Model to Support Patent Retrieval in the Context of Innovation-Processes by Means of Dialogue and Information Visualisation

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Abstract: Innovations are an essential factor of competition for manufacturing companies in technical industries. Patent information plays an important role within innovation-processes and for human innovators working on innovations.

Innovation-processes support the combination of cross-organisational spread information and resources from patent databases and digital libraries is necessary in order to gain profit for innovation experts. The central challenge is to overcome the current information deficit and to fulfil the information need of the experts in the innovation-process.

Classical information retrieval (IR) research has been dominated by the system-oriented view in the past. A user formulates a query and then evaluates the elements found through the query according to their relevance. But this rather static setting does not always correspond to the communication and interaction needs of humans. IR systems should explicitly support also the cognitive abilities of the users in order to realize a dynamic dialogue between the user and the system. An information dialogue which does not only support an individual query but also the complete search process is necessary. Only in this way is it possible to satisfy an information need and support the innovation-process.

In this paper we present in detail three innovation scenarios to highlight the challenges of advanced information systems, query reusability and result visualisation. By defining the essential activities and conditions of a search task, it is possible to develop user interfaces which offer assistance in the form of a connection of dialogues. From this we derive the elementary information sets and activities in the next step. An example illustrates the applicability and utility of the innovation scenarios described and shows how the activities satisfy the user's information dialogue context. As part of the example we apply a cognitive walkthrough on a patent database. Aiming for an implementation of Daffodil-System we will benefit from these results.

Keywords: information retrieval, innovation-process, interactive systems, patent retrieval, result visualisation, information visualisation

1. Introduction and problem description

Innovation seeking enterprises can no longer rely on products created by accidental creativity or by isolated ingenious inventors hunting for ideas. Novel technical solutions are a competition factor and essential for entrepreneurial success (Grabowski & Paral 2004).Therefore companies want to create new products systematically (Grabowski & Paral 2004) considering restrictions of time and costs, while increasing product quality ((Bullinger 2006), (Völker et al. 2007)). Systematic development of unique products demands innovation-processes providing all available and relevant information. A current information deficit in patent retrieval as apart of innovation-processes is emphasised here as a significant challenge.

Innovation-processes: Are defined sequences of activities with the goal to development new products (Vogel & Hemmje 2007). Innovation-processes help to structure activities systematically, e.g. in a chronological order of work. Advantages of innovation-processes - for human experts - are reproducibility of single activities, sequences and the whole innovation-process. ((Vogel & Hemmje 2006a), (Vogel & Hemmje 2006b)) introduced the concept of master innovation-process and related innovation-process instances as part of the research field *Knowledge-Based and Process-Oriented Innovation Management (WPIM).* Thereby, in a first step the master innovation-process is defined and enriched with available and useful documents as patents, check-lists and templates In a second step the Expert will instantiate the master innovation-process for each new process cycle especially used for incremental and follow-up innovations. Documents can be reused and also templates and check-lists can be filled and filed. To profit from ideas and unique solutions, patents are used to claim and protect intellectual property rights (Bullinger 2006). Applications for patents are the closing activities in an innovation-process. When innovators (generally, a large number of experts across different domains, e.g. engineers, scientists, developers and patent attorneys) work on innovation-process activities (patent research or analysis of available products, etc.), they need to extract valuable information within their company from distributed databases of different file types

Reference this paper as:
Landwich, P. et al. "Model to Support Patent Retrieval in the Context of Innovation-Processes by Means of Dialogue and Information Visualisation." *The Electronic Journal of Knowledge Management* Volume 7 Issue 1 2009, pp. 87 - 98, available online at www.ejkm.com

and formats. Innovation-processes become more and more cross-organisational, often with suppliers´ and customers´ experts as corporate partners supporting collaborative development and creation of novel products (Meixner 2003). (Völker et al. 2007) provide an overview of knowledge sources for innovation-processes and state, that next to company internal knowledge, external knowledge sources adopt a significant role, e.g. knowledge of patent agencies, research facilities, federations and associations.

Classical information retrieval: Innovating experts have to retrieve information from external information sources, e.g. external data memories and digital libraries, which are often only accessible by proprietary text-driven search services. Many times, the difficulty for experts in technical industries is due to a lack of information caused by impenetrable information, difficult search mechanisms and insufficient result visualisation. Information that is unavailable or not utilizable may cause prolongation of development time lines and time-to-market. Information as a result of information retrieval and patent research is a key-resource and also a determining factor of successful innovations.

After this Introduction, in the second section innovation scenarios are used to point out information needs of experts working on innovations. These scenarios have been identified in high-tech manufacturing industries where process stability and reliability is a must, not only for production but also for innovation. From these needs, challenges to advanced information systems like query reusability and result visualisation are derived. Section three gives an overview of innovative search with related work in the fields of information and patent retrieval. In section four we present our understanding of an information dialogue and retrieval mechanism (with elementary information sets and activities) and offer a cognitive walkthrough. In the final section, we provide an outlook on future information retrieval systems.

2. Innovation scenarios and resulting challenges for patent retrieval

Innovation experts who are involved in structured innovation-processes complain about information deficits. They know which activity or process-phase has to be done next, but the required information and documents are not obvious or available in a simple step to them.

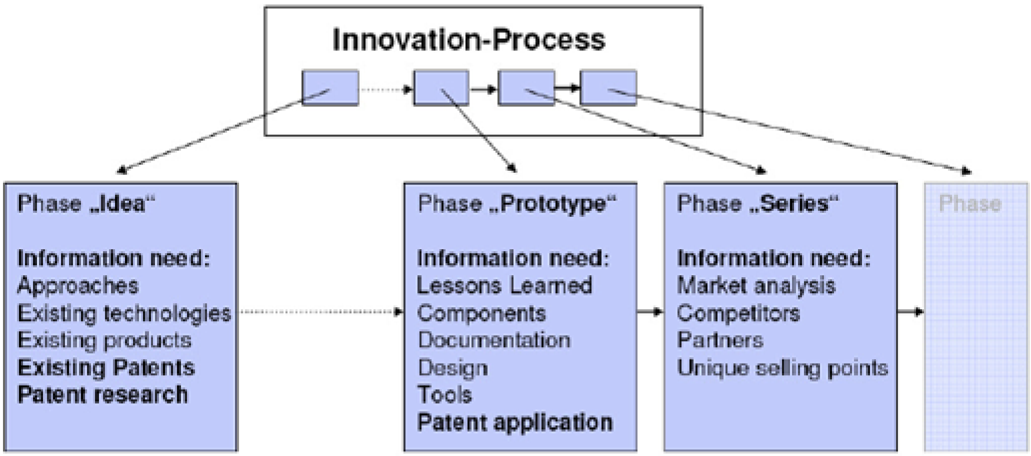

Figure 1: Phases-driven innovation-process with certain patent information needs

Following scenarios within innovation-processes point out information needs of experts inside companies, but also cross-organisational. Each scenario description explains goals to be fulfilled by process-oriented approaches and is used to derive challenges on information retrieval, especially challenges in patent retrieval, retrieval mechanisms, query entering, information access and information visualisation.

2.1 Interfaces for information need description and query reusability

Experts working on innovations will start to analyse existing patents to figure out, which claims already exist and which solutions are available, free of charge or even under license. On one hand, there is patent information available in patent databases; on the other hand there is a need of information by experts.

- How to make experts´ lack of information and patent information overloads match?

The goal is to combine information supply and information demand. Experts seeking information have to externalise and formulate questions or keywords.

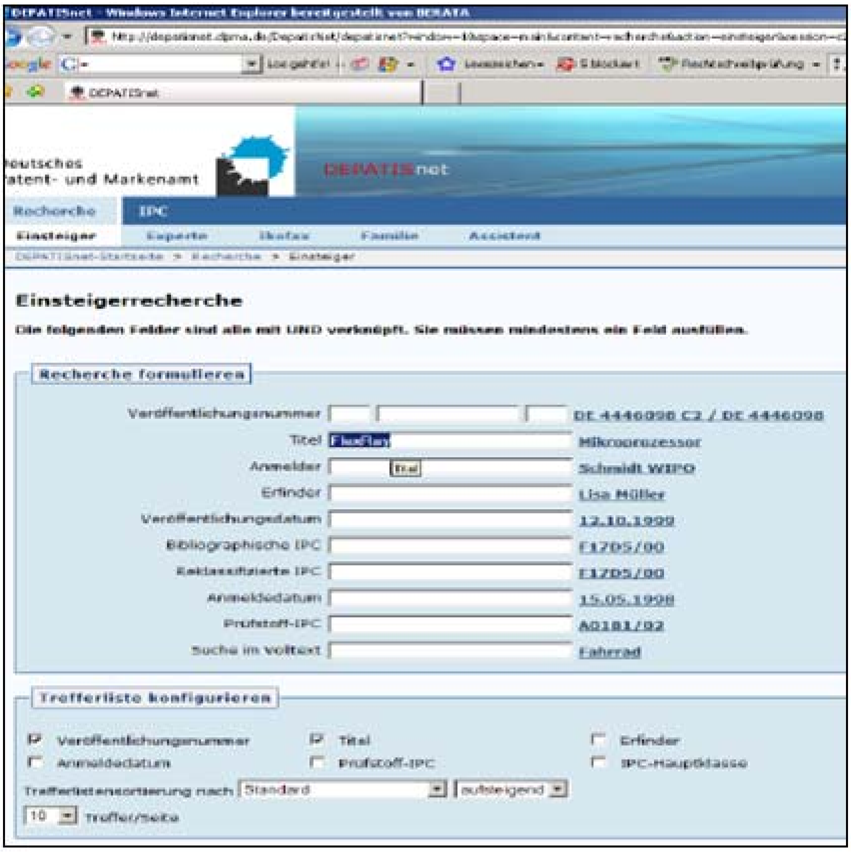

Figure 2: Conventional text-based patent search dialogue (http://depatisnet.dpma.de)

They have to describe their informational needs. Furthermore they have to formalise and construct a syntactically correct query to feed text-based user interfaces of patent search engines.

- What happens if the search results are neither matching nor satisfying?

Usually experts enter complete new queries or combinations of last tried keywords. How about using similar keywords with different syntax or abbreviations? How about synonyms and keywords in different languages?

Incremental innovation-processes ((Meixner 2003), (Grabowski & Paral 2004)) are used to force innovations in discrete time steps. These processes are for example used to enforce continuous development and improvement of technical products, e.g. (next generation) electronic control units for vehicles (Vogel & Hemmje 2006a). So in discrete time, engineers will restart text-based search by using same or similar queries.

- Would it make sense to save, provide and reuse search queries for the next search?

For advanced informational retrieval systems it is a challenge to setup simple, interactive and self-describing user interfaces to reuse query.

2.2 Collaboration on innovation due to combination of external information

In inter-organisational innovation-processes different companies can collaborate on innovations. Manufacturing companies in technical industries demand their business partners, e.g. customers and suppliers to contribute initial ideas to innovative products. But also cooperation and collaboration with research organisations, patent agencies and scientific communities are common.

- The goal is to combine external knowledge with ones own business model aiming for unique innovations.

In such a collaborating environment, so called innovation-network (Queitsch & Baier 2004) experts believe an information deficit and an information need to understand the field of work their cooperating partners are specialised in. If necessary, manufacturing companies are willing to pay a license fee to cooperation partners or patent owners. An example is the *CAN-Bus* (http://www.semiconductors.bosch.de/en/20/can/index.asp) technology, a patent hold by Robert Bosch GmbH. Most car manufacturers pay for using *CAN-Bus*. A further example for collaborating on innovations is the *Night-Vision* (http://www.bosch-nightvision.com) project, developed in cooperation between Robert Bosch GmbH and Daimler AG ((Vogel & Hemmje 2006a), (Vogel

& Hemmje 2006b)). Future solutions in automotive bus technologies will be under *FlexRay* (http://www.FlexRay.de) licensing.

Collaborating partners share their ideas, documents and patents. Thereby it is challenging to access and retrieve information from external databases of cooperating organisations.

- How to fetch information, e.g. FlexRay patents from a patent agency database and FlexRay specification documents from FlexRay webpage in a single step?

Information seeking experts want to receive a single, combined result set of one query, containing information retrieved from spread external information sources as digital libraries, distributed patent collections and the web.

2.3 Innovation experts expect advanced result visualisation

An activity within innovation-processes can be research inside a patent database before applying and claiming an own patent (Vogel & Hemmje 2006b). Intention is to figure out related fields of innovation and existing claims. Today's patent retrieval services as *DEPATISnet* (http://depatisnet.dpma.de) present retrieved results text-driven, as an index or a list. Text-based representations confuse experts, because even in unstructured lists, results at the top line are interpreted as results of higher match or value. Also too many matches and a flood of results make humans feel lost in information.

- Innovating experts and engineers need a self-explaining presentation or visualisation of retrieved search results.

Also retrieval experts receive patent text based results while using conventional expert search engines.

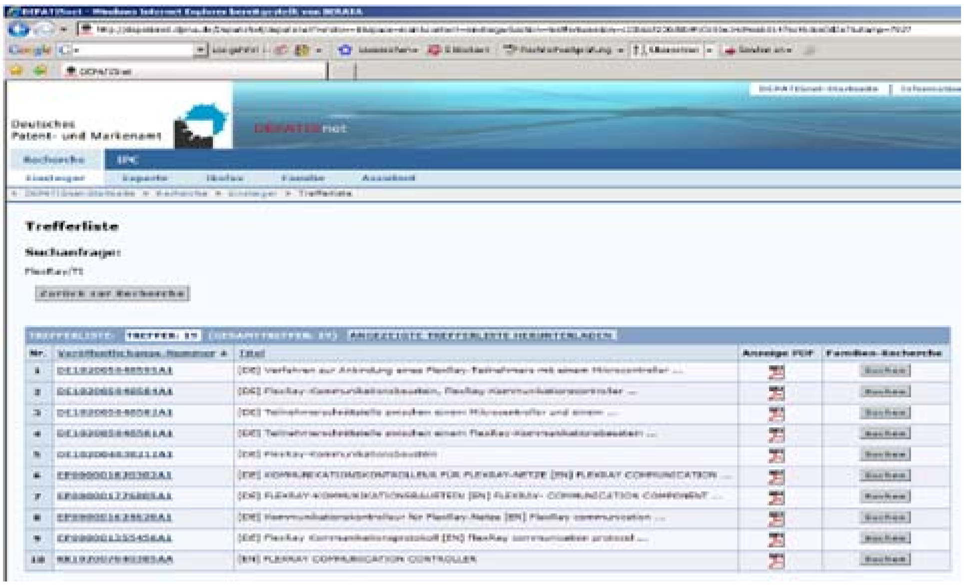

Figure 3: Search results conventional text-based (http://depatisnet.dpma.de)

When patent officers receive a new patent application they check if demanded claims are already reserved. In order to find patents from same applicants it can be helpful to search the patent database by (sets of) inventors' names. Retrieval experts should be supported in storing, integrating and combining different retrieval sets by result visualisation.

These three scenarios exemplify the central challenges in patent retrieval within innovation-processes. To support experts on innovations advanced retrieval mechanisms, query reusability, interactive interfaces and result visualisations are demanded.

3. Innovative search

The challenges to patent retrieval are incentive to investigate possible innovations of information retrieval systems. The goal is a conceptual framework for interactive patent retrieval that goes beyond the text-based Boolean retrieval. The design of the user interface has to satisfy the communication and interaction needs of the users. Therefore interactive functions that allow the user to describe information needs and transfer these needs into a query must be offered. Using appropriate visualisation tools, the perception and analysis of the information-objects and the context can then be supported in order to advance the iterative process of the search further. It is on this occasion important to capture the entire search-process with its elaborated context and to represent it if necessary. On this basis, strategic support can then be offered to the user.

3.1 Related work

Cooper (Cooper 1971) has already established specific measures for the quality of information systems based on relevance and usefulness. The aim of increasing not only the relevance but also the usefulness of results was presented in the information behaviour model by Wilson (Wilson 2000), which opened two related fields of research. The first went in the direction of user interfaces of information systems and the second in the direction of information visualisation.

Visual presentation, perception and cognitive interpretation of information were considered for a long time (Larkin & Simon 1987) as an efficient communication method for informational situations. For this purpose tools were developed which visualise the exploration by means of query construction and (re)formulation (Schaefer et al. 2005) and the result presentation ((Komlodi et al. 2006), (Davis 2006), (Harper & Kelly 2006)). In consequence visualisation is not only representation but also stimulation for interaction and dialogue. First approaches in this direction were implemented and studied e.g. by the *LyberWorld* (Hemmje et al. 1994), *VisMeB* (Müller et al. 2003) and *prefuse* (Heer et al. 2005) systems.

Hemmje (Hemmje et al. 1996) was motivated by the leading thought for the support of dialogue when he introduced a cognitive model of the information dialogue and a model of an interactive information visualisation cycle supporting an IR dialogue (Hemmje 1999). Landwich (Landwich et al. 2007) took up this approach and introduced a cognitive enhanced model of IR which led to a model for visually direct-manipulative information retrieval dialogues

In order to optimise information systems, models in which the human users are not only a part of the system (e.g. providing only input) but also become an important component of the system and even its centre respectively were developed. Kuhlthau (Kuhlthau 1988) investigated how information seeking and corresponding access can be understood. In consequence cognitively oriented models and approaches to support the concept of information seeking were introduced. Information need often changes during a seeking process due to changes in user awareness, the understanding of the concept of information access was extended and with Belkin (Belkin et al. 1994) the first so called information strategies were identified and investigated. Many other works ((Pharo 2004), (Rose 2006), (Xu 2007)) showed the complexity of the information search and their activities.

All introduced research areas flow into the design of user interfaces. Different works ((Klas et al. 2005), (Resnick & Vaughan 2006), (Davis 2006)) investigate this problem and examine the challenges for the optimisation of the human being-computer-interface.

4. Formal description of the information dialogue in order to develop a framework

Results of existing research have been used to design user interfaces. This has resulted in user interfaces not being practicable. As Thimbleby (Thimbleby 2007) wrote: "Most user interfaces are unknown, in that they have grown from adding features.... Instead, *build simple, explicit interaction frameworks* to lay the foundation for clear interaction structures." Keeping this basic principle in mind allows us to focus on the core element of interfaces the dialogue.

Landwich (Landwich et al. 2007) showed that the dialogue is extracted from the information dialogue context, as the basis for managing and coupling the states of e.g. the database management system or the retrieval engine in their consecutive operations. It supports users in reducing their expressed uncertain state of information need.

In order to receive a first simple, explicit interaction framework we analyze the basic elements of the dialogue of IR-systems. In doing so, we have to ask ourselves the following questions:

- What are the possible activities?
- How do activities affect our information dialogue context?

To answer these questions, we have to describe the different sets of information objects which are present, as well as those that could be created in sequence of activities. Furthermore we provide a formal description of the activities.

4.1 Scenario and possible sets of information objects

In order to clarify the definitions, we outline a scenario within a virtual patent database. In this database we find a large amount of patents. So we define:

Content set: Let *O* be an information object, e.g. digital patent. Then the content set *C* of a data source a user has access to, is the set of all contained information objects.

On the other hand a certain number of patents exist, that would help us to solve our information problem. But these do not have to be contained within the database.

Interest set: The interest set *I* exists as a set of concrete information objects which are able to reduce an information deficit. For the simplification we assume *I* is constant.

So the set of available and relevant articles is defined as

Relevance set: The relevance set *R* derives itself from the intersection of the contents set *C* and the interest set *I*.

In search for relevant articles, we access the database and a result set is returned as an answer.

Result set: For a query *q* onto the data source we receive the result set r_q which is a subset of the contents set *C*.

Figure 4 illustrates the targets of our formal definitions by means of a single query so far.

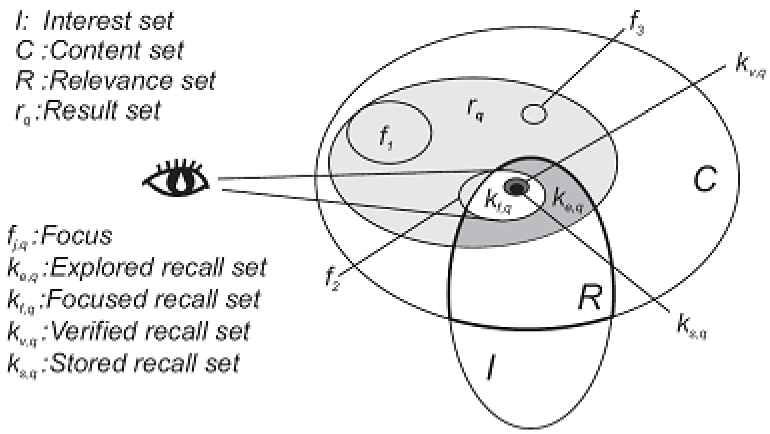

Figure 4: Dialogue state after a first explorative query

4.2 Cognitive walkthrough and possible activities

We employ the cognitive walkthrough method for a first usability inspection. Aiming for an implementation of Daffodil-System we will benefit from these results.

Beginning with the defined sets (see 5.1) we start our seeking process. The user has to find a specific article to satisfy his information need. With the walkthrough we want to introduce the activities EXPLORATION, FOCUS, NAVIGATION, INSPECTION, EVALUATION and STORE.

In our simulated search the user is looking for a specific patent, but he is also interested in patents which deal with the same research field. He starts a first query with some keywords. With this starting point the first activity EXPLORATION is started.

1. EXPLORATION: The access to the content set *C* in the form of a query *q* and the visualisation and realisation of the produced result set r_q defines the EXPLORATION. A change (e.g. an enlargement) of the informal context is caused by this EXPLORATION.

   For this first query, the result set r_q contains many information objects. But only a certain part of r_q will be a part of the interest set *I* and is defined as the

Explored recall set: The intersection of the result set r_q of a query q and the interest set I defines the explored recall set $k_{e,q}$

Due to the size of the visualised result set, only a part of the articles can always be captured cognitively. For this we define:

2. FOCUS: The focus set $f_{n,q}$ represents the subset of information objects O_i of a result set r_q which reach the field of vision of the user through a visualisation and is the result of the activity FOCUS.

   If there are relevant information objects within the focus set we can define:
   Focused recall set: The intersection of the relevance set R and the focus set $f_{n,q}$ defines the focused recall set $k_{f,q}$

In order to identify elements of the explored recall set $k_{e,q}$, the user will scroll through the result list and consider single articles in detail. These activities are defined as:

3. NAVIGATION: The movement within a set of information objects (information room) or between different information rooms. This causes a change of the focus $f_{n,q.}$

Our user remembers, that he is looking for patents which are published in the year 2006. For this he resorts to the result set, which also causes a change of the focus. This is also a NAVIGATION activity. When the user finds information objects of interest, he will try to get more detailed information about these articles. This activity is called:

4. INSPECTION: INSPECTION is used for the cognitive determination of the state of an information object.

In the database the user can open the summery of an patent and also open the full text. Following the INSPECTION the user himself classifies the information object referring to his assessment of relevance. This activity is defined as:

5. EVALUATION: EVALUATION gives the system a feedback of the user's understanding of relevance and appoints the verified recall set.

   Verified recall set: Within different INSPECTIONS the user identifies relevant information objects. This set of information objects is defined as the verified recall set k_v for this query.

6. STORE: This activity allows the user to store found documents. It either happens logically in form of a storage box on the user interface or physically when a document is downloaded or printed.

   Stored recall set: The stored recall set $k_{s,q}$ represents the subset of information objects O_i of the focused recall set $k_{f,q}$.

Even if the user can browse in a result list, the user will not always find a result due to a potentially large quantity of found patents. The user will be forced to rephrase and run more queries to narrow the search.

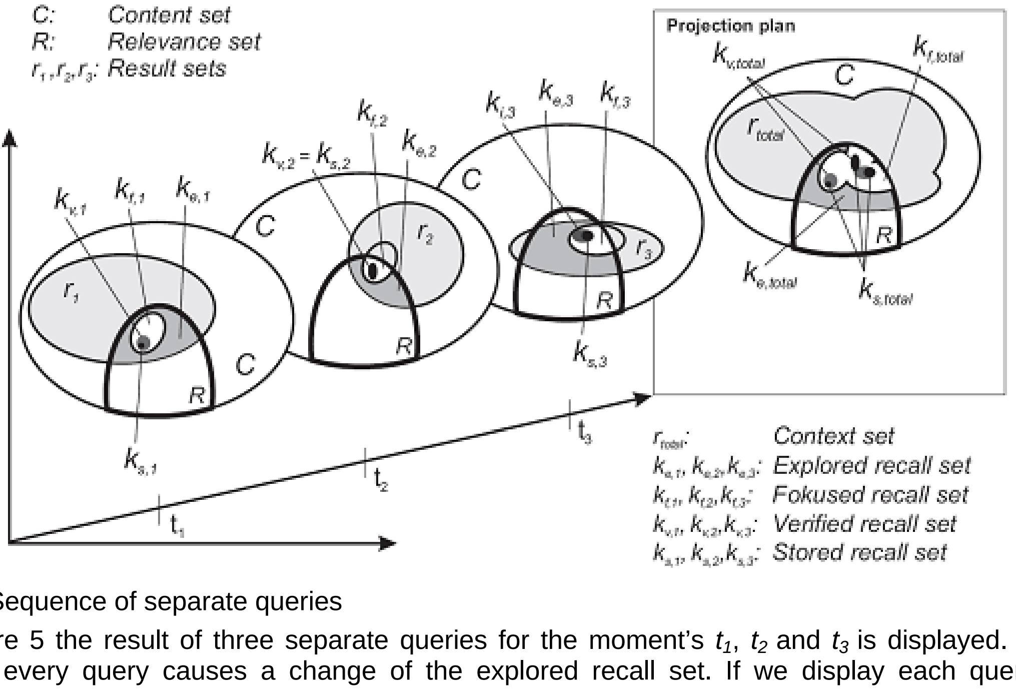

Figure 5: Sequence of separate queries

Within figure 5 the result of three separate queries for the moment's t_1, t_2 and t_3 is displayed. It becomes clear, that every query causes a change of the explored recall set. If we display each query onto the projection plane the union sets becomes visible.

Context: Context r_{total} is defined as the union of all result sets r_q and stretches the information room in which the user moves

So as the context r_{total} increases, also the explored, the focused and the verified recall set ($k_{e,total}$, $k_{f,total}$, $k_{v,total}$) will grow with every new exploration. This constant extension of the context however cannot be used by most information retrieval systems. So, with every new query, the information is eliminated from the user's field of vision. But with the presented definitions we are now able to analyze existing systems. This makes it possible for us, to improve existing systems or to define goals for new systems.

4.3 Analysis and challenge

By the use of the cognitive walkthrough method we gained experience. This gathered information is the initial point for the following analysis.

In figure 4 and 5 three interactive modes can be identified:

1. The mode of *Access*, that causes a change of the informational context set of through access the database by means of a query.
2. The mode of *Orientation* which changes the view onto the informational context set and represents a movement bet
3. The mode of *Assessment*, which identifies information objects of the interest set.

Every mode is totally enclosed and has its own activities. The first mode is *Access*. Within this mode there is only one activity, EXPLORATION. After the first EXPLORATION the user changes into the second mode *Orientation*. Activities for this mode are NAVIGATION, FOCUS and INSPECTION. The user has now the ability to change the visual as well as the informational focal point in an information visualisation of the dialogue context. The mode Assessment is reached, if the user finds objects of interest during his inspection. For this mode the activities EVALUATION and STORE are available. They help to express the user's appreciation of relevance and to define the identified recall set.

The projection displays the weak points of traditional information retrieval systems very well. Every exploration produces only a snapshot of the complete seeking process and navigation is only possible within a single exploration step. However, through such a sequence of interactions the users are only able to identify and manage the sum of all relevant information objects. Therefore, tools supporting this demand in the user interface as well as utilising it within the underlying retrieval engine are of great potential.

To support all these types of activities the IR system has to provide appropriate interaction tools. In order to navigate within a single exploration step also in the projection plane. If an optimal intersection between focus and recall set is achieved through such interactions, further tools become necessary to support the narrowing down of the focus (up to the single objects again) to be able to support a more detailed inspection, analysis and assessment of the information objects.

Also, it has to be investigated in which way an optimised focus of an information dialogue step can be transferred to the next step, e.g. speed up the focusing process in the next step. Furthermore, the sequence of dialogue can also provide insight in the type of information behaviour that users are performing and, in the ideal case, an information strategy can be identified and utilized to derive successive dialogue steps from a given starting point. By applying corresponding visualisation and interaction tools, the users are enabled to strategically optimise their information behaviour and reach the satisfaction of their information need faster.

To be able to actually support and evaluate our framework we need a system which meets the following demands: The system should:

- fundamentally support the *interaction model*,
- map the described *activities* to support the user,
- enable the *quantitative and qualitative evaluation* of the model,
- be highly flexible and extensible to integrate new visualisation techniques.

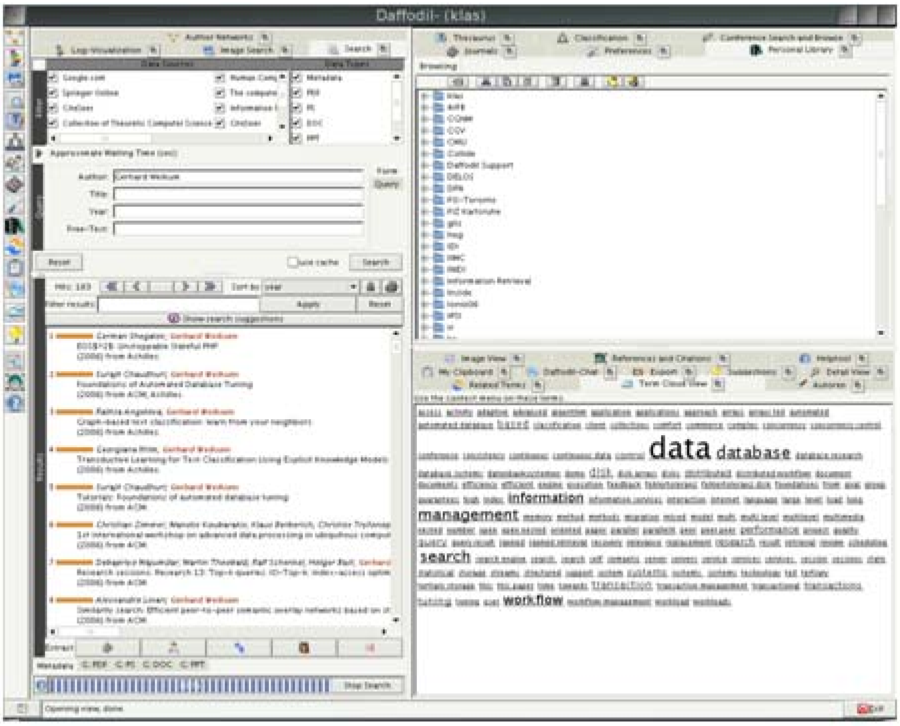

Figure 6: Screenshot of DAFFODIL

Following the formal description of the information dialogue and given the demands we will use the DAFFODIL-system as an experimental system for further development and evaluation of the above described framework.

DAFFODIL is a virtual digital library system targeted at strategic support of users during the information seeking and retrieval process (Fuhr et al. 2002, Klas et al. 2005). It provides not only basic and but also sophisticated search functions for exploring and managing digital library objects including meta-data annotations over a federation of heterogeneous digital libraries. It already matches the above named demands to a high degree and can be instantly used to verify the new framework.

5. Summary

The idea of this paper is to support innovators searching for patent information within innovation-processes through an advanced information retrieval system. With the presented formal description of sets and activities -- EXPLORATION, FOCUS, NAVIGATION, INSPECTION, EVALUATION and STORE -- we are now in the position to illustrate, store and exploit the search process in a series of finite steps. Over the set-oriented description and the derivation of definite sets it becomes clear, how the search process for one or more queries satisfies the innovation experts' need for information.

An added value has been created by the appliance of the advanced retrieval system in the domain of innovation processes. As showed by the cognitive walkthrough experts on innovation can be supported when searching patent databases and digital libraries. By the visualisation of result sets and query reuse a benefit is created for the patent seeking expert. Innovations are inspired by a systematic information retrieval. Patent information can deploy it's full potential.

With an analysis of the DAFFODIL-system on the basis of the presented activities it was shown that it already implemented major parts of the requirements, but also leaves enough challenges for further research. Every development of the challenges improves the DAFFODIL-system under the points of view dialogue and search process.

6. Outlook

We see different aspects to extend DAFFODIL.

The first step is to integrate a task manager. This manager will be the entry point for the user. He will be able to create a new task for his problem or information need. Or he can choose an existing task to continue his search process. These tasks are important because they are the container of our information context.

We see a special importance, however, in the implementation of relevance-feedback. And here in particular the question how activities express relevance feedback explicitly as well as implicitly.
Furthermore we want to develop a tool to visualize our derived sets of information objects. We want to do this with venn diagrams (Figure 7).

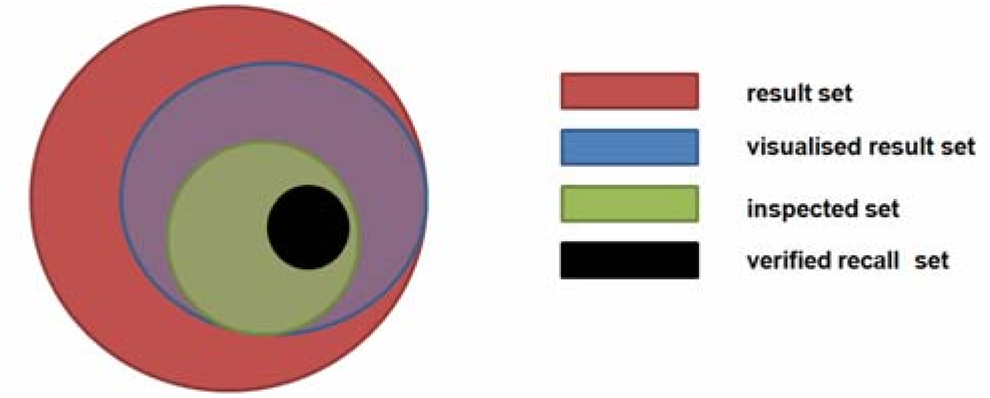

Figure 7: Venn diagram

These diagrams can figure out the logical relations between the sets. For that we can illustrate for example the relative complement of the verified recall set in the inspected set. This is useful to fade out all information objects which are already in my mind as objects of my interest.

A next step is to arrange the interface in views depending on the mode in which the user is situated (Figure 7). Therefore we will have a view for the mode access collecting all tools to formulate a query or to express the information need. We will have a view for the mode navigation which will collect tools to navigate and to visualize. At last we have a view for the mode assessment which will help the user to express his assessment of relevance.

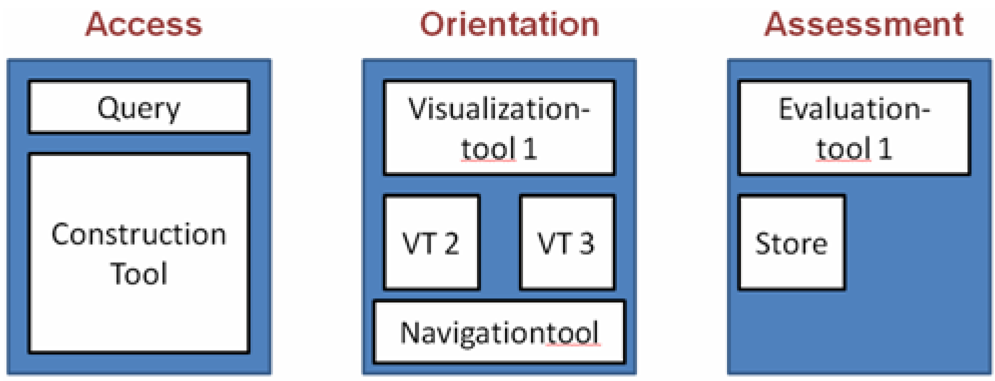

Figure 8: Mode-oriented assistance

We must have the ability to apply this tool for every exploration but also for the whole search-process.

On the theoretical side we will deepen the new framework and relate it to existing models on the information seeking process.

Acknowledgements

This work is funded via the German Science Foundation (DFG) through project LACOSTIR.

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