Interactive Information Retrieval (IR) Models: Tradition and Development*

인터액티브 정보검색 모형

김양우 (Yang-woo Kim)**

ABSTRACT

This paper is divided into two parts. The first part elaborates on four Information Retrieval (IR) models: a traditional IR model and three more recent, user-oriented models of IR interaction presented by Belkin, Ingwersen, and Saracevic. The strengths and limitations of each model are discussed. The second part, based on an analysis of the previous models, presents the author's interactive model, namely, the Iceberg Model. The rationales that are given to explain the design of this model are associated with the following: a greater specificity of system attributes; more concrete interplays among different components of IR interaction; and, the increased role of the Human Information Intermediary (HII). In sum, the new model presents a framework that can evolve in varying information-seeking contexts.

초록

본 논문은 다음과 같은 두 부분으로 구성된다. 논문의 전반부는 네 개의 정보검색 모형을 다루고 있는데 이는 전통적 정보검색 모형과 보다 최근에 나온 세 연구자의 이용자 중심 인터액티브 모형을 포함한다. 인터액티브 정보검색 모형은 Belkin, Ingwersen, 그리고 Saracevic 에 의하여 제시된 것인데, 전통적 정보검색 모형을 포함한 각 모형의 장점과 한계점이 기술된다. 논문의 후반부에서 저자는 이상과 같은 모형들의 분석을 토대로 그 자신의 인터액티브 모형, 즉 빙산모형(Iceberg Model)을 제시하고 있다. 빙산모형의 타당성으로 다음과 같은 세 가지 사항을 강조하고 있는데, 즉, 보다 구체화된 시스템 특성의 포함, 보다 명확한 인터액티브 정보검색 요소간의 상호작용, 그리고 정보매개자의 증가된 역할 등이 그것이다. 요약하면, 빙산모형은 변화하는 정보추구환경에서 진화할 수 있는 틀을 제시하고 있다.

Key Words: Information Retrieval Model, Interactive Information Retrieval Model, Information Search, Information-seeking Behavior, User Study, Information Retrieval, Information Intermediary

정보검색모형, 쌍방향 정보검색 모형, 인터액티브 정보검색모형, 정보탐색, 정보추구행태, 이용자연구, 정보검색, 정보매개자

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** Full-time Lecturer (Tenure Track), Hansung University (ykim@hansung.ac.kr).

1. Introduction

The Library and Information Science (LIS) research community has a long history of studies on the human(or user[1])-centered approach. Various studies have been conducted in association with different segments of the users' information-seeking processes. One common drawback indicated by relevant literature including Saracevic (1999) concerns the lack of connections between two neighboring research communities: the human-centered community and the system-centered community.

Among others, the studies on information-seeking behavior models (Eisenberg & Berkowitz 1990; Krikelas 1983; Leckie, Pettigrew & Sylvain 1996; Wilson 1981, 1999) have such a restriction. While these studies have successfully secured the generalizability of their output to a broad environment, the domain of the models remained very limited in terms of system perspective. This can be a significant drawback because the system component represents a substantial portion of the users' information-seeking environment.

Considering this, a significant meaning can be found in the studies of interactive Information Retrieval (IR) models conducted by a number of scholars. More specifically, several authors (Belkin 1993, Belkin, Cool, Stein & Thiel 1995; Ingwersen 1992, 1996; Saracevic 1996, 1997) have elaborated on the cognitive aspects of IR beyond the traditional IR model, thus presenting an interactive IR model. Their models attempted to connect the user- and the system-side and emphasized the importance of the human aspects of IR in association with related system perspective. Nevertheless, further developments or applications of these models have been limited in the relevant research community.

Based on this reality, this paper compares and analyzes four models, the traditional IR models and three interactive IR models of three authors (Belkin, Ingwersen, and Saracevic). The strengths and limitations of each model are presented. In developing the strengths of each model and

1) As in many relevant literatures, the terms 'human-' and 'user-' are used interchangeably in this paper.

minimizing their shortcomings, this paper presents an adapted form of a model, namely, the Iceberg Model. The differences from the existing models are mainly comprised of the following three characteristics:

(1) adopting more specific attributes of IR systems with respect to their retrieval mechanisms and interface features;

(2) further elaborating interplays among different components of the interactive IR model;

and,

(3)specifically addressing the role of the Human Information Intermediary(HII) in the processes of information-seeking and retrieval.

The above differences constitute the significance of the new model. This new model addresses IR interactions by discussing more detailed features and components of the information-seeking and retrieval environment. In particular, possible interventions of HII were elaborated in such interactions. In sum, the new model attempts to draw a broad picture of information-seeking and retrieval processes. It presents a theoretical, conceptual and pragmatic framework for IR interactions.

2. Literature Review

While it is not easy to pinpoint the onset of the human-centered tradition in LIS researches, it seems that a strong trend became associated with such a tradition in the 1980s. During this decade, a series of theoretical studies were published in this area, which made a substantial impact to the LIS research community. Some of the principal authors at this time were Belkin (1980), Dervin (1983), Kuhlthau (1988a, b), and Bates (1989), who supplemented Taylor's (1968) work conducted a decade earlier.

In particular, Dervin and Nilan's (1986) Annual Review Of Information Science and Technology (ARIST) article provided a thorough survey of this trend. Emphasizing its significance, Dervin and Nilan called the trend as "a paradigm shift" in the LIS research community. They note that the emerging paradigm emphasized the following: subjective information beyond

objective information; active users beyond passive users; situationality beyond trans-situationality; a wholistic view of experience beyond an atomistic view. These shifts reflect the major characteristics of the interactive IR models discussed in this paper.

Another group of studies associated with the above trend pertains to information-seeking behavior models. Several of these models present a solid theoretical grounding for users' information-related behaviors by representing a specific aspect of their information-seeking (Eisenberg & Berkowitz 1990; Krikelas 1983; Leckie, Pettigrew & Sylvain 1996; Wilson 1981, 1996). Yet, as discussed above, these studies showed limited application to the system perspective of users' information-seeking environment.

The above-mentioned studies were not the only ones to show such a restriction. In particular, Dervin (1980) presents a negative view of an overemphasis on "interactions with systems." She promotes "wholistic views of experience" rather than "atomistic views," calling for an examination of information behaviors "outside system contexts so that they can be examined independently of system constraints" (as discussed by Dervin & Nilan, 1986, 15). The emphasis on *user* as the essential element of the information-seeking process has been accompanied by a priority on human attributes (i.e., users' cognitive, affective, and situational states) in studying users' information-seeking contexts. Relatively little attention has been paid to relating such human attributes to the characteristics of information systems used within a context.

Yet, substantial changes in the functions and performances of information systems have increased the importance of examining users' interactions with systems within specific contexts. Rather than confining the research scope to user attributes "outside system contexts," this paper suggests the need to address user perceptions and behaviors more broadly, encompassing both system and resource contexts.

Perhaps, another good example of the narrow scope of the research frame "outside system contexts" can be found in a series of relevance

studies conducted in the 1990s, which identified user-based relevance criteria in several similar empirical approaches (Barry 1994; Park 1993, 1994; Wang & Soergel 1998). While these studies achieved significant progress in identifying various dimensions and criteria of relevance based on user-text interactions (the key element in Belkin's interactive IR model), their applications for actual system improvements were rather limited.

Considering this, a strong connection between the user- and the system-side can be identified as a distinct benefit of the interactive IR models initiated by Belkin(1993: Belkin et al. 1995), Ingwersen(1992, 1996), and Saracevic (1996, 1997), although this paper suggests that even these models need to be extended.

More recently, several studies have incorporated human elements into the examination of IR processes and related systems. These studies pursued research in specific aspects of interactive IR, yet did not attempt to present an interactive model in a broad basis as did the previous studies (Belkin 1993, Belkin et al. 1995; Ingwersen 1992, 1996; Saracevic 1996, 1997). These studies can be classified into the following four categories.

(1) *representation of documents* — a cognitive conception of polyrepresentation (Ingwersen 2002); examination of cognitively different interpretations of the same documents (Larsen 2002);

(2) *use and user* — a cognitive model of document use (Wang & Soergel 1998); users' interaction with Web resources (Wang, Hawk, & Tenopir 2000); role of users in interactive IR based on the contexts of their perceived work tasks and information-seeking behavior (Ingwersen 2001a);

(3) *evaluation* — an extension of the interactive IR model with respect to strategy interactive feedback (Spink 1997); evaluation of interactive IR systems (Borlund & Ingwersen 1997; Borlund 2000a, b);

and finally,

(4) *review* — an extensive review of the literature on the analytic and empirical research of cognitive IR (Ingwersen 2001b).

Again, further development or application of the interactive models in an

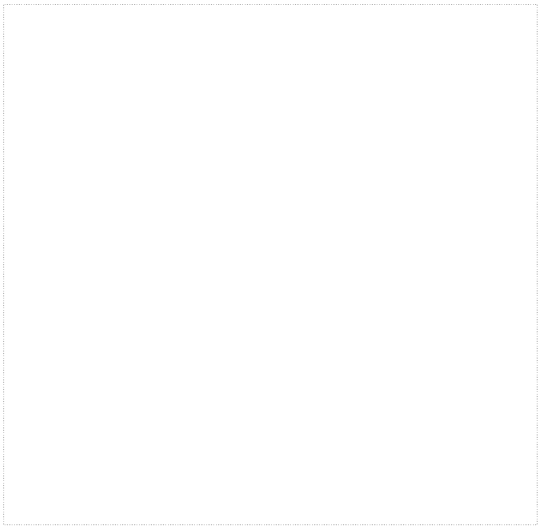
extensive domain has not been made.

3. Traditional IR model

The traditional IR model (Figure 1) is one of the most influential schemes in modeling the information retrieval. It works particularly well in narrowly defined situations, such evaluations of given IR algorithms (Saracevic 1997).

This model incorporates a *traditional way of access* in IR, which locates documents by comparing the query term and previously indexed terms. Yet, such a method still accommodates a variety of retrieval mechanisms in operational systems. An important rationale concerns the notable role of text surrogates in the search process.

In many electronic bibliographic databases currently in use, documents can be located when one uses, as a search term, any index terms of a surrogate record prepared by the database. This mechanism best involves conventional bibliographic databases that provide only surrogate records without access to full-text articles. Yet, even for databases that



<Figure 1> Traditional IR Model

provide full-text access, this model still fits because many databases are searchable only by indexed terms in the surrogate records.

The more recent free-text or full-text searching[2] also can be addressed by the model. For example, the search engines Google and Yahoo, as with most Web search tools, the search engines index virtually all terms appearing in the full-text sites of the retrieved items, including terms generally known as stop words. These engines are able to search for the occurrence of any single word or phrase in full-text documents and allow users to locate documents when using such a word or phrase as a query term. Even this broader technique of IR can be incorporated into the traditional IR model although this less explicitly accommodates the model's distinct characteristic.[3]

Meanwhile, some authors have indicated the shortcomings of this model. Belkin(1993) suggests two strong assumptions underlying this view of IR.

> "The first is that there exists some static information need associated with the user, which is, at least in principle, specifiable. The second is that the most appropriate way to address that need is to search for, and select, the text or texts which can best resolve that need……. There is a long history of research and practice in IR within this 'paradigm.'" (Belkin 1993, 3).

According to Belkin (1993), "this paradigm" ignores the significance of the interaction between the 'user' and the text. It does not incorporate user behaviors associated with the uncertain state of articulating and representing information needs.

Saracevic (1997) presented a more explicit critical view:

> "……However, the traditional model has a serious limitation: it does not incorporate IR interaction which is commonplace in real life, as opposed to laboratories. An IR paradox resulted: a large proportion of IR research, particularly the one dealing with algorithms is non-interactive,

2) This does not refer to the format of the search output here. "Full-text searching" in this context means the system will go through all terms that appear in the full-text document during the retrieval process to check for matching with a user's search term.

3) A confined volume of index terms represents a whole document.

while the total of IR practice today is interactive." (Saracevic 1997, 325)

Certainly, this view is still valid while more improved features of operating systems are appearing nowadays, supporting the user's interaction with resources.

In sum, then, several studies (Belkin 1993, Belkin et al. 1995; Ingwersen 1992, 1996; Saracevic 1996, 1997) have discussed the limitations of the traditional IR model. They emphasized the inadequacy of the traditional matching mechanism between query terms and index terms in accommodating essential aspects of the information-seeking process associated with users. According to the research, the traditional model is distinctly limited in depicting the interactive aspects of IR such as the cognitive and situational components of the users' information-seeking process.

Now, based on the main points of the above studies, the next section of this paper elaborates on a number of interactive models of IR.

4. Interactive IR Models

4.1 Belkin's IR Model of User-Text Interaction

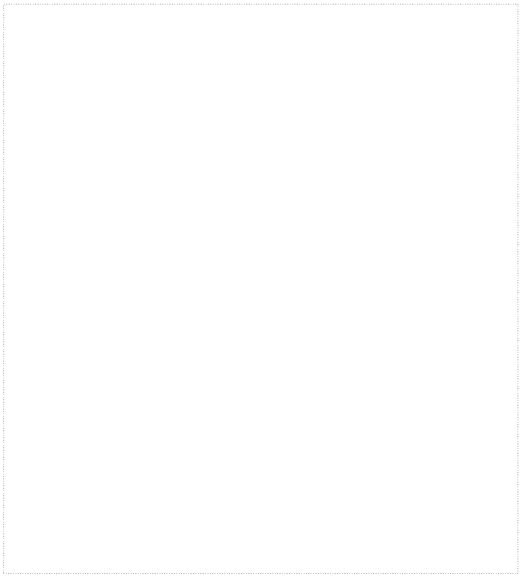
Belkin (1993, 1995) attempted to establish an alternative view of IR, the basis of which was to embed IR within the general context of human interaction with texts, and specifically referring to information-seeking behaviors.

According to Belkin (1993), information retrieval is most properly considered as information-seeking behavior. This somewhat unique view considers the user as the central component of the information retrieval system; it also regards user interaction with text as the central process of information retrieval.

To Belkin (1993), information-seeking is inherently an interactive process, characterized by the general features of people's interactions with texts. Yet, Belkin did not completely ignore the basic idea of the traditional IR model.

"Such a model of IR [his alternative view] would not reject the work which had been done in the standard paradigm, but rather incorporate it as support for particular classes of interaction, and information-seeking behaviors." (Belkin 1993, 57)

Based on the above view, Belkin (1993, 1995) presented an IR model of user-text interaction (Figure 2). Here, the following elements constitute the interactions between users and information resources, ("text" or "information" in his term): *judgment, use, interpretation*, and *modification*. This view could be best incorporated by "browsing-like information-seeking" as demonstrated by Belkin (1993) with examples of earlier studies: I3R (Croft & Thompson 1987) and THOMAS (Oddy 1977). In addition, Belkin's model of IR interaction enumerates a number of essential components of IR processes that support interactions between users and information: *representation, comparison, summarization, navigation* and *visualization.*



<Figure 2> Belkin's Model of IR Interaction

The strength of this model is associated with these surrounding

components that relate to a variety of IR techniques. These components could support different aspects of the users' interaction with the system. Possible extensions include: (1) text representation and comparison — traditional matching; (2) need representation — search interface; (3) summarization — surrogate records; (4) navigation — browsing; and (5) visualization — search and display features.

A limitation of the model concerns the lack of connections between user-text interactions and the surrounding components. In other words, specific combinations of the essential elements of interactions (e.g., judgment, use) and the surrounding components (e.g., representation, summarization) can be addressed.

Another feasible approach to extend this model would relate to splitting the entire retrieval process into separate stages: pre-retrieval, post-retrieval and—more pragmatically—an in-between stage. Search interface features and retrieval mechanisms that support those features in an operating system would constitute the pre-retrieval stage. Browsing tools such as search and display features could be incorporated into the in-between stage. The final post-retrieval stage can be divided into two areas. One concerns search and display features that facilitate the subsequent searches. The other relates to the 'use' of located information objects within the context of relevance 'judgments.'

4.2 Ingwersen's Model

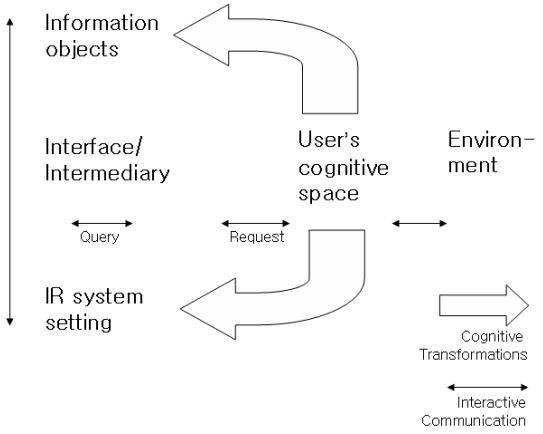
Ingwersen (1992, 1996) discussed the basic elements of a global cognitive theory for information retrieval interactions from a cognitive point of view. Based on the global cognitive theory, he presented two different, yet related models. This section of the paper discusses those models: the cognitive model of IR interaction and the global model of polyrepresentation in IR.

4.2.1 Cognitive Model of IR Interaction

In the cognitive model of IR interaction (Figure 3), Ingwersen (1992, 1996) considers the IR interaction in a broad view. Here, IR interaction is a set of processes of cognition occurring within all the information processing elements of IR. At this point, fundamental questions arise. What consists of "all the information processing elements in IR"? In a related aspect, what would be the domain relating to "cognitive" or "cognition"?

Perhaps, a significant part of the answers for these questions can be obtained by answering this next set of probing. What does the users' cognition involve? Is the process associated only with their information need or with the information system as well?

Certainly, Ingwersen's view is broad enough to encompass the system perspective, not only the user perspective. As shown in the figure below, his model depicts both human and system aspects of the information-seeking and retrieval processes.



<Figure 3> Ingwersen's Cognitive Model of IR Interaction.

The sub-components of each main component of the model as stated below clarify the broad scope of his view.

(1) Information Object: Full text, pictures, etc.

(2) IR system setting: IR technique, Database structure, Indexing rule, Computational logic, etc.
(3) Cognitive space: Information need, Uncertainty, Problem/Goal, Current cognitive state, Work task/Interest, Information behavior
(4) Social/Organizational environment: Domains, Strategies/Goals, Tasks & Preferences.

The breadth of Ingwersen's model—specifically the inclusion of specific components of IR system setting—affirms its strengths.

One limitation of Ingwersen's (1996) model seems to be its lack of sufficient explanations on how each element interacts with the others. For example, it does not address how the representation of information needs in cognitive space is theoretically and pragmatically related to the indexing rule in the IR system setting. Perhaps, Ingwersen's polyrepresentation model better addresses these interactions, albeit in a restricted domain. The next section of this paper discusses this different yet related model.

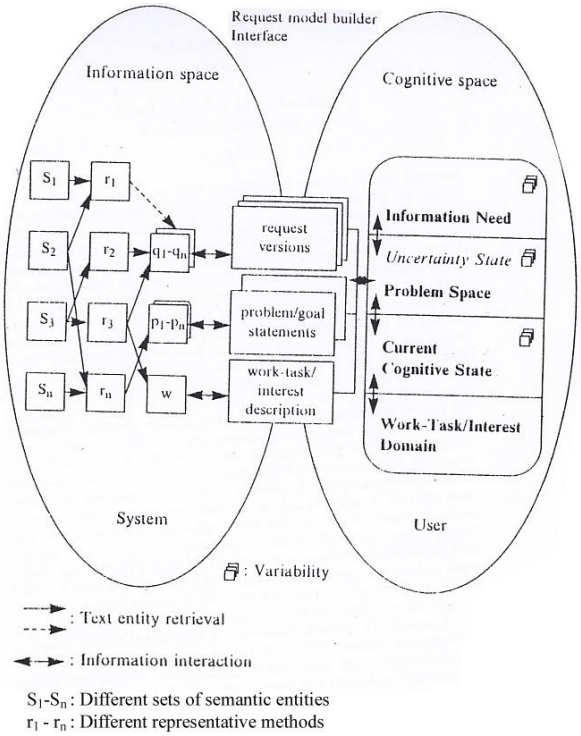
4.2.2 A Global Model of Polyrepresentation in IR

Ingwersen's (1996) global model of polyrepresentation in IR (Figure 4) consists of two major parts: the user's cognitive space and the information space of IR systems. Within this framework are outlined the principles underlying the concept of polyrepresentation as applied simultaneously to both spaces.

A basic premise of this model is that both cognitive and information space cannot be sufficiently represented by a single description or entity. In other words, the model proposes that more than one element is necessary for the representations.

4.2.2.1 The Polyrepresentative nature of the cognitive space

The concept of the polyrepresentation of the user's cognitive space in Ingwersen's model involves representing not only the current (often topical) information need, but also (and more importantly) the underlying problem space, actual work task or interest, and the dominant work domain(s).



<Figure 4> Ingwersen's Global Model of Polyrepresentation in IR

The concept of polyrepresentation seeks to represent each of the above elements in the form of contextual structures of causality. In other words, one element has a causal effect upon the other—for example, problem space as it affects the user's information need.

Further details for the above breakdowns (information need, problem space, work task/interest and domains) are as follows(see Figure 4). First, the user's information need is represented by request versions. The request version, depicts, what is currently known about the unknown (the user's wish or desire for information). Here, whether the requested need is known depends on the user's cognitive state, in other words, his knowledge state.

Second, the user's problem space, a broader scope than his information need is mainly represented by problem/goal statements. Finally, work-task/interest domain, the largest scope, in this chain of causality, is represented by work-task interest descriptions. Again, the current cognitive state of the user influences his or her problem space and work-task domain.

A distinct strength of Ingwersen's (1996) model with respect to the polyrepresentative nature of the cognitive space is that it provides a theoretical grounding for a user-centered retrieval process, what he terms "contextualization in IR." The main idea is that the user's cognitive space consists of multiple arrays of the information-seeking context that requires adopting a different representation and retrieval technique. Such an adoption depends on the element in which the user's information-seeking process is engaged in: the information need, problem space or work-task domain.

Obviously, the emergence of this idea is not completely new. As discussed earlier, Taylor (1968) proposed a similar view though he did not use the term, "polyrepresentation." Yet this view is still meaningful particularly because Ingwersen further elaborated on it in association with the specific information-seeking and retrieval processes.

In sum, then, by introducing the concepts of 'problem space' and 'work task/domain', in addition to the traditional 'request' formation, the model demonstrates that supplementary separate paths[4] for exploration and retrieval should be available. These paths might otherwise never be reached via the need associated query version alone.

According to Ingwersen (1996), a goal of the IR system designer is to improve the intellectual access to the information sources and, simultaneously, to provide the IR system with an enriched contextual platform that can support the user's information-seeking—that is, "contextualization in IR." Perhaps, a browsing-like search would be best

4) Perhaps, search specification features would be such examples of separate paths in an operating system particularly in a structured search attempt.

served by this idea if applied to a real information seeking situation. By incorporating polyrepresentative principles, as Ingwersen insists, "contextualization in IR," can be mostly closely achieved, especially as seen from the user's point of view.

One possible restriction on this model, however, is the inadequate discussion of the interface that supports "contextual platform" for the IR system. The theoretical framework on the interface that supports the beyond-search term box features would be essential to strengthen the idea of this model.

Ingwersen (1996) emphasizes that an estimation of the cognitive nature and quality of the information need are crucial to the system. For example, if the user is perceived to simply wish to verify and locate items already explicitly known, then the logical in-built intention of the interface should be to abandon redundancy and apply exact-match retrieval to simplified representations of the entities in the information space.

A fundamental question then arises: What if the user wishes to gain more beyond that—for example, to locate resources with only a vague intention of doing so, or to find information objects that have more analytic contents, possibly within the context of 'problem space' or 'work-task domain'? Again, an essential point would be how the *interface* perceives the user's wish. An additional component that supports this aspect would strengthen Ingwersen's model.

4.2.2.2 The Polyrepresentative nature of the information space

At the left-hand side of the model, the (S...) notation signifies sets or clusters of semantic entities from information objects. The (r...) notation signifies nodes of concepts derived from different representation methods (-> r...) applied to the semantic entity nodes (S...). This part of the model suggests that multiple ways of representation techniques can be applicable to different information objects. Next, q, p, w (q..., p..., w) represent

different representations inputted from the user's cognitive space, that are query, problem space and work-task domain, respectively.

Based on the above idea, Ingwersen (1996) proposes that each of the query("request version" in his model), problem/goal statement and work-task interest descriptions be connected to a certain part or parts of a represented zone on the system side.

However, as discussed, a shortcoming in this part of the model may well be the lack of explanation for the system interface features, which supports the above connections. Such connections would be facilitated by improved interfaces beyond a simple search term box for a query input. By contrast, though, a distinct strength of the polyrepresentative view in both a theoretical and practical sense involves inter-author and inter-era inconsistencies.

Ingwersen (1996) emphasizes that information space is consequently seen as a polyrepresentative structure in which *time* plays an important role: the same issue or topic is treated in conceptually and philosophically different ways, at a given moment by different authors, and over time. He indicates that social, psychological and scientific attitudes change over time, and, accordingly, new knowledge, cognition and questions emerge, generating the inter-era inconsistency. These attitudes are also different among individuals, thus yielding the decade-old inter-indexer inconsistencies in the system setting.

The above discussion explicitly provides a theoretical grounding for the authority control that involves treatment of various forms of terms for an identical concept. These inconsistency phenomena are highly valuable and worthy of exploration, favoring a more precise understanding of IR as Ingwersen indicated.

4.3 Saracevic's Stratified Model of IR Interaction

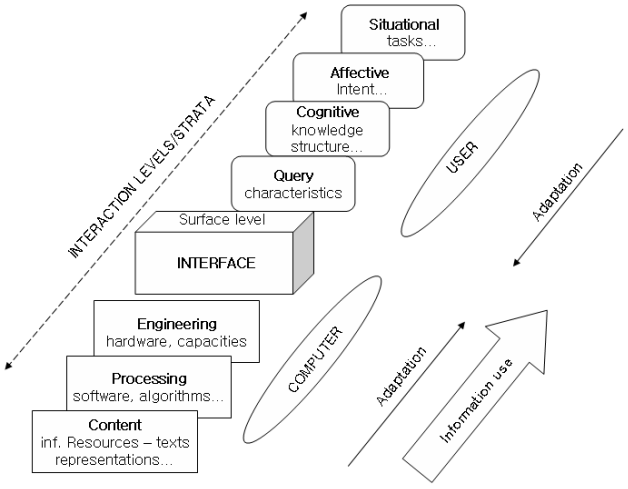
Saracevic (1997) insisted that the IR model does not yet represent the interactive processes in adequate detail. Several models were proposed, he argued, but not one has been widely accepted. Saracevic's own personal

interest was in a "symbiotic interplay" between human elements and computer (or system) elements.

Saracevic (1997) argues that at issue is not only representing the human elements or variables in the interaction (as often done in human-centered studies), or the computer elements (as done in system-centered studies), but also representing a combination of both human and computer elements in a symbiotic interplay.

Saracevic (1996, 1997) named his model as "the stratified model of IR interaction."(see Figure 5) The interactive IR model views the retrieval processes as involving a surface level where the user and the computer meet through an interface, followed by several distinct levels or strata for each. For users Saracevic postulated cognitive, affective and situational levels, as follows:

(1) On the cognitive level users interact with texts and their representations in the information resources considering them to be a cognitive structure. These strata mainly concerns users' knowledge structure.



<Figure 5> Saracevic's Stratified Model of IR Interaction

(2) On the affective level users interact with their intentions, beliefs and motivations.

(3) On the situational level users interact with the given situation or problem-at-hand which produces the information need.

For the computer Saracevic suggested engineering, processing, and content levels.

Further breakdowns in the system side are as follows.

(1) On the engineering level are the hardware and its various operational and design attributes such as capacity, efficiency and processing power.

(2) On the processing level, the focus is on software and retrieval algorithms.

(3) On the content level, the focus is on information resources related to texts and text representations.

According to Saracevic (1997), an understanding of interaction requires an understanding of the interplays between levels or strata. In other words, he insists that interaction is an interplay between all these different levels (see Figure 5).

Saracevic's model has several main strengths. First, the model points out a major limitation of existing models; that is, the lack of specific connections among relevant elements in a model.

Second, in a similar vein, the model presents a useful framework related to 'interplays' among neighboring elements. This framework could then possibly be further developed to design another model in IR interaction.

The third strength concerns the discussion of the role of the Human Information Intermediary (HII) in interactive processes. Saracevic (1997) suggested that the study of HII's roles and actions is one of the most useful elements for furthering an understanding of interaction. For example, HII plays an important role both in user modeling and search term selection, possibly becoming an essential element of the interactive IR model.

Although Saracevic (1997) suggested a need to elaborate on 'interplays'

among related levels in the interactive processes, his model nonetheless lacks a specific extension associated with interplays. For example, he could have further discussed interplays between levels such as: on the user side, the "cognitive level" and the "affective level"; and more important, on the different side of user and computer, the "cognitive level" and the "processing level." In other words, Saracevic's discussion did not encompass how those interplays could specifically occur.

The same restriction applies to two other aspects of interactions discussed by Saracevic: search term selection and Human Information Intermediary (HII). Saracevic (1997) asserts that search terms selection is a complex process that can also be explained as the result of interactions involving different levels, yet having confined discussions about how the interaction and search term section theoretically and pragmatically relate to each other. Similarly, Saracevic's discussion of HII was somewhat limited, not specifically extending into its relationship with other 'levels' in the model.

In sum, Saracevic (1997) suggested a broad depiction of various elements for IR and the interactions surrounding it. In the application of such elements, however, more concentration was spent on the user side with a greater degree of specificity on his discussions, as reflected by the extension of his model to neighboring elements. Relevance, user modeling, and search terms selection,—with which Saracevic extended the discussion of his model—all provide in-depth analysis on the user attributes.

The next part of the paper attempts to supplement Saracevic's view and the three previously discussed models with missing components that broaden user-system interactions even further.

5. The Iceberg Model of User-System Interaction

Based on the above discussion of previous IR models founded on the traditional and cognitive approach, this paper now presents the present author's Iceberg Model of interactive IR with a somewhat different

perspective of the nature of user-system interaction. The new model incorporates a broad aspect of user-system interaction and build on both the strengths and limitations of the previous models.

The iceberg model also provides a developed framework extending the author's previous output related to the following: ambiguity of user representation of information problems (Kim 2003a); and topicality and beyond-topicality of user needs and documents (Kim 2003b). While the previous work emphasizes a restricted aspect of the information-seeking and retrieval processes, this study has broadened discussions by elaborating on such relevant elements as the interface system features among many others.

The iceberg model has the following characteristics. First, the model emphasizes the specific attributes of IR systems that an individual user can involve in a real information-seeking context. This is depicted as a *system context* beyond the more common use of the term, 'context,' which mainly deals with the user's cognitive and situational environment rather than with a system perspective. The previous models (Belkin 1993, Belkin et al. 1995, Ingwersen 1996, Saracevic 1996, 1997) accommodated the system perspective to a certain degree, yet mostly within the context of the broader aspects of IR systems (i.e., representation and comparison in Belkin's model, database structure in Ingwersen's model, retrieval algorithm in Saracevic's model) rather than addressing the specific features of operational systems.

Second, the iceberg model attempts to elaborate on *interplays*[5] among relevant components in the process of information seeking and retrieval. As discussed, Saracevic (1997) pointed out the lack of 'interplays' in Belkin (1993) and Ingwersen's (1996) models, yet did not specifically develop this aspect in his own model. This particular aspect is important in an interactive IR model because it clarifies the essential components that *interact* with others in the process of information-seeking and retrieval.

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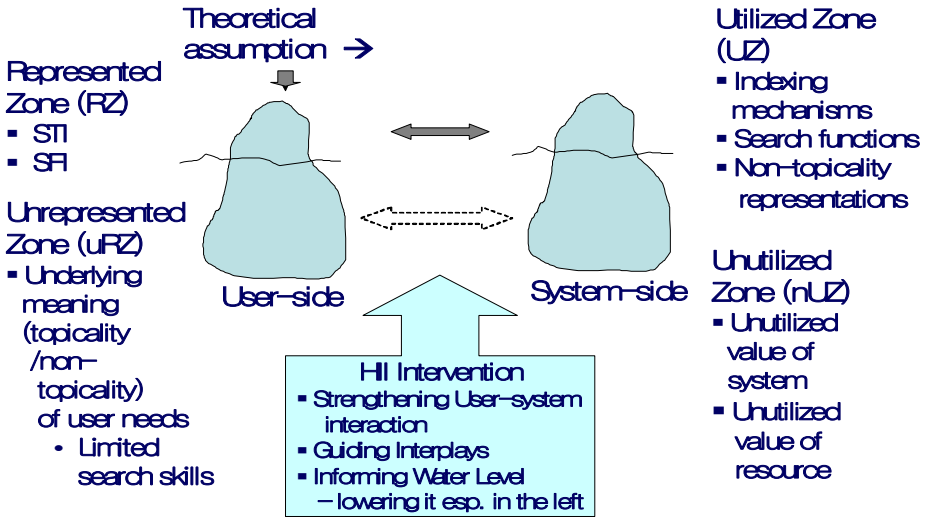
5) Exemplary pairs of *interplay* are summarized in the conclusion section of the paper.

Third, the iceberg model addresses the role of the Human Information Intermediary (HII) in a related context. Saracevic (1997) raised the importance of this element, yet without accommodating it in his model. Understanding HII's interaction with other elements in the interactive processes is meaningful, particularly for LIS education, which aims to raise future information intermediaries.

5.1 Represented Zone (RZ)

The analytic flow of this model begins from the Represented Zone (RZ) at the upper left side of Figure 6. The underlying assumption of the model here is that an information system can recognize only a limited portion of what users need (or think), labeled as the Represented Zone (RZ). In the model, this zone is illustrated as the visible portion of an iceberg above the water's surface.



<Figure 6> Establishing a Framework for User-System Interaction: An Iceberg Model

This view is elaborated further as follows. A limited portion of user need was represented and inputted either because of the user's limited search skill or insufficient system features. Thus, the unrepresented need was not recognized by the system, and remained unreflected in the retrieval process.

The Represented Zone (RZ), mainly consisting of two components, can be characterized as follows. One component involved is Search Term Input(STI), mostly topical terms, yet possibly ambiguous terms especially when the searcher uses relatively a small number of query terms. The other is Search Feature Input (SFI), mainly concerning non-topical aspects of user needs and documents. SFI reflects specific aspects that are supported by the system and utilized by the user - for example, metadata elements and search feature selections, respectively.[6)]

5.2 Unrepresented Zone (uRZ)

The Unrepresented Zone (uRZ) at the lower left side of Figure 6 addresses a specific portion of the user's need that was not presented to the system. As discussed, this zone can be explained either by the user's limited search skills or the system's restricted functions. Accordingly, the information intermediary would be responsible to determine these aspects of the information-seeking processes and reflect upon them. In doing so, an important task should be to help the user to lower the water level.

The Unrepresented Zone (uRZ) cannot be recognized by the system because it remains invisible as the underwater portion in the model. This zone mainly accommodates the following two components. One is the underlying meaning (or intention) of the user's needs, which can potentially provide a clue to disambiguate the user's query, mainly in a topical sense. The other component mostly addresses the beyond-topical aspects of the user's needs. This aspect was not supported by the system interface features nor was it utilized by the user even when it is available.

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6) STI and SFI do not restrict the scope of this model; they possibly accommodate both text and multi-media retrieval.

Given the above components, the intermediary could make the following interventions for the user's attempts to lower the water level.

(1) For STI: to understand the underlying meaning/intention of the user's needs and to help the user to represent his or her need more effectively, e.g., to disambiguate a query;

(2) For SFI: to inform the user of specific search and/or display features unutilized although they are offered or to suggest an alternative system that has improved features.

5.3 Utilized Zone (UZ)

The Utilized Zone (UZ) in the upper right corner of the model (Figure 6) accommodates several aspects of documents utilized when particular documents are retrieved. Various aspects have been identified for this zone and this paper depicts a number of exemplary ones.

The limited space of UZ at the top right accounts for a confined portion utilized during the retrieval process, out of the entire *value* of the system or resources stored within the system. While confined in terms of *value* utilized, this space would not be quite as limited in number of documents retrieved in most current systems that are effective in generating a high recall return. Yet it would be essential for both end-users and professional intermediaries to understand the limited aspects of documents in terms of the *value*. A few exemplary aspects, which are associated with the system's access points to the users are as follows.

The first aspect with respect to the indexing mechanisms of the system concerns *controlled vocabulary indexing* vs. *free text representations.* This aspect of the system will influence an important segment of the search process. If the system adopts controlled vocabulary index terms, the user (or intermediary) needs to consider this during search term selection. More selective terms particularly in a topical sense would be effective. Yet such words as jargon, informal language, and stop words would not be appropriate choices.

On the other hands, *free text searching*, the term occurrence-based retrieval mechanism of full-text searching, enables the systems to search for the occurrence of any single word or phrase within full-text documents. This provides an altogether different environment. The user is allowed to use any possible words or combinations of the words as search terms, thereby making the user—especially a novice searcher—more comfortable with term selection. Yet, the result may actually distract the user because it can yield a high number of irrelevant returns for each search, burdening the end-user with sorting out an enormous set of items. Accordingly, if the user wishes to improve the precision of the search result, a more careful selection of search terms is necessary, conducted in a different way from controlled vocabulary search.

The second aspect pertains to more specific treatment of the inputted search terms by the system. Such search functions as boolean operators, truncation and proximity search belong to this category. Depending on how the system treats the user's search terms with respect to these functions, the user (or the intermediary) needs to take an appropriate action for each search term selection.

The third aspect concerns the extent to which the system utilizes a beyond-topical characteristic of the documents during the retrieval process. Some progress has recently been made on this aspect of the retrieval processes. The IR system nowadays has a greater capability to represent non-topical attributes of texts stored in the system. A variety of search features in online scholarly databases (i.e., peer review articles only) and in the Web search engines (i.e., language or file format specification) reflects such progress.

As discussed in the relevant literature including Green (1997) among others, a retrieval system with an improved capability of this aspect—utilizing non-topical aspects of the documents—facilitates a higher precision in the search results. Accordingly, understanding the capability of an IR system for this aspect is an important task for both the end-user and the information intermediary. Greater understanding will improve the

search process and the corresponding service for both parties. In particular, the intermediary is responsible to determine the interface features relating to non-topicality and to inform the user of an alternative system, if necessary. Surely, such a responsibility applies to the first two aspects of the documents discussed earlier.

The above discussion has elaborated on a few important aspects of IR systems, which can influence the user's interaction with the system. The next section describes the attributes of the resources unutilized during the retrieval process, thus providing no platform of interactions with the user.

5.4 Unutilized Zone (nUZ)

The invisible portion at the right lower side accounts for the unutilized value of system or resources stored in the system(Figure 6). The entire value of the system could be utilized to a limited extent due to the end-user's limited search skills and/or a lack of search experience. As discussed earlier (section 5.2), the intermediary could make an intervention by informing the user of specific unutilized features or by suggesting an alternative system which is more suitable to the user's personal preference.

This part of the model also concerns the potential value of the resources stored in the system. This value might not be completely utilized due to shortcomings of the retrieval mechanism. For example, a heavy reliance on the topical term occurrence would constitute such a restriction. If a particular system retrieved an irrelevant item because of a specific characteristic of the search terms used — e.g, polysemy or homonymy, this would be such an example. Again, the information intermediary can inform end-users of the limited utilization of the resource attributes by the system and have them take appropriate action. The additional use of topical search terms and/or non-topical search features to reduce the search space can be possible actions.

Lowering the water level in the system-side with respect to the unutilized value of the resources would be the ultimate goal of system

designers, thus reducing this portion of the iceberg. Important progress has been recently made, yet relevant research shows that end-users still experience a significant amount of trial and error in the searching process. A more acute understanding of 'water level' on this side of the model by the intermediary would facilitate improved services.

6. Conclusion

An important goal of interactive IR systems is to devise mechanisms that connect relevant areas in the model (Figure 6): the two specific areas at the top, Represented Zone (RZ) and Utilized Zone (UZ) and the two specific areas at the bottom, Unrepresented Zone (uRZ) and Unutilized Zone (nUZ) on the left and right sides of the figure, respectively. This paper attempts to foster ideas to improve these mechanisms with respect to user-system interactions and the intervention of information intermediaries in such interactions. More detailed components of such interactions discussed include: representations (both in the user- and the system-side), retrieval mechanisms, and interface designs.

The following discussion concludes the paper by addressing further major characteristics of the Iceberg Model.

First, the model proposed detailed attributes of IR systems as the components of IR interactions. These attributes are associated with controlled vocabulary, truncations, and non-topical search functions and so on. The previous models showed a restricted degree of specificity on this matter. Although Ingwersen (1996) addressed this issue most explicitly, he only gave limited consideration to system interfaces.

An extended discussion of the attributes of IR systems reflects a somewhat different view of the present author on the concept of "context." The term, "context" is typically used to address a user's information need, as associated with its cognitive and situational aspects *out of the system context*. Here, the author emphasizes the need to extend the domain of the concept (context) with respect to the system environment in which

individual users are engaged in. An underlying assumption is that if an interactive IR model does not provide a sufficient platform associated with the system attributes (i.e., retrieval mechanisms, interface features), it cannot provide a complete picture of the process ongoing in the user's information-seeking environment.

Second, the iceberg model elaborates on *interplays* among its relevant components. As pointed out, the interplays illustrate interactions among various elements in an interactive model. As elaborated in the previous sections (5.1-5.3), exemplary pairs that constitute the interplays in the model from the user- and the system-side include: (1) a certain term selection in Search Term Input (STI) and a specific rule of indexing mechanism; (2) a combination of query terms in Search Term Input (STI) and a specific use of search functions (i.e., Boolean, truncation); (3) a limited search skill of the user and an unutilized value of the system; (4) a selection of Search Feature Input (SFI) and a certain element of non-topical representations; and finally, (5) Human Information Intermediary (HII) intervention and any component of the above possible combinations.

Third, the Iceberg Model emphasizes the role of the Human Information Intermediary (HII) as a component of "interplay," in the processes of information-seeking and retrieval. Understanding HII's interaction with its neighboring elements is essential particularly for LIS education, especially as the disciplinary field aims to raise information intermediaries of the future. Nevertheless, the role of HII in the interactive processes has gained less attention in related studies.

The growing trend of end-users' direct use of searching systems without an intermediary's intervention might provide a rationale to critically view this aspect of the model. This trend seems to be evident although there exist regional differences on the quantity of the use of the intermediary's service. However, this trend can be viewed in another way. Such a trend also suggests to the LIS community the need for an enhanced model for improved interventions. Improved interventions would attract more patrons. Another rationale concerns to what specific circumstances this aspect of

the model is applicable. A traditional reference service setting would not be the only setting of such an application. The intervention could occur in diverse occasions, including library instruction services, either via online or on the traditional setting, and collaborative work environments.

Finally, and perhaps most important, the Iceberg Model establishes a theoretical and pragmatic framework for IR interaction, which can be useful for both end-users and information intermediaries. A variety of user needs and system and resource attributes can be accommodated by the framework as the model suggests. The framework consists of four separate zones: Represented Zone (RZ), Unrepresented Zone (uRZ), Utilized Zone (UZ), and Unutilized Zone (nUZ), as well as the HII intervention. The framework can evolve as the relevant elements vary. The evolution can occur as the components of four different zones change, much like the metaphorical varying levels of water surfaces in the Iceberg Model.

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