VIEWCACHE: An Incremental Pointer-Base Access Method for Distributed Databases

Part I: The Universal Index System Design Document
Part II: The Universal Index System Low-Level Design Document
Part III: User’s Guide
Part IV: Reference Manual
Part V: UIMS Test Suite

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Part I: The Universal Index System Design Document
PROJECT SUMMARY

Today, there is a great diversity of computers, operating systems, database management systems, and communication protocols. As a result of this heterogeneity, computer users are required to learn many different data access methods in order to obtain the information they need. This causes an attitude of "it's too much trouble to learn all these different systems," which leads to a significant amount of software and data duplication.

There are several approaches that can be taken to solve the heterogeneity problem: two of which are standardization and uniformization. Standardization is the concept of choosing one specific system to use, and expecting or requiring everyone to follow this standard. This, however, does not provide an adequate solution because it could be extremely costly to change to the standard if a different system was being used. Uniformization is the concept of creating a layer on top of current systems that provides uniform access to all data, regardless of the underlying system. This allows the underlying systems to remain unchanged, yet also provides a single common access method for users to access data.

The Universal Index System (UIS) is a system that uses uniformization to solve the heterogeneity problem among database management systems. UIS provides an easy-to-use common interface to access all underlying data, but also allows different underlying database management systems, storage representations, and access methods.
1. SYSTEM OVERVIEW

1.1. Main UIS Components

UIS is a system that manages and maintains indexes, sets, indexsets, and indexkits. An index is an object that associates terms with pointers. A simple example of an index is the index of a book. It associates a term used in the book with the page number(s) on which that term appears. Another example of an index is a subject index in a library catalog, which associates library books with different subjects.

A set is an object that contains only pointers. Usually sets are created by extracting the pointer field from an index. Using the example of a book’s index, a set could be created from the index by the definition "all the page numbers that contain the words 'database', 'data model', 'data definition language', or 'data manipulation language'."

An indexset is a catalogued collection of indexes and sets. Every index and set must be associated with exactly one indexset. In addition to the indexes and sets belonging to an indexset, an indexset also contains an index catalog to maintain all the information for managing indexes, and a set catalog to maintain all the information for managing sets.

An indexkit is a logical grouping of an introduction, index, dictionary and thesaurus. The introduction component of an indexkit is an object which contains a textual description of the index. The dictionary component of an indexkit is an object that associates terms given in the index with their definition. It is used to assist the user in accessing the index. The thesaurus component of an indexkit is an object that associates terms given in the index with other terms. The thesaurus supports both generalization and specialization of terms in the index. The thesaurus is also used to assist the user in accessing the index. The introduction, dictionary and thesaurus components are neither managed nor maintained by UIS. Figure 1 shows the relationships among the different objects managed by UIS.

1.2. UIS Capabilities

UIS provides commands that allow the user to create and manipulate indexes, sets, indexsets, and indexkits.
1.2.1. Index Commands

UIS uses the notion of current objects to simplify the index commands. The user specifies which instance of an object is to be current i.e. to be "worked on," and then subsequent commands are performed on the current object. The index commands rely on the existence of a current index, current index row, and current index boolean.

The current index row is set to be the tuple in the current index that was most recently accessed by the navigation routines (see below for a description of the navigation routines). The current index boolean is a boolean condition chosen by the user to assist in navigation.

UIS provides a relationally complete set of commands for indexes. In addition to commands that allow the user to create, insert into, delete from, save and destroy indexes, there are routines that allow the user to retrieve a previously created index for either modification or read only, return an index (the opposite of retrieve) and pick an index to be the current index.
There are commands to allow the user to navigate both forward and backward through an index, accessing a single tuple at a time. UIS provides the user with index booleans and index selects to assist in this navigation. An index boolean is a boolean condition defined by the user to restrict the search to a subset of the index. For example, the user could define an index boolean, “camseq = "LFP1010"” to restrict the search on an index to only those tuples of an IUE index having “LFP1010” as camera sequence number. The user can create index booleans during a user session, but they do not persist beyond the end of that session. UIS provides commands to create, modify, list (display), pick (make as current), and delete index booleans. There are also commands to allow the user to reproduce indexes. These include copying and moving an index to an indexset.

To support interfaces to programming languages, there are commands to allow the user to bind attribute values to program variables, i.e. embedding UIS commands in an application written in C. There are two commands for binding to program variables, one for binding a single attribute (column) from an index, and one that allows for binding a whole row from an index. These commands cannot be used during an interactive session.

1.2.2. Indexset Commands

UIS provides a few commands to manipulate indexsets. At this point a user can only create and destroy indexsets. In the future, we plan to add commands such as include copy, subset, intersect, subtract and union, and commands to copy and move indexsets.

1.2.3. Indexkit Commands

Although not implemented in the current prototype, several commands to manipulate indexkits have been designed for UIS. In addition to commands that allow a user to create and destroy indexkits, there are commands to allow the user to reproduce indexkits. These include copy, subset, intersect, subtract and union. Subsetting an indexkit is defined to be a new indexkit, whose components are the result of subsetting each of the components in the original indexkit. Intersecting two indexkits is defined to be a new indexkit, whose components are the result of intersecting corresponding components of the two original indexkits. Similar definitions hold for union and subtraction.
1.2.4. Command Summary

Tables A, B, C, and D provide a summary of the index, set, indexset and indexkit commands, respectively.
Table A: Index Commands

<table>
<thead>
<tr>
<th>Index Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create index</td>
</tr>
<tr>
<td>update index</td>
</tr>
<tr>
<td>drop index</td>
</tr>
<tr>
<td>insert index</td>
</tr>
<tr>
<td>move index</td>
</tr>
<tr>
<td>delete index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Reproduction Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>copy index</td>
</tr>
<tr>
<td>subtract index</td>
</tr>
<tr>
<td>intersect index</td>
</tr>
<tr>
<td>union index</td>
</tr>
<tr>
<td>subset index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Searching Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>find term in index</td>
</tr>
<tr>
<td>build set with term</td>
</tr>
<tr>
<td>build set with list</td>
</tr>
<tr>
<td>build set with range</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Browsing Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>retrieve index</td>
</tr>
<tr>
<td>pick index</td>
</tr>
<tr>
<td>save index</td>
</tr>
<tr>
<td>return index</td>
</tr>
<tr>
<td>list indexes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Navigation Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>first in index</td>
</tr>
<tr>
<td>last in index</td>
</tr>
<tr>
<td>next in index</td>
</tr>
<tr>
<td>previous in index</td>
</tr>
<tr>
<td>fetch using index</td>
</tr>
<tr>
<td>build index boolean</td>
</tr>
<tr>
<td>modify index boolean</td>
</tr>
<tr>
<td>list index booleans</td>
</tr>
<tr>
<td>drop index boolean</td>
</tr>
<tr>
<td>pick index boolean</td>
</tr>
<tr>
<td>build index select</td>
</tr>
<tr>
<td>modify index select</td>
</tr>
<tr>
<td>list index selects</td>
</tr>
<tr>
<td>drop index select</td>
</tr>
<tr>
<td>pick index select</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Run-Time Environment Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>bind index column</td>
</tr>
<tr>
<td>bind index table</td>
</tr>
</tbody>
</table>
Table B: Set Commands

<table>
<thead>
<tr>
<th>Set Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>build empty set</td>
</tr>
<tr>
<td>drop disk set</td>
</tr>
<tr>
<td>insert set</td>
</tr>
<tr>
<td>delete set</td>
</tr>
<tr>
<td>update set</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Set Reproduction Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>combine sets</td>
</tr>
<tr>
<td>restrict sets</td>
</tr>
<tr>
<td>sort sets</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Set Browsing Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>retrieve set</td>
</tr>
<tr>
<td>pick set</td>
</tr>
<tr>
<td>build empty memory set</td>
</tr>
<tr>
<td>save set</td>
</tr>
<tr>
<td>return set</td>
</tr>
<tr>
<td>list sets</td>
</tr>
<tr>
<td>drop set</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Set Navigation Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>first in set</td>
</tr>
<tr>
<td>last in set</td>
</tr>
<tr>
<td>next in set</td>
</tr>
<tr>
<td>previous in set</td>
</tr>
<tr>
<td>build set boolean</td>
</tr>
<tr>
<td>modify set boolean</td>
</tr>
<tr>
<td>list set booleans</td>
</tr>
<tr>
<td>drop set boolean</td>
</tr>
<tr>
<td>build set select</td>
</tr>
<tr>
<td>modify set select</td>
</tr>
<tr>
<td>list set selects</td>
</tr>
<tr>
<td>drop set select</td>
</tr>
<tr>
<td>pick set boolean</td>
</tr>
<tr>
<td>pick set select</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Set Run-Time Environment Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>bind set column</td>
</tr>
</tbody>
</table>
### Table C: Indexset Commands

<table>
<thead>
<tr>
<th>Indexset Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create indexset</td>
</tr>
<tr>
<td>alter indexset</td>
</tr>
<tr>
<td>drop indexset</td>
</tr>
<tr>
<td>move indexset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indexset Reproduction Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>copy indexset</td>
</tr>
<tr>
<td>subtract indexset</td>
</tr>
<tr>
<td>intersect indexset</td>
</tr>
<tr>
<td>union indexset</td>
</tr>
<tr>
<td>subset indexset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indexspace Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create indexspace</td>
</tr>
<tr>
<td>alter indexspace</td>
</tr>
</tbody>
</table>

### Table D: Indexkit Commands

<table>
<thead>
<tr>
<th>Indexkit Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create indexkit</td>
</tr>
<tr>
<td>update indexkit</td>
</tr>
<tr>
<td>drop indexkit</td>
</tr>
<tr>
<td>move indexkit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indexkit Reproduction Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>copy indexkit</td>
</tr>
<tr>
<td>subtract indexkit</td>
</tr>
<tr>
<td>intersect indexkit</td>
</tr>
<tr>
<td>union indexkit</td>
</tr>
<tr>
<td>subset indexkit</td>
</tr>
</tbody>
</table>
2. THE DESIGN OF UIS

The development of the UIS prototype was divided into several phases: the requirements phase, the design phase, the implementation phase and the testing and integration phase. This approach was taken in an attempt to resolve any conflicts in the proposed system as early as possible.

The requirements document contains a functional description of what the system should do. The purpose of the design phase is to convert the functional description of what the system should do into an algorithmic description of how the system should do it.

The design phase primarily concentrated on two tasks. First, we had to determine what information needed to be available to the system during execution and what information needed to be available from one execution to the next (persistent information). Second, we needed to translate the functional requirements of the user commands into design specifications. These two tasks were performed in a stepwise fashion to yield a cohesive and consistent design.

2.1. System Information

UIS manages and maintains four different types of objects: indexes, sets, indexsets, and indexkits. In order to do so properly and efficiently, the system needs to have available certain information about each object. As an example, consider a library: how useful or efficient would a library be if it did not have a catalog that listed what books were contained in the library, or where they were located? Probably not very useful, definitely not very efficient. In the same way that a library catalogs all the objects that it manages, so must UIS. This section describes which information UIS needs to efficiently manage its objects.

2.1.1. System Catalog — Indexes

In Section 1 we defined conceptually what an index is. To determine what persistent information we need for indexes, we need to know what an index is structurally. "Structurally, an index is a table in which some of the columns are the items indexed and the last column is the pointer. An index is of type k if it has k-item tuples (columns). The format of an index depends on the internal representation of the index. Examples of formats are B-trees, R-trees, and heaps."

Given this structural definition, we see that some of the information that needs to be stored include the name of the index, its type, and its format. Other information that is necessary are the attribute or column
names, their types, lengths and their location within the tuple (offset). This information is necessary when checking whether or not a user's command is valid, and to assist the system in locating and extracting attribute values. Another piece of information used to assist the system in index manipulation and validation is the index's tuple width (the total size of the tuple). In addition, we decided it would be helpful to store whether or not a given index had an indexkit associated with it. This would allow us to remain consistent with the indexkit system information (discussed later).

Because an index can have any number of attributes, we decided it would be easier to have two system catalogs. The first one contains all the information about the index except for the attribute information. A second catalog contains the attribute information. This approach was taken to simplify the catalog access routines (if a single catalog were used, the access routines would have to support variable length entries). Figure 2 describes pictorially the system catalog information for indexes. It contains two example indexes:

<table>
<thead>
<tr>
<th>Index Catalog</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Index Name</strong></td>
</tr>
<tr>
<td>FOLLEY_EOTN</td>
</tr>
<tr>
<td>SUBJECTS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute Catalog</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Index Name</strong></td>
</tr>
<tr>
<td>FOLLEY_EOTN</td>
</tr>
<tr>
<td>FOLLEY_EOTN</td>
</tr>
<tr>
<td>SUBJECTS</td>
</tr>
<tr>
<td>SUBJECTS</td>
</tr>
<tr>
<td>SUBJECTS</td>
</tr>
<tr>
<td>SUBJECTS</td>
</tr>
<tr>
<td>SUBJECTS</td>
</tr>
</tbody>
</table>

Index Format =
{ BTREE, RTREE, HEAP }

Attr Type =
{ INT, FLOAT, CHAR, STRING }

Figure 2 - System Catalog Information for Indexes.
2.1.2. System Catalog — Indexsets

An indexset has several components (see Figure 3). It contains an index catalog discussed in the previous section, a set catalog, a transaction log, and then the indexes and sets themselves that belong in the indexset. The transaction log contains information about updates to the indexes and sets in the indexset. It is used in transaction management (currently unimplemented). UIS allows the user to explicitly specify all the buffer management constants needed for the management of indexset components. As a result, the system catalog information for indexsets must store all this information.

Before explaining the system catalog information for indexsets, we need to clarify what is meant by databook and indexspace. When defining an indexset, the user creates a logical space in which indexes and sets will belong at some point in the future. The databook objects are these logical spaces. An indexspace is the physical storage space on the disk that corresponds to the logical space defined by the databooks. Indexspaces can contain several databooks, and databooks can span more than one indexspace. Having the user be able to specify both logical space and physical space allows the user to place indexes physically near each other or logically near each other.

Given these new objects, an indexset is composed of the following components: index catalog, set catalog, transaction log, any number of databooks, and any number of indexspaces. For each of these components, the system needs to have information about the names of each of these components, the initial physical size of these components, their maximum size, and the rate at which these components can increase (when an insertion needs to be made and there is no space, an increase is requested and as long as the maximum size has not been reached, the increase is allowed).

Storing all this information creates a complicated system catalog structure. The databook and indexspace information for indexsets is stored in its own catalog. This is due to the fact that there can be any number of these objects in an indexset (similar to the attribute information for indexes). Since the directory, index catalog, set catalog and transaction log components are required for each indexset, and an indexset can contain at most one of each component, all of this information can be stored in a single catalog along with the indexset name. In addition, it was decided to have entries in this catalog for the total number of databooks and
Figure 3 - Physical Structure of an Indexset
indexspaces in the indexset, to assist in retrieval from the other catalogs.

Figure 4 describes pictorially the system catalog information for indexsets. It contains two examples of indexsets: FOLLET_SET (an indexset that contains all the index information about Ken Follet's books) and SUBJECT_SET (an indexset that contains all the subject information at a specific library). For example, the index catalog component for FOLLET_SET says that the index catalog is located in the file FOLLET_IDX. Its initial size is 4096 bytes, and when the system needs more space for the index catalog, space is allocated in blocks of 1096 bytes. If the size of the index catalog reaches 200000, no more space will be allocated to the

---

**Indexset System Catalog**

<table>
<thead>
<tr>
<th>Indexset</th>
<th># databook</th>
<th># indexspaces</th>
<th>Directory Info</th>
<th>Index Catalog Info</th>
<th>Set Catalog Info</th>
<th>Log Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOLLET_SET</td>
<td>1</td>
<td>1</td>
<td>Device Name: FOLLET_DIR</td>
<td>Device Name: FOLLET_IDX</td>
<td>Device Name: FOLLET_SET</td>
<td>Device Name: FOLLET_LOG</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Init Size: 4096</td>
<td>Incr Size: 1096</td>
<td>Max Size: 200000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBJECT_SET</td>
<td>1</td>
<td>1</td>
<td>Device Name: SUBJECT_DIR</td>
<td>Device Name: SUBJECT_IDX</td>
<td>Device Name: SUBJECT_SET</td>
<td>Device Name: SUBJECT_LOG</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Init Size: 4096</td>
<td>Incr Size: 1096</td>
<td>Max Size: 200000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Databook System Catalog**

<table>
<thead>
<tr>
<th>Indexset</th>
<th>Device_name</th>
<th>Init Size</th>
<th>Incr Size</th>
<th>Max Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOLLET_SET</td>
<td>EARLY_WORKS</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>SUBJECT_SET</td>
<td>COMPUTER_SC</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
</tbody>
</table>

**Indexspace System Catalog**

<table>
<thead>
<tr>
<th>Indexset</th>
<th>Device_name</th>
<th>Init Size</th>
<th>Incr Size</th>
<th>Max Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBJECT_SET</td>
<td>COMPUTER_SC</td>
<td>4096</td>
<td>1096</td>
<td>400000</td>
</tr>
<tr>
<td>FOLLET_SET</td>
<td>EARLY_WORKS</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
</tbody>
</table>

Figure 4 - System Catalog Information for Indexsets.
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index catalog. The Databook System Catalog and the Indexspace System Catalog contain similar information about the databooks and indexspaces in the indexset.

2.1.3. System Catalog — Indexkits

As defined in Section 1, an indexkit is a logical grouping of an introduction, index, dictionary and thesaurus. In order for the system to understand this logical grouping, it needs to keep track of which instances of each component make up this logical grouping. As a result, the system information needed for each indexkit is the name of the indexkit, the introduction name and its location (intro_set), the index name and its location (indexset), the dictionary name and its location (dict_set), and the thesaurus name and its location (thes_set) (Remember that the introduction, dictionary and thesaurus components are not managed by UIS). With this information, the system can efficiently execute all the indexkit commands.

Figure 5 illustrates the system catalog information for indexkits. It contains two example indexkits (they correspond to the two index examples of Figure 2: FOLLET_EOTN (an indexkit corresponding to the index, having the same name), and SUBJECT_LIB (an indexkit corresponding to the subject index of a library catalog). Indexkits are not implemented in the current prototype.

2.2. Run-Time Information

In addition to persistent information about each object in the system, during execution, there is a need to track additional information about the state of objects currently being manipulated or accessed by the system. Tracking such information is essential to maintaining a consistent system. This information will be particularly crucial in a multi-user environment, when it is possible for different users to try to update the same data.

<table>
<thead>
<tr>
<th>Indexkit Name</th>
<th>Intro Name</th>
<th>Intro Set</th>
<th>Index Name</th>
<th>Index Set</th>
<th>Dictionary Name</th>
<th>Dictionary Set</th>
<th>Thesaurus Name</th>
<th>Thesaurus Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOLLET_EOTN</td>
<td>FOLLET_EOTN_INTRO</td>
<td>FOLLET_EOTN</td>
<td>FOLLET_EOTN</td>
<td>BOOKS</td>
<td>FOLLET_DICTIONARY</td>
<td>NOVEL_DICTS</td>
<td>NOVEL_ THES</td>
<td>NOVEL_ THES</td>
</tr>
<tr>
<td>SUBJECT_LIB</td>
<td>SUBJECTS_INTRO</td>
<td>LIBRARY_INTROS</td>
<td>SUBJECTS</td>
<td>LIBRARY</td>
<td>SUBJECT_DICTIONARY</td>
<td>LIBRARY_DICTS</td>
<td>LIBRARY_ THES</td>
<td>LIBRARY_ THES</td>
</tr>
</tbody>
</table>

Figure 5 - System Catalog Information for Indexkits.
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at exactly the same time. If the system were keeping no information about objects currently in the system, then it would have no way of preventing different users from updating the same data at the same time; there would be no way to guarantee a consistent system. This section describes what information UIS needs during execution to maintain consistency of the objects.

2.2.1. Run-Time Information — Indexes

As described in Section 1, the index routines support the notion of a current index. What this means in terms of execution, is that a user can have any number of indexes retrieved at a time (i.e. open and accessible), of which at most one may be the current index. We adopted the notion of using a tag (unique identifier) to identify indexes that have been retrieved to allow us to quickly access the indexes. As a result, anytime an index is retrieved, an index tag is assigned to it. For each index that is retrieved by the system, the tag must be readily available in order to manipulate the index. This run-time variable is designated by Index Tag.

A pointer into the index file must also be readily available to the system if the index is to be accessed at all. Clearly, if the index weren't going to be accessed at all, there would be little reason for the user to retrieve it. Therefore, a file descriptor for each index must also be kept as run-time information while the system is being used. This run-time variable is designated by F_ptr.

An index can be retrieved for either modification or read only. There are two pieces of run-time information that need to be kept related to the retrieval mode of indexes. The first is the actual retrieval mode. The system needs to know whether an index has been retrieved for modification or read only in order to prevent the user from trying to modify an index that was retrieved for read only. This is especially crucial in a multi-user environment, when more than one user may want to access the same index. This run-time variable is designated by Mode. Secondly, the system needs to keep track of whether the index has actually been modified (in the case of retrieval for modification). This information is used in the “save index” command. An index that has been retrieved for modification, but not actually modified does not need to be saved even if the user issues the save index command. Having this information available permits the system to detect these occurrences and not waste its time saving an index that has not actually changed. This run-time variable is designated by Dirty. Dirty is set to TRUE if the index has been modified, but not saved. Dirty is set to FALSE if the index has not been modified since the last time it was saved.
Finally, the system needs to know which indexes that are currently in the system have been created, but not saved. The reason for this is as follows. We cannot guarantee that a newly created index will be small enough to be completely contained in main memory. Therefore, when the user creates a new index, all persistent information is entered into the system catalog and the index files are created. The system needs to be able to distinguish these "created but not saved" indexes from those that either have been recently created but saved, or those that were retrieved. This distinction is necessary because if the user quits the system without saving these indexes, the system needs to know that they are to be deleted. This run-time variable is designated by Saved. Saved is set to TRUE if the index was retrieved during this user session (i.e. created sometime in the past) or if the index was created during this user session and has already been saved. Saved is set to FALSE if the index was created during this user session but has not yet been saved.

The remaining run-time information that needs to be available is the information found in the system catalog. Therefore, a pointer to the system catalog information is also needed at run-time. This run-time variable is designated by SC_info. Figure 6 shows the information that UIS needs to manage and manipulate indexes correctly.

2.2.2. Run-Time Information — Indexsets

As defined in Section 2, an indexset is a catalogued group of indexes and sets. Therefore, when an index or set is to be retrieved from an indexset, its system catalog information is found in the catalog components of the indexset (refer to Figure 1). At execution time, the system needs to maintain file descriptors to the catalog components of the indexset in order to be able to retrieve indexes and sets. These run-time variables are desig-

![Table]

<table>
<thead>
<tr>
<th>Index Tag</th>
<th>Saved?</th>
<th>Mode</th>
<th>Dirty?</th>
<th>SC_info</th>
<th>F_ptr</th>
</tr>
</thead>
<tbody>
<tr>
<td>i1</td>
<td>FALSE</td>
<td>MODIFY</td>
<td>TRUE</td>
<td>**</td>
<td>3</td>
</tr>
<tr>
<td>i2</td>
<td>TRUE</td>
<td>READONLY</td>
<td>FALSE</td>
<td>**</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 6 - Run-Time Catalog Information for Indexes.
nated by Fd_I_cat, Fd_I_attr_cat, and Fd_S_cat. They correspond to the index catalog, the index attribute catalog and the set catalog components of the indexset, respectively.

If multiple indexes or sets are retrieved from a single indexset, we need to be very careful in making sure that only one set of catalog file descriptors are used for that indexset. If every retrieved index and set has its own file descriptor information for the indexsets catalog, then it would be very easy for the system to encounter read/write conflicts in the indexsets catalog components. Therefore, we need to have a way to maintain a single copy of the indexset information, and still know exactly how many indexes and sets from that indexset are currently retrieved. This suggests a need for run-time variables to count the number of retrieved indexes and sets for each indexset. This has two advantages. First, it prevents having multiple file descriptors to the indexset catalog components and prevents read/write conflicts. Second, it allows us to have the indexset retrieved for as small an amount of time as necessary. By keeping track of how many indexes and sets are currently retrieved, the system is able to return the indexset as soon as those numbers are zero. The run-time variables that designate these counts are I_count for indexes, and S_count for sets.

The remaining run-time information that needs to be available is the information found in the system catalog. Therefore, pointers to the system catalog information are also needed at run-time. These run-time variables are designated by SC_info, Databook, and Indexspace, which point to the different system catalog entries for the indexset. Figure 7 shows the information that UIS needs to manage and manipulate indexsets correctly.

2.2.3. Run-Time Information — Indexkits

There is no run-time information needed for indexkits. Because an indexkit is nothing more than a collection of system catalog information, all commands involving indexkits update only this system catalog

<table>
<thead>
<tr>
<th>Fd_I_cat</th>
<th>Fd_I_attr_cat</th>
<th>I_count</th>
<th>Fd_S_cat</th>
<th>S_count</th>
<th>SC_info</th>
<th>Databook</th>
<th>Indexspace</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>&lt;&lt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>&lt;&lt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7 - Run-Time Catalog Information for Indexsets.
information. As a result, the catalog is only accessed at the exact moment a request is made. There is no notion of retrieving an indexkit, and at some later time making some modification to it.
Part II: The Universal Index System Low-Level Design Document
DESCRIPTION

User commands were designed at the same time as the system and run-time information was determined. The designs for indexes and sets were done first, since they are the fundamental objects managed by UIS. After those designs were almost complete, the indexkit and indexset commands were designed. This allowed us to isolate the differences between the objects at an early stage, and also allowed us to use our complete understanding of the index and set routines when trying to create an integrated design of the indexkit and indexset routines.

A template was used while creating the designs to facilitate a complete design. Each design contains the following sections: System Requirements, System Architecture, System Data Structures, System Data Flow, System Control Flow, Design Rationale, Test Plan and Issues. The System Requirements section describes the functionality of the command. It is taken from the requirements document. The System Architecture section presents an algorithm in pseudo-code describing what the system needs to do to execute the command. The System Data Structures section lists the input and output arguments needed to execute the command. Any error messages that are returned are also included in this section. The System Data Flow section provides a description of how the data flows among the different parts of the algorithm. The System Control Flow section provides a description of how execution control flows among the different parts of the algorithm.

The Design Rationale section gives a detailed explanation of the algorithm, and if necessary justifies why certain things are done, or why certain things need to be performed in a specific order. The Test Plan section suggests what type of tests should be run to properly and completely test the command and suggests some robustness tests. The Issues section discusses any side-effects of the routine, any hardware or software requirements for the execution of the routine, and provides explanations for any unclear information presented in the previous sections. The Issues section is also used to present unanswered questions about the design or the interaction of this routine with others.

The low-level design of the index, indexset and indexkit commands follows.
Routine Name: Create Index (I_create())

Routine Number: 3.1.2.2

1. System Requirements

Create index allows the user to create an index object. The user must specify the type of the index, the storage format, and the attributes and their type that make up the index. Formats include btrees, rtrees, ascii, virtual, etc. The type is expressed in the form (m,n) where m is the multiplicity of the item tuples, and n is the number of item tuples in the table.

2. System Architecture

- parse
- validate
- create_index_files
- allocate_WA
- assign_tag
- RTIC_insert
- SIC_insert

3. System Data Structures

1. Input

| index_name | string | < the name for the index to create > |
| indexspace | string | < indexspace to place index created > |

Optional:

| indexset | string | < indexset to place index created > |
| type | TYPE | < dimension of index > |
| format | string | < storage format: btree, rtree ... > |
| table | array of ATTR_DESC | < (attr_name, attr_type, attr_len) pairs for each attribute that makes up the index > |

2. Output

| tag | TAG | < tag of index created, NULL if error > |

4. System Data Flow

- parse --> validate
- validate --> create_index_files
- allocate_WA
- assign_tag
- RTIC_insert
- SIC_insert
- create_index_files --> RTIC_insert
- SIC_insert
- assign_tag --> RTIC_insert
SIC_insert

5. System Control Flow

I_create <--
  parse
  validate
  assign_tag
  create_index_files
  RTIC_insert
  SIC_insert

6. Design Rationale

This routine will create an empty index. First it will check that the index to create does not already exists. It will also check that the type and format arguments are valid. It will also check that the types of the attributes are valid attribute types. If none of these checks produces an error, then the index will be created, and a catalog entry will be created for it. A logical tag will be assigned to the newly created index. The catalog value for I_saved will be FALSE (meaning that this index has not been saved since creation time), index_mode will be 'm' (for modify), and for dirty will be 'true', so that the index will be saved as empty if no insertions are performed.

7. Test Plan

Test all supported formats, all supported types, creation of pre-existing index, insufficient arguments, and, of course, successful creation of an index. Also test invalid formats to make sure error is caught.

8. Issues
Routine Name: Drop Index (I_drop())

Routine Number: 3.1.8.1

1. System Requirements

The 'drop index' command allows the user to delete (or destroy) an index.

2. System Architecture

parse
validate
remove_files
SIKC_update(indexkit information update)
SIC_delete

3. System Data Structures

1. Input

index_name string < name of the index to delete >
indexset_name string < name of the indexset containing index >

2. Output

IME_OK success
IME_FAILURE general error
IME_DNE index to drop does not exist
IME_BAD_MODE index not retrieved for modification

4. System Data Flow

parse --> validate
validate --> remove_files
SIKC_update
SIC_delete

5. System Control Flow

I_drop <-- parse
validate
remove_files
SIKC_update
SIC_delete

6. Design Rationale

This routine will delete an index from an indexset. First, it will check that the index to drop actually exists. If it does, then it will be deleted, and the catalogs will be updated. If the index has an indexkit associated with it, an indexkit call will be made to
update the indexkit catalog entry.

7. Test Plan
   Test all error codes.

8. Issues
Routine Name: Insert Index (I_Insert() )

Routine Number: 3.1.3.1.2

1. System Requirements

   The 'insert into index' command allows one to modify an index by inserting a new row.

2. System Architecture

   parse
   validate

   I_retrieve

   for each tuple in the list
   IC_insert(attr_name attr_value pairs)

   I_save

3. System Data Structures

1. Input

   index_name          string       < name of Index to be updated >
   indexset_name       string       < indexset name of Index to be updated >
   attr_vals           array of     < (attribute name, value) pairs for index entry
                         ATTR_PAIR    to be inserted >

2. Output

   IME_OK             I_insert successful
   IME_FAILURE        general failure
   IME_NONUNIQUE      non-unique indexset/name combination
   IME_BAD_VALUE      bad pointer/attribute value
   IME_DNE            index DNE

4. System Data Flow

   parse --&gt; validate
   validate --&gt; IC_insert
               I_Save

5. System Control Flow

   I_Insert &lt;-- parse
               validate
               IC_insert
               I_Save

6. Design Rationale
Tuple is inserted and Index is saved.

7. Test Plan

Test Cases should check for correct handling of invalid index names, bad pointer values, and attribute values that are not part of the index. Also check for attempt to insert incomplete tuples (containing NULLs).

8. Issues
Routine Name: Update Index (I_Update)

Routine Number: 3.1.3.1.1

1. System Requirements

The 'update index' command updates the specified index using the given attribute and pointer values. The user must specify a valid index name and indexset name, attribute value(s), and/or pointer value(s), using the correct syntax to indicate whether the pointer or the attribute is being altered.

2. System Architecture

parse
validate

IB_build

I_first
I_fetch
alter_tuple
IC_delete
IC_insert

(repeat as necessary the 6 following commands)
I_next
I_fetch
alter_tuple
IC_delete
IC_insert
I_save

3. System Data Structures

1. Input

    index_name      string      < name of Index to be updated >
    indexset_name   string      < indexset name of Index to be updated >
    set_vals        array of    < array of (attribute name, value) pairs to be passed to IC_Update >
                        ATTR_PAIR
    bool_val        string      < condition to be used to build a boolean to traverse the index and select tuples to be modified >

2. Output

    IME_OK          I_update successful
    IME_FAILURE     general failure
    IME_NONUNIQUE   non-unique indexset/name combination
    IME_BAD_VALUE   bad attribute value
    IME_DNE         index DNE
4. System Data Flow

parse --> validate
validate --> IB_build
I_first
I_fetch
alter_tuple
IC_delete
IC_insert
I_next
I_save

5. System Control Flow

I_update<-- parse
validate
IB_build
I_first
I_fetch
alter_tuple
IC_delete
IC_insert
I_next
I_save

6. Design Rationale

Get the index to be updated. Fetch tuples by traversing the index using the boolean condition given in the update command (bool_val). Update each qualifying tuple by setting the attributes/pointer as specified in the update command (set_vals). When no more tuples qualify, save the changes.

7. Test Plan

Test Cases should check for correct handling of invalid index names, bad pointer values, bad data values.

8. Issues
Routine Name: Move Index (I_move())

Routine Number: 3.1.5.1

1. System Requirements

The move index command allows the user to move an index from one location to another. (potentially renaming the index in the process).

2. System Architecture

parse
validate
check_uniqueness
move_index

RTIC_retrieve < update both indexset catalogs >
RTIC_delete
RTIC_insert
SIC_retrieve < update both indexset catalogs >
SIC_delete
SIC_insert

3. System Data Structures

1. Input

   | index_name   | string   | < name of the index to move > |
   | old_indexset | string   | < current location of index > |
   | new_indexset | string   | < place to move and name to give index > |

2. Output

   IME_OK        | success     | success |
   IME_FAILURE  | general error | general error |
   IME_DNE      | index to move non-existent | index to move non-existent |
   IME_NONUNIQUE | index to move will not be unique in new location | index to move will not be unique in new location |

4. System Data Flow

parse --> validate
validate --> check_uniqueness
move_index --> RTIC_retrieve
             RTIC_delete
             RTIC_insert
             SIC_retrieve
             SIC_delete
             SIC_insert

5. System Control Flow
6. Design Rationale

This routine will move an index from one indexset to another. First it will check that the index to move currently exists and will remain unique in its new indexset. If so, it will move the index files from one indexset to another, updating the catalogs of both indexsets to reflect the change.

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Delete from Index (I_Delete())

Routine Number: 3.1.3.1.3

1. System Requirements

The 'delete from index' command allows one to modify an index by removing one index tuple or all the tuples with a given attribute value.

2. System Architecture

parse
validate
IB_build
I_first
IC_delete

(repeat as necessary the 3 following commands)
I_next
IC_delete
I_save

3. System Data Structures

1. Input

index_name string < name of Index to be modified >
indexset_name string < indexset name of Index to be modified >
bool_val string < boolean condition for traversing the index and selecting tuples to be deleted >

2. Output

IME_OK I_delete successful
IME_NONUNIQUE non-unique indexset/name combination
IME_BAD_VALUE bad attribute/pointer value
IME_DNE index DNE

4. System Data Flow

parse ---> validate
validate ---> IB_build
I_first
IC_delete
I_next
IC_delete
I_save
5. System Control Flow

\begin{verbatim}
I_delete <-- parse validate IB_build I_first IC_delete I_next IC_delete I_save
\end{verbatim}

6. Design Rationale

Open the index. Position the pointer to point to a tuple, using the boolean built with attr_vals. Delete that tuple, move on to the next one.
When no more tuples qualify, save the index.

7. Test Plan

Test Cases should check for correct handling of invalid index names, bad pointer values, and bad data values.

8. Issues
Routine Name: Copy Index (I_copy())

Routine Number: 3.1.4.1.1

1. System Requirements

The copy index command allows the user to make identical copies of indexes.

2. System Architecture

\[
\text{B = copy(A)}
\]

parse
validate

I_retrieve(A)
I_create(B)

for each tuple in A
    insert_tuple into B
end loop

I_save(B)
I_return(A)
I_return(B)

3. System Data Structures

1. Input

| index1      | string | < name for index to be copied from > |
| indexset1   | string | < indexset containing index1 > |
| index2      | string | < name of the index to copy into > |
| indexset2   | string | < indexset to contain index2 > |

Optional:

format string < storage representation of index >

2. Output

IME_OK success
IME_FAILURE general error
IME_DNE index to copy does not exist
IME_NONUNIQUE new index name already exists

4. System Data Flow

parse --\rightarrow validate
validates \rightarrow I_retrieve
I_create
copy_loop
I_save
I_return
I_return

5. **System Control Flow**

I_copy <-- parse
    validate
    I_retrieve
    I_create
    copy_loop
    I_save
    I_return
    I_return

6. **Design Rationale**

This routine will make a duplicate copy of the specified index (with potentially a different format). First it will check that the index to copy exists, and the resulting index will be unique. If no errors are produced from these checks, then the new index will be created with the same parameters as the index to be copied. The index name and format are taken from the argument list. Specifying the format is optional. If no format is specified, it is taken from the catalog entry of the index to copy. The index is copied, and the catalog is updated. The new index is saved and both indexes are returned.

7. **Test Plan**

Test all error codes.

8. **Issues**
Routine Name: Intersect Index (I_intersect())

Routine Number: 3.1.4.1.4

1. System Requirements

The 'intersect index' command allows the user to intersect indexes.

2. System Architecture

\[ C = A - B \]

parse
validate

I_retrieve(A)
I_retrieve(B)
test_compatibility(A,B)
I_create(C)

for every tuple in A
    if there exists an equivalent tuple in B then
        insert_tuple(C)
    end loop

I_save(C)
I_return(A)
I_return(B)
I_return(C)

3. System Data Structures

1. Input

index1 string < name of one index to intersect >
indexset1 string < indexset containing index1 >
index2 string < name of the other index to intersect >
indexset2 string < indexset containing index2 >
new_index string < name of the new index to create >
indexset3 string < indexset containing new_index >

Optional:
new_index_format string < see Create Index 3.3.2 >

2. Output

IME_OK success
IME_FAILURE general error
IME_DNE an index to intersect does not exist
IME_NONUNIQUE index to create as result already exists
IME_INCOMPATIBLE indexes to intersect are of incompatible types

4. System Data Flow
5. **System Control Flow**

I_intersect <-- parse
   validate
   I_retrieve
   I_retrieve
   test_compatibility
   I_create
   intersection_loop
   I_save
   I_return
   I_return

6. **Design Rationale**

This routine will compute the intersection of two indexes. First it will check that the two indexes to intersect actually exist and are of compatible types. It will also check that the resulting index does not already exist. If none of these checks produces an error, then it will create the new index, compute the intersection, and save the newly created index. The arguments passed to I_create will be obtained from the catalog entry of the first index to be intersected. The name of the index and the format of the index are provided by the argument list. Specifying the format is optional. If it is not specified, it will be taken from the first index to be intersected.

7. **Test Plan**

Test all error codes.

8. **Issues**
Routine Name: Subset Index (I_subset())

Routine Number: 3.1.4.1.2

1. System Requirements

   The 'subset index' command allows one to make an index from a subset of another index.

2. System Architecture

   \[ B = \text{subset}(A) \]

   parse
   validate
   I_retrieve(A)
   IS_syntax(select)
   IB_build(boolean)
   I_create(B)
   get first record in index
   test record with boolean
   fetch record from index
   insert into index using select
   (repeat as necessary the 4 following commands)
   get next record in index
   test record with boolean
   fetch record from index using select
   insert into index
   I_save(B)
   I_return(A)
   I_return(B)

3. System Data Structures

   1. Input

      index1              string  < name of index to be created >
      indexset1           string  < indexset containing index1 >
      index2              string  < name of index to be subsetted >
      indexset2           string  < indexset to contain index2 >
      select              string  < attribute names of indexed attrs to be subsetted >
      bool_str             string  < boolean condition used to select tuples to go into new index >
      format               string  < indicates r-tree, b-tree, or ascii >

   2. Output
IME_OK
IME_FAILURE
IME_NONUNIQUE
IME_DNE

4. System Data Flow

parse --> validate
validate --> I_retrieve
           IS_syntax
           IB_build
           I_create
           get_first_rec
           fetch_rec_w_select
           insert_rec
           get_next_rec
           fetch_rec_w_select
           insert_rec
           I_save
           I_return
           I_return

5. System Control Flow

I_subset <-- parse
           validate
           I_retrieve
           IS_syntax
           IB_build
           I_create
           get_first_rec
           fetch_rec_w_select
           insert_rec
           get_next_rec
           fetch_rec_w_select
           insert_rec
           I_save
           I_return
           I_return

6. Design Rationale

Check that index to subset exists, build select, build boolean, check that the index to create with result does not already exist. Create the new index. Navigate the index. Insert the selected parts of the retrieved tuples into the newly created index. Save the new index. Return the two indexes.

7. Test Plan

Test Cases should check for correct handling of invalid index names, bad format values.

8. Issues
Routine Name: Subtract Index (I_subtract())

Routine Number: 3.1.4.1.5

1. System Requirements

The subtract index command allows the user to subtract the different parts of indexes.

2. System Architecture

\[ C = A - B \]

parse
validate

I_retrieve(A)
I_retrieve(B)
tesLcompatibility(A,B)
I_create (C)

for every tuple in A
  if there does not exist an equivalent tuple in B then
    insert_tuple(C)
end loop

I_save (C)
I_return(A)
I_return(B)
I_return(C)

3. System Data Structures

1. Input

   index1 string < name of one index to subtract >
   indexset1 string < indexset of index 1 >
   index2 string < name of the other index to subtract >
   indexset2 string < indexset of index2 >
   index3 string < name of the new index to create >
   indexset3 string < indexset of new index >

Optional:
new_index_format string < see Create Index 3.3.2 >

2. Output

   IME_OK success
   IME_FAILURE general error
   IME_DNE an index to subtract does not exist
   IME_INCOMPATIBLE indexes to subtract are of incompatible types
   IME_NON_UNIQUE index to create as result already exists

4. System Data Flow
Design Rationale

This routine will compute the subtraction of two indexes. First it will check that the two indexes to subtract actually exist and are of compatible types. It will also check that the resulting index does not already exist. If none of these checks produces an error, then it will create the new index, compute the subtraction, and save the newly created index. The arguments passed to I_create will be obtained from the catalog entry of the first index to be subtracted. The name of the index and the format of the index are provided by the argument list. Specifying the format is optional. If it is not specified, it will be taken from the first index to be subtracted.

Test Plan

Test all error codes.

Issues
Routine Name: Union Indexes (I_union())

Routine Number: 3.1.4.1.3

1. System Requirements

The 'union index' command allows one to create an index that is the union of two other indexes.

2. System Architecture

[C = A union B]

parse
validate

I_retrieve(A)
I_retrieve(B)
test_compatibility(A,B)
I_create(C)

(for each index being unioned)
get first record in index
fetch record from index
insert into index

(repeat as necessary the 3 following commands)
next record in index
fetch record from index
insert into index

(end repeat for each index)

I_save(C)
I_return(A)
I_return(B)
I_return(C)

3. System Data Structures

1. Input

index1          string             < name of index to be unioned >
indexset1       string             < indexset containing index1 >
index2          string             < name of index to be unioned >
indexset2       string             < indexset containing index2 >
new_index       string             < name of index to be created >
indexset3       string             < indexset to contain new index >
format          string             < indicates r-tree, b-tree, or ascii >

2. Output

IME_OK               successful union index
**IME FAILURE**
failure: index does not exist

**IME_DNE**
non-unique indexset/name combination

**IME_NONUNIQUE**
indexes to union are incompatible

**IME_INCOMPATIBLE**

4. **System Data Flow**

\[\text{parse} \rightarrow \text{validate} \]
\[\text{validate} \rightarrow \_\text{retrieve} \]
\[\text{I\_retrieve} \text{test\_compatibility} \]
\[\text{I\_create} \text{union\_loop} \]
\[\text{I\_save} \text{I\_return} \]
\[\text{I\_return} \]

5. **System Control Flow**

\[\text{I\_union} \leftarrow \text{parse} \]
\[\text{validate} \text{I\_retrieve} \text{I\_retrieve} \text{test\_compatibility} \]
\[\text{I\_create} \text{union\_loop} \text{I\_save} \text{I\_return} \]
\[\text{I\_return} \]

6. **Design Rationale**

Check that indexes to union exist and are compatible, and check that the index to create as result does not already exist.
Create the new index. Navigate the indexes being unioned, retrieving tuples and inserting them into the newly created index. Save the newly created index, and return all indexes retrieved and created.

7. **Test Plan**

Test Cases should check for correct handling of invalid index names, bad format values.

8. **Issues**

Boolean is TRUE and Select is *.
Routine Name: Find Term in Index (I_find_term())

Routine Number: 4.1.1.3

1. System Requirements

The 'find term in index' command will enable the user to obtain from the current index component a list of terms alphabetically surrounding a submitted term in the logical text file.

In the Menu access, the default editor is automatically invoked to read the logical text file. In the Host Language Interface, the result can also be in the logical text string.

2. System Architecture

process form
parse
validate

IB_build

get first record in index
test record with boolean
fetch record from index
add to term list

(repeat as necessary the 3 following commands)
get next in index
test record with boolean
fetch record from index
add to term list

Return Term List

3. System Data Structures

1. Input (input is gotten by Process_form and returned in a string)

   term_string  string  < string form "attr_name attr_value" >

2. Output

   term_list  array of strings  < each string is a found term. NULL value indicates error or no terms found >

4. System Data Flow

   form_new  -->  parse
   parse  -->  validate
   validate  -->  IB_build
               get_first_rec
5. **System Control Flow**

```
I_Find_Term<-- form_new
        parse
        validate
        IB_build
        get_first_rec
        fetch_rec
        add_to_term_list
        get_next_rec
        return_term_list
```

6. **Design Rationale**

A boolean is built using 'term' and some pre-set range decided by the system to be an acceptable alphabetical range for single term queries. The index is navigated and terms are added to the term-list as they are fetched. The term-list is returned when the entire index has been searched.

7. **Test Plan**

Test Cases should check for correct handling of invalid attribute names and bad term values.

8. **Issues**

The pre-defined ranges are set in the system.
Routine Name: Build Set from Index with Term (I_build_set_term())

Routine Number: 4.1.1.4.1

1. System Requirements

The 'build set with term' command will enable the user to build a set of Entrids which are associated with a submitted term in the current index. The system will assign a tag to the new set and print in the logical text file the set tag, set description, and set size.

In the Menu access, the logical text file is automatically displayed. In the Host Language Interface access, the result can also be in the logical text string.

2. System Architecture

parse
validate

IB_build

S_build_empty
get first record in index
fetch record from index using select
insert into set

(repeat as necessary the 3 following commands)
next in index
fetch record from index using select
insert into set

return set description

3. System Data Structures

1. Input

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>set_name</td>
<td>string</td>
</tr>
<tr>
<td>attr_name</td>
<td>string</td>
</tr>
<tr>
<td>term</td>
<td>string</td>
</tr>
<tr>
<td>set_attr</td>
<td>string</td>
</tr>
</tbody>
</table>

2. Output

<table>
<thead>
<tr>
<th></th>
<th>SET_INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>set_desc</td>
<td>&lt; string containing set tag, set description, and set size. NULL value indicates error &gt;</td>
</tr>
</tbody>
</table>

4. System Data Flow

parse --> validate
validate --> S_build_empty
IB_build
get_first_rec
fetch_rec
insert_into_set
get_next_rec
fetch_rec
insert_into_set
return_set_desc

5. System Control Flow

I_build_set_w_term <-- parse
validate
S_build_empty
IB_build
get_first_rec
test_w_boolean
fetch_rec
insert_into_set
get_next_rec
return_set_desc

6. Design Rationale

A boolean is built using 'term'. The index is navigated and pointer values are added to the set as they are fetched. The set description is returned when the entire index has been searched.

7. Test Plan

Test Cases should check for correct handling of invalid attribute names and bad term values.

8. Issues
Routine Name: Build Set from Index with List (I_build_set_list())

Routine Number: 4.1.1.4.2

1. System Requirements

The 'build set with list' command will enable the user to build a set of Entrids which are associated with a list of terms contained in a submitted file in the current index. The system will assign a tag to the new set and print in the logical text file the set tag, set description, and set size.

In the Menu access, the logical text file is automatically displayed. In the Host Language Interface access, the result can also be in the logical text string.

2. System Architecture

parse
validate

IB_build
S_build_empty

get first record in index
test record with boolean
fetch record from index
insert into set

(repeat as necessary the 3 following commands)
next in index
test record with boolean
fetch record from index
insert into set

return set description

3. System Data Structures

1. Input

<table>
<thead>
<tr>
<th>set_name</th>
<th>string</th>
<th>&lt; name of the set to be built &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>attr_name</td>
<td>string</td>
<td>&lt; name of the attribute for the terms &gt;</td>
</tr>
<tr>
<td>term_list</td>
<td>array of strings</td>
<td>&lt; terms to be searched for &gt;</td>
</tr>
<tr>
<td>set_attr</td>
<td>string</td>
<td>&lt; attribute to project into set &gt;</td>
</tr>
</tbody>
</table>

2. Output

| set_desc          | SET_INFO | < contains set tag, set description, and set size. NULL value indicates error > |

4. System Data Flow
5. **System Control Flow**

L_build_set_list <-- parse
validate
S_build_empty
IB_build
get_first_rec
fetch_record
insert_into_set
get_next_rec
fetch_record
insert_into_set
return_set_desc

6. **Design Rationale**

A boolean is built using the terms in 'term_list'. The index is navigated and pointer values are added to the set as they are fetched. The set description is returned when the entire index has been searched for every term in the list.

7. **Test Plan**

Test Cases should check for correct handling of invalid attribute names and bad term values.

8. **Issues**
1. **System Requirements**

The 'build set with range' command will enable the user to build a set of Entrys which are associated with a boolean expression in the current index. The system will assign a tag to the new set and print in the logical text file the set tag, set description, and set size.

In the Menu access, the logical text file is automatically displayed. In Host Language Interface access, the result can also be in the logical text string.

2. **System Architecture**

```
parse
validate

IB_build

S_build_empty

get first record in index
test record with boolean
fetch record from index
insert into set

(repeat as necessary the 4 following commands)
get next record in index
test record with boolean
fetch record from index
insert into set

return set description
```

3. **System Data Structures**

1. **Input**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>set_name</td>
<td>string</td>
<td>&lt; name of the set to be built &gt;</td>
</tr>
<tr>
<td>attr_name</td>
<td>string</td>
<td>&lt; name of attribute having values &gt;</td>
</tr>
<tr>
<td>term_list</td>
<td>array of strings</td>
<td>&lt; values to create range from &gt;</td>
</tr>
<tr>
<td>set_attr</td>
<td>string</td>
<td>&lt; attribute to project into set &gt;</td>
</tr>
</tbody>
</table>

**E.g.**

If term_list = { 1, 12, 18, 22, 29, 33, NULL }
then that means get all tuples from the current index
where

- 1 < attr_name < 12 OR
- 18 < attr_name < 22 OR
- 29 < attr_name < 33

2. **Output**
4. System Data Flow

parse --> validate
validate --> S_build_empty
      IB_build
      get_first_rec
      fetch_rec
      insert_into_set
      get_next_rec
      fetch_rec
      insert_into_set
      return_set_desc

5. System Control Flow

I_build_set_w_range <-- parse
    validate
    S_build_empty
    IB_build
    get_first_rec
    fetch_rec
    insert_into_set
    get_next_rec
    fetch_rec
    insert_into_set
    insert_into_set
    return_set_desc

6. Design Rationale

A boolean is built using the information in term_list to build the
range as described above. The index is navigated and pointer values
are added to the set as they are fetched. The set description is
returned when the entire index has been searched.

7. Test Plan

Test Cases should check for correct handling of invalid attribute names
and bad term values.

8. Issues
Routine Name: Retrieve Index (I_retrieve())

Routine Number: 4.1.1.1.1

1. System Requirements

The 'retrieve index' command enables the user to retrieve or open an index component. The retrieval can be for 'read-only' or 'modify' mode. The system will automatically assign the retrieved component to a logical tag. If the component does not exist, then an error message appears in the logical error file.

2. System Architecture

parse
validate
SIC_retrieve
RTIC_insert

3. System Data Structures

1. Input

index_name string < name of index to be retrieved >
indexset_name string < indexset name of index to be retrieved >
mode integer < signifies read-only or modify mode >

2. Output

IME_OK successful retrieval of index
IME_FAILURE general failure
IME_DNE index does not exist

4. System Data Flow

parse --> validate
validate --> SIC_retrieve
RTIC_insert

5. System Control Flow

I_retrieve <-- parse
validate
SIC_retrieve
RTIC_insert

6. Design Rationale

First check that the index is not already retrieved, and if so, return an error. Otherwise, retrieve the system catalog information, assign it a tag, and update the RT catalogs to
reflect this.

7. **Test Plan**

Test all error codes, plus the retrieval of an already retrieved index.

8. **Issues**

Should you be allowed to retrieve the same index more than once?  
-->NO
Routine Name: Pick Index (I_pick())

Routine Number: 4.1.1.1.3

1. System Requirements

The 'pick index' command will enable the user to make as 'current' one of the retrieved index components. If the component does not exist, then an error message appears in the logical error file.

2. System Architecture

parse
validate

RTIC_retrieve
I_bind_retrieve
CWA_I_update

3. System Data Structures

1. Input

   tag TAG < identifier for retrieved index >

2. Output

   IME_OK successful picking of index
   IME_BAD_TAG bad tag

4. System Data Flow

   parse --> validate
   validate --> RTIC_retrieve
              CWA_I_update

5. System Control Flow

   I_pick <-- parse
              validate
              RTIC_retrieve
              CWA_I_update

6. Design Rationale

   Search the RTC for the tag of the index to be made current. When a match is found, update the CWA to point to the RTC entry for that index. Also, update the pointer to current binding for the newly picked index.

7. Test Plan

   Test for invalid tag values and tags that don't belong to an index
component.

8. Issues

The current index boolean and current index select are automatically updated to the default boolean (TRUE) and select (*), to guarantee that at all times the boolean and select are compatible with the
Routine Name: Save Index (I_save())

Routine Number: 4.1.1.1.4

1. System Requirements

The 'save index' command enables the user to save the 'current' retrieved index component. If the component was not retrieved in 'modify' mode, then an error message appears in the logical error file.

2. System Architecture

parse
validate
flush buffers to disk
RTIC_update

3. System Data Structures

1. Input

2. Output

IME_OK successful save
IME_FAILURE general failure
IME_BAD_MODE wrong mode on index
IME_BAD_TAG invalid tag

4. System Data Flow

parse --> validate
validate --> flush_buffers_to_disk
RTIC_update

5. System Control Flow

I_save <-- parse
validate
flush_buffers_to_disk
RTIC_update

6. Design Rationale

After validating that the index is open for modify mode and has been modified since the last save, flush the buffers containing the updated copy of the index to disk. Update the RTC to reflect that the index has not been modified since the last save.

7. Test Plan

Test for bad mode.
Routine Name: Return Index (I_return())

Routine Number: 4.1.1.1.5

1. System Requirements

The 'return index' command will enable the user to return a retrieved index component. If the index was retrieved for modify mode and was not saved, an error message appears in the logical error file.

2. System Architecture

parse
validate
RTIC_delete
CWA_I_update (if necessary)
I_bind_delete

3. System Data Structures

1. Input
tag
   TAG < tag for index to be returned >

2. Output
   IME_OK successful save
   IME_FAILURE general failure
   IME_NOTSAVED index modified but not saved
   IME_BAD_TAG bad tag value

4. System Data Flow

parse --> validate
validate --> RTIC_delete
CWA_I_update
I_bind_delete

5. System Control Flow

I_return <-- parse
   validate
   RTIC_delete
   CWA_I_update
   I_bind_delete

6. Design Rationale

First check to see if any modification has been done since the last save, and if none has, remove its entry from the RTC. If the index you are returning is the current index, then the CWA for indexes will
have to be updated. If the index has been modified, it will still be returned, but an error message is returned.

7. **Test Plan**

Test for bad tags and for an attempt to return a modified index before saving it.

8. **Issues**

Since minirel is being used as the underlying system, when an index that has been modified is returned, it is considered saved. In other words, the modifications become permanent.
Routine Name: List Indexes (I_list())

Routine Number: 4.1.1.1.2

1. System Requirements

The 'list indexes' command will enable the user to obtain a list of the retrieved index components of the current book.

In the Menu access, the default text editor is automatically invoked to read the logical text file. In Host Language Interface access, the result can also be in the logical text string.

2. System Architecture

RTIC_traverse

3. System Data Structures

1. Input

2. Output

val_list LIST < a structure containing the number of indexes currently retrieved, and an array of tag, index-name pairs about each index >

4. System Data Flow

5. System Control Flow

I_list <-- RTIC_traverse

6. Design Rationale

Search the run-time catalog for indexes, return the tag, name, and indexset name of each index entry found.

7. Test Plan

Test for case where there are no retrieved indexes.

8. Issues
Routine Name: First in Index (I_first())

Routine Number: 4.1.1.5.1.1

1. System Requirements

The 'first in index' command will enable the user to position the current row pointer to point to the first row of the current index component with respect to the current index boolean (see section 4.3.5.2). If no such row is found, then an error is indicated in the logical error file.

2. System Architecture

parse
validate

search with boolean
I_bind_info
CWA_I_update

3. System Data Structures

1. Input

2. Output

IME_OK successful search
IME_FAILURE general failure
IME_NO_CURRENT no current index
IME_NO_QUALIFY no qualifying row

4. System Data Flow

parse --> validate
validate --> search_w_boolean
I_bind_info
CWA_I_update

5. System Control Flow

I_first <-- parse
validate
search_w_boolean
I_bind_info
CWA_I_update

6. Design Rationale

This routine will search from the beginning of the index file, looking for the first tuple in the index to satisfy the current index boolean. I_current_row is updated. Binding to program variables is performed.
7. **Test Plan**

Test all error codes.

8. **Issues**
Routine Name: Next in Index (I_next())

Routine Number: 4.1.1.5.1.2

1. System Requirements

The 'next in index' command will enable the user to position the current row pointer in the CWA to point to the next row of the current index component with respect to the current index boolean (see section 4.3.5.2). If no such row is found, then an error is indicated in the logical error file.

2. System Architecture

parse
validate

relative search with boolean

I_bind_info
CWA_I_update(I_current_row)

3. System Data Structures

1. Input

2. Output

IME_OK successful search
IME_FAILURE general failure
IME_NO_CURRENT no current row
IME_NO_QUALIFY no qualifying row

4. System Data Flow

parse → validate
validate → relative_search_w_boolean
 I_bind_info
CWA_I_update

5. System Control Flow

I_next ← parse
 validate
 relative_search_w_boolean
 I_bind_info
 CWA_I_update

6. Design Rationale

Relative_Search_w_Boolean will search from the value of I_current_row forward through the index, looking for the next tuple that satisfies the current index boolean. Binding to program variables is performed.
7. **Test Plan**
   Test for case with no qualifying row.

8. **Issues**
Routine Name: Fetch from Index (I_fetch())

Routine Number: 4.1.1.5.1.4

1. System Requirements

The 'fetch from index' command will enable the user to obtain a row of the current index component with respect to the current index row address. The row is output to the logical text file. The amount of the row output is defined by the current index select (see section 4.3.5.3).

In the Menu access, the default text editor is automatically invoked to read the logical text file. In Host Language Interface access, the result can also be in the logical text file, logical text string, or assigned to program variables (see section 4.3.7).

2. System Architecture

parse
validate
return tuple

3. System Data Structures

1. Input

2. Output

tuple_val

TUPLE < selected parts of the current index row will be null if there's an error >

4. System Data Flow

parse --> validate
validate --> return_tuple

5. System Control Flow

I_fetch <-- parse
validate
return_tuple

6. Design Rationale

Return the tuple pointed to by the current row pointer in the current working area.

7. Test Plan

8. Issues
Routine Name: Last in Index (I_last())

Routine Number: 4.1.1.5.1.5

1. System Requirements

The 'last in index' command will enable the user to position the current row point of the CWA to point to the last row of the current index component with respect to the current index boolean (see section 4.3.5.2). If no such row is found, then an error is indicated in the logical error file.

2. System Architecture

parse
validate

backward search with boolean

I_bind_info
CWA_I_update

3. System Data Structures

1. Input

2. Output

| IME_OK               | successful search           |
| IME_FAILURE         | general failure             |
| IME_NO_CURRENT      | no current index            |
| IME_NO_QUALIFY      | no qualifying row           |

4. System Data Flow

parse --> validate
validate --> backward_search_w_boolean
          I_bind_info
          CWA_I_update

5. System Control Flow

I_last <-- parse
          validate
          backward_search_w_boolean
          I_bind_info
          CWA_I_update

6. Design Rationale

This routine will search backward from the end of the index file looking for the first (remember searching backward) tuple that satisfies the current index boolean. The value of I_current_row is
updated. Binding to program variables is performed.

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Previous in Index (I_previous())

Routine Number: 4.1.1.5.1.3

1. **System Requirements**

   The 'previous in index' command will enable the user to position the current row pointer in the CWA to point to the previous row of the current index component with respect to the current index boolean (see section 4.3.5.2). If no such row is found, then an error is indicated in the logical error file.

2. **System Architecture**

   parse
   validate

   relative backward search with boolean

   I_bind_info
   CWA_I_update

3. **System Data Structures**

   1. Input
   2. Output

   IME_OK successful search
   IME_FAILURE general failure
   IME_NO_CURRENT no current row
   IME_NO_QUALIFY no qualifying row

4. **System Data Flow**

   parse --> validate
   validate --> relative_backward_search_w_boolean
               I_bind_info
               CWA_I_update

5. **System Control Flow**

   I_previous <-- parse
   validate
               relative_backward_search_w_boolean
               I_bind_info
               CWA_I_update

6. **Design Rationale**

   Get the previous row wrt the current row and current boolean. Update the CWA current row pointer. Binding to program variables is performed.
7. **Test Plan**
   Test all error codes.

8. **Issues**
Routine Name: Build Index Boolean (IB_build())

Routine Number: 4.1.1.5.2.1

1. System Requirements

The system will enable the user to build an index boolean for navigating through the index rows. The user receives in the logical text file an index boolean form for building such a boolean. The user completes the form and submits it. The system assigns the index boolean a tag. If an error in building the boolean is made, then an error is returned.

In Menu and Command access, the form is input/output through the logical text file. In the Menu access, the default text editor is automatically invoked to build the form. In Host Language Interface access, the form can be built through the logical text string.

2. System Architecture

form_new
parse
validate
assign_tag
RTI_BC_insert

3. System Data Structures

1. Input
2. Output

| tag          | TAG | the tag of the index boolean just created. NULL if error occurs. |

4. System Data Flow

| form_new --> parse |
| parse --> validate |
| validate --> assign_tag |
| RTI_SC_insert     |

5. System Control Flow

IS_build <-- form_new
parse
validate
assign_tag
RTI_SC_insert

6. Design Rationale

This routine will build an index boolean and insert it into the
catalog. The user is given a form to complete defining the index boolean. This definition is then parsed into an internal format, checking that the expression is syntactically correct. A catalog entry is created and a tag is assigned to the boolean definition.

There is no compatibility check done at this time. That is done at the time the user 'picks' the index Boolean as current.

7. Test Plan

8. Issues

This routine receives it's input from form_new that is spawned. The form_new will give this routine's input in string format.

Boolean_list string < boolean condition >

It is up to us to parse the string into our internal format.

A valid boolean condition must follow the following rules:
Relational operators supported are <, >, =, <=, >=.
Logical operators supported are AND, OR, NOT.
Attribute types supported are characters, integers, floats, and strings.
A simple clause is of the form:
[NOT] <attr_name> <rel_op> { <attr_name> | <constant> }

NOT is optional, and if specified implies the negation of the entire simple clause. The first operand MUST ALWAYS be an attribute name. The second operand can be either an attribute name or a constant.

Constants are of the following forms:
Integer constants the number e.g. 345 10 0 -3
Float constants the number e.g. 3.1415 0.3 -3.553
Character constants the character enclosed in single quotes e.g. 'a' 'x' '?' '@' '1'
String constants the string enclosed in double quotes (note the quotes are NOT part of the string) "cindy" "Delaware" "TOMORROW"

Simple clauses can be connected using AND or OR.
No order of evaluation can be imposed using parenthesis.
The boolean is evaluated such that AND has higher operator precedence than OR.
E.g. A < B AND C > D OR A < E is automatically evaluated as the following: ((A < B) AND (C > D)) OR (A < E).
The user is responsible for ensuring that these rules are followed.
Routine Name: List Index Booleans (IB_List())

Routine Number: 4.1.1.5.2.2

1. System Requirements

The 'list index booleans' command will enable the user to obtain a list in the logical text file of all of the constructed Index Booleans. The list contains the boolean tag and the boolean body for each boolean.

In the Menu access, the default text editor is automatically invoked to read the logical text file. In Host Language Interface access, the result can also be in the logical text string.

2. System Architecture

RTI_BC_traverse

3. System Data Structures

1. Input

2. Output

val_list LIST pointer < each entry contains tag and body of a currently defined boolean. val_list will be NULL if there is an error. >

4. System Data Flow

5. System Control Flow

IB_List <-- RTI_BC_traverse

6. Design Rationale

Search the Run-time Catalog for indexes, return the tag and body of each boolean entry found.
Note the actual return value is LIST *, a NULL terminated list of entries, containing the tag and boolean condition in string format.

7. Test Plan

Test for case where there are no retrieved booleans.

8. Issues

Must return both tags and bodies. Tags alone are meaningless to the user.
Routine Name: Pick Index Boolean (IB_Pick() )

Routine Number: 4.1.1.5.2.3

1. System Requirements

The 'pick index boolean' command will enable the user to make 'current' one of the index booleans. If the index boolean does not exist, then an error message appears in the logical error file. If the chosen boolean cannot be used to search the current index, an error message appears in the logical text file.

2. System Architecture

parse
validate

RTI_BC_retrieve
test_compatibility

CWA_I_update(IB_current)

3. System Data Structures

1. Input

tag

TAG < identifier for retrieved boolean>

2. Output

IME_OK successful picking of boolean
IME_BAD_TAG bad tag
IME_INCOMPATIBLE boolean not compatible with index
IME_NO_CURRENT no current index

4. System Data Flow

parse --> validate
validate --> RTI_BC_retrieve
test_compatibility

CWA_I_update

5. System Control Flow

I_Pick <-- parse
validate
RTI_BC_retrieve
test_compatibility

CWA_I_update

6. Design Rationale

This routine will make current the specified boolean. First it checks
that there is a current index to test compatibility with. Then it searches the run-time boolean catalog for the given tag. If it is found, test for the compatibility of the boolean for searching the current index (e.g. attribute names are attributes of the index, values are in the domain of values for the index).

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Modify Index Boolean (IB_modify())

Routine Number: 4.1.1.5.2.4

1. System Requirements

The system will enable the user to modify a index boolean. The user receives the current index boolean definition in the logical text file for modifying. The user then alters the definition and the system replaces the old definition with the new one.

In the Menu access, the default text editor is automatically invoked to read the logical text file. In Host Language Interface access, the result can also be in the logical text string.

2. System Architecture

form_modify (give it the current boolean definition)
parse
validate
test_syntax
test_compatibility
RTI_BC_update

3. System Data Structures

1. Input

2. Output

IME_OK success
IME_FAILURE general error
IME_INCOMPATIBLE boolean incompatible with current index
IME_BAD_BOOL boolean syntactically invalid
IME_NO_CURRENT no current index to test compatibility against

4. System Data Flow

form_modify --> parse
parse --> validate
validate --> test_syntax
test_compatibility

RTI_BC_update

5. System Control Flow

IB_modify <-- form_modify
parse
validate
test_syntax
test_compatibility
6. **Design Rationale**

This routine will update the current definition for the current index boolean. First it will check that there is a current index, in order to test for compatibility. Next it checks that the user is not trying to modify the default boolean "TRUE". Then it will check that the current index boolean exists. The user is given a copy of the current boolean definition and is allowed to modify it through form_modify. The new definition is then tested for syntactic correctness and compatibility with the current index. If it is compatible, then the old definition is replaced with the new one. If it is not compatible, no change is made. See Section 4.1.1.5.2.1 for valid syntax of boolean conditions.

7. **Test Plan**

Test all error codes.

8. **Issues**

This routine will pass to form_modify the current select definition and receive back the modified select definition in string format.
Routine Name: Drop Index Boolean (IB_drop())

Routine Number: 4.1.1.5.2.5

1. System Requirements

The system enables the user to delete a index boolean. If the index boolean does not exist, then an error message appears in the logical error file.

2. System Architecture

```
parse
validate
RTI_BC_delete          (deallocate_WA)
CWA_I_update(IB_current = "TRUE") (if dropped is current)
```

3. System Data Structures

1. Input

```
tag       TAG       < tag for index boolean >
```

2. Output

```
IME_OK     success
IME_FAILURE general error
IME_BAD_TAG tag specified does not exist
```

4. System Data Flow

```
parse  -->  validate
validate --> RTI_BC_delete
           CWA_I_update
```

5. System Control Flow

```
IB_drop  <--  parse
          validate
          RTI_BC_delete
          CWA_I_update
```

6. Design Rationale

This routine will drop any index boolean that is currently in the CWA. The user is not allowed to delete the default boolean, so there is a check to make sure the user is not trying to delete this boolean. It will then delete the catalog entry for the index boolean. If the index boolean that was deleted was the current index boolean then the current index boolean is updated to equal the default index boolean "TRUE".

7. Test Plan
Test all error codes.

8. Issues
Routine Name: Build Index Select (IS_build())

Routine Number: 4.1.1.5.3.1

1. System Requirements

The system will enable the user to build an index select for navigating through the index rows. The user receives in the logical text file an index select form for building such a select. The user completes the form and submits it. The system assigns the index select a tag. If an error in building the select is made, then an error is returned.

In Menu and Command access, the form is input/output through the logical text file. In the Menu access, the default text editor is automatically invoked to build the form. In Host Language Interface access, the form can be built through the logical text string.

2. System Architecture

form_new
parse
validate
assign_tag
RTI_SC_insert

3. System Data Structures

1. Input

2. Output

tag

TAG

tag of the index select created.

NULL if error.

4. System Data Flow

form_new --> parse
parse --> validate
validate --> assign_tag
RTI_SC_insert

5. System Control Flow

IS_build --> form_new
parse
validate
assign_tag
RTI_SC_insert

6. Design Rationale

This routine will build an index select and insert it into the catalog.
The user is given a form to complete defining the index select. This definition is then parsed into an internal format. A catalog entry is created and a tag is assigned to the select definition. There is compatibility check done at this time. That is done at the time the user 'picks' the index select as current. The tag is returned. If an error is encountered then NULL is returned.

7. Test Plan

8. Issues

This routine receive it's input from the form process that is spawned. The form process will give this routine's input in string format.

```
select_list string < list of the attributes of the select >
```

It is up to us to parse the string into our internal format.

The characters accepted as part of an attribute name are A-Z, a-z, . - * (to allow for select *). Any other character or sequence of characters can be used as a separator, as long as there are no interspersed spaces.

i.e.

```
a : b is acceptable. (separator = ":")
a #: b is acceptable. (separator = "#:")
a : , b is not acceptable because the separator is ":" and it tries to parse ",," as an attribute name.
a b is acceptable. (separator doesn't exist, but that's ok)
```
Routine Name: List Index Selects (IS_list0)

Routine Number: 4.1.1.5.3.2

1. System Requirements

The system will enable the user to obtain a list in the logical text file of the constructed index selects for the index.

In the Menu access the default text editor is automatically invoked to read the logical text file. In Host Language Interface access, the result can also be in the logical text string.

2. System Architecture

RTI_SC_traverse

3. System Data Structures

1. Input

2. Output

select_list LIST pointer < array of tag and definitions NULL if error >

4. System Data Flow

5. System Control Flow

IS_list <-- RTI_SC_traverse

6. Design Rationale

This routine will return a list of tags and definitions for all index selects currently defined in the current working area. This information is retrieved from the index select run-time catalog. If there does not currently exist any index selects, then NULL is returned. The actual type of what is returned is LIST * (a NULL-terminated list of index select information).

7. Test Plan

Test the listing of index selects when none are defined, and also when at least one is defined.

8. Issues
Routine Name: Pick Index Select (IS_pick())

Routine Number: 4.1.1.5.3.3

1. System Requirements

The system will enable the user to make as "current" one of the index selects. If the index select does not exist, an error message appears in the logical error file.

2. System Architecture

```
parse
validate
test_compatibility
CWA_I_update(IS_current)
```

3. System Data Structures

1. Input

| tag     | TAG | < tag of the index select to pick > |

2. Output

| IME_OK       | success          |
| IME_FAILURE  | general error    |
| IME_BAD_TAG  | invalid tag      |
| IME_INCOMPATIBLE | select to pick is incompatible with current index |
| IME_NO_CURRENT | no current index to test compatibility with |

4. System Data Flow

```
parse --> validate
validate --> test_compatibility
          CWA_I_update
```

5. System Control Flow

```
IS_pick <-- parse
          validate
test_compatibility
          CWA_I_update
```

6. Design Rationale

This routine will update the current index select. First it checks that there is a current index to verify compatibility. Next it checks that the tag given is a valid index select tag, and that the select currently exists. Next the compatibility is checked against the current index. The current working area index select variable is updated.
7. **Test Plan**
   Test all error codes.

8. **Issues**
Routine Name: Modify Index Select (IS_modify())

Routine Number: 4.1.1.5.3.4

1. System Requirements

The system will enable the user to modify a index select. The user receives the current index select definition in the logical text file for modifying. He then alters the definition and the system replaces the old definition with the new one.

In the Menu access, the default text editor is automatically invoked to read the logical text file. In Host Language Interface access, the result can also be in the logical text string.

2. System Architecture

```
form_modify ( give it the current select definition )
parse
validate
test_compatibility
RTI_SC_update
```

3. System Data Structures

1. Input
2. Output

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IME_OK</td>
<td>success</td>
</tr>
<tr>
<td>IME_FAILURE</td>
<td>general error</td>
</tr>
<tr>
<td>IME_INCOMPATIBLE</td>
<td>select definition incompatible with current index</td>
</tr>
<tr>
<td>IME_BAD_SELECT</td>
<td>modified definition is syntactically incorrect</td>
</tr>
</tbody>
</table>

4. System Data Flow

```
form_modify --> parse
parse  --> validate
test_compatibility --> RTI_SC_update
```

5. System Control Flow

```
IS_modify <-- form_modify
parse
validate
test_compatibility
RTI_SC_update
```

6. Design Rationale

This routine will update the current definition for the current index select.
There is a default index select "*" to select all attributes that the user is not allowed to modify. First it will check that the current index select exists, and can be modified. The user is given a copy of the current select definition and is allowed to modify it through form_modify. The new definition is then tested for validity against the current index (both syntactically and semantically). If it is compatible, then the old definition is replaced with the new one. If it is not compatible, no change is made. See Section 4.1.1.5.3.1 for definition of acceptable select input.

7. Test Plan

Test all error codes.

8. Issues

This routine will pass to form_modify the current select definition and receive back the modified select definition in string format.
Routine Name: Drop Index Select (IS_drop())

Routine Number: 4.1.1.5.3.5

1. System Requirements

The system enables the user to delete an index select. If the index select does not exist, then an error message appears in the logical error file.

2. System Architecture

```
parse
validate
RTI_SC_delete
CWA_I_update(IS_current = "*") (if dropped is current)
```

3. System Data Structures

1. Input

| tag | TAG | < tag for index select > |

2. Output

| IME_OK          | success |
| IME_FAILURE     | general error |
| IME_BAD_TAG     | tag specified does not exist |

4. System Data Flow

```
parse  -->  validate
validate  -->  RTI_SC_delete
            CWA_I_update
```

5. System Control Flow

```
IS_drop  <--  parse
          validate
          RTI_SC_delete
          CWA_I_update
```

6. Design Rationale

This routine will drop any index select that is currently in the CWA. The user is not allowed to delete the default select, so there is a check to make sure the user is not trying to delete this select. It will then delete the catalog entry for the index select. If the index select that was deleted was the current index select then the current index select is updated to equal the default index select "*". If the tag was invalid, an error is returned.

7. Test Plan
Test all error codes.

8. **Issues**
Routine Name: Bind Column Index (I_bind_column)

Routine Number: 4.1.1.7.1

1. System Requirements

The system will enable the user to bind a program variable with a column of the index. He provides the name of the column, a pointer to the program variable, the type of the variable, and the length of the program variable. When the database is being navigated, the system places the column into the program variable.

2. System Architecture

parse
validate
test_compatibility
fill_I_bind_struct
CWA_I_update(I_binding = TRUE)

3. System Data Structures

1. Input

attribute_name string < name of the attribute to bind >
variable_ptr string < pointer to some variable >
variable_type string < type of variable to bind to >
variable_length int < length of variable to bind to >

2. Output

IME_OK success
IME_FAILURE general error
IME_NO_CURRENT no current index to validate binding
IME_BAD_ATTR invalid attribute name for current_index
IME_BAD_TYPE type does not match attribute in index

4. System Data Flow

parse --> validate
validate --> test_compatibility
fill_I_bind_struct
CWA_I_update

5. System Control Flow

I_bind_column <-- parse
validate
test_compatibility
fill_I_bind_struct
CWA_I_update

6. Design Rationale
This routine will set up for binding tuple values to program variables. First it verifies that only one column is specified. Then it checks that the column name given is a valid column name for the current index, that the variable_type matches the type of the column in the index. This information is then entered into the binding structure, and the current working area is updated to reflect that there is binding for the current index. During navigation, the values of tuples are copied into the program variables.

7. Test Plan

Test all error codes.

8. Issues

The bind column command must be executed after the user has picked the corresponding index. It is at the time the user defines the bind (i.e. here) that a compatibility check is done.
Routine Name: Bind Table Index (I_bind_table())

Routine Number: 4.1.1.7.2

1. System Requirements

The system will enable the user to bind a set of program variables with a set of columns of the current index. The user makes current the index. He then provides a pointer to a data structure containing names of the columns, pointers to the program variables, type of the variables, and the lengths of the program variables. When the database is being navigated, the system places the columns into the program variables.

2. System Architecture

parse
validate
test_compatibility
fill_I_bind_struct
CWA_I_update(I_binding = TRUE)

3. System Data Structures

1. Input
bind_info variable_binding pointer

2. Output
IME_OK success
IME_FAILURE general error
IME_NO_CURRENT no current index to validate binding
IME_BAD_ATTR invalid column name for current_index
IME_BAD_TYPE type does not match column in index
IME_BAD_BIND other compatibility or syntax errors

4. System Data Flow

parse --> validate
test_compatibility
fill_I_bind_struct
CWA_I_update

5. System Control Flow

I_bind_table <-- parse
validate
test_compatibility
fill_I_bind_struct
CWA_I_update

6. Design Rationale
This routine will set up for binding tuple values to program variables. First it is checked that the column names given are a valid column names for the current Index, that the variable_types matche the type of the columns in the index. This information is then entered into the binding structure, and the current working area is updated to reflect that there is binding for the current index. During navigation, the values of tuples are copied into the program variables.

7. **Test Plan**

Test all error codes.

8. **Issues**

The bind table command must be executed after the user has picked the corresponding index. It is at the time the user defines the bind (i.e. here) that a compatibility check is done.
Routine Name: Create Indexset (ISET_create())

Routine Number: 3.1.2.1.1

1. System Requirements

The create indexset command allows one to create the directory, databook, catalog, and log devices of the indexset objects.

Example:
create indexset library
directory:
  { device = [usr.smith.library]library.dat1,
  initsize = 4096,
  incrsize = 1096,
  maxsize = 200000 },
databook:
  { device = [usr.smith.library]library.dat1,
  initsize = 4096,
  incrsize = 1096,
  maxsize = 200000 },
catalog:
  { device = [usr.smith.library]library.dat1,
  initsize = 4096,
  incrsize = 1096,
  maxsize = 200000 },
  { device = [usr.smith.library]library.dat1,
  initsize = 4096,
  incrsize = 1096,
  maxsize = 200000 },
log:
  { device = [usr.smith.library]library.dat1,
  initsize = 4096,
  incrsize = 1096,
  maxsize = 200000 };

The argument list for the previous example would look like this, where each COLUMN is one of the arguments: (Note: there can be any number of "rows" labeled 'databook', but there should be exactly two "rows" labeled 'catalog', and only one "row" labeled log. The create command must have no "rows" labeled 'directory').

<table>
<thead>
<tr>
<th>object_names</th>
<th>device_name</th>
<th>initsize</th>
<th>incrsize</th>
<th>maxsize</th>
</tr>
</thead>
<tbody>
<tr>
<td>directory</td>
<td>[usr.smith.library]library.dat1</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>databook</td>
<td>[usr.smith.library]library.dat1</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>catalog</td>
<td>[usr.smith.library]library.dat1</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>catalog</td>
<td>[usr.smith.library]library.dat1</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>log</td>
<td>[usr.smith.library]library.dat1</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
</tbody>
</table>

2. System Architecture

parse
3. System Data Structures

1. Input

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>iset_name</td>
<td>string</td>
<td>&lt; name of the indexset to create &gt;</td>
</tr>
<tr>
<td>iset_loc</td>
<td>string</td>
<td>&lt; location of indexset to create &gt;</td>
</tr>
<tr>
<td>object_names</td>
<td>array of strings</td>
<td>&lt; object names for each element described in corresponding locations of other arrays &gt;</td>
</tr>
<tr>
<td>device_names</td>
<td>array of strings</td>
<td>&lt; device names for each component of the indexset &gt;</td>
</tr>
<tr>
<td>initsizes</td>
<td>array of integers</td>
<td>&lt; initial sizes for each component of the indexset &gt;</td>
</tr>
<tr>
<td>incrsizes</td>
<td>array of integers</td>
<td>&lt; incremental sizes for each component of the indexset &gt;</td>
</tr>
<tr>
<td>maxsizes</td>
<td>array of integers</td>
<td>&lt; maximum sizes for each component of the indexset &gt;</td>
</tr>
</tbody>
</table>

NOTE: all of these arrays act as parallel arrays, in that entry i of each array is related to entry i of every other array.

2. Output

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IME_OK</td>
<td>ISET_create successful</td>
</tr>
<tr>
<td>IME_FAILURE</td>
<td>general error</td>
</tr>
</tbody>
</table>

4. System Data Flow

parse ---> validate
validate ---> create catalogs
           something
something ---> SISET_insert

5. System Control Flow

ISET_create <-- parse
                      validate
                      something
                      RTISET_update
                      SISET_retrieve
                      SISET_delete
SISET_insert

6. Design Rationale

This routine will create a new indexset. It will first check that the indexset to create does not already exists. It will then do SOMETHING, and create an indexset catalog entry for the indexset.

7. Test Plan

Test the creation of an existing and nonexistent indexset. Test errors that relate to SOMETHING.

8. Issues
Routine Name: Drop Indexset (ISET_drop())

Routine Number: 3.1.8.2

1. System Requirements

The drop indexset command allows one to drop an indexset.

2. System Architecture

```plaintext
parse
validate
for each index in the catalog
    I_drop { drop the index }
end loop

remove catalog

for each set in the catalog
    S_drop_disk
end loop

remove catalog

SISET_delete
```

3. System Data Structures

1. Input

- `iset_name` : string  < name of indexset to drop >
- `iset_loc` : string  < location of indexset to drop >

2. Output

- `IME_OK`  ISET_drop successful
- `IME_FAILURE`  general failure
- `IME_DNE`  indexset to drop does not exist

4. System Data Flow

- `parse` --> `validate`
- `validate` --> `remove index loop`
- `remove index catalog`
- `remove set loop`
- `remove set catalog`
- `SISET_delete`

5. System Control Flow

- `ISET_drop` <-- `parse`
- `validate`
- `remove index loop`
remove index catalog
remove set loop
remove set catalog
SISET_delete

6. Design Rationale

This routine will check that the indexset to drop exists, and is not the current indexset. It will then remove each index (and potentially any associated index_kits), and each set, and then delete the index and set catalogs belonging to the indexset. Finally it will remove the system catalog entry.

Note: Cannot drop the current indexset.

7. Test Plan

Test all error codes.

8. Issues

Should ISET_drop cascade down to index_kit deletion ...NO!!
Routine Name: Alter Indexset (ISET_alter())

Routine Number: 3.1.3.2.5

1. System Requirements

The alter indexset command allows one to alter the databook, catalog, and log devices of the indexset objects. The directory devices cannot be altered without dropping the indexset.

Example:
alter indexset library
databook:
{device = [usr.smith.library]library.dat1,
initsize = 4096,
inrsize = 1096,
maxsize = 200000},
{device = [usr.smith.library]library.dat2,
initsize = 4096,
inrsize = 1096,
maxsize = 200000},
catalog:
{device = [usr.smith.library]library.icat,
initsize = 4096,
inrsize = 1096,
maxsize = 200000},
{device = [usr.smith.library]library.scat,
initsize = 4096,
inrsize = 1096,
maxsize = 200000},
log:
{device = [usr.smith.library]library.log,
initsize = 4096,
inrsize = 1096,
maxsize = 200000};

My guess is that you can only alter the device and initsize if the object is empty, but you can modify the incrsize anytime, and the maxsize as long as the current size is less than the proposed maxsize.

The argument list for the previous example would look like this, where each COLUMN is one of the arguments: (Note: there can be any number of "rows" labeled 'databook', but there should be no more than two "rows" labeled 'catalog', and only one "row" labeled 'log'. The alter command must have no "rows" labeled 'directory').

<table>
<thead>
<tr>
<th>object_names</th>
<th>device_name</th>
<th>initsize</th>
<th>incrsize</th>
<th>maxsize</th>
</tr>
</thead>
<tbody>
<tr>
<td>databook</td>
<td>[usr.smith.library]library.dat1</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>databook</td>
<td>[usr.smith.library]library.dat2</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>catalog</td>
<td>[usr.smith.library]library.icat</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>catalog</td>
<td>[usr.smith.library]library.scat</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>log</td>
<td>[usr.smith.library]library.log</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
</tbody>
</table>
2. System Architecture

parse
validate

SOMETHING
RTISET_update /* retrieve the catalog entry */
SISET_retrieve /* delete the old catalog entry */
SISET_delete /* insert the updated catalog entry */

3. System Data Structures

1. Input

iset_name string < name of the indexset to alter >
iset_loc string < location of indexset to alter >
oobject_names array of strings < object names for each element described in corresponding locations of other arrays >
device_names array of strings < device names for each component of the indexset >
init_sizes array of integers < initial sizes for each component of the indexset >
incr_sizes array of integers < incremental sizes for each component of the indexset >
max_sizes array of integers < maximum sizes for each component of the indexset >

NOTE: all of these arrays act as parallel arrays, in that entry i of each array is related to entry i of every other array.

2. Output

IME_OK ISET_alter successful
IME_FAILURE general error

4. System Data Flow

parse --> validate
validate --> RTISET_update
       SISET_retrieve
       SISET_delete
       SISET_insert
SOMETHING --> RTISET_update
       SISET_retrieve
       SISET_delete
5. System Control Flow

\[
\text{ISET\_alter} \leftarrow \text{parse} \\
\text{validate} \\
\text{SOMETHING} \\
\text{RTISET\_update} \\
\text{SISET\_retrieve} \\
\text{SISET\_delete} \\
\text{SISET\_insert}
\]

6. Design Rationale

This routine will alter the indexset. It will first check that the indexset to alter already exists. It will then do SOMETHING, and update the indexset catalog entry for the indexset.

7. Test Plan

Test the altering of an existing and nonexistent indexset. Test errors that relate to SOMETHING.

8. Issues

When altering indexsets, must you respecify EVERYTHING that was originally specified when the indexset was created? If not, then how do you know, for example, which databook element they are implying to alter (for example if you change the name).
Routine Name: Move Indexset (ISET_move())

Routine Number: 3.1.5.2

1. System Requirements

The move indexset command allows one to move an indexset from one user to another.

2. System Architecture

```
parse
validate

check_uniqueness
for each index in the index catalog
  I_move
for each set in the set catalog
  S_move
SISET_retrieve
SISET_delete
SISET_insert

{ not I_move exactly, but move to new location }
{ not S_move exactly, but move to new location }
{ from old user indexset catalog }
{ from old user indexset catalog }
{ to new user indexset catalog }
```

3. System Data Structures

1. Input

- `iset_name`: string  < name of indexset to move >
- `iset_loc_old`: string  < user currently owning indexset >
- `iset_loc_new`: string  < user to move indexset to >

2. Output

- `IME_OK`: ISET_move successful
- `IME_FAILURE`: general error
- `IME_DNE`: indexset to move does not exist
- `IME_NONUNIQUE`: user to move indexset to already has indexset with the same name

4. System Data Flow

```
parse --> validate
validate --> check_uniqueness
           move index loop
           move set loop
           SISET_retrieve
           SISET_delete
           SISET_insert
```

5. System Control Flow

```
ISET_move <-- parse
           validate
```
check_uniqueness
move index loop
move set loop
SISET_retrieve
SISET_delete
SISET_insert

6. Design Rationale

This routine will move an indexset from one user to another. First it will check that the indexset to move exists. Next, it will check that the new user does not already have an indexset with the same name. Then for each index and set in the indexset, it will move them to the indexset at the new user's location. It will delete the catalog entry from the old user's system indexset catalog, and insert a catalog entry into the new user's system indexset catalog.

7. Test Plan

Test all error codes.

8. Issues

What should happen with associated index_kits when indexes are moved to different users? I think they should move too.
Routine Name: Copy Indexset (ISET_copy())

Routine Number: 3.1.4.2.1

1. System Requirements

The copy indexset command allows the user to make identical copies of indexsets.

2. System Architecture

\[ B = \text{copy}(A) \]

parse
validate
ISET_create(B)

for each index in the index catalog
I_copy(A.index,B.index)

for each set in the set catalog
S_copy(A.set,B.set)

3. System Data Structures

1. Input

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>iset_name1</td>
<td>string</td>
<td>&lt; name of indexset to copy &gt;</td>
</tr>
<tr>
<td>iset_loc1</td>
<td>string</td>
<td>&lt; location of indexset to copy &gt;</td>
</tr>
<tr>
<td>iset_name2</td>
<td>string</td>
<td>&lt; name of indexset to copy into &gt;</td>
</tr>
<tr>
<td>iset_loc2</td>
<td>string</td>
<td>&lt; location of indexset to copy into &gt;</td>
</tr>
</tbody>
</table>

2. Output

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IME_OK</td>
<td>ISET_copy successful</td>
</tr>
<tr>
<td>IME_FAILURE</td>
<td>general error</td>
</tr>
<tr>
<td>IME_DNE</td>
<td>indexset to copy does not exist</td>
</tr>
<tr>
<td>IME_NONUNIQUE</td>
<td>indexset to copy into already exists</td>
</tr>
</tbody>
</table>

4. System Data Flow

parse --> validate
validate --> ISET_create
index copy loop
set copy loop

5. System Control Flow

ISET_copy <-- parse
validate
ISET_create
index copy loop
set copy loop
6. Design Rationale

This routine will make an identical copy of an indexset. First it checks that the indexset to copy exists, and that the indexset to create does not already exist. It then will copy each index from one indexset to the other. The ISET_create command will get ALL of its input from the indexset to copy from.

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Intersect Indexset (ISET_intersect())

Routine Number: 3.1.4.2.4

1. System Requirements

   The intersect indexset command allows one to intersect the different parts of indexsets.

2. System Architecture

   \[ C = A \cap B \]

   parse
   validate
   ISET_create(C)

   for each index in the index catalog of A
     if there is a compatible index in the index catalog of B
       I_intersect(A.index,B.index,C.index)
   end loop

3. System Data Structures

   1. Input

      iset_name1  string  < name of indexset to intersect >
      iset_loc1   string  < location of indexset to intersect >
      iset_name2  string  < name of indexset to intersect >
      iset_loc2   string  < loc of indexset to intersect >
      iset_name3  string  < name of indexset to intersect into >
      iset_loc3   string  < loc of indexset to intersect into >

   2. Output

      IME_OK        ISET_intersect successful
      IME_FAILURE   general error
      IME_DNE       indexset to intersect does not exist
      IME_NONUNIQUE indexset to create as result already exists

4. System Data Flow

   parse --> validate
   validate --> ISET_create
               intersection loop

5. System Control Flow

   ISET_intersect <-- parse
                    validate
                    ISET_create
                    intersection loop
6. Design Rationale

This routine will intersect compatible indexes in the two different indexsets. First it must check that the two indexsets to intersect actually exist, and that the resulting indexset does not already exist. Next it will check for pairwise compatible indexes, each from a different indexset. If any such pairs exist, it will compute the intersection of them and place the resulting index in the newly created indexset. A catalog entry is created for the new indexset.

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Subset Indexsets (ISET_subset())

Routine Number: 3.1.4.2.2

1. System Requirements

   The 'subset indexset' command enables users to make indexsets from subsets of indexsets.

2. System Architecture

   \[ B = \text{subset}(A) \]
   
   Parse
   Validate

   for each index in A
   \[ \text{I_subset}(A\text{.index}, B) \]

3. System Data Structures

   1. Input

      | indexset_name | string | < name of result indexset > |
      | sub_indexset_name | string | < name of indexset to be subsetted > |
      | select_list | string | < attribute names of indexed attrs to be subsetted > |
      | bool_list | string | < string containing boolean condition to subset according to > |

   2. Output

      IME_OK: successful subset indexset
      IME_FAILURE: general failure
      IME_NONUNIQUE: non-unique name for new/subsetted indexset or indexspace
      IME_BAD_BOOL: boolean syntax error

4. System Data Flow

   parse --> validate
   validate --> I_subset

5. System Control Flow

   ISET_subset<-- parse
   validate
   I_subset

6. Design Rationale

   The indexset and indexspace(s) for the result to go into must have already been created and must have the same indexspace names as the
iset to be subsetted.

7. Test Plan

Test Cases should check for correct handling of invalid names, bad booleans, bad selects.

8. Issues
Routine Name: Subtract Indexset  (ISET_subtract())

Routine Number: 3.1.4.2.5

1. System Requirements

The subtract indexset command allows one to subtract the different parts of indexsets. [Namely the indexes and sets?]

2. System Architecture

\[ C = A - B \]

parse
validate

ISET_create(C)

for each index in the index catalog of A
    if there is a compatible index in the index catalog of B
        I_subtract(A.index,B.index,C.index)
    end loop

3. System Data Structures

1. Input

| set_name1 | string | < name of indexset to subtract > |
| set_loc1  | string | < location of indexset to subtract > |
| set_name2 | string | < name of indexset to subtract > |
| set_loc2  | string | < loc of indexset to subtract > |
| set_name3 | string | < name of indexset to subtract into > |
| set_loc3  | string | < loc of indexset to subtract into > |

2. Output

IM_OK      ISET_subtract successful
IME_FAILURE general error
IME_DNE    indexset to subtract does not exist
IME_NONUNIQUE indexset to create as result already exists

4. System Data Flow

parse  -->  validate
validate  -->  ISET_create
            subtraction loop

5. System Control Flow

ISET_subtract  <--  parse
                 validate
                 ISET_create
                 subtraction loop
6. Design Rationale

This routine will subtract compatible indexes in the two different indexsets. First it must check that the two indexsets to subtract actually exist, and that the resulting indexset does not already exist. Next it will check for pairwise compatible indexes, each from a different indexset. If any such pairs exist, it will compute the subtraction of them and place the resulting index in the newly created indexset. A catalog entry is created for the new indexset.

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Union Indexsets (ISET_union())

Routine Number: 3.1.4.2.3

1. System Requirements

   The 'union indexset' command enables users to union the different parts of indexsets.

2. System Architecture

   \[ C = A \cup B \]

   parse
   validate

   for each pair of compatible indexes in A and B
   \[ I_{\text{union}}(A\text{.index},B\text{.index},C\text{.index}) \]

3. System Data Structures

   1. Input

      \begin{align*}
      &\text{result\_indexset} & \text{string} & < \text{name of indexset to be created}> \\
      &\text{un\_indexset\_name1} & \text{string} & < \text{name of indexset to be unioned} > \\
      &\text{un\_indexset\_name2} & \text{string} & < \text{name of indexset to be unioned} > \\
      \end{align*}

   2. Output

      \begin{align*}
      &\text{IME_OK} & \text{ISET\_union successful} \\
      &\text{IME\_FAILURE} & \text{general failure} \\
      &\text{IME\_NONUNIQUE} & \text{non-unique name for new indexset or indexspace} \\
      &\text{IME\_DNE} & \text{indexset to union does not exist} \\
      \end{align*}

4. System Data Flow

   \begin{align*}
   \text{parse} & \rightarrow \text{validate} \\
   \text{validate} & \rightarrow \text{I\_union} \\
   \end{align*}

5. System Control Flow

   \begin{align*}
   \text{ISET\_union} & \leftarrow \text{parse} \\
   \text{validate} & \rightarrow \text{I\_union} \\
   \end{align*}

6. Design Rationale

   The result indexset must have already been created, with indexspaces matching those in indexset 1 being unioned.

   For each combination of indexes from indexsets 1 and 2, union the indexes.
7. Test Plan

Test Cases should check for correct handling of invalid names.

8. Issues

If none of the indexes in either indexset are compatible for union, what should the resulting indexset look like?
--> No indexes in it, but indexspaces matching indexset 1 being unioned.

How do we know what indexspace to put the index in?
--> Put it in the one corresponding to the one in indexset 1 (indexes will have same names, indexspaces but different isets)

What happens when we run out of space in the ispace?
Routine Name:    Create Indexspace    (ISPACE_create())

Routine Number: 3.1.2.1.2

1. System Requirements

The create indexspace command allows one to create the databook devices associated with the indexspace.

Example:
create indexspace library
databook:
{device = [usr.smith.library]library.dat1,
initsize = 4096,
incrsize = 1096,
maxsize = 200000},
{device = [usr.smith.library]library.dat2,
initsize = 4096,
incrsize = 1096,
maxsize = 100000};

The argument list for the previous example would look like this, where each COLUMN is one of the arguments:

device_name    initsize    incrsize    maxsize
-----------------------------------------------
[usr.smith.library]library.dat1    4096    1096    200000
[usr.smith.library]library.dat2    4096    1096    100000

2. System Architecture

parse
validate

SOMETHING
SISET_insert

3. System Data Structures

1. Input

<table>
<thead>
<tr>
<th>ispace_name</th>
<th>string</th>
<th>&lt; name of indexspace to create &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>iset_name</td>
<td>string</td>
<td>&lt; name of indexset to create indexspace in &gt;</td>
</tr>
<tr>
<td>iset_loc</td>
<td>string</td>
<td>&lt; location of indexset &gt;</td>
</tr>
<tr>
<td>device_names</td>
<td>array of strings</td>
<td>&lt; device names for indexset components &gt;</td>
</tr>
<tr>
<td>initsizes</td>
<td>array of integers</td>
<td>&lt; initial sizes for indexset components &gt;</td>
</tr>
<tr>
<td>incrizes</td>
<td>array of integers</td>
<td>&lt; increment sizes for indexset components &gt;</td>
</tr>
<tr>
<td>maxsizes</td>
<td>array of integers</td>
<td>&lt; maximum sizes for indexset components &gt;</td>
</tr>
</tbody>
</table>

2. Output
4. System Data Flow

parse --> validate
validate --> SOMETHING
SOMETHING --> SISET_insert

5. System Control Flow

ISPACE_create <-- parse
validate
SOMETHING
SISET_insert

6. Design Rationale

This routine will create the indexspace within an indexset. It will first check that there does not already exist an indexspace with the same name in the indexset. It will then do SOMETHING, and insert an entry into the indexset catalog expressing the creation of an indexspace.

7. Test Plan

Test all error codes.

8. Issues

What is this routine supposed to do?
Routine Name: Alter Indexspace (ISPACE_alter())

Routine Number: 3.1.3.2.4

1. System Requirements

The alter indexspace command allows one to alter the databook devices associated with the indexspace.

Example:
alter indexspace library
databook:
{device = [usr.smith.library]library.dat1,
initsize = 4096,
incrsize = 1096,
maxsize = 200000},
{device = [usr.smith.library]library.dat2,
initsize = 4096,
incrsize = 1096,
maxsize = 100000};

The argument list for the previous example would look like this, where each COLUMN is one of the arguments:

<table>
<thead>
<tr>
<th>device_name</th>
<th>initsize</th>
<th>incrsize</th>
<th>maxsize</th>
</tr>
</thead>
<tbody>
<tr>
<td>[usr.smith.library]library.dat1</td>
<td>4096</td>
<td>1096</td>
<td>200000</td>
</tr>
<tr>
<td>[usr.smith.library]library.dat2</td>
<td>4096</td>
<td>1096</td>
<td>100000</td>
</tr>
</tbody>
</table>

2. System Architecture

parse
validate

SOMETHING
SISET_update

3. System Data Structures

1. Input

| iset_name         | string       | < name of the indexset to alter indexspace > |
| iset_loc          | string       | < location of indexset >                     |
| device_names      | array of strings | < device names for indexset components >    |
| initsizes         | array of integers | < initial sizes for indexset components >   |
| incrsizes         | array of integers | < increment sizes for indexset components > |
| maxsizes          | array of integers | < maximum sizes for indexset components >   |

2. Output
IME_OK
IME_FAILURE

4. System Data Flow

parse --> validate
validate --> SOMETHING
SISET_update
SOMETHING --> SISET_update

5. System Control Flow

ISPACE_alter <-- parse
validate
SOMETHING
SISET_update

6. Design Rationale

This routine will alter the indexspaces within an indexset. It will first check that the indexspaces within that indexset already exist in order to alter them. It will then do SOMETHING, and update the indexset catalog entry, updating the indexspace information within the indexset catalog entry.

7. Test Plan

Test all error codes.

8. Issues

What is this routine supposed to do?
Routine Name: Create Index Kit (IK_create())

Routine Number: 3.1.2.5

1. System Requirements

   The 'create indexkit' command allows one to create indexkit objects.

2. System Architecture

   parse
   validate
   SIK_insert

3. System Data Structures

1. Input

   indexkit string < name of indexkit to create >
   kitset string < name of kit_set to contain indexkit >

2. Output

   IME_OK indexkit creation successful
   IME_FAILURE general error
   IME_NONUNIQUE indexkit with same name already exists in kitset

4. System Data Flow

   parse --> validate
   validate --> SIK_insert

5. System Control Flow

   IK_create <-- parse
   validate
   SIK_insert

6. Design Rationale

   This routine will create an empty catalog entry for an indexkit. This routine will check that an indexkit with the same name does not already exist in the kitset. The only field that will have any value is the indexkit name. All other catalog fields are changed using the IK_update command. (See design 3.1.3.5).

7. Test Plan

   Test all error codes.

8. Issues
Routine Name: Drop Index Kit (IK_drop() )

Routine Number: 3.1.8.5

1. System Requirements

   The 'drop indexkit' command allows one to drop an indexkit.

2. System Architecture

   parse
   validate
   component_update < update the component catalogs if necessary >
   SIK_delete

3. System Data Structures

1. Input

   indexkit string < indexkit to drop >
   kitset string < kitset containing indexkit >

2. Output

   IME_OK successful dropping of indexkit
   IME_FAILURE general error
   IME_DNE indexkit to drop does not exist

4. System Data Flow

   parse --> validate
   validate --> component_update
             SIK_delete

5. System Control Flow

   IK_drop <-- parse
             validate
             Component_update
             SIK_delete

6. Design Rationale

   This routine will check that the indexkit to drop exists, and if so, will delete the system catalog entry for the indexkit. Because an indexkit is just a logical grouping of several physical objects, the actual objects are not deleted, just the logical grouping. If any of the components track indexkit associations, then those catalogs will be updated too.
7. Test Plan

Test all error codes.

8. Issues

Component catalog changes are currently only made for indexes. If the other components' catalog tracks indexkit associations, that code needs to be added.
Routine Name: Move Index Kit (IK_move())

Routine Number: 3.1.5.5

1. System Requirements

The 'move indexkit' command allows one to move an indexkit from one kitset to another.

2. System Architecture

parse
validate

check_uniqueness

SIK_retrieve < update both kitset catalogs >
SIK_delete
SIK_insert

3. System Data Structures

1. Input

   indexkit string < name of indexkit to move >
   kitset_old string < name of kitset to move from >
   kitset_new string < name of kitset to move to >

2. Output

   IME_OK move indexkit successful
   IME_FAILURE general error
   IME_DNE indexkit does not exist
   IME_NONUNIQUE kitset to move to already has indexkit w/same name.

4. System Data Flow

   parse --> validate
   validate --> check_uniqueness
   check_uniqueness
   SIK_retrieve
   SIK_delete
   SIK_insert

5. System Control Flow

   IK_move --> parse
   parse
   validate
   check_uniqueness
   SIK_retrieve
   SIK_delete
   SIK_insert

6. Design Rationale
This routine will move an indexkit from one kitset to another. This routine will check that the indexkit to move does in fact exist. This routine will check that the new kitset to move the indexkit to does not already have an indexkit with the same name. If it does not, it will move the indexkit files to the new kitset, and update the catalogs so that the indexkit catalog entry is in the new kitset catalog. It will also need to update the components catalog entries, if they track indexkit associations.

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Update Index Kit (IK_update())

Routine Number: 3.1.3.5

1. System Requirements

   The 'update indexkit' command enables users to update any of the components of the indexkit individually.

2. System Architecture

   parse
   validate

   update component catalog
   update system catalog for indexkits

3. System Data Structures

1. Input

   kitset                   string       < name of kitset for kit >
   indexkit                string       < name of the kit to be altered >
   component               string       < name of the component to update >
   comp_name               string       < new component value >
   comp_set                string       < name of the component-set >

2. Output

   IME_OK                   < successful update >
   IME_FAILURE             < general failure >
   IME_DNE                 < indexkit, kitset, or component non-existent >

4. System Data Flow

   parse   -->   validate
   validate -->   update_comp_cat
                 SIKC_update

5. System Control Flow

   IK_update  <--  parse
                 validate
                 update_comp_cat
                 SIKC_update

6. Design Rationale

   This routine provides a means for associating a component with an indexkit. The name and set for the component is given and the Indexkit is updated by making calls to update the right catalogs. Issuing this command more than once will result in changing the component from what it was before to the new value.
7. Test Plan

Test for invalid component, set, and kit names.

8. Issues

Unique identifier for an indexkit is the kitname and the kitset-name.

Currently, this routine will update the system catalog for indexkits, for all component changes, but it will only change the component's catalog for indexes. If the other components' catalog tracks indexkit associations, that code needs to be added.

There is currently no check to make sure that the component name that a component is being updated to actually exists. The index component checks for existence by default, because it must exist in order to update the index component's catalog entry.
Routine Name: Copy Index Kit (IK_copy())

Routine Number: 3.1.4.5.1

1. System Requirements

The 'copy indexkit' command allows one to make identical copies of indexkits.

2. System Architecture

[ B = copy(A) ]

parse
validate

IK_create(B)
MAN_copy(A.intro,B.intro)
IK_update(B.intro)
I_copy(A.index,B.index)
IK_update(B.index)
DBC_copy(A.dict,B.dict)
IK_update(B.dict)
BK_copy(A.thes,B.thes)
IK_update(B.thes)

3. System Data Structures

1. Input

   indexkit1 string < name of indexkit to copy >
   kitset1 string < kitset containing 'indexkit1' >
   indexkit2 string < name of indexkit to create copy into >
   kitset2 string < kitset to contain new indexkit >

2. Output

   IME_OK successful copy of indexkit
   IME_FAILURE general error
   IME_DNE 'indexkit1' does not exist
   IME_NONUNIQUE 'indexkit2' already exists

4. System Data Flow

   parse --> validate
   validate --> IK_create
               MAN_copy
               IK_update
               I_copy
               IK_update
               DBC_copy
               IK_update
               BK_copy
IK_update

5. System Control Flow

IK_copy <-- parse
    validate
    IK_create
    MAN_copy
    IK_update
    I_copy
    IK_update
    DBC_copy
    IK_update
    BK_copy
    IK_update

6. Design Rationale

This routine will create an identical copy of an indexkit. First it will check that the indexkit to copy does in fact exist, and then it will check that the indexkit to create does not already exist. It will try to create the new indexkit. Then the introduction, index, dictionary, and thesaurus components of the indexkit are copied, and a catalog entry in the indexkit is created.

7. Test Plan

Test all error codes.

8. Issues

The objects that result from copying the different components of the indexkit are automatically placed in the 'set' associated with the first kit's components.
Routine Name: Intersect Index Kit (IK_intersect())

Routine Number: 3.1.4.5.4

1. System Requirements

The 'intersect indexkit' command allows one to intersect the different parts of indexkits.

2. System Architecture

\[
C = A \text{ intersect } B
\]

```plaintext
parse
validate
IK_create(C)
MAN_intersect(A.intro, B.intro, C.intro) < manuscript intersection >
IK_update(C.intro)
I_intersect(A.index, B.index, C.index) < index intersection >
IK_update(C.index)
DBC_intersect(A.dict, B.dict, C.dict) < database intersection >
IK_update(C.dict)
BK_intersect(A.thes, B.thes, C.thes) < book intersection >
IK_update(C.thes)
```

3. System Data Structures

1. Input

<table>
<thead>
<tr>
<th>Input</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexkit1</td>
<td>string</td>
<td>&lt; name of indexkit to intersect</td>
</tr>
<tr>
<td>kitset1</td>
<td>string</td>
<td>&lt; kitset containing 'indexkit1'</td>
</tr>
<tr>
<td>indexkit2</td>
<td>string</td>
<td>&lt; name of indexkit to intersect</td>
</tr>
<tr>
<td>kitset2</td>
<td>string</td>
<td>&lt; kitset containing 'indexkit2'</td>
</tr>
<tr>
<td>indexkit3</td>
<td>string</td>
<td>&lt; name of indexkit to contain result</td>
</tr>
<tr>
<td>kitset3</td>
<td>string</td>
<td>&lt; kitset to contain 'indexkit3'</td>
</tr>
</tbody>
</table>

2. Output

- **IME_OK** successful intersection
- **IME_FAILURE** general error
- **IME_DNE** 'indexkit1' or 'indexkit2' does not exist
- **IME_NONUNIQUE** 'indexkit3' already exists

4. System Data Flow

```plaintext
parse --> validate
validate --> IK_create
           MAN_intersect
           IK_update
           I_intersect
           IK_update
```
5. System Control Flow

IK_intersect <-- parse
   validate
   IK_create
   MAN_intersect
   IK_update
   I_intersect
   IK_update
   DBC_intersect
   IK_update
   BK_intersect
   IK_update

6. Design Rationale

This routine will make sure that the indexkit to create as the result does not already exist, and that the two indexkits to intersect do already exist. It will then create the new indexkit, and then proceed to intersect corresponding parts of each indexkit.

7. Test Plan

Test all error codes.

8. Issues

The objects that result from intersecting the different components of the indexkits are automatically placed in the 'set' associated with the first kit's components.
Routine Name: Subset Index Kit (IK_subset() )

Routine Number: 3.1.4.5.2

1. System Requirements

The 'subset indexkit' command enables users to make indexkits from subsets of indexkits.

2. System Architecture

\[ B = \text{subset}(A) \]

parse
validate

IK_create(B)

MAN_subset(A.intro,B.intro)
IK_update(B.intro)

I_subset(A.index,B.index)
IK_update(B.index)

DBC_subset(A.dict,B.dict)
IK_update(B.dict)

BK_subset(A.thes,B.thes)
IK_update(B.thes)

3. System Data Structures

1. Input

<table>
<thead>
<tr>
<th>indexkit1</th>
<th>string</th>
<th>&lt; name of indexkit to be subsetted &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>kitset1</td>
<td>string</td>
<td>&lt; kitset containing 'indexkit1' &gt;</td>
</tr>
<tr>
<td>indexkit2</td>
<td>string</td>
<td>&lt; name of resulting indexkit &gt;</td>
</tr>
<tr>
<td>kitset2</td>
<td>string</td>
<td>&lt; kitset to contain 'indexkit2' &gt;</td>
</tr>
<tr>
<td>bool_cond</td>
<td>string</td>
<td>&lt; boolean condition for subset &gt;</td>
</tr>
</tbody>
</table>

2. Output

IME_OK successful creation of subset indexkit
IME_FAILURE general failure
IME_NONUNIQUE 'indexkit2' already exists
IME_DNE 'indexkit1' does not exist

4. System Data Flow

parse --> validate
validate --> IK_create
          MAN_subset
          IK_update
          IK_update
5. System Control Flow

IK_subset <-- parse
   validate
   IK_create
   MAN_subset
   IK_update
   I_subset
   IK_update
   DBC_subset
   IK_update
   BK_subset
   IK_update

6. Design Rationale

A new indexkit is created. Objects for the new kit are created by subsetting the objects of the original indexkit according to the boolean condition. The new indexkit is updated so that these newly created kit objects are associated with it.

7. Test Plan

Test all error codes.

8. Issues

The objects created by subsetting the different components of the indexkits belong to the 'sets' associated with the component being subsetted.
Routine Name: Subtract Index Kit (IK_subtract())

Routine Number: 3.1.4.5.5

1. System Requirements

The 'subtract indexkit' command allows one to subtract the different parts of indexkits.

2. System Architecture

\[ C = A - B \]

parse
validate

IK_create(C)

MAN_subtract(A.man, B.man, C.man) < manuscript subtraction : intro >
I_subtract(A.index, B.index, C.index) < index subtraction : index >
DBC_subtract(A.dict, B.dict, C.dict) < db cluster subtraction : dict >
BK_subtract(A.thes, B.thes, C.thes) < book subtraction : thesaurus >

3. System Data Structures

1. Input

indexkit string < name of indexkit to subtract >
kitset1 string < kitset containing 'indexkit1' >
indexkit string < name of indexkit to subtract >
kitset2 string < kitset containing 'indexkit2' >
indexkit string < name of indexkit to be result >
kitset3 string < kitset to contain 'indexkit3' >

2. Output

IME_OK successful indexkit subtraction
IME_FAILURE general error
IME_DNE 'indexkit1' or 'indexkit2' does not exist
IME_NONUNIQUE 'indexkit3' already exists

4. System Data Flow

parse --&gt; validate
validate --&gt; IK_create
    MAN_subtract
    IK_update
    I_subtract
    IK_update
    DBC_subtract
    IK_update
    BK_subtract
    IK_update
5. System Control Flow

IK_subtract <-- parse
  validate
  IK_create
  MAN_subtract
  IK_update
  I_subtract
  IK_update
  DBC_subtract
  IK_update
  BK_subtract
  IK_update

6. Design Rationale

This routine will subtract all components of an indexkit. This
routine will check that the indexkit to create does not already exist.
This routine will check that the two indexkits to subtract do
actually exist, and if so, will subtract corresponding parts of each
indexkit, placing the result in the newly created indexkit.

7. Test Plan

Test all error codes.

8. Issues
Routine Name: Union Index Kit (IK_union() )

Routine Number: 3.1.4.5.3

1. System Requirements

The 'union indexkit' command enables users to union the different parts of indexkits.

2. System Architecture

\[ C = A \cap B \]

parse
validate
IK_create(C)
MAN_union(A.intro,B.intro,C.intro)
IK_update(C.intro)
I_union(A.index,B.index,C.index)
IK_update(C.index)
DBC_union(A.dict,B.dict,C.dict)
IK_update(C.dict)
BK_union(A.thes,B.thes,C.thes)
IK_update(C.thes)

3. System Data Structures

1. Input

<table>
<thead>
<tr>
<th>indexkit1</th>
<th>string</th>
<th>&lt; name of indexkit to be unioned &gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>kitset1</td>
<td>string</td>
<td>&lt; kitset containing 'indexkit1' &gt;</td>
</tr>
<tr>
<td>indexkit2</td>
<td>string</td>
<td>&lt; name of indexkit to be unioned &gt;</td>
</tr>
<tr>
<td>kitset2</td>
<td>string</td>
<td>&lt; kitset containing 'indexkit2' &gt;</td>
</tr>
<tr>
<td>indexkit3</td>
<td>string</td>
<td>&lt; name of resulting indexkit &gt;</td>
</tr>
<tr>
<td>kitset3</td>
<td>string</td>
<td>&lt; kitset to contain 'indexkit3' &gt;</td>
</tr>
</tbody>
</table>

2. Output

<table>
<thead>
<tr>
<th>IME_OK</th>
<th>successful creation of union indexkit</th>
</tr>
</thead>
<tbody>
<tr>
<td>IME_FAILURE</td>
<td>general failure</td>
</tr>
<tr>
<td>IME_NONUNIQUE</td>
<td>'indexkit3' already exists</td>
</tr>
<tr>
<td>IME_DNE</td>
<td>'indexkit1' or 'indexkit2' does not exist</td>
</tr>
</tbody>
</table>

4. System Data Flow

parse --> validate
validate --> IK_create
           MAN_union
5. System Control Flow

IK_union <-- parse
       validate
       IK_create
       MAN_union
       IK_update
       I_union
       IK_update
       DBC_union
       IK_update
       BK_update
       IK_update

6. Design Rationale

Create a new indexkit. Create each of the elements in the index kit by unioning the two objects in the original kits. Use update to associate the new elements with the new indexkit.

7. Test Plan

Test cases should check for correct handling of invalid names.

8. Issues

The objects that result from unioning the different components of the indexkits are automatically placed in the 'set' associated with the first kit's components.
Part III: User's Guide
Although all commands and operations described in Part I of this report were designed, only a subset was implemented. Table E lists the operations that were implemented both at the Host Language Interface and at the Command Language Interface. In the rest of this section we give the User's Guide for the Command Language Interface.

**Table E: UIMS Commands**

<table>
<thead>
<tr>
<th>Index Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create index</td>
</tr>
<tr>
<td>update index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Browsing Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>retrieve index</td>
</tr>
<tr>
<td>return index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Navigation Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>first in index</td>
</tr>
<tr>
<td>last in index</td>
</tr>
<tr>
<td>build index boolean</td>
</tr>
<tr>
<td>modify index boolean</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Run-Time Environment Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create column binding</td>
</tr>
<tr>
<td>drop column binding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indexset Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create indexset</td>
</tr>
</tbody>
</table>

Indexes
In this section, we discuss the use of the indexes commands.

1. Creating Index Objects
We specify how to create indexsets and indexes.

1.1. Creating Indexsets
The create indexset command allows one to create the directory databook, catalogue and log devices of the indexset objects. The format of the command is shown in Figure 1a. Figure 1b contains requests to create indexsets nssdca.smith.library and ipac.smith.library.

```
create indexset <indexset_name>
```

Figure 1a: Creating indexsets

```
create indexset nssdca.smith.library
create indexset ipac.smith.library
```

Figure 1b: Creating indexsets

1.2. Creating Indexes
The create index command allows one to create index objects within indexsets. The format of the command is shown in Figure 2a. "type" can be one of "btree, heap, rtree", while schema is a file containing the information about the attributes of the index, and is a file with the following structure

<table>
<thead>
<tr>
<th>attribute1_name</th>
<th>type</th>
<th>length</th>
</tr>
</thead>
<tbody>
<tr>
<td>attribute2_name</td>
<td>type</td>
<td>length</td>
</tr>
<tr>
<td>attribute3_name</td>
<td>type</td>
<td>length</td>
</tr>
<tr>
<td>......</td>
<td>...</td>
<td>......</td>
</tr>
</tbody>
</table>

"type" can be one of string, int and float. Figure 2b contains requests to create indexes subject, grid and grid-time within indexset nssdca.smith.smith.
create index <index_name> <indexset> <type> <schema>

Figure 2a: Creating indexes

create subject nssdca.smith.library btree btree.schema
create grid nssdca.smith.library rtree 2rtree.schema
create grid-time nssdca.smith.library rtree 1rtree.schema

Figure 2b: Creating indexes

where the schema files are respectively

btree.schema:
  subject string 20
  pointer int 4

2rtree.schema:
  lon1 real 8
  lat1 real 8
  lon1 real 8
  lat2 real 8
  pointer int 4

1rtree.schema:
  time1 real 8
  time2 real 8
  pointer int 4

2. Deleting Index Objects
We specify how to delete indexsets and indexes.

2.1. Deleting Indexsets
The delete indexset command allows one to delete the indexset objects. The format
of the command is shown in Figure 3a. Figure 3b contains requests to delete indexsets
nssdca.smith.library and ipac.smith.library.
2.2. Deleting Indexes
The `delete index` command allows one to delete index objects from indexsets. The format of the command is shown in Figure 4a. Figure 4b contains requests to create indexes subject, and grid within indexset nssdca.smith.smith.

```
drop index <index_name> <indexset>
```

Figure 4a: Deleting indexes

```
drop subject nssdca.smith.library
drop grid nssdca.smith.library
```

Figure 4b: Deleting indexes

3. Modifying Index Objects
The `update`, `insert` and `delete index` commands allow one to modify indexes. The format of the commands is shown in Figure 3a. "update" updates the current row with the values in "row". "insert" inserts a new row with values in "row" after the current row, while "delete" deletes the current row. Figure 3b contains requests to modify index subject within indexset nssdca.smith.smith.
Figure 5a: Modifying indexes

Figure 5b: Modifying indexes

4. Reproducing Index Objects
We specify how to reproduce indexes. The reproducing commands copy and move allow one to reproduce information about one index into another index.

4.1. Copying Indexes
The copy command allows one to make identical copies of indexes. The format of the command is shown in Figure 6a. Figure 6b contains requests to copy the subject index from indexset nssdca.smith.library onto another index "newsubject" within the indexset ipac.smith.library.

Figure 6a: Copying Indexes

copy index <index_name1> <indexset1> <index_name2> <indexset2>

Figure 6b: Copying Indexes
copy index subject nssdca.smith.library newsubject ipac.smith.library
4.2. Moving Indexes
The move command allows one to one index from one indexset to another, or within an indexset to a different name. The format of the command is shown in Figure 7a. Figure 7b contains requests to move the subject index from indexset nssdca.smith.library into another index "newsubject" within the indexset ipac.smith.library.

```
move index <index_name1> <indexset1>  <index_name2> <indexset2>
```

Figure 7a: Copying Indexes

```
move index subject nssdca.smith.library newsubject ipac.smith.library
```

Figure 7b: Copying Indexes

5. Searching Index Objects
We specify how to navigate through and search indexes. The navigation commands first, next, previous, last, allow one to position the cursor to the elements of an index. The command fetch allows one to bring in a record. Indexes are retrieved, in the beginning, then saved (if they have been modified), and finally returned. The commands pick and list allow one to make an index current and check which indexes are opened respectively.

5.1. Opening Indexes
The retrieve command allows one to open an index. The format of the command is shown in Figure 8a. "mode" can be one of "read-only" and "modify". "tag" is a unique identifier that the user supplies; if not present the system generates one. Figure 8b contains requests to retrieve the subject and the grid index from indexset nssdca.smith.library.

```
retrieve index <index_name1> <indexset1>  <mode> [<tag>]
```
5.2. Listing Retrieved Indexes
The list command allows one to list the opened indexes and see their tags. The format of the command is shown in Figure 9a. It has no arguments. Figure 9b shows the output of the command.

list index

INDEX: nssdca.smith.library/subject  t1
INDEX: nssdca.smith.library/grid      t2

5.3. Picking Indexes
The pick command allows one to pick an opened index and make it current. The format of the command is shown in Figure 10a. "tag" is a unique identifier that the user supplies. Figure 10b contains a request to pick the subject index from indexset nssdca.smith.library.

pick index <tag>
5.4. Saving Indexes
The save command allows one to save permanently an opened and modified index. The format of the command is shown in Figure 11a. "tag" is a unique identifier that the user supplies. Figure 11b shows how to save the subject index in indexset nssdca.smith.library.

```
save index <tag>
```

Figure 11a: Picking Indexes

```
save index t1
```

Figure 11b: Picking Indexes

5.4. Returning Indexes
The return command allows one to close an opened index. The format of the command is shown in Figure 12a. "tag" is a unique identifier that the user supplies. Figure 12b shows how to close the subject index from the indexset nssdca.smith.library.

```
return index <tag>
```
5.5. Positioning within Indexes

The navigation commands **first**, **next**, **previous**, **last**, allow one to position the cursor to the elements of an index. These can be executed after an index has been picked to be the current one and a boolean for the search has been defined (if no such boolean has been defined it is assumed that one want to navigate through all of the elements). The command **fetch** allows one to bring in a record.

The format of the commands is shown in Figure 13a. "tag" is a unique identifier that the user supplies. Figure 13b shows how to navigate and get records from the subject index from the indexset nssdca.smith.library.

**Figure 13a: Navigating Through Indexes**

```
first in index
next in index
previous in index
last in index
fetch from index
```

**Figure 13b: Navigating Through Indexes**

```
open subject index and
pick it to be the current one; then
first in index
fetch from index
next in index
fetch from index
fetch from index
last in index
fetch from index
previous in index
```
6. Manipulating Booleans
We specify how to define booleans and use them for searching through indexes.

6.1. Building Booleans
The build boolean command allows one to define booleans and use them for searching through indexes. The format of the command is shown in Figure 14a. "expression" is a boolean expression and "tag" is a unique identifier that the user supplies; if not present the system generates one. Figure 14b contains requests to build two booleans.

build boolean <expression> [tag]

Figure 14a: Building Booleans

build boolean subject="New Title"
build boolean lat1=15 b2

Figure 14b: Building Booleans

6.2. Listing Booleans
The list boolean command allows one to list the defined indexes and see their tags. The format of the command is shown in Figure 15a. It has no arguments. Figure 15b shows the output of the command.

list boolean

Figure 15a: Listing Booleans

| BOOLEAN: | subject="New Title" | b1 |
| BOOLEAN: | lat1=15 | b2 |

Figure 15b: Listing Booleans
6.3. Picking Booleans
The **pick boolean** command allows one to pick a previously defined boolean and make it current. The format of the command is shown in Figure 16a. "tag" is a unique identifier that the user supplies. Figure 16b contains a request to pick the subject boolean.

```
pick boolean <tag>
```

Figure 16a: Picking Booleans

```
pick boolean b1
```

Figure 16b: Picking Booleans

6.4. Modifying Booleans
The **modify boolean** command allows one to change the expression of a defined boolean. The format of the command is shown in Figure 17a. Figure 17b shows how to modify a previously defined boolean.

```
modify boolean <new_expression>
```

Figure 18a: Modifying Booleans

```
modify boolean subject="Second Title"
modyfy boolean lat1=20
```

Figure 18b: Modifying Booleans
6.5. Dropping Booleans

The `drop boolean` command allows one to drop a previously defined boolean. The format of the command is shown in Figure 19a. "tag" is a unique identifier that the user supplies. Figure 19b shows how to drop the boolean defined on "subject".

```
drop boolean <tag>
```

Figure 19a: Dropping Booleans

```
drop boolean b1
```

Figure 19b: Dropping Booleans
Part IV: Reference Manual
Although all commands and operations described in Part I of this report were designed, only a subset was implemented. Table E (repeated from Part III) lists the operations that were implemented both at the Host Language Interface and at the Command Language Interface. In the rest of this section we give the Reference Manual for both Interfaces.

Table E: UIMS Commands

<table>
<thead>
<tr>
<th>Index Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create index</td>
</tr>
<tr>
<td>drop index</td>
</tr>
<tr>
<td>insert index</td>
</tr>
<tr>
<td>copy index</td>
</tr>
<tr>
<td>update index</td>
</tr>
<tr>
<td>move index</td>
</tr>
<tr>
<td>delete index</td>
</tr>
<tr>
<td>search index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Browsing Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>retrieve index</td>
</tr>
<tr>
<td>pick index</td>
</tr>
<tr>
<td>save index</td>
</tr>
<tr>
<td>return index</td>
</tr>
<tr>
<td>list indexes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Navigation Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>first in index</td>
</tr>
<tr>
<td>next in index</td>
</tr>
<tr>
<td>fetch using index</td>
</tr>
<tr>
<td>last in index</td>
</tr>
<tr>
<td>previous in index</td>
</tr>
<tr>
<td>build index boolean</td>
</tr>
<tr>
<td>list index booleans</td>
</tr>
<tr>
<td>pick index boolean</td>
</tr>
<tr>
<td>modify index boolean</td>
</tr>
<tr>
<td>drop index boolean</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Index Run-Time Environment Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create column binding</td>
</tr>
<tr>
<td>create row binding</td>
</tr>
<tr>
<td>drop column binding</td>
</tr>
<tr>
<td>drop row binding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indexset Management Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>create indexset</td>
</tr>
<tr>
<td>drop indexset</td>
</tr>
</tbody>
</table>
Host Language Interface
Function Name:
   ISET_create

Purpose:
   To create an indexset.

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: char *indexset The name of the indexset

Description:
   To create an indexset
   ISET_create(indexset)

Errors:
   If there is an existing indexset with the same name

Examples:
   ISET_create("iueobs");

See Also:
Function Name:
  ISET_delete

Purpose:
  To delete an indexset.

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: char *indexset The name of the indexset

Description:
  To delete an indexset
      ISET_delete(indexset)

Errors:
  If there is no indexset with the given name

Examples:
  ISET_delete("iucobs");

See Also:
Function Name:
  _create

Purpose:
  To create an index in an indexset.

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: WA *wa A pointer to a work area
  IN: char *indexname The name of the source index
  IN: char *indexset The name of source parent indexset
  IN: FORMAT *mode The type of the new index (heap, hash, b-tree, r-tree)
  IN: ATTR_DESC **attr_info An array indicating the structure of the index attributes

Description:
  To create an index
    _create(wa, indexname, indexset, mode, attr_info)

Errors:
  If there is no such indexset, or attribute information is incorrect

Examples:

    WA *wa /* work area definitions */
    ATTR_DESC **attr_info; /* attribute information structure */ ...
    WA_open ("nick r", "ccc", wa);
    Fill_in_attr_info(attr_info);
    _create(wa, "objclass", "iueobs", "b-tree", attr_info);

See Also:
Function Name:
    I_drop

Purpose:
    To drop an index from an indexset

Function Module:
    uinms.a

Function Type:
    integer. Returns OK or an error code

Parameters:
    IN: char *indexname The name of the source index
    IN: char *indexset The name of source parent indexset

Description:
    To drop an index
        I_drop(indexname, indexset)

Errors:
    If there is no such index, or such indexset.

Examples:
    I_drop("objclass", "iueobs");

See Also:
Function Name:
I_insert

Purpose:
To insert a row into the current index of an indexset.

Function Module:
uinms.a

Function Type:
integer. Returns OK or an error code

Parameters:
WA *wa A pointer to a work area
IN: char *buffer The buffer area holding the row to be inserted

Description:
To insert into an index:
I_insert(wa, buffer)

Errors:
If the current index is not open for modify. The type of the data is inconsistent with the definition.

Examples:
+ WA *wa /* work area definitions */
   TAG *tagl;
   BUFFER *buffr;
   ...
   WA_open("nick r", "ccc",wa);
   I_retrieve(wa, "objclass", "iueobs", 2, tagl);
   I_pick (wa, tagl);
   setup_row(buffr); /* sets the values of the columns */
   I_first(wa);
   I_next(wa);
   I_insert(wa, buffer);
   I_save(wa);
   I_return(wa);
   WA_close (wa);

See Also:
Function Name:
  I_update

Purpose:
  To update the current row of the current index of an indexset.

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: WA *wa A pointer to a work area
  IN: char *row The new row to replace the existing one

Description:
  To update current row of the current index:
    I_update(wa, row)

Errors:
  If the current index is not open for modify. The type of the data is inconsistent with the definition.

Examples:
  Suppose "objclass" is an index with two columns, "class" and "id", and we want to replace the second row of this index with the row (LWR,15)
    WA *wa /* work area definitions */
    ...
    TAG *tag1;
    BUFFER *buffrl;
    WA_open ("nick r", "ccc", wa);
    I_retrieve(wa, "objclass", "iueobs", 1, tag1);
    I_pick (wa, *tagl);
    insert_to_buffer (buffrl,"LWR",15);
    I_first(wa);
    I_next(wa);
    I_update(wa, buffrl);
    I_save(wa);
    I_return(wa, *tagl);

See Also:
Function Name:
I_move

Purpose:
To move an index from an indexset into another index

Function Module:
uinms.a

Function Type:
integer. Returns OK or an error code

Parameters:
IN: WA *wa A pointer to a work area
IN: char *indexname1 The name of the source index
IN: char *indexset1 The name of source parent indexset
IN: char *indexname2 The name of the destination index
IN: char *indexset2 The name of destination parent indexset

Description:
To move an index
   I_move(wa, indexname1, indexset1, indexname2, indexset2)

Errors:
If there is no such source index, or such source indexset.

Examples:
WA *wa /* work area definitions */

WA_open ("nick r", "ccc", wa);
I_move(wa, "objclass", "iueobs", "objclass", "newiueobs");

See Also:
Function Name:  
   I_delete

Purpose:  
   To delete current row of the current index of an indexset.

Function Module:  
   uinms.a

Function Type:  
   integer. Returns OK or an error code

Parameters:  
   IN: WA *wa A pointer to a work area

Description:  
   To delete current row from the current index:  
   I_delete(wa)

Errors:  
   If the current index is not open for modify.

Examples:  

   WA *wa /* work area definitions */  
   TAG *tagl;  
   BUFFER *buffr;  
   VAR *classbuf;  
   ...  
   WA_open ("nick r", "ccc", wa);  
   I_retrieve(wa, "objclass", "iueobs", i, tagl);  
   I_crbind(wa, tagl, buffr);  
   I_ccbind(wa, tagl, "class", clasbuf);  
   I_pick (wa, tagl);  
   I_first(wa);  
   I_fetch(wa);  
   I_next(wa);  
   I_fetch(wa);  
   I_delete(wa);  
   I_dcbind(wa, tagl, "class", clasbuf);

See Also:  

Function Name:
I_copy

Purpose:
To copy an index from an indexset into another index

Function Module:
uinms.a

Function Type:
integer. Returns OK or an error code

Parameters:
IN: WA *wa A pointer to a work area
IN: char *indexname1 The name of the source index
IN: char *indexset1 The name of source parent indexset
IN: char *indexname2 The name of the destination index
IN: char *indexset2 The name of destination parent indexset
IN: FORMAT *mode The type of the new index (heap, hash, b-tree, r-tree)

Description:
To copy an index
I_copy(wa, indexname1, indexset1, indexname2, indexset2, mode)

Errors:
If there is no such source index, or such source indexset.

Examples:
WA *wa /* work area definitions */
...
TAG *tag1, *tag2;

WA_open ("nick r", "ccc", wa);
I_copy(wa, "objclass", "iueobs", "objclass1", "newiueobs", "b-tree");

See Also:
Function Name:
  I_search

Purpose:
  To search the current index of an indexset.

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: IN: WA *wa A pointer to a work area
  IN: FILE *infile Name of file containing terms
  IN/OUT: FILE *outfile Name of file containing pointers
  IN/OUT: FILE *pairfile Name of file containing term-pointer pairs
  IN/OUT: FILE *statfile Name of file containing statistics

Description:
  To search an index:
    I_search(wa, infile, outfile, pairfile, statfile)

Errors:
  If there is no current index. If there is no input or output file.

Examples:
  WA *wa /* work area definitions */
  TAG *tag1:

  WA_open ("nick r", "ccc",wa);
  I_retrieve(wa, "objclass", "iueobs", 1, tag1);
  I_pick (wa, *tag1);
  I_search(wa, "windows", "output", "pairs", "stats");

  For example, the contents of file "windows" may be:
    99
    24

  Then, the contents of file "output" might be:
    LWP2346
    LWP2347

  while the contents of file "pairs" will be:
    99 LWP2346
    24 LWP2347

  The contents of file "stats" will be:
    3 records found

See Also:
Function Name:

I_retrieve

Purpose:

To retrieve an index in an indexset.

Function Module:

uinms.a

Function Type:

integer. Returns OK or an error code

Parameters:

IN: WA *wa A pointer to a work area
IN: char *index Name of the index
IN: char *indexset Name of the indexset
IN: int mode mode of access e.g., read (0) or write (1). Default is read
IN/OUT: TAG *tag Optional tag name (the system generates a tag if none is specified)

Description:

To retrieve an index:

I_retrieve(wa, index, indexset, mode, tag)

Errors:

If there is no index. If there is no indexset. If the mode is not correct.

Examples:

+ WA *wa /* work area definitions */
  ...
  TAG *tag1;
  TAG *tag2;

  WA_open ("nick r", "ccc", wa);
  I_retrieve(wa, "objclass", "iueobs", 1, tag1);
  I_retrieve(wa, "objclass", "rectss", 1, tag2);

See Also:
Function Name:
  I_pick

Purpose:
  To pick an index

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: WA *wa A pointer to a work area
  IN: TAG tag The tag of the index

Description:
  To pick an index
     I_pick(wa, tag)

Errors:
  If there is no tag of that name.

Examples:

    WA *wa /* work area definitions */
    ...
    TAG *tag1, *tag2;

    WA_open ("nick r", "ccc", wa);
    I_retrieve(wa, "objclass", "iueobs", 1, tag1);
    I_retrieve(wa, "objclass", "rectss", 1, tag2);
    I_pick (wa, *tag1);
    I_first(wa);
    process rows
    I_pick (wa, *tag2);
    I_first(wa);
    process rows

See Also:
Function Name:
   I_save

Purpose:
   To save an index in an indexset.

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: WA *wa A pointer to a work area
   IN: TAG tag The tag of the index

Description:
   To save an index:
      I_save(wa, tag)

Errors:
   If there is no such tag

Examples:

   + WA *wa /* work area definitions */
     ...
     TAG *tag1, *tag2;

     WA_open ("nick r", "ccc",wa);
     I_retrieve(wa, "objclass", "iueobs", 1, tag1);
     I_retrieve(wa, "objclass", "rectss", 0, tag2);
     update indexes
     I_save(wa, *tag1);
     I_save(wa, *tag2);
     I_return(wa, *tag1);
     I_return(wa, *tag2);

See Also:
Function Name:
   I_return

Purpose:
   To return an index in an indexset.

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: WA *wa A pointer to a work area
   IN: TAG tag The tag of the index

Description:
   To return an index:
   
   I_return(wa, tag)

Errors:
   If there is no such tag

Examples:

   + WA *wa /* work area definitions */
     ...
   
   TAG *tag1, *tag2;

   WA_open ("nick r", "ccc", wa);
   I_retrieve(wa, "objclass", "iueobs", 1, tag1);
   I_retrieve(wa, "objclass", "rectss", 0, tag2);
   process indexes
   I_return(wa, *tag1);
   I_return(wa, *tag2);

See Also:
**Function Name:**

I_list

**Purpose:**

To list the retrieved indexes

**Function Module:**

uinms.a

**Function Type:**

integer. Returns OK or an error code

**Parameters:**

IN: WA *wa A pointer to a work area

**Description:**

To list all indexes

I_list(wa)

**Errors:**

None.

**Examples:**

```
WA *wa /* work area definitions */
...
TAG *tagl, *tag2;

WA_open ("nick r", "ccc",wa);
I_retrieve(wa, "objclass", "iueobs", 1, tagl);
I_retrieve(wa, "rects", "iueobs", 1, tag2);
I_list(wa);
```

The result is:

```
INDEX: iueobs/objclass TAG: I1
INDEX: iueobs/rects TAG: I2
```

**See Also:**
Function Name:
   I_first

Purpose:
   To make the first row of the current index current.

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: WA *wa A pointer to a work area

Description:
   To get the first row of the current index:
   I_first(wa)

Errors:

Examples:
   WA *wa /* work area definitions */
   TAG *tag1;
   BUFFER *buffr;
   ...
   WA_open ("nick r", "occ",wa);
   I_retrieve(wa, "objclass", "iueobs", 1, tag1);
   I_pick (wa, tag1);
   I_first(wa);
   buffr = I_fetch(wa);
   print_row(buffr);

See Also:
Function Name:

I_next

Purpose:
To make the next row of the current index current.

Function Module:
uinms.a

Function Type:
integer. Returns OK or an error code

Parameters:
IN: WA *wa A pointer to a work area

Description:
To get the next row of the current index:
I_next(wa)

Errors:

Examples:

WA *wa /* work area definitions */
WA *wa /* work area definitions */
TAG *tagl;
BUFFER *buffr;
...
WA_open ("nick r", "ccc", wa);
I_retrieve(wa, "objclass", "iueobs", 1, tagl);
I_pick (wa, tagl);
I_first(wa);
buffr = I_fetch(wa);
print_row(buffr);
I_next(wa);
buffr = I_fetch(wa);
print_row(buffr);

See Also:
Function Name:
   I_fetch

Purpose:
   To get the current row of the current index.

Function Module:
   uinms.a

Function Type:
   pointer to character string (the buffer to hold the row)

Parameters:
   IN: WA *wa A pointer to a work area

Description:
   To get the current row of the current index:
   I_fetch(wa)

Errors:
   If there is no current row.

Examples:
   WA *wa /* work area definitions */
   TAG *tag1;
   BUFFER *buffr;
   ...
   WA_open ("nick r", "ccc", wa);
   I_retrieve(wa, "objclass", "iueobs", 1, tag1);
   I_pick (wa, tag1);
   I_first(wa);
   buffr = I_fetch(wa);
   print_row(buffr);
   I_next(wa);
   buffr = I_fetch(wa);
   print_row(buffr);

See Also:
Function Name:
   _I_last

Purpose:
   To make the last row of the current index current.

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: WA *wa A pointer to a work area

Description:
   To get the last row of the current index:
   _I_last(wa)

Errors:

Examples:

   WA *wa /* work area definitions */
   TAG *tagl;
   BUFFER *buffr;
   ...
   WA_open ("nick r", "ccc", wa);
   _I_retrieve(wa, "objclass", "iueobs", 1, tagl);
   _I_pick (wa, tagl);
   _I_last(wa);
   buffr = _I_fetch(wa);
   print_row(buffr);

See Also:
Function Name:
    I_previous

Purpose:
    To make the previous row of the current index current.

Function Module:
    uinms.a

Function Type:
    integer. Returns OK or an error code

Parameters:
    IN: WA *wa A pointer to a work area

Description:
    To get the previous row of the current index:
    
    I_previous(wa)

Errors:

Examples:

    WA *wa /* work area definitions */
    TAG *tag1;
    BUFFER *buffr;
    ...
    WA_open ("nick r", "ccc",wa);
    I_retrieve(wa, "objclass", "iueobs", 1, tag1);
    I_pick (wa, *tag1);
    I_last(wa);
    buffr = I_fetch(wa);
    print_row(buffr);
    I_previous(wa);
    buffr = I_fetch(wa);
    print_row(buffr);

See Also:
Function Name:
   IB_build

Purpose:
   To build a boolean for searching an index in an indexset.

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: WA *wa A pointer to a work area
   IN: BOOL *boolean The boolean
   IN/OUT: TAG *tag The tag of the boolean

Description:
   To build a boolean for searching an index in an indexset:
   IB_build (wa, boolean, tag);

Errors:
   If there is an incorrectly specified boolean.

Examples:
   WA *wa /* work area definitions */
   ...
   TAG *tag1;
   BUFFER *buffrl;

   TAG *tag2;
   BUFFER *buffr2;

   WA_open ("nick r", "ccc",wa);
   I_retrieve(wa, "objclass", "iueobs", 1, tag1);
   I_crbind(wa, tag1, buffrl);

   To search for the first row of a b-tree index with named objclass in indexset iueobs
   satisfying the condition objclass = 99
   I_pick (wa, "il");
   strcpy(log_txt_str, "objclass=99");
   IB_build (wa, log_txt_str, "bl");
   IB_pick(wa, "bl");
   I_first(wa);
   I_fetch(wa);

See Also:
Function Name:
    IB_list

Purpose:
    To list the booleans.

Function Module:
    uinms.a

Function Type:
    integer. Returns OK or an error code

Parameters:
    IN: WA *wa A pointer to a work area

Description:
    To list all booleans:
        IB_list(wa)

Errors:
    None.

Examples:
    WA *wa /* work area definitions */
        ...
        TAG *tagl, *b1, *b2;
        BUFFER *log_txt_str;

        WA_open ("nick r", "ccc", wa);
        I_retrieve(wa, "objclass", "iueobs", 1, tagl);
        I_pick (wa, tagl);
        strcpy(log_txt_str, "objclass=99");
        IB_build (wa, log_txt_str, b1);
        strcpy(log_txt_str, "objclass=101");
        IB_build (wa, log_txt_str, b2);
        IB_list (wa);

    The result is:
        BOOLEAN: objclass=99 TAG: B1
        BOOLEAN: objclass=101 TAG: B2

See Also:
Function Name:
IB_pick

Purpose:
To pick a boolean.

Function Module:
uinms.a

Function Type:
integer. Returns OK or an error code

Parameters:
IN: WA *wa A pointer to a work area
IN: TAG tag The tag of the boolean

Description:
To pick a boolean:
IB_pick(wa, tag)

Errors:
If there is no tag of that name.

Examples:
WA *wa /* work area definitions */
...
TAG *tagl, *bl;
BOOL *log_txt_str;

WA_open ("nick r", "ccc", wa);
I_retrieve(wa, "objclass", "iueobs", 1, tagl);
I_pick (wa, *tagl);
strcpy(log_txt_str, "objclass=99");
IB_build (wa, log_txt_str, bl);
IB_pick(wa, *bl);
I_first(wa);
....

See Also:
Function Name:
  IB_modify

Purpose:
  To modify a boolean for searching an index in an indexset.

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: WA *wa A pointer to a work area
  IN: BOOL *boolean The boolean expression

Description:
  To modify a boolean
  
  IB_modify (wa, boolean);

Errors:
  If there is an incorrectly specified boolean.

Examples:
  WA *wa /* work area definitions */
    ...
    TAG *tagl;
    BOOL *boolean;
    char *buffer;

    WA_open ("nick r", "ccc", wa);
    I_retrieve(wa, "objclass", "iueobs", 1, tagl);
    I_pick (wa, tagl);
    strcpy(boolean, "objclass=99");
    IB_build (wa, boolean, bl);
    IB_pick(wa, *bl);
    I_first(wa);
    buffer = I_fetch(wa);
    print_row(buffer);
    strcpy(boolean, "objclass=101");
    IB_modify (wa, boolean);
    I_first(wa);
    buffer = I_fetch(wa);
    print_row(buffer);
    WA_close (wa);

See Also:
Function Name:
IB_drop

Purpose:
To drop a boolean.

Function Module:
uinms.a

Function Type:
integer. Returns OK or an error code

Parameters:
IN: WA *wa A pointer to a work area
IN: TAG tag The tag of the boolean

Description:
To drop a boolean:
IB_drop(wa, tag);

Errors:
If there is no such tag

Examples:
WA *wa /* work area definitions */
...
TAG *tag1, *bl;
BUFFER *buffr;

WA_open ("nick r", "ccc", wa);
I_retrieve(wa, "objcclass", "iueobs", i, tag1);
I_crbind(wa, tag1, buffr);
I_pick (wa, tag1);
strcpy(log_txt_str, "objcclass=99");
IB_build (wa, log_txt_str, bl);
IB_pick(wa, *bl);
I_first(wa);
I_fetch(wa);
print_row(buffr);
IB_drop((wa, *bl));
I_drbind(wa, tag1, buffr);

See Also:
Function Name:
  _ccbind

Purpose:
  To bind a column to a buffer area

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: WA *wa A pointer to a work area
  IN: char *column The column to bind
  IN: char *var The buffer area (variable)
  IN: char *var_type The type of the variable to be used
  IN: char *var_len The length of the variable to be used

Description:
  To bind a column to a buffer area
    _ccbind(wa, column, var, var_type, var_len)

Errors:
  If the column does not exist, or space has not been allocated for the buffer area

Examples:

  WA *wa /* work area definitions */
  TAG *tag1;
  BUFFER *buffr;
  VAR *classbuf;
  ...
  WA_open ("nick r", "ccc", wa);
  _retrieve(wa, "objclass", "iueobs", 1, tag1);
  _pick (wa, tag1);
  _crbind(wa, buffr);
  _ccbind(wa, "class", clasbuf, "string", 20);
  _first(wa);
  _fetch(wa);
  _next(wa);
  _fetch(wa);
  _delete(wa);
  _dcbind(wa, "class", classbuf);

See Also:
Function Name:
  _I_dcbind

Purpose:
  To drop a binding of a column

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: WA *wa A pointer to a work area
  IN: char *column The column to bind
  IN: char *buffer The buffer area

Description:
  To drop a binding of a column
      _I_dcbind(wa, column, buffer)

Errors:
  If the column does not exist or the binding was never established

Examples:

    WA *wa /* work area definitions */
    TAG *tag1;
    BUFFER *buffr;
    VAR *classbuf;
    ...
    WA_open ("nick r", "ccc", wa);
    I_retrieve(wa, "objclass", "iueobs", 1, tag1);
    I_pick (wa, tag1);
    I_orbind(wa, buffr);
    I_ccbind(wa, "class", clasbuf);
    I_first(wa);
    I_fetch(wa);
    I_next(wa);
    I_fetch(wa);
    I_delete(wa);
    _I_dcbind(wa, "class", classbuf);

See Also:
Function Name:
  I_crbind

Purpose:
  To bind a row to a buffer area

Function Module:
  uinms.a

Function Type:
  integer. Returns OK or an error code

Parameters:
  IN: WA *wa A pointer to a work area
  IN/OUT: char *buffer The buffer area

Description:
  To bind a row to a buffer area
  I_crbind(wa, buffer)

Errors:
  If space has not been allocated for the buffer area

Examples:

  WA *wa /* work area definitions */
  TAG *tagl;
  BUFFER *buffr;
  VAR *classbuf;
  ...
  WA_open ("nick r", "ccc",wa);
  I_retrieve(wa, "objcass", "iueobs", l, tagl);
  I_pick (wa, tagl);
  I_crbind(wa, buffr);
  I_first(wa);
  I_fetch(wa);
  print_row(buffr);
  I_next(wa);
  I_fetch(wa);
  print_row(buffr);
  I_delete(wa);
  I_drbind(wa, buffr);

See Also:
Function Name:
   _drbind

Purpose:
   To drop the binding of a row

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: WA *wa A pointer to a work area
   IN: char *buffer The buffer area

Description:
   To drop the binding of a row
   _drbind(wa, buffer)

Errors:
   If the binding was never established

Examples:
   WA *wa /* work area definitions */
   TAG *tag1;
   BUFFER *buffr;
   VAR *classbuf;
   ...
   WA_open ("nick r", "ccc",wa);
   _pick (wa, tag1);
   _retrieve(wa, "objclass", "iueobs", 1, tag1);
   _crbind(wa, buffr);
   _first(wa);
   _fetch(wa);
   print_row(buffr);
   _next(wa);
   _fetch(wa);
   print_row(buffr);
   _delete(wa);
   _drbind(wa, buffr);

See Also:
Function Name:
   WA_open

Purpose:
   To initialize a work area.

Function Module:
   uinms.a

Function Type:
   integer. Returns OK or an error code

Parameters:
   IN: USER *user The name of the user
   IN: PASS *pass The password of the user
   OUT: WA *wa A pointer to a work area

Description:
   To initialize a work area.
   
   WA_open (user, pass, wa);

Errors:
   If the user, or password is incorrect.

Examples:

   WA *wa /* work area definitions */
   ...
   WA_open ("nick r", "ccc", wa);
   ...
   WA_close (wa);

See Also:
Function Name:
    WA_close

Purpose:
    To close a work area.

Function Module:
    uinms.a

Function Type:
    integer. Returns OK or an error code

Parameters:
    IN: WA *wa A pointer to a work area (ret)

Description:
    To close a work area.
        WA_close (wa);

Errors:
    If the work area pointer is incorrect.

Examples:
    WA *wa /* work area definitions */
        ...
        WA_open ("nick r", "ccc", wa);
        ...
        WA_close (wa);

See Also:
Command Language Interface
Command Name:
   create indexset

Purpose:
   To create an indexset.

Command Module:
   uinms.exe

Synopsis:
   create indexset <indexset>

Parameters:
   indexset- name of parent indexset

Description:
   To create an indexset
       create indexset <indexset>

Errors:
   If there is an existing indexset with the same name

Examples:
   create indexset iueobs

See Also:
Command Name:
   delete indexset

Purpose:
   To delete an indexset.

Command Module:
   uinms.exe

Synopsis:
   delete indexset <indexset>

Parameters:
   indexset- name of parent indexset

Description:
   To delete an indexset
   delete indexset <indexset>

Errors:
   If there is no existing indexset with name given

Examples:
   delete indexset iueobs

See Also:
Command Name:
create

Purpose:
To create an index in an indexset.

Command Module:
uinms.exe

Synopsis:
create index <indexname> <indexset> <mode> <definition_file>

Parameters:
indexname- name of the index
indexset- name of parent indexset
mode- mode of access (e.g., heap, hash, b-tree, r-tree) Default is heap
definition_file- the file containing the schema of the index

Description:
To create an index:
create index <indexname> <indexset> <mode> <definition_file>

Errors:
If there is no indexset. If there is no correct mode. etc.

Examples:
To create a b-tree index with name "objclass" in indexset "iueobs" with definition file "schema"
create index objclass iueobs b-tree schema
Assuming that the two fields in the index are "name" and "id", the file "schema" will have the following information
name string 30
id int 4
If we would have liked to create an r-tree index on a set of rectangles, the file "schema" would contain
attra int 4
attrb int 4
attrc int 4
attrd int 4
id int 4

See Also:
Command Name:
  drop

Purpose:
  To drop an index in an indexset.

Command Module:
  uinms.exe

Synopsis:
  drop index <indexname> <indexset>

Parameters:
  indexname - name of the index
  indexset - name of parent indexset

Description:
  To drop an index:
    drop index <indexname> <indexset>

Errors:
  If there is no such index, or such indexset.

Examples:
  To drop an index with name "objclass" in indexset "iueobs"
    drop index objclass iueobs

See Also:
Command Name: insert

Purpose: To insert a row into the current index of an indexset.

Command Module: uinms.exe

Synopsis: insert into index <row>

Parameters: row - the row to be inserted

Description: To insert into an index:

    insert into index <row>

Errors: If the current index is not open for modify. The type of the data is inconsistent with the definition.

be inserted using the symbol "|

Examples:

    retrieve index objclass iueobs modify i1
    retrieve index rects iueobs modify i2

To insert into a b-tree index with name objclass in indexset iueobs with format:

    objclass integer
    cam string 9

we do the following:

    pick i1
    insert into index objclass|99|cam|LWP2344

To insert into an r-tree index with name rects in indexset iueobs with format:

    ral integer 4
    decl integer 4
    ra2 integer 4
    dec2 integer 4
    cam string 9

we do the following:

    pick i2
    insert into index ral|2344|decl|37384|ra2|39494|dec2|23399|cam|LWP2346

See Also:
Command Name:
update

Purpose:
To update current row of the current index of an indexset.

Command Module:
uinms.exe

Synopsis:
update index <row>

Parameters:
row- the row to be updated

Description:
To update current row of the current index:
update index <row>

Errors:
If the current index is not open for modify. The type of the data is inconsistent with the definition.

Examples:
retrieve index objclass iueobs modify il
retrieve index rects iueobs modify i2
To update the first row of a b-tree index "objclass" in "iueobs" with format:
objclass integer
camseq string 9
we do the following:
pick il
first in index
fetch from index
update index objclass\{99\}camseq\{LWP2345\}
To update the first row of an r-tree index "objclass" in "iueobs" with format
ra1 integer 4
decl integer 4
ra2 integer 4
dec2 integer 4
camseq string 9
we do the following:
pick i2
first in index
fetch from index
update index ra1\{2344\}decl1\{37384\}ra2\{39494\}dec2\{23399\}camseq\{LWP2348\}

See Also:
insert
**Command Name:**
move

**Purpose:**
To move an index from an indexset into another index

**Command Module:**
uinms.exe

**Synopsis:**
move index <indexname1> <indexset1> <indexname2> <indexset2>

**Parameters:**
- indexname1 - name of the source index
- indexset1 - name of source parent indexset
- indexname2 - name of destination index
- indexset2 - name of destination parent indexset

**Description:**
To move an index:
move index <indexname1> <indexset1> <indexname2> <indexset2>

**Errors:**
If there is no such source index, or such source indexset. The new index retains the structure of the source index.

**Examples:**
To move an index with name "objclass" in indexset "iueobs" into index "objcass2" in indexset "oldiue"
move index objcass iueobs objcass2 oldiue

**See Also:**
Command Name:
delete

Purpose:
To delete current row of the current index of an indexset.

Command Module:
uinms.exe

Synopsis:
delete from index

Parameters:
none

Description:
To delete current row from the current index:
delete from index

Errors:
If the current index is not open for modify.

Examples:
retrieve index objclass iueobs modify il
retrieve index rects iueobs modify i2

To delete the first row of a b-tree index "objclass" in "iueobs" with format:
objcclass integer
camseq string 9

we do the following:
pick i1
first in index
fetch from index
delete from index

To delete the second row of an r-tree index "rects" in "iueobs" with format:
ra1 integer 4 decl integer 4
ra2 integer 4 dec2 integer 4
camseq string 9

we do the following:
pick i2
first in index
fetch from index
next in index
fetch from index
delete from index

See Also:
Command Name:
copy

Purpose:
To copy an index from an indexset into another index

Command Module:
uinms.exe

Synopsis:
copy index <indexname1> <indexset1> <indexname2> <indexset2> <mode>

Parameters:
indexname1- name of the source index
indexset1- name of source parent indexset
indexname2- name of the destination index
indexset2- name of destination parent indexset
mode- type of the new index (heap, hash, b-tree, r-tree)

Description:
To copy an index:
copy index <indexname1> <indexset1> <indexname2> <indexset2> <mode>

Errors:
If there is no such source index, or such source indexset.

Examples:
To copy an index with name "objclass" in indexset "iueobs" into another b-tree index "objclass2" in indexset "oldiue"
copy index objclass iueobs objclass2 oldiue b-tree

See Also:
Command Name:
  search

Purpose:
  To search the current index of an indexset.

Command Module:
  uinms.exe

Synopsis:
  search index <infile> <outfile> <statfile>

Parameters:
  infile- name of file containing terms
  outfile- name of file containing pointers
  pairfile- name of file containing term-pointer pairs
  statfile- name of file containing statistics

Description:
  To search an index:
    search index <infile> <outfile> [<pairfile>] [<statfile>]

Errors:
  If there is no index. If there is no indexset. If there is no input file.

Examples:
  retrieve index objclass iueobs read-only i1
  retrieve index rects iueobs read-only i2

  To search a b-tree index with name objclass in indexset iueobs where the input file
  is "windows" and the output file is "observations", pairsfile is "pairs" and the statfile
  is "stats"
    pick i1
    search index windows observations pairs stats

  The contents of file "windows" will be:
    99
    24
    38

  The contents of file "observations" will be:
    LWP2346
    LWP2346
    LWP2347

  The contents of file "pairs" will be:
    99  LWP2346
    24  LWP2346
    24  LWP2347

  The contents of file "stats" will be:
    3 records found

  To search n r-tree index with name objclass in indexset iueobs where the input file
is "windows" and the output file is "rects.dat", pairsfile is "pairs" and the statfile is "stats"

```plaintext
pick i2
search index rects iueobs windows rects.dat pairs stats
```

the contents of file "windows" will be:

```
2344 37384 39494 23399
5344 47384 33394 83399
5344 47384 33394 83399
```

the contents of file "rects.dat" will be:

```
LWP2346
LWP2347
LWP2349
```

the contents of file "pairs" will be:

```
2344 37384 39494 23399 LWP2346
5344 47384 33394 83399 LWP2347
5344 47384 33394 83399 LWP2347
```

The contents of file "stats" will be:

```
3 records found
```

See Also:
Command Name:
    retrieve

Purpose:
    To retrieve an index in an indexset.

Command Module:
    uinms.exe

Synopsis:
    retrieve index <indexname> <indexset> <mode> [<tag>]

Parameters:
    indexname- name of the index
    indexset- name of parent indexset
    mode- mode of access (e.g., read or write) Default is read
    tag- optional tag name (the system generates a tage if none is specified)

Description:
    To retrieve an index:
        retrieve index <indexname> <indexset> <mode> [<tag>]

Errors:
    If there is no index. If there is no indexset. If there is no correct mode. etc.

Examples:
    To retrieve a b-tree index with name objclass in indexset iueobs where the mode is read:
        retrieve index objclass iueobs read-only
    To retrieve a hash index with name objclass in indexset iueobs where the mode is write:
        retrieve index objclass iueobs modify t3
    To retrieve an r-tree index with name rects in indexset iueobs where the mode is read:
        retrieve index rects iueobs read-only

See Also:
Command Name:
pick

Purpose:
To pick an index in an indexset and make it current.

Command Module:
uinms.exe

Synopsis:
pick index <tag>

Parameters:
tag - tag name

Description:
To pick an index:
pick index <tag>

Errors:
If there is no tag of that name.

Examples:
To pick an index tl:
pick index tl

See Also:
Command Name:
   save

Purpose:
   To save an index in an indexset.

Command Module:
   uinms.exe

Synopsis:
   save index <tag>

Parameters:
   tag- tag name

Description:
   To save an index:
       save index <tag>

Errors:
   If there is no tag of that name.

Examples:
   To save a b-tree index t1 with name objclass in indexset iueobs where the mode is modify:
       save index t1
   To save a hash index t2 with name objclass in indexset iueobs where the mode is modify:
       save index t2
   To save an r-tree index t3 with name rects in indexset iueobs where the mode is modify:
       save index t3

See Also:
Command Name:
return

Purpose:
To return an index in an indexset.

Command Module:
uinms.exe

Synopsis:
return index <tag>

Parameters:
tag- tag name

Description:
To return an index:
    return index <tag>

Errors:
If there is no tag of that name.

Examples:
To return a b-tree index t1 with name objclass in indexset iueobs where the mode is
read:
    return index t1
To return a hash index t2 with name objclass in indexset iueobs where the mode is
write:
    return index t2
To return an r-tree index t3 with name rects in indexset iueobs where the mode is
read:
    return index t3

See Also:
Command Name:
    list

Purpose:
    To list the retrieved indexes.

Command Module:
    uinms.exe

Synopsis:
    list index

Parameters:
    none

Description:
    To list all retrieved indexes:
        list index

Errors:
    If there is no tag of that name.

Examples:
    retrieve index objclass iueobs modify i1
    retrieve index rects iueobs modify i2

    To list all indexes:
        list index

    The result is:
        INDEX: iueobs/objclass TAG: i1
        INDEX: iueobs/rects  TAG: i2

See Also:
Command Name:
    first

Purpose:
    To make the first row of the current index current.

Command Module:
    uinms.exe

Synopsis:
    first in index

Parameters:
    none

Description:
    To get the first row of the current index:
        first in index

Errors:
    If no index has been picked as current.

Examples:
    retrieve index objclass iueobs modify il
    retrieve index rects iueobs modify i2
    To retrieve first row of index i1:
        pick il
        first in index
        fetch from index
    To retrieve first row of index i2:
        pick i2
        first in index
        fetch from index

See Also:
Command Name:
next

Purpose:
To make the next row of the current index current.

Command Module:
uinms.exe

Synopsis:
next in index

Parameters:
none

Description:
To get the next row of the current index:
next in index

Errors:
If no index has been picked as current.

Examples:
retrieve index objclass iueobs modify i1
retrieve index rects iueobs modify i2

To retrieve next row of index i1:
pick i1
first in index
next in index
fetch from index

To retrieve next row of index i2:
pick i2
first in index
next in index
fetch from index

See Also:
Command Name:
  fetch

Purpose:
  To display the current row of the current index.

Command Module:
  uinms.exe

Synopsis:
  fetch from index

Parameters:
  none

Description:
  To display the current row of the current index:
    fetch from index

Errors:
  If there is no current row.

Examples:
  retrieve index objclass iueobs modify i1
  retrieve index rects iueobs modify i2

  To fetch last row of index i1:
    pick i1
    last in index
    fetch from index

  The last row is:
    99   "LWP2345"

  To fetch first row of index i2:
    pick i2
    first in index
    fetch from index

  The first row is:
    2344 37384 39494 23399 "LWP2348"

See Also:
Command Name:
  last

Purpose:
  To make the last row of the current index current.

Command Module:
  uinms.exe

Synopsis:
  last in index

Parameters:
  none

Description:
  To get the last row of the current index:
    last in index

Errors:
  If no index has been picked as current.

Examples:
  retrieve index objclass iueobs modify i1
  retrieve index rects iueobs modify i2
  
  To retrieve last row of index i1:
    pick i1
    first in index
    last in index
    fetch from index
  
  To retrieve last row of index i2:
    pick i2
    first in index
    last in index
    fetch from index

See Also:
Command Name:
   previous

Purpose:
   To make the previous row of the current index current.

Command Module:
   uinms.exe

Synopsis:
   previous in index

Parameters:
   none

Description:
   To get the previous row of the current index:
   previous in index

Errors:
   If no index has been picked as current.

Examples:

   retrieve index objclass iueobs modify il
   retrieve index rects iueobs modify i2

   To retrieve previous row of index i1:
   pick il
   last in index
   previous in index
   fetch from index

   To retrieve previous row of index i2:
   pick i2
   last in index
   previous in index
   fetch from index

See Also:
Command Name:

build boolean

Purpose:

To build a boolean for searching an index in an indexset.

Command Module:

uinms.exe

Synopsis:

build boolean <expression> [<tag>]

Parameters:

expression - boolean condition

<tag> - optional tag name (the system generates a tag if none is specified)

Description:

To build a boolean for searching an index in an indexset:

build boolean <expression> [<tag>]

Errors:

If there is an incorrectly specified boolean.

Examples:

retrieve index objclass iueobs modify il
retrieve index rects iueobs modify i2

To search for the first row of a b-tree index with name objclass in indexset iueobs satisfying the condition objclass = 99:

pick index il
build boolean objclass=99 bl
pick boolean bl
first in index
fetch from index

To search for the first row of an r-tree index with name rects in indexset iueobs satisfying the condition (ra1,dec1,ra2,dec2) overlaps (23,3456,85754,5599):

pick index i2
build boolean (ra1,dec1,ra2,dec2) OV (23,3456,85754,5599) bl
pick boolean bl
first in index
fetch from index

See Also:
Command Name:
    list boolean

Purpose:
    To list the booleans.

Command Module:
    uinms.exe

Synopsis:
    list boolean

Parameters:
    none

Description:
    To list all booleans:
        list boolean

Errors:
    None.

Examples:
    retrieve index objclass iueobs modify l
    retrieve index rects iueobs modify l2

    To search for the first row of a b-tree index with name objclass in indexset iueobs
    satisfying the condition objclass = 99:
        build boolean objclass=99 bl
        build boolean (r1,dec1,ra2,dec2) OV (23,3456,85754,5599) bl

    To list all boolean:
        list boolean

    The result is:
        BOOLEAN: objclass=99 TAG: bl
        BOOLEAN: (r1,dec1,ra2,dec2) OV (23,3456,85754,5599) TAG: b2

See Also:
Command Name:
  pick boolean

Purpose:
  To pick a boolean.

Command Module:
  uinms.exe

Synopsis:
  pick boolean <tag>

Parameters:
  tag- tag name

Description:
  To pick a boolean:
    pick boolean <tag>

Errors:
  If there is no tag of that name.

Examples:
  To pick an boolean b1:
    pick boolean b1

See Also:
Command Name:
modify boolean

Purpose:
To modify current boolean.

Command Module:
uinms.exe

Synopsis:
modify boolean <boolean>

Parameters:
boolean- the new boolean

Description:
To modify current boolean:
modify boolean <boolean>

Errors:
If the boolean is syntactically incorrect.

Examples:
retrieve index objclass iueobs modify i1
retrieve index rects iueobs modify i2

To search for the first row of a b-tree index with name objclass in indexset iueobs satisfying the condition objclass = 99:
build boolean objclass=99 b1
build boolean (ra1,dec1,ra2,dec2) OV (23,3456,85754,5599) b1

To modify boolean b1:
pick boolean b1
modify boolean objclass=24

To modify boolean b2:
pick boolean b2
modify boolean (ra1,dec1,ra2,dec2) OV (23,3456,85754,5598)

See Also:
Command Name:
    drop boolean

Purpose:
    To drop a boolean.

Command Module:
    uinms.exe

Synopsis:
    drop boolean <tag>

Parameters:
    tag- tag name

Description:
    To drop a boolean:
        drop boolean <tag>

Errors:
    If there is no tag of that name.

Examples:
    To drop boolean b1:
        drop boolean b1

See Also:
**Command Name:**
create indexset

**Purpose:**
To create an indexset.

**Command Module:**
uinms.exe

**Synopsis:**
create indexset <indexset>

**Parameters:**
indexset- name of parent indexset

**Description:**
To create an indexset
create indexset <indexset>

**Errors:**
If there is an existing indexset with the same name

**Examples:**
create indexset iueobs

**See Also:**
Command Name:
    delete indexset

Purpose:
    To delete an indexset.

Command Module:
    uinms.exe

Synopsis:
    delete indexset <indexset>

Parameters:
    indexset- name of parent indexset

Description:
    To delete an indexset
        delete indexset <indexset>

Errors:
    If there is no existing indexset with name given

Examples:
    delete indexset iueobs

See Also:
UIMS TEST SUITE

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Final Report
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Goddard Space Flight Center
Greenbelt, Maryland 20771

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README FILE

This directory tree contains the source code, libraries, executable, script, data and test directories for the NASA sponsored UIMS system.

Directory List and Contents:

README - this file

Source Code Directories:
include    - header files (.h) which define UIMS internal structures
bTREE     - source and object code for "B-Tree" index type
bind       - source code for binding indexes to names
bool       - source and object code which deal with boolean expressions
index      - source and object code common to all index types
minirel    - source and object code for basic file operations
rindex     - r-tree index source and object code (not available)
sec        - source and object code for B-Tree creation
sec_aux    - utility source and object code for B-Trees
select     - source and object code for index selection
tools      - source and object code for UIMS utilities

Library Directory:
lib        - object code libraries (made from the source directories)

Executable Directory:
bin        - where the "index" executable is created/run from

Test Directories:
script     - contains test scripts - command execution files
data       - contains test data used by the scripts
db         - (empty) directory where test may scripts be run

To Make a new version of the system:
Change directory (cd) to each of the source code directories (excluding "include" and saving "index" for last) an type:
make all

For each directory excepting "index", this will compile the source code into object code and create an object code library in "lib". Typing this in "index" will result in compiling the source code there and then link it with the libraries to create the "index" executable in "bin".

Testing the System
If you wish to test the system, there are script files in UIMS/script that act as input to an interactive program demonstrating the system.
Change to the "db" directory then execute the following command scripts. They will completely test all functioning user level routines.

```
./bin/index < ./script/input.create.load.unload.help > test1
./bin/index < ./script/input.copy.move > test2
./bin/index < ./script/input.retrieve.navigate.return > test3
./bin/index < ./script/input.boolean.navigate > test4
./bin/index < ./script/input.modify > test5
./bin/index < ./script/input.drop > test6
```

All the 'test' files will show the error codes/return values for each command in the input file. There are some commands that are intended to give error codes back (e.g. trying to update an index that was retrieved for read only, requesting the previous tuple when currently at the beginning of the index, etc.).
TEST SUIT

The test suite consists of 6 scripts. Below are the scripts and the output of each of these tests.

SCRIPT 1

input.create.load.unload.help
sarah
passwd
create indexset sarahiset
create indexset aliset
create indexset jeniset
create indexset joiset
create index indexhp sarahiset heap ../data/heap.def
create index indexhs sarahiset hash ../data/hash.def
create index indexbt sarahiset btree ../data/btree.def
create index indexrt sarahiset rtree ../data/rtree.def
load index indexhp sarahiset ../data/sarahiset.data
load index indexhs sarahiset ../data/aliset.data
load index indexbt sarahiset ../data/jeniset.data
load index indexrt sarahiset ../data/rtree.data
unload index indexhp sarahiset indexhp.unload
unload index indexhs sarahiset indexhs.unload
unload index indexbt sarahiset indexbt.unload
unload index indexrt sarahiset indexrt.unload
help index indexhp sarahiset indexhp.help
help index indexhs sarahiset indexhs.help
help index indexbt sarahiset indexbt.help
help index indexrt sarahiset indexrt.help
quit

TS-4 UIMS TEST SUITE
SCRIPT 2

input.copy.move
sarah

move index indexhp sarahiset indexhp aliset
move index indexhs sarahiset indexhs aliset
move index indexbs sarahiset indexbt aliset
move index indexrt sarahiset indexrt aliset
move index indexhp sarahiset indexhs1 jeniset hash
move index indexhs sarahiset indexbt1 jeniset btree
move index indexhs sarahiset indexhp1 jeniset heap
move index indexhs sarahiset indexbt2 jeniset btree
move index indexbt sarahiset indexhp2 jeniset heap
move index indexbt sarahiset indexhs2 jeniset heap
move index indexhp sarahiset indexhp joiiset
move index indexhs sarahiset indexhs joiiset
move index indexbt sarahiset indexbt joiiset
move index indexrt sarahiset indexrt joiiset
quit
SCRIPT 3

input.retrieve.navigate.return
sarah
passwd
retrieve index indexhpi joiset read_only ihp
list index
pick index ihp
first in index
fetch from index
previous in index
first in index
next in index
fetch from index
last in index
fetch from index
next in index
last in index
previous in index
fetch from index
return index ihp
retrieve index indexhs joiset read_only ihs
pick index ihs
first in index
fetch from index
previous in index
first in index
next in index
fetch from index
last in index
fetch from index
next in index
last in index
previous in index
fetch from index
return index ihs
retrieve index indexht joiset read_only ibt
pick index ibt
first in index
fetch from index
previous in index
first in index
next in index
fetch from index
last in index
fetch from index
next in index
last in index
previous in index
fetch from index
return index ibt
retrieve index indexrt joiset readonly irt
pick index irt
batch search index ../data/rtree.search rtree-id.out rtree-tup.out
Advanced Communications Technology Inc.

return index irt
quit
SCRIPT 4

input boolean navigate
sarah
passwd
retrieve index indexhp joiset read_only ihp
list index
pick index ihp
build boolean attra < "barbara" ibl
pick boolean ibl
first in index
fetch from index
previous in index
first in index
next in index
fetch from index
last in index
fetch from index
next in index
last in index
previous in index
fetch from index
return index ihp
retrieve index indexhs joiset read_only ihs
pick index ihs
pick boolean ibl
first in index
fetch from index
previous in index
first in index
next in index
fetch from index
last in index
fetch from index
next in index
last in index
previous in index
fetch from index
return index ihs
retrieve index indexbt joiset read_only ibt
pick index ibt
pick boolean ibl
first in index
fetch from index
previous in index
first in index
next in index
fetch from index
last in index
fetch from index
next in index
last in index
last in index
previous in index
fetch from index
fetch from index
return index ibt
drop boolean ibl
quit
input modify
sarah
passwd
retrieve index indexhp joiset modify ihp
list index
pick index ihp
last in index
fetch from index
update index attralimos sellis|id|3030
last in index
fetch from index
delete from index
last in index
fetch from index
insert into index attranick roussopoulous|id|9090
last in index
fetch from index
save index ihp
return index ihp
retrieve index indexhs joiset modify ihs
pick index ihs
last in index
fetch from index
update index attralrichard wallace|id|3030
last in index
fetch from index
delete from index
last in index
fetch from index
insert into index attranick roussopoulous|id|9090
last in index
fetch from index
save index ihs
return index ihs
retrieve index indexbt joiset modify ibt
pick index ibt
last in index
fetch from index
update index attratimos sellis|id|3030
last in index
fetch from index
delete from index
last in index
fetch from index
insert into index attranick roussopoulous|id|9090
last in index
fetch from index
save index ibt
return index ibt
retrieve index indexhp joiset read_only ihp
list index
pick index ihp
last in index
fetch from index
update index attrajtimos sellis|id|3030
last in index
fetch from index
delete from index
last in index
fetch from index
insert into index attrajnick roussopoulous|id|9090
last in index
fetch from index
save index ihs
return index ihs
retrieve index indexhs joiset read_only ihs
pick index ihs
last in index
fetch from index
update index attrajtimos sellis|id|3030
last in index
fetch from index
delete from index
last in index
fetch from index
insert into index attrajnick roussopoulous|id|9090
last in index
fetch from index
save index ibt
return index ibt
retrieve index indexibt joiset read_only ibt
pick index ibt
last in index
fetch from index
update index attrajtimos sellis|id|3030
last in index
fetch from index
delete from index
last in index
fetch from index
insert into index attrajnick roussopoulous|id|9090
last in index
fetch from index
save index ibt
return index ibt
quit
SCRIPT 6

input.drop
sarah
passwd

drop index indexhp aliset
drop index indexhs aliset
drop index indexbt aliset
drop index indexhp joiset
drop index indexhs joiset
drop index indexbt joiset
drop index indexhp1 janiset
drop index indexhp2 janiset
drop index indexhs1 janiset
drop index indexhs2 janiset
drop index indexbt1 janiset
drop index indexbt2 janiset
delete indexset sarahiset
delete indexset aliset
delete indexset janiset
delete indexset joiset
quit
TEST 1

Please enter your username: Please enter your password:
Need to validate user and password.

COMMANDS AND THEIR SYNTAX:

create index  <indexname>  <indexset>  <format>  <infile>
drop index   <indexname>  <indexset>
copy index   <from-index>  <from-indexset>  <to-index>  <to-indexset>  [<format>]
move index   <from-index>  <from-indexset>  <to-index>  <to-indexset>
help index   <indexname>  <indexset>
load index   <indexname>  <indexset>  <infile>
unload index <indexname>  <indexset>  <outfile>
insert into index  <attr, value, attr, value, ...>
update index  <attr, value, attr, value, ...>
delete from index
delete rectangle  <id>
first in index
next in index
last in index
previous in index
fetch from index
batch search index  <infile>  <idfile>  [<tuplefile>]
search index  <idfile>  [<tuplefile>]
list index
retrieve index  <indexname>  <indexset>  <mode>  [<tag>]
save index   <tag>
return index  <tag>
pick index   <tag>
buid boolean  <boolean definition>  [<tag>]
list boolean
pick boolean  <tag>
modify boolean <boolean definition>
don boolean  <tag>
build select  <attr, attr, ...>  [<tag>]
list select
pick select   <tag>
modify select  <attr, attr, ...>
drop select   <tag>
create indexset  <indexset>
delete indexset <indexset>

>>> COMMAND EXECUTED: create indexset sarihiset
RETURN CODE: 0

>>> COMMAND EXECUTED: create indexset aliset
RETURN CODE: 0

>>> COMMAND EXECUTED: create indexset jeniset
RETURN CODE: 0

>>> COMMAND EXECUTED: create indexset joiset
RETURN CODE: 0

>>> COMMAND EXECUTED: create index indexhp sarihiset heap ../data/heap.def
RETURN CODE: 0

>>> COMMAND EXECUTED: create index indexhs sarihiset hash ../data/hash.def
RETURN CODE: 0

>>> COMMAND EXECUTED: create index indexbt sarihiset btree ../data/btree.def
RETURN CODE: 0
RETURN CODE: 0
>>> COMMAND EXECUTED: create index indexrt sarahiset rtree ../data/rtree.def
RETURN CODE: 0
>>> COMMAND EXECUTED: load index indexhp sarahiset ../data/sarahiset.data
RETURN CODE: 0
>>> COMMAND EXECUTED: load index indexhs sarahiset ../data/aliset.data
RETURN CODE: 0
>>> COMMAND EXECUTED: load index indexbt sarahiset ../data/jeniset.data
RETURN CODE: 0
>>> COMMAND EXECUTED: load index indexrt sarahiset ../data/rtree.data
RETURN CODE: 0
>>> COMMAND EXECUTED: unload index indexhp sarahiset indexhp.unload
RETURN CODE: 0
>>> COMMAND EXECUTED: unload index indexhs sarahiset indexhs.unload
RETURN CODE: 0
>>> COMMAND EXECUTED: unload index indexbt sarahiset indexbt.unload
RETURN CODE: 0
>>> COMMAND EXECUTED: unload index indexrt sarahiset indexrt.unload
RETURN CODE: 0
>>> COMMAND EXECUTED: help index indexhp sarahiset indexhp.help
RETURN CODE: 0
>>> COMMAND EXECUTED: help index indexhs sarahiset indexhs.help
RETURN CODE: 0
>>> COMMAND EXECUTED: help index indexbt sarahiset indexbt.help
RETURN CODE: 0
>>> COMMAND EXECUTED: help index indexrt sarahiset indexrt.help
RETURN CODE: 0
>>> COMMAND EXECUTED: quit
RETURN CODE: 0
TEST 2

Please enter your username:  Please enter your password:
Need to validate user and password.

COMMANDS AND THEIR SYNTAX:

create index  <indexname> <indexset> <format> <infile>
drop index  <indexname> <indexset>
copy index  <from-index> <from-indexset> <to-index> <to-indexset> [ <format>]move index  <from-index> <from-indexset> <to-index> <to-indexset>
help index  <indexname> <indexset>
load index  <indexname> <indexset> <infile>
unload index  <indexname> <indexset> <outfile>
insert into index  <attr, value, attr, value, ...>
update index  <attr, value, attr, value, ...>
delete from index
delete rectangle  <id>
first in index
next in index
last in index
previous in index
fetch from index
batch search index  <infile> <idfile> [ <tuplefile>]
search index  <idfile> [ <tuplefile>]
list index
retrieve index  <indexname> <indexset> <mode> [ <tag>]
save index  <tag>
return index  <tag>
pick index  <tag>
built boolean  <boolean definition> [ <tag>]
list boolean
pick boolean  <tag>
modify boolean  <boolean definition>
drop boolean  <tag>
built select  <attr, attr, ...> [ <tag>]
list select
pick select  <tag>
modify select  <attr, attr, ...>
drop select  <tag>
create indexset  <indexset>
delete indexset  <indexset>

>>> COMMAND EXECUTED: copy index indexhp sarahiset indexhp aliset
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexhs sarahiset indexhs aliset
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexbt sarahiset indexbt aliset
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexrt sarahiset indexrt aliset
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexhp sarahiset indexhs1 jeniset hash
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexhp sarahiset indexbt1 jeniset btree
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexhs sarahiset indexhpl jeniset heap

TS-15
UIMS TEST SUITE
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexhs sarahiset indexbt2 jeniset btree
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexbt sarahiset indexhp2 jeniset heap
RETURN CODE: 0
>>> COMMAND EXECUTED: copy index indexbt sarahiset indexhs2 jeniset hash
RETURN CODE: 0
>>> COMMAND EXECUTED: move index indexhp sarahiset indexhp joiset
RETURN CODE: 0
>>> COMMAND EXECUTED: move index indexhs sarahiset indexhs joiset
RETURN CODE: 0
>>> COMMAND EXECUTED: move index indexbt sarahiset indexbt joiset
RETURN CODE: 0
>>> COMMAND EXECUTED: move index indexrt sarahiset indexrt joiset
RETURN CODE: 0
>>> COMMAND EXECUTED: quit
RETURN CODE: 0
TEST 3

Please enter your username: Please enter your password:
Need to validate user and password.

COMMANDS AND THEIR SYNTAX:

create index <indexname> <indexset> <format> <infile>
drop index <indexname> <indexset>
copy index <from-index> <from-indexset> <to-index> <to-indexset> [<format>]
move index <from-index> <from-indexset> <to-index> <to-indexset>
help index <indexname> <indexset>
load index <indexname> <indexset> <infile>
unload index <indexname> <indexset> <outfile>
insert into index <attr, value, attr, value, ...>
update index <attr, value, attr, value, ...>
delete from index
delete rectangle <id>
first in index
next in index
last in index
previous in index
fetch from index
batch search index <infile> <idfile> [<tuplefile>]
search index <idfile> [<tuplefile>]
list index
retrieve index <indexname> <indexset> <mode> [<tag>]
save index <tag>
return index <tag>
pick index <tag>
bUILD boolean <boolean definition> [<tag>]
list boolean
pick boolean <tag>
modify boolean <boolean definition>
drop boolean <tag>
bUILD select <attr, attr, ...> [<tag>]
list select
pick select <tag>
modify select <attr, attr, ...>
drop select <tag>
create indexset <indexset>
delete indexset <indexset>

>>> COMMAND EXECUTED: retrieve index indexhp joiset read_only ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: list index

Tag: IHPP Value: JOISET/INDEXHP

RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: aloysius yoon[123
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index

TS-17
UIMS TEST SUITE
RETURN CODE: -2
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: jennifer carle1234
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: barb tower45
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: -2
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: dean perkins34
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexhs joiset read_only ihs
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ihs
RETURN CODE: 0
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: stephen wallace15678
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: -2
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: lillian wallace16789
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: richard wallace12345
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: -2
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: sandra wallace1234
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexbt joiset read_only ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: allen wallace7890
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: -2
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: amy wallace12
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: wally tower56
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: peggy wallace8901
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexrt joiset read_only irt
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index irt
RETURN CODE: 0
>>> COMMAND EXECUTED: batch search index ../data/rtree.search rtree-id.out rtree-tup.out
RETURN CODE: 0
>>> COMMAND EXECUTED: return index irt
RETURN CODE: 0
>>> COMMAND EXECUTED: quit
RETURN CODE: 0
TEST 4

Please enter your username: Please enter your password:
Need to validate user and password.

COMMANDS AND THEIR SYNTAX:

```plaintext
create index <indexname> <indexset> <format> <infile>
drop index <indexname> <indexset>
copy index <from-index> <from-indexset> <to-index> <to-indexset> [<format>]
move index <from-index> <from-indexset> <to-index> <to-indexset>
help index <indexname> <indexset>
load index <indexname> <indexset> <infile>
unload index <indexname> <indexset> <outfile>
insert into index <attr, value, attr, value, ...>
update index <attr, value, attr, value, ...>
delete from index
delete rectangle <id>
first in index
next in index
last in index
previous in index
fetch from index
batch search index <infile> <idfile> [<tuplefile>]
search index <idfile> [<tuplefile>]
list index
retrieve index <indexname> <indexset> <mode> [<tag>]
save index <tag>
return index <tag>
pick index <tag>
built boolean <boolean definition> [<tag>]
list boolean
pick boolean <tag>
modify boolean <boolean definition>
drop boolean <tag>
built select <attr, attr, ...> [<tag>]
list select
pick select <tag>
modify select <attr, attr, ...>
drop select <tag>
create indexset <indexset>
delete indexset <indexset>
```
>>> COMMAND EXECUTED: fetch from index
Tuple: aloysius yoon
RETURN CODE: 0

>>> COMMAND EXECUTED: previous in index
RETURN CODE: -2

>>> COMMAND EXECUTED: first in index
RETURN CODE: 0

>>> COMMAND EXECUTED: next in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: allen wallace
RETURN CODE: 0

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: previous in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: barb tower
RETURN CODE: 0

>>> COMMAND EXECUTED: next in index
RETURN CODE: -2

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: previous in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: amy wallace
RETURN CODE: 0

>>> COMMAND EXECUTED: return index ihp
RETURN CODE: 0

>>> COMMAND EXECUTED: retrieve index indexhs joiset read_only ihp
RETURN CODE: 0

>>> COMMAND EXECUTED: pick index ihp
RETURN CODE: 0

>>> COMMAND EXECUTED: pick boolean ib1
RETURN CODE: 0

>>> COMMAND EXECUTED: first in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: amy wallace
RETURN CODE: 0

>>> COMMAND EXECUTED: previous in index
RETURN CODE: -2

>>> COMMAND EXECUTED: first in index
RETURN CODE: 0

>>> COMMAND EXECUTED: next in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: allen wallace
RETURN CODE: 0

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: allen wallace
RETURN CODE: 0

TS-21  
UIMS TEST SUITE
>>> COMMAND EXECUTED: next in index
RETURN CODE: -2
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: amy wallace12
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexibt joiset read_only ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: pick boolean ibl
RETURN CODE: 0
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: allen wallace7890
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: -2
>>> COMMAND EXECUTED: first in index
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: amy wallace12
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: barb tower45
RETURN CODE: 0
>>> COMMAND EXECUTED: next in index
RETURN CODE: -2
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: previous in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: amy wallace12
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: drop boolean ibl
RETURN CODE: 0
>>> COMMAND EXECUTED: quit
RETURN CODE: 0

TS-22 UIMS TEST SUITE
Please enter your username: Please enter your password:
Need to validate user and password.

**COMMANDS AND THEIR SYNTAX:**

```
create index <indexname> <indexset> <format> <infile>
drop index <indexname> <indexset>
copy index <from-index> <from-indexset> <to-index> <to-indexset> [<<format>>]
move index <from-index> <from-indexset> <to-index> <to-indexset>
help index <indexname> <indexset>
load index <indexname> <indexset> <infile>
unload index <indexname> <indexset> <outfile>
insert into index <attr, value, attr, value, . . .>
update index <attr, value, attr, value, . . .>
delete from index
delete rectangle <id>
first in index
next in index
last in index
previous in index
fetch from index
batch search index <infile> <idfile> [<tuplefile>]
search index <idfile> [<tuplefile>]
list index
retrieve index <indexname> <indexset> <mode> [<tag>]
save index <tag>
return index <tag>
pick index <tag>
built boolean <boolean definition> [<tag>]
list boolean
pick boolean <tag>
modify boolean <boolean definition>
drop boolean <tag>
built select <attr, attr, . . .> [<tag>]
list select
pick select <tag>
modify select <attr, attr, . . .>
drop select <tag>
create indaxset <indexset>
delete indaxset <indexset>

>>> COMMAND EXECUTED: retrieve index indexhp joiset modify ihp
RETURN CODE: 0

>>> COMMAND EXECUTED: list index
Tag: IHP     Value: JOISET/INDEXHP
RETURN CODE: 0

>>> COMMAND EXECUTED: pick index ihp
RETURN CODE: 0

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: barb tower|45
RETURN CODE: 0

>>> COMMAND EXECUTED: update index attra|times sellis|id|3030
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: timos sellis|3030
RETURN CODE: 0
>>> COMMAND EXECUTED: delete from index
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: dean perkins|34
RETURN CODE: 0
>>> COMMAND EXECUTED: insert into index attractnick roussopoulous|id|9090
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: nick roussopoulous|9090
RETURN CODE: 0
>>> COMMAND EXECUTED: save index ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexh8 joiset modify ih8
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ih8
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: richard wallace|2345
RETURN CODE: 0
>>> COMMAND EXECUTED: update index attractrichard wallace|id|3030
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: richard wallace|3030
RETURN CODE: 0
>>> COMMAND EXECUTED: delete from index
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: sandra wallace|1234
RETURN CODE: 0
>>> COMMAND EXECUTED: insert into index attractnick roussopoulous|id|9090
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: sandra wallace|1234

TS-24 UIMS TEST SUITE
RETURN CODE: 0
>>> COMMAND EXECUTED: save index ihb
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ihb
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexibt joiset modify ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: wally tower56
RETURN CODE: 0
>>> COMMAND EXECUTED: update index attral timos sellis|id3030
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: timos sellis|3030
RETURN CODE: 0
>>> COMMAND EXECUTED: delete from index
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: peggy wallace|8901
RETURN CODE: 0
>>> COMMAND EXECUTED: insert into index attral nick roussopoulous|id9090
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: peggy wallace|8901
RETURN CODE: 0
>>> COMMAND EXECUTED: save index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: return index ibt
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexhp joiset read_only ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: list index
Tag: IHP Value: JOISET/INDEXHP
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: nick roussopoulous|9090
RETURN CODE: 0
>>> COMMAND EXECUTED: update index attral timos sellis|id3030
RETURN CODE: -9
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>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: nick roussopoulous|9090
RETURN CODE: 0
>>> COMMAND EXECUTED: delete from index
RETURN CODE: -9
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: nick roussopoulous|9090
RETURN CODE: 0
>>> COMMAND EXECUTED: insert into index attr|nick roussopoulous|id|9090
RETURN CODE: -9
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: nick roussopoulous|9090
RETURN CODE: 0
>>> COMMAND EXECUTED: save index ihp
RETURN CODE: -9
>>> COMMAND EXECUTED: return index ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: retrieve index indexhs joiset read_only ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: pick index ihp
RETURN CODE: 0
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: sandra wallace|1234
RETURN CODE: 0
>>> COMMAND EXECUTED: update index attr|timos sellis|id|3030
RETURN CODE: -9
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: sandra wallace|1234
RETURN CODE: 0
>>> COMMAND EXECUTED: delete from index
RETURN CODE: -9
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: sandra wallace|1234
RETURN CODE: 0
>>> COMMAND EXECUTED: insert into index attr|nick roussopoulous|id|9090
RETURN CODE: -9
>>> COMMAND EXECUTED: last in index
RETURN CODE: 0
>>> COMMAND EXECUTED: fetch from index
Tuple: sandra wallace|1234
RETURN CODE: 0
Advanced Communications Technology Inc.

>>> COMMAND EXECUTED: save index ihs
RETURN CODE: -9

>>> COMMAND EXECUTED: return index ihs
RETURN CODE: 0

>>> COMMAND EXECUTED: retrieve index indexibt joiset read_only ibt
RETURN CODE: 0

>>> COMMAND EXECUTED: pick index ibt
RETURN CODE: 0

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: peggy wallace[8901
RETURN CODE: 0

>>> COMMAND EXECUTED: update index attr|timos sellis|id|3030
RETURN CODE: -9

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: peggy wallace[8901
RETURN CODE: 0

>>> COMMAND EXECUTED: delete from index
RETURN CODE: -9

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: peggy wallace[8901
RETURN CODE: 0

>>> COMMAND EXECUTED: insert into index attr|nick roussopoulous|id|9090
RETURN CODE: -9

>>> COMMAND EXECUTED: last in index
RETURN CODE: 0

>>> COMMAND EXECUTED: fetch from index
Tuple: peggy wallace[8901
RETURN CODE: 0

>>> COMMAND EXECUTED: save index ibt
RETURN CODE: -9

>>> COMMAND EXECUTED: return index ibt
RETURN CODE: 0

>>> COMMAND EXECUTED: quit
RETURN CODE: 0
TEST 6

Please enter your username: Please enter your password:
Need to validate user and password.

COMMANDS AND THEIR SYNTAX:

create index <indexname> <indexset> <format> <infile>
drop index <indexname> <indexset>
copy index <from-index> <from-indexset> <to-index> <to-indexset> [<format>]
move index <from-index> <from-indexset> <to-index> <to-indexset>
help index <indexname> <indexset>
load index <indexname> <indexset> <infile>
unload index <indexname> <indexset> <outfile>
insert into index <attr, value, attr, value, ...>
update index <attr, value, attr, value, ...>
delete from index
delete rectangle <id>
first in index
next in index
last in index
previous in index
fetch from index
batch search index <infile> <idfile> [<tuplefile>]
search index <idfile> [<tuplefile>]
list index
retrieve index <indexname> <indexset> <mode> [<tag>]
save index <tag>
return index <tag>
pick index <tag>
build boolean <boolean definition> [<tag>]
list boolean
pick boolean <tag>
modify boolean <boolean definition>
drop boolean <tag>
build select <attr, attr, ...> [<tag>]
list select
pick select <tag>
modify select <attr, attr, ...>
drop select <tag>
create indexset <indexset>
delete indexset <indexset>

>>> COMMAND EXECUTED: drop index indexhp aliset
RETURN CODE: 0

>>> COMMAND EXECUTED: drop index indexhs aliset
RETURN CODE: 0

>>> COMMAND EXECUTED: drop index indexbt aliset
RETURN CODE: 0

>>> COMMAND EXECUTED: drop index indexhp joiset
RETURN CODE: 0

>>> COMMAND EXECUTED: drop index indexhs joiset
RETURN CODE: 0

>>> COMMAND EXECUTED: drop index indexbt joiset
RETURN CODE: 0

>>> COMMAND EXECUTED: drop index indexhpl jeniset

TS-28          UIMS TEST SUITE
RETURN CODE: 0
>>> COMMAND EXECUTED: drop index indexhp2 jeniset
RETURN CODE: 0
>>> COMMAND EXECUTED: drop index indexhs1 jeniset
RETURN CODE: 0
>>> COMMAND EXECUTED: drop index indexhs2 jeniset
RETURN CODE: 0
>>> COMMAND EXECUTED: drop index indexbt1 jeniset
RETURN CODE: 0
>>> COMMAND EXECUTED: drop index indexbt2 jeniset
RETURN CODE: 0
>>> COMMAND EXECUTED: delete indexset sarahiset
RETURN CODE: 0
>>> COMMAND EXECUTED: delete indexset aliset
RETURN CODE: 0
>>> COMMAND EXECUTED: delete indexset jeniset
RETURN CODE: 0
>>> COMMAND EXECUTED: delete indexset joiset
RETURN CODE: 0
>>> COMMAND EXECUTED: quit
RETURN CODE: 0
**VIEWCACHE: An Incremental Pointer-Based Access Method for Distributed Databases**

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**Abstract:**
The goal of the Universal Index System (UIS), is to provide an easy-to-use and reliable interface to many different kinds of database systems. The impetus for this system was to simplify database index management for users, thus encouraging the use of indexes. As the idea grew into an actual system design, the concept of increasing database performance by facilitating the use of time-saving techniques at the user level became a theme for the project. This Final Report describes the Design, the Implementation of UIS, and its Language Interfaces. It also includes the User's Guide and the Reference Manual.

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