

many more combination classes than were available in the prescribed classification. Does he create the same class of equivalents with respect to a specific inquiry as he would have selected from the prescribed manual classification? The manual classification does provide guidelines on the basis of the past. It reveals the "pattern of knowledge"⁶ to the user. How does the use of a machine system add to and cut across this pattern of knowledge?

There is a great deal of research to be done before these questions can be answered. The making of a mechanized system is only a very small part of much more fundamental studies of classificatory information retrieval systems and their performance in a man-machine environment.

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An Introduction to Deep (Coordinate) Indexes*

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Received February 20, 1963

I. What is an Index?—An index is a guide to the information in a document or in a collection of documents. The word has its origin in Latin and means "to point out, to guide, to direct, to locate." A searcher in need of information consults the index available to him and, through proper use of it, is guided or directed to the source or has the source pointed out to him or located for him. When an collection exists without an index, retrieval of information must be accomplished by searching the documents themselves. Generally the index to the information in a file or in a collection of documents is external to and separate from the file or collection itself. However, the index to the information in a file of documents *can* be incorporated with the information in a number of ways. For example, each document may have entered on its face sheet or cover the index entries for the information it contains, in which case the searcher evaluates each document not by examining the body or text, but rather by examining the index entries. The searcher examines *serially* or *sequentially* the potential sources of information to identify those which are pertinent by the process of comparing description of each with description he is seeking. Separate entry of these index data on cards produces a card catalog, a familiar form of external index or locator device.

There are a number of systems in which either the complete documents themselves or their abstracts have been stored on film or computer tapes. The index entries have been stored with each document to produce a ma-

chine-searchable serial file of the collection. The index has been incorporated with and is integral with the file.

The more familiar relationship of index to file is that exemplified by books, in which the searcher is directed to specific page locations in the text, and by card catalogs, in which the searcher is directed to specific shelf locations for sources. In card catalogs, each card represents a document. Each document in the collection is accessible by a number of cards. Typical catalogs include cards for each author and for the several broad classifications to which a cataloger has decided the document properly belongs. The description on each card usually takes the form of a subject heading, a multiconcept statement of information content.

Other familiar forms of conventional indexes classify documents according to broad subcategories of disciplines, such as chemistry or biology. Each reference included in the index is entered usually under only one subcategory, such as Agricultural Chemistry, Dye Chemistry, or Food Chemistry. The bibliographic data may be presented by themselves or an abstract may be included. Access to information in this type of index is more severely limited than in card catalogs since references or access points are much fewer in number.

The filing schemes maintained by most professional persons for their own collections actually are forms of classification indexes. The file folder labels are index descriptions and indexing for these schemes consists of filing each document in that folder on which the index description is considered most appropriate for content.

II. What is a Coordinate Index?—Unlike indexes based on limited information description such as classification

* Presented before the Division of Chemical Literature, 142nd National Meeting, of the American Chemical Society, Atlantic City, N. J., September 10, 1962.

schemes and subject heading assignment, coordinate indexes provide the potential for much more extensive and detailed description. Since there is no requirement that content identification be made to conform to a rigid classification schedule, information can be identified by many terms each of which represents a unit concept or single idea. Terms to represent both highly specific and broadly generic concepts can be selected. Similarly, it is not necessary to formulate multiconceptual subject headings according to prescribed cataloging rules. In coordinate indexing, the indexer selects from the text of the document as many terms which represent unit concepts as seem justifiable based on relatively objective and quantitative considerations such as frequency of use of the words in the text and their apparent uniqueness. Thus, coordinate indexing frequently is a gross identification, even in some cases based on selection of high-frequency words by computer. In many instances, coordinate indexing unfortunately has been considered as requiring no more than clerical competence with the result that description has been inadequate, incorrect, and wholly inefficient.

Retrieval of information using coordinate indexes is accomplished by locating those documents which were identified at the time of indexing by terms representing concepts on which we now want information. The list of terms by which a document was indexed may be A, B, C, D, and E. This document should be retrieved when we conduct a search for all sources in which B and D have been topics of consideration.

A coordinate index of the conventionally arranged type could consist of a card catalog with one card for each document. These cards might show bibliographic data and the terms by which each document was indexed. A search for sources of information on B and D, in the above example, would require a serial or sequential examination of the entire catalog to find those cards on which both B and D had been entered. However, most coordinate indexes are of the inverted type in which there are no document cards. The system records are term cards, one card for each term by which documents in the collection have been indexed. For retrieving pertinent references for the search we have been discussing, term cards B and D are selected and document numbers on them are compared. Documents listed on both terms B and D are considered sources of information of these concepts in combination. The search is thus selective or parallel and the laborious serial searches of conventional indexes have been eliminated.

Coordinate indexes are sometimes referred to as manipulative, combinatorial, correlative, or associative. Terms are sometimes referred to as aspects, clue words, unit terms, keywords, locators, or descriptors. Regardless of these differences in terminology, the following is an acceptable but very oversimplified statement of the approach: When information is stored, it is described by word symbols representing unit concepts, and when information is retrieved, it is located by appropriately reassociating or recombining the word symbols by which it was described. The several systems of terminology used to explain this one fundamental approach arise from superficial, rather than basic differences among several individual proponents of the approach.

III. What is a Deep Index?—A deep index is a specific type of coordinate index which can be stored either on the conventional arrangement or the inverted arrangement. The word symbols for unit concepts might be referred to by any of the alternatives mentioned. The basic differences between a coordinate index and a deep index are these: For a coordinate index the analysis step is based on a relatively nonintellectual selection of terms, without relating the value of the information in a document to the value of other documents in the collection or to the current and anticipated needs and objectives of the user group. (The seemingly unfavorable comment concerning coordinate indexing is based on what has been the practice, not necessarily on what was intended to be the practice when original ideas on the approach were first presented.) In deep indexing, those who perform the analytical operations on the information are professionally qualified in the disciplines treated in the documents they index. These indexers evaluate the content and intent of the information in each document in reference to other individual documents in the collection and to the over-all coverage of the collection. They relate their evaluation of content and intent to the current and anticipated needs and objective of the organization the system is to serve. They adjust their depth of description, on both the specific and generic levels, not only according to the relative value of the information and to the organizational objectives, but also to the composition of the user group. Adjustment of depth of indexing for composition of the user group must include consideration of both group and individual experience and education as well as consideration of changing assignments.

Deep indexes store descriptive data and manipulate for retrieval in exactly the same manner as coordinate indexes. The input operations for deep indexing are less "word-oriented," and more "value-oriented" and "use-oriented" than for observed coordinate indexing systems. Deep indexing requires the discriminating judgment of professional personnel appropriately qualified for their situation.

IV. Can a Subject Heading Catalog be Converted to a Coordinate Index?—One of the principal objections to subject heading catalogs is that extensive description of information produces a large number of cards for each document and hence two problems—filing the cards and the continuously increasing size of the catalog or index itself. If the input processing of a document produces an average of 20 cards, that number of cards must be filed, and the catalog increases in size at that rate of cards for each new acquisition.

A typical subject heading system is based on the description of information which produces a number of entries such as

"methyl acetate, synthesis of, from methanol and acetic acid, by esterification, using vanadium oxytrichloride as catalyst."

This subject heading is filed in its proper catalog subdivision in alphabetical order and access to the information described is convenient only if a searcher uses the file point "methyl acetate." Access to the information by way of the concepts *synthesis, methanol, acetic acid, esterification, vanadium oxytrichloride*, and

catalysts is possible only if the subject heading is rotated six times so as to bring each principal concept to the filing position. If documents are described by an average of eight subject headings comparable to the one just described and if each contains a total of seven important concepts, then complete rotation would result in 56 catalog cards.

A completely rotated subject heading index of the type described provides much greater access than the traditional type in which each subject heading is filed only once, that is, on an arbitrarily determined "most important" concept. Even with complete rotation, the subject heading index does not provide for generic or class searches.

An inverted coordinate index can be produced directly from a completely rotated subject heading index by creating for each filing point concept a term record, such as a uniterm card, onto which are entered the identifying numbers of all documents represented by the catalog cards on which the concept is the filing point. Thus 100 cards (that is, item records) in the catalog section for "methyl acetate" could be converted to just one term card (that is, one uniterm record) with 100 documents listed on it. In this way, a system is made much more readily searchable. It is in a much more easily and economically reproducible format. This type of conversion of a subject heading index to an inverted coordinate index is being accomplished by Monsanto and others.

While the type of conversion just discussed is desirable to improve availability of the index, retrievability of documents in the collection remains dependent on the quality of the original indexing and on the depth of that indexing. In conversion, by being isolated from others in the subject headings, the concepts lose context and relationship unless a system of links and roles is utilized. There has been created no greater power of generic or class retrieval unless the vocabulary of the resulting coordinate index is refined in an editing operation.

A reproducible coordinate index can become as valuable a tool in the hands of professional workers as their standard reference works, handbooks, and dictionaries. The means of access is brought to them; they need no longer suffer the inconveniences, frustrations, and delays which so universally characterize central catalog systems.

V. Storage Devices for Coordinate Indexes.—Conventionally arranged coordinate indexes are exemplified by systems at Western Reserve University and the United States Navy Bureau of Ships.

In the Western Reserve approach, coded index data are stored on computer tape in a serially ordered arrangement according to document number. The codes for terms are assembled in a rigidly structured relationship dependent on order with respect to one another and on a system of connectives, known as role indicators, which convey elements of syntax. Searches produce source or reference identification numbers to which the searcher must go to obtain the desired information. This is a reference storage and retrieval system; the product of the search is a list of references, not the information itself.

In the Bureau of Ships Rapid Selector, a microrecord of each document is stored on film along with a coded record of the indexing terms for the document. A search requires passing the film of serially ordered documents through a reading head which scans the records of their

index data for those which correspond to the pattern of index data being sought. When stored index terms correspond to those required by the search pattern, the document so identified is printed out directly in full-size hard copy. Thus the product of the search is the information itself. This is truly information storage and retrieval, although the capability for selectively printing out only the desired statements from a larger record is not present. McBee Keysort systems can be used for conventionally arranged coordinate indexes—they may produce only references or they may produce the information directly if an abstract or the source article is typed on or attached to the card. Aperture cards are another form of storage for records of information and in addition they can be used for storage of coordinate index terms in conventional arrangements.

By far, the largest number of inverted coordinate indexes are stored on alphabetically filed uniterm cards. Retrieval is a manual operation in which document numbers on selected term records are visually compared. Optical coincidence cards, such as those of the Peek-a-Boo system of the National Bureau of Standards and the Termatrix system, function in retrieval on the same principle as uniterm card systems but document identification is by visual observation of coincidences of light rather than by visual comparison of document numbers.

Another frequently encountered means of storage for inverted coordinate indexes is punched cards. A deck of cards representing term B is processed through a collator with a deck of cards representing term D. Each individual card represents a document. Identification of a pertinent source document is accomplished whenever a card in term deck B is found to have the same document number as a card in term deck D. Here the manual and visual comparison is mechanized—the cards in serial order in each term deck must be examined by machine to identify accession numbers common to both decks.

The three storage media for inverted indexes discussed so far do not lend themselves conveniently to duplication for inexpensive multiple dissemination. A modified form of uniterm card storage is the dual dictionary coordinate index, originally developed by Dr. Mortimer Taube, in which individual cards in the uniterm index are "shingled" in alphabetical order, photographed, reduced in size, and printed. Two sets of these photographed uniterm decks are mounted side by side to facilitate manual comparison of document numbers—hence the term, dual dictionary. Indexes of this type are those of the Pacific Aeronautical Library and the Index to Chemical Patents, published by Information for Industry, Inc. The dual dictionary coordinate index in a format substantially modified from the two just mentioned is published by the Monsanto Chemical Company and by the Polychemicals Department of duPont. The copy for these latter two dual dictionaries is obtained as print-out of computer-stored coordinate indexes, which also are searchable by computer programs. Comparably stored indexes, searchable by computer but not used to produce dual dictionaries, are used by Douglas Aircraft Company and General Electric Company. Magnetic disks as well as magnetic tapes may be used for storage.

Whether stored for manual or machine search, the inverted coordinate index arrangement is the same. Term

records with document numbers entered thereon are the system units. The products of searches are lists of accession numbers; hence, coordinate indexes function as reference storage and retrieval systems, not, to be exactly correct, as document or information storage and retrieval systems.

Magnetic tapes can be reproduced at the location of the central index for distribution to and processing at local or regional information centers. Search capability by computer at a number of geographically remote locations may be the ultimate solution for extremely large systems such as that of the Armed Services Technical Information Agency.

VI. Summary.—An information system of the type we have described here consists of two parts, the file and the index. The file is organized by arranging the documents in locations relative to each other according to assigned nonsignificant accession numbers. To provide for retrieval of information stored in the documents in the file, there is created a search device known as an index, which serves as a locator system. The locator system generally is external to and separate from the file. It is the device to which the searcher goes to locate information contained in documents in the file. The locator system (the index) is created as the result of indexing. Indexing is the operation performed on information contained in documents before they become a part of the file. Indexing is performed by qualified indexers or analysts to describe or characterize information in unit concept terms which can later be used to locate that information. Terms provided in indexing thus later serve as "locators." This type of system, in which an index made up of terms or locators provides searchers with document accession numbers, addresses, or locations, is truly a *reference retrieval system*. The records of information in the file are referred to as *items* or *documents*. The *locators* in the search device are *terms*, usually of one or two-word length; no more words are used in each locator than necessary to identify the *unit concepts* discussed in the documents. Concepts are the *most concrete or specific units of knowledge* referred to in the information. In the search device, items or documents are identified by accession numbers, item numbers, or document numbers. If search devices are composed of alphabetically arranged records, each one of which is dedicated to a term, then the system is said to have an inverted arrangement; document numbers are entered on term records. Conventional systems traditionally have system units which are item records; on these are entered the terms which have been used to describe the information in the item. Retrieval in *traditional systems* requires *serial search*; a searcher must proceed through the entire file or major subdivisions of it, examining each item record to locate those which are pertinent to his information needs. In inverted concept coordination systems the search is selective or parallel; the searcher selects those terms which describe the information he wants and compares document numbers appearing on those term records. Retrieval is effected by coordinating terms representing concepts, hence the name, coordinate index. Whether or not a coordinate index is a deep index is dependent on the philosophical approach to information analysis and on the professional competence utilized in the indexing operation.

SUGGESTED READINGS

The following titles have been selected especially for those who may be relatively inexperienced in information storage and retrieval and who wish to increase their knowledge of coordinate or deep indexes and indexing. The list has been selected in part from *Information Handling and Scientific Information*, Paul C. Janaske, Editor, published by American Institute of Biological Sciences, Washington, D. C. The reader will find many additional references of value in that annotated bibliography.

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