and/or their staff) of the Services divisions of the institution. This was usually done in separate sessions, such as a tool introduction and training, analysis of the tool usage in the different divisions (e.g. domain specific data modeling), and support in the actual content creation and editing. We also set up and maintained several wiki resources, including tutorials (in form of documentations, step-by-step user tutorials, and FAQs) and community wiki spaces which had the goal of making the usage of the tool more transparent (e.g. ownership and responsibilities of the different contents). An example of one of the tutorials can be seen in Figure 12. We also employed an open tool development process providing the possibility for users to report bugs, check status and latest features, suggest features and develop a close cooperation with the developers.

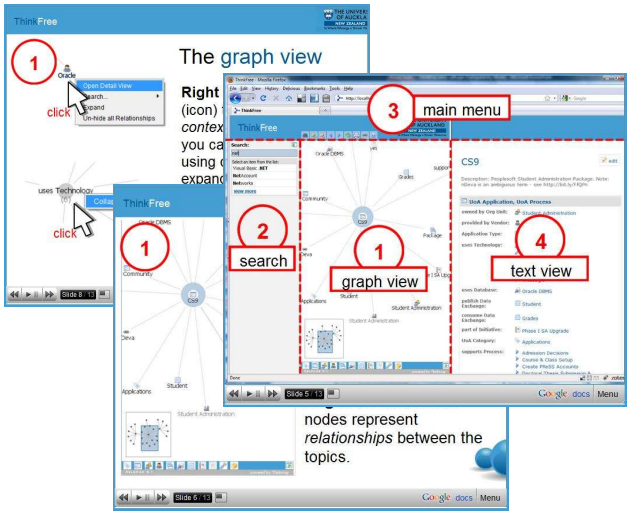

Figure 12. Tutorials used for user trainings

4. EVALUATION & DISCUSSION

As part of our previous work [8] we have conducted a qualitative evaluation of some of our Visual Wiki prototypes, including an early version of ThinkFree (VBKE). The evaluation aimed to find out, how the different versions of the Visual Wiki influence different knowledge management tasks. Our overall findings concluded that (not surprisingly) the Visual Wikis are most useful for tasks related to search and discovery. ThinkFree, in particular, stood out as being rated especially useful for organizing content (e.g. for re-arranging and editing existing content). These results gave us early encouragement, and together with the identified

shortcomings (e.g. tasks related to content creation were rated less user-friendly) we could focus on implementing ThinkFree in its current version.

Since the roll-out of ThinkFree towards the end of 2009, we have recruited several core users in the different Services divisions. Amongst them are around 10 frequent users, who have contributed most of the content to date. Although this might seem like a relatively small number we have been successful in substantially growing the content of ThinkFree with the help of these early adopters. Following this path we aim to achieve a critical mass, which will dramatically increases the usefulness of the application. In a period of six months, the amount of data roughly tripled from the 500 modeled entities with which we started, to around 1500 entities. More importantly, about 4000 triples (or facts, e.g. "PeopleSoft – provided by – Oracle") have been created by the users. Although, we would have hoped to gain more users, we believe several issues can be considered as possible reasons for this. First of all, it takes a considerable amount of patience for people to migrate over to a new way of working [11], and so we believe it will simply take more time to see a broader adoption of the application. A further aspect might be related to the maturity of ThinkFree itself. For instance the usability for certain tasks could still be improved, and we are working on those. Lastly, limited resources for both development as well as training of the tool restrict us somewhat in regards to a more rapid proliferation of ThinkFree. Nevertheless, we have been encouraged that our core contributors have seen enough value in using ThinkFree to have contributed the significant volume of material they have to date.

To understand this further, we conducted an anonymous survey among the core contributors of ThinkFree and asked them about their work habits related to documentation tools in general and their experiences with ThinkFree in particular. All participants reported that they use many different information management and collaboration tools during their daily work, including the Confluence wiki, SharePoint, as well as other tools (e.g. local files plus Email). In respect to ThinkFree, all of them stated that they used it on a regular basis (ranging from weekly to monthly) for both editing as well as browsing/searching of information. Some participants stated that they will probably use the tool less frequently once most of their contents of interest have been modeled, indicating their motivation is primarily to use the tool to communicate with their own constituents. Advantages of ThinkFree, as pointed out by the participants, re-confirm the major design features of the application: Most importantly, the "visual representation and incredible flexibility [of modeling information] are powerful tools in understanding relationships". Furthermore, "the ability to create relationships between information" combined with the focus-plus-context view, "which allows you to drill down from [those] high level topics to specific details", has been pointed out as very useful. Users state that ThinkFree "looks good and it is easy to search for information" as well as "easy to maintain and update" the content. Disadvantages of ThinkFree, as reported by the participants, are related to the accessibility and transparency of the tool. Users are concerned that, due to the open access mentality, it will be hard to keep track of changes, and that the responsibility and ownership of contents are not sufficiently accessible, a common tension in corporate knowledge management approaches. A further reported shortcoming is the growing complexity of the data schema, of which users need to have a "good understanding [in order] to know where to add things". Related to that, are suggestions to improve the editing interface, in order to e.g. make it more transparent what contents (entities) are already created. This will reduce the amount of redundant contents as well as improve the usability. Lastly, participants state that in order to be really useful, ThinkFree needs to be more widely used and more widely contributed to.

5. CONCLUSIONS & LESSONS LEARNED

We have introduced *ThinkFree*, a corporate Visual Wiki application which aim it is to improve the way end users explore knowledge of IT Enterprise Architecture assets that is documented in a large enterprise wiki. Motivated by the difficulties users were facing managing and navigating a growing corporate wiki, we designed and implemented ThinkFree. The application provides graph based interactive visualizations of enterprise architecture assets and integrates those with the corporate wiki and other information management tools. This integral approach together with a focus-plus-context view and an open collaboration mentality allows users to collaboratively author high-dimensional, visually appealing knowledge representations and link those back into existing low-level information repositories.

We have described our mixture of a top-down and bottom-up approach to the corporate rollout, and the current status of it. Following a brief analysis of the user statistics and a survey amongst core users of ThinkFree, we conclude that the rollout so far has been somewhat slow but successful. Reported strengths of the application relate to the fundamental Visual Wiki concept, such as easy to use and navigate visual representations of high-level information and their inter-relatedness, and the ability to drill down from those to specific details. Weaknesses of the current ThinkFree version are usability issues with certain specific editing tasks as well as the level of editing transparency and ownership clarifications.

Lessons learned during the design, development and corporal rollout divide into those regarding technical issues, and those regarding more human related issues. Technical issues include lessons about the experience with a corporate wiki in general as well as lessons about the design choices and implementation of the ThinkFree Visual Wiki in particular. As described in the Motivation section, the EA Office at the University of Auckland has adopted an "EA as knowledge management" approach to managing IT knowledge assets, and is predominantly using a corporate wiki for achieving this. Due to a rapid growth of the wiki knowledge base and the increasing difficulty for the casual user to use it efficiently, it was realized that there is a need for a more structured approach. The following lessons which we have learned in respect to ThinkFree as a knowledge management tool are worth pointing out: (1) Simplicity is important: The more diverse the user group of an application gets, the more important it is to keep things simple. In the case of ThinkFree, this principle is true e.g. for the user interface and the resulting user experience. Furthermore, it is also true for the complexity of the data model. We have found the process of making decisions about an appropriate level of detail for the data model to be a crucial part during the early phase of content population, and a relatively simple model was almost always favorable. (2) Integration and reuse make things easier: As described in the Implementation

section, in an early version of ThinkFree we used a local database as our data repository. This approach had several shortcomings and a switch to an external service (Freebase) which better supports our data model and provides authoring features was a favorable alternative. The utilization of a visualization framework (Thinkmap) as well as the integration with our existing information management solutions helped us to avoid re-inventing the wheel. Having said that, investing time and resources into a customized In-House solution, which brings together the mentioned applications, seems to be worth doing. (3) Release early: Releasing ThinkFree early and gradually during the development process (first to small user groups and then to a wider audience) has been very useful in identifying issues and working on those in close cooperation with the users. (4) Looks count: a visually appealing look of an application should not be underestimated. Even in the early phase, when it was still lacking some features but already had a responsive and appealing user interface, ThinkFree's value could easily be demonstrated to potential users.

More challenging issues are those related to human issues. Lessons learned in that area are around the rollout of ThinkFree, the process of training people in the use of the tool, and the progress of users switching to the application. Reactions of potential users to an introduction of ThinkFree were often mixed. While many users could instantly see the benefits of the application and were very keen to try it out, others reacted more skeptically: not necessarily disliking the tool, but seeing it as another tool they would have to learn how to use. While the former reaction tended to come from the younger employees, and the latter from the more senior ones, it is hard to draw conclusions about this correlation. Regarding our mix of a top-down and bottom-up approach it has become clear that there might be more potential in the top-down approach, i.e. it has to be clearly communicated by the management, what the desired outcome and expected input from the users is. Nevertheless, we have been successful in recruiting several key users to populate the repository and first synergic effects can already be observed as the contents of different service divisions become more and more connected. As McAfee suggests, finding these "pockets of energy, highlighting them, discussing them, [and] showing the good stuff that emerges" [11] is a good strategy to get started. However, as observed by one of the participants in our evaluation, ThinkFree "is a great tool, but to be of real use it needs to be more widely used with many more contributors."

6. FUTURE WORK

Our future work will concentrate on improving the features and the usability of ThinkFree as well as making the adoption of the application more successful. We will work on overcoming the identified technical shortcomings (see Evaluation section). This includes an implementation of a customized editing interface for the contents in Freebase; some improvements to the currently implemented edit history view (see Figure 11) such as automatic change notifications; and implementing additional and differently structured views to better understand and appreciate the growing amount of content. In order to improve the adoption within the workforce, we are planning to continue our current approach of identifying and training key users (the "pockets of energy"), work in close support with them, and use their contents as show cases in order to attract further potential users.

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