Bridging Navigation, Search and Adaptation: from Dexter, through AHAM, to GAF

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ABSTRACT
Adaptive Hypermedia Systems (AHS) have long been concentrating on adaptive guidance of links between domain concepts. In this paper we first study parallels between navigation and linking in hypertext on the one hand and information searching or querying on the other hand. We show that to a large extent linking and searching can be modeled in the same way. Secondly we present a transition towards search in AHS by aligning the web search process with the layered structure of AHS and link adaptation process.

Categories and Subject Descriptors
H.3.3 [Information Search and Retrieval]: Search process; H.5.4 [Hypertext/Hypermedia]: ArchitecturesNavigationTheory

Keywords
Search, Navigation, Adaptation, Dexter Model, Open Corpus

1. INTRODUCTION
The most referenced (but certainly not only) Adaptive Hypermedia (AH) model dates back to 1999. Since AHAM [3] new terms, definitions and models have been introduced and realized in prototypes. Most AH models focus on a layered architecture and concentrate on adaptation to the linking and navigation between concepts of an application domain. This architecture dates back to the Dexter Hypertext Model [4]. With the exploding popularity of the Web searching rather than linking is becoming the prevailing form of information access. Hence, apart from adaptive linking there is now also a need to provide personalized search in order to meet the requirements of every particular user. This paper deals with bringing linking and search together, both in an adaptive hypermedia context. We consider the issues of adaptive searching, searching in an adaptive environment, or for instance more familiar in AH field - Open Corpus Adaptation [1].

In this paper we bring navigation and search in an adaptive hypermedia context together by means of the following steps:

• We revisit Dexter Hypertext Model and draw parallels between navigation links and queries (section 2);
• We look at the problem of adaptive search and have a brief look at search in Open Corpus environments as a representative use-case (section 3);
• We show 2 use-cases for the interchangeability of navigation and search (section 4);
• (In section 5) we show the evolution of Hypertext/Hypermedia modelling from Dexter Model through AHAM to the proposed GAF model, outline advantages of each framework in adaptive environment and as a result we align the conventional search process with the generic adaptation process model (derived from GAF);
• In (section 6) we conclude with the issues and advantages of comparing search methods to conventional hypermedia navigation; we outline challenges and future work directions.

2. NAVIGATION AND QUERIES: THE DEXTER MODEL REVISITED
In this section we revisit the Dexter Model to show that hyperlinks are essentially already represented by queries, which makes it possible to replace the navigation structure of the hypertext model with queries (and particularly considering search queries) instead of resolving navigation links.

In Figure 4 (left model) the layered structure of the Dexter Hypertext Reference model is presented. Here the storage layer emphasizes ‘glueing’ components and links together to form hypertext networks. These components are generic containers of data (where there is no difference between content types, graphical and textual components). On the other hand, the within-component layer of the Dexter Model is concerned with the contents and structure within the components of the hypertext network.

The Hypertext system requires functions to refer to locations/items within the content of an individual component. It is done by anchoring (e.g. to support span-to-span links). These anchors provide aforementioned functionality while at the same time maintain a clear separation of storage and within-component layers.

In Figure 1 we can see that the basic addressability in the storage layer of the Dexter Model concerns the component. This component could be an atom, a link, or a composite entity which may be comprised of other components. Atomic components are primitives which are determined by the within-components layer. Atomic instances can be called ‘nodes’ of the hypertext system. Links here
Adaptive IR contributes to the AH field and brings Open Corpus other custom systems [7]. As a result a 'search' mechanism or TaskSieve' where link ordering and generation is done and many AH can be found in the 'SisKill' and 'Webert' systems where link mechanisms. Examples of keyword-based search in Open-Corpus (Adaptive IR), typically implemented using keyword-based search in particular it is represented by Adaptive Information Retrieval search falls under one of the types of information access in AHS. Open Corpus Search and Navigation.

user modelling aspects involved in the search process. This starts with adaptation of the input parameters, then the search query itself and finally output results. We also touch upon each referring to a component in the hypertext. A more detailed structure of links in the storage layer is shown in Figure 1.

Figure 1: Dexter Model Storage layer (incl. specifiers, links, anchors)

Simplifying the model and considering only the Web model of linking, where only the ‘TO’ resolver exists (in terms of Dexter Model) we can see the complementarity of a linking and searching notions (Figure 2).

Figure 2: Linking - Query model

3. ADAPTIVE SEARCH

In this section we summarize adaptation methodologies that are (or can be) applied in the search environment, such as querying information using a web search engine. Figure 3 represents conventional Web search functionality enhanced with adaptation.

To supplement the picture of ‘adaptive search’ in table 1 we generalize how these approaches can be applied within the search process. This starts with adaptation of the input parameters, then the search query itself and finally output results. We also touch upon user modelling aspects involved in the search process.

Open Corpus Search and Navigation. As defined in [1] search falls under one of the types of information access in AHS. In particular it is represented by Adaptive Information Retrieval (Adaptive IR), typically implemented using keyword-based search mechanisms. Examples of keyword-based search in Open-Corpus AH can be found in the ‘SisKill’ and ‘Webert’ systems where link ordering and annotation is performed or in ‘ML-Tutor’, and ‘YourNews, TaskSieve’ where link ordering and generation is done and many other custom systems [7]. As a result a ‘search’ mechanism or Adaptive IR contributes to the AH field and brings Open Corpus adaptation closer. Therefore we consider that employing the complementarity of search and navigation may have a high impact in Open Corpus Adaptation.

4. USE-CASES

We show two representative use-cases which fully comply with the idea of ‘query-link’ interchangeability.

**Use-Case 1: I’m Feeling Lucky.** Using the ‘I’m Feeling Lucky’ button on Google takes you directly to the first result page. This is an example of what we mean by link-query interchangeability: the search query is interpreted as a link specification and in fact the ‘click’ works just like a web link.

**Use-Case 2: Collaborative Searching and Linking.** Collaborative linking and recommendations were investigated in the field of data mining involving collaborative filtering and recommendations [8]. Here we consider it from the perspective of navigation and search. When the system recommends a link to a user, this link is represented by the query which filters the results of others, aggregates, then ranks and presents the top rated link to the concerned user based on the collaborative results.

Often these links are represented by the immediate query which is executed on the click. It retrieves and presents the result to the user, rather than showing some pre-calculated link. In fact the navigation here is completely replaced by the query execution and data retrieval process, but the user still sees the hyperlink on the web page and perceives this as a navigation rather than as querying.

Thus ‘collaborative link’ (and navigation in general) is essentially a query which takes into account the premises of all the users involved in inferencing (filtering) a particular link and resolves the destination by presenting the result of the query. The ‘HeyStaks’ [8] — social networking and recommendation engine is a good example of collaborative linking, querying and presenting links as a result of a query over preferences of a multiple users involved in ‘stak’ creation which serves a basis for recommendation and ranking using mechanisms of collaborative promotions.

5. FROM DEXTER, THROUGH AHAM, TO GAF

In Figure 4 we show the evolution of the Hypertext reference models, from Hypertext to Adaptive Hypermedia to the new Generic Adaptation Framework (GAF) which encapsulates most recent developments in AH and adjacent fields.

A brief discussion of the Dexter model can be found in (section 2), so here we would like to concentrate on the adaptation features evolution and outline major differences of these systems.

The AHAM [3] reference model could be considered as an adaptive extension to the Dexter model. Here are the major point of AHAM:

- Any AHAM application must be based on a Domain Model (DM), describing how the information content of the application or ‘hyper-document’ is structured (using a conceptual representation of knowledge);
- A User Model (UM) must be devised and its sustainability should be maintained representing preferences, knowledge, goals, navigation and other relevant user aspects;
The presentation of content and link structure must be adapted to the user’s behaviour as well as to the user’s knowledge and interest. Thus an Adaptation Model (AM) should be defined consisting of adaptation rules. The rules define both the process of generating the adaptive presentation and that of updating UM.

In AHAM the Storage layer split to support Domain and User modelling in order to facilitate adaptation to user attributes based on the conceptual structure of the domain, represented by the concept-link structure. And the Adaptation Model (AM) encapsulates the Adaptive Engine (AE) functionality, the rule system performing adaptation based on the value of UM attributes.

Moving towards a more elaborate framework, GAF [5] will enhance adaptation capabilities and include new methodologies and techniques, facilitating more elaborate adaptation. In figure 5 we present an extended draft architecture of GAF and briefly outline the enhancements (comparing to AHAM).

- Ontologies will be used in order to provide interoperability in adaptive applications. These ontologies must be agreed
The search process complies with the reference structure of AHS as follows:

- **The User states the goal** thus formulating a new search query, which can be considered as stating or choosing a particular concept (set of concepts) to follow in AHS. It can be interpreted and aligned with DM (availability of concepts, concept structures and sequences, etc.) and UM (considering user competencies, preferences, experience, etc.) thus re-formulating and refining the search query (matching it with the common lexicon or using semantically related terms);

- The **Domain Model** is defined by the search index, representing keywords used to facilitate fast and reliable information retrieval, which is acquired from the **Resource Model** (and essentially WWW). The index information is obtained from WWW by means of crawling which is similar to the process of resolving content information of a concept in AHS;

- The **Context Model** defines user and usage context properties such as IP address, user profile/stereotype, or search and result histories accordingly;

- The **Group Model** refers to maintaining a collaborative profile of the user or stereotyping search results by location or user age group and gender, which later can be used to rank and recommend results;

- Retrieving and updating UM refers to **storing and accumulating UM search history** which can be used to reformulate queries or retrieve personalized results;

- **Application and Adaptation Models** may refer to the Search Engine and Ranking mechanisms, however it may not be entirely clear how to distinguish some particular parts of those. Here we would refer to the Adaptation Model for Ranking, since they both to some extent perform adaptation of the results. The Application Model then serves as the core of the system: coupling other layers and dispatching information in AHS or performing a search as the Search Engine;

- The **Presentation Model** renders search results and presents a ranked result list, snippets, additional rank information, groups result, etc.

6. **CONCLUSIONS AND FUTURE WORK**

We conclude by summarizing the benefits of linking and querying interoperability in an AH context.

**Links and Queries in Adaptation** — flexibility and interchangeability of links and queries incite the area of AH research more towards the direction of Open Corpus adaptation, AE rule systems and Recommender systems. The flexibility to choose between conventional adaptive navigation techniques or adapt search queries using corresponding techniques will facilitate AHS development and face
them towards the area of more traditional web search and web information systems (WIS) in general.

Interoperability and Re-usability — usage of linking and queries makes systems more flexible in terms of interoperability, compatibility and re-usability. Queries have more flexibility as an intermediate interchange format (e.g. for Rule Systems used in AH systems). The lack of of this properties actually stops the spread of AHS into the area of Open Corpus, that’s why it could become a pushing point.

Dynamic Nature of Queries — Queries are more of a dynamic nature rather than links. Queries represent a parametric structure, which makes them more dynamic and in practice they can generalise different link types.

Data Provenance — Queries contain provenance information that can be easily analysed and interpreted (e.g. using data base query provenance information). This is also possible with the linked structures, however comparing to conventional hyperlinks requires additional metadata.

Search and Recommender Engines are more flexible for introducing or discovering new rules — Rule systems which are conventionally used in AHS are facilitated by using queries, providing the compatibility properties with the existing AH rule systems (e.g. ECA type of rules).

In the future we plan to extend the search adaptation process sequence, elaborate the description, in particular inter-layer transactions, emphasizing the interoperability of a new AH developments (Ontologies, Open Corpus, Higher-Order Adaptation etc.) in the context of the search process. This may require unifying search and linking methods for AH field. We also plan to present new use-cases and show how exactly user experience, data provenance and open corpus adaptation are facilitated by the linking and search interchangeability and compliance in the AH field.

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8. REFERENCES