Developing a Multilingual Index to Access Health-Care Terminologies

by D.C. Walker and Richard F. Walters

Abstract

The language of health care is complex and dynamic. There is a growing need to use computers to contain health-care costs and monitor standards of health care, which in turn requires precise and consistent terminology usage. Traditional terminologies are being challenged and reexamined. Uniformity of health-care terminologies is increasingly required within countries. The Unified Medical Language System (UMLS) in the United States currently seems to be leading the way. [1] There is a need for the world to collaborate in computerized medical research, and share in the use of knowledge-based systems and databases. For this to occur, the terminologies from various countries in various languages will need to be uniform. This article offers a glimpse of a few terminologies used in health care; illustrates custom browsers, which are necessary to comprehend terminologies; suggests an extension of the UMLS approach to the unification of major terminologies used throughout the world; proposes a multilingual index to access terminologies in multiple languages; and mentions the use of input conversion engines, interlingua computer storage, and output generation engines for each language of such an index. The new internationalization extensions passed by the MUMPS Development Committee (MDC) will lift M above other high-level programming languages in the ability to unify health-care terminology across language barriers.

Introduction and Overview of Health-Care Terminologies

Health-care information is one of the most complex domains of human knowledge. Among the more important problems facing the health-informatics community are the subtleties of nomenclature, the ambiguities inherent in classification of diseases, the changing nature of clinical information, the rapid evolution of computing methods, and the partially understood nature of the medical problems requiring solution.

The practice of medicine depends on collecting and recording patient information, history-taking, examination, and investigations; referencing this information to acquired knowledge from training, through experience, or the literature; and finally a decision-making process. At each step, the practitioner deals with concepts that form pictures in the "mind's eye." These concepts are expressed in various ways by different patients, doctors, and laboratories. The practitioner's mind automatically translates the expressions to conjure up the appropriate concepts. Knowledge related to a concept hovers in the mind. Combinations of concepts cause others to appear. Many observations and conclusions are made quite unconsciously.

If any part of the process of the practice of medicine is to be computerized, then a fundamental requirement is that the computer recognize (and perhaps later "understand") the many concepts involved. Recording in a computer the words (in "free text") used by the patient and doctor is of little help to the computer. The computer is able to become little more than a word processor by presenting notes in a legible form.

The computer requires that the words used to express each concept be converted to a standard expression—this could be regarded as the "preferred term." Many similar and related expressions then can be linked to this "preferred term." A unique "number" can be given to each preferred term, which can then be used as a code by the computer (not the practitioner).

Often when recording and thinking about medical things, the practitioner automatically places concepts into appropriate categories or groups: reference to an "antibiotic" includes all antibiotics, whereas "penicillins" draws a picture of a subgroup of antibiotics. Again, this process occurs largely subconsciously. The computer also is required to arrange medical concepts into various groups and orders, according to the circumstances and application. The resulting groups and hierarchies are achieved with ease when "hierarchy numbers" are given to "concepts."

The combination of "preferred term," "related and similar terms," "code number," and "hierarchy numbers" is referred to as a "terminology." Depending on the major use, a terminology may be called a "classification," "thesaurus," "nomenclature," "controlled vocabulary," or simply "a coding system." Included in some systems are definitions and rules for their use.

The "code number" is often used as the "hierarchy number." The resulting single and fixed hierarchy then limits the use of the system. A few systems provide multiple "hierarchy numbers" for a single concept. This enables the concept to be used in several contexts, and is a normal event in medicine.

Terminologies and Browsers

Because of the size and complexity of many medical terminologies, computer presentations are helpful to demonstrate their contents and scope. Such presentations are called "terminology browsers."

Several separate terminologies are used within one country to cope with specific tasks. Many terminologies have evolved in different languages and cultures, each with its particular strength.

The *International Classification of Disease, 9th Revision* (ICD9) is the World Health Organization classification that reports international diseases and morbidity statistics. Its successor, ICD10, is likely to be adopted in the next five to ten years. ICD9 contains about eight thousand concepts.

The *International Classification of Disease, 9th Revision with Clinical Modifications* (ICD9-CM) is used throughout the United States, Canada, parts of Europe, and Australia. [2] It is ICD9 with the addition of some clinical codes to enable the management of hospital funding. Diagnosis-related groupings (DRGs) are a subset of ICD9-CM. ICD9-CM contains some nineteen thousand concepts.

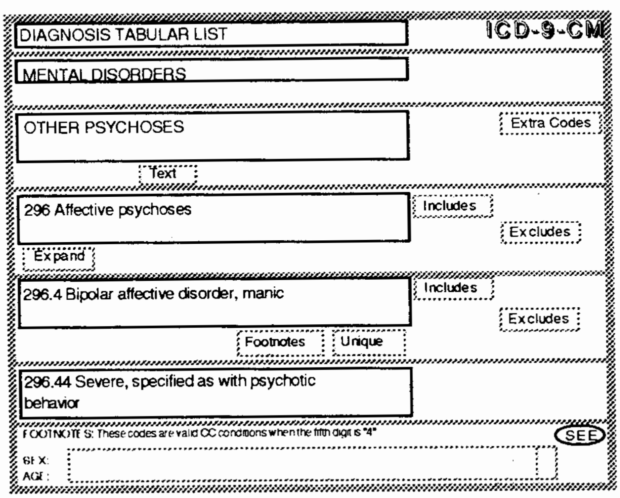

Figure 1. An ICD9-CM browser.

A browser for ICD9-CM is shown in figure 1. [3] Pull-down selectable lists of terms for each level of the hierarchy enable browsing through the concepts. If associated information exists at any level, an appropriate sign appears (e.g., "Exclude"). By clicking the "SEE" button, full details appear in a window. Colored flags indicate the existence of various coding instructions. Age and sex information is also shown.

The *International Classification of Primary Care* is a classification of some eight hundred diagnostic concepts, appropriate for the general practitioner/family physician. [4] It incorporates the 380 concepts of ICHPPC-2-defined (*International Classification of Health Problems in Primary Care, 2nd Revision*), which is "defined" in considerable clinical detail. [5] The first and the seventh components of ICPC are mapped to ICD9, ICD10, and ICHPPC.

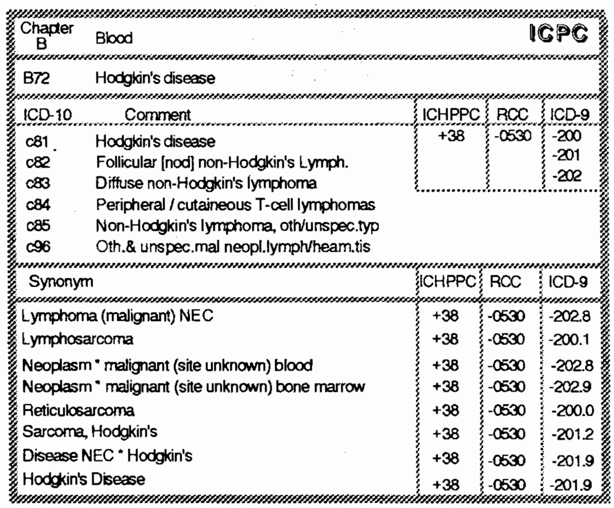

Figure 2. An ICPC browser.

Figure 2 shows a browser for ICPC. [6] Double-clicking on a concept displays a hierarchy for browsing. It then expands to show more detailed information and displays a sublist of terms. The "components" and "chapters" indicate whether the concept is a symptom, investigation, treatment, result, referral, or diagnosis. There is a topographical system list display. The diagnoses are mapped to ICHPPC, RCGP (*Royal College of General Practitioners Classification of Disease*), ICD9 and ICD10. A multilanguage layer has been developed. [7]

Medical Subject Headings, or MeSH, is the controlled vocabulary used for indexing biomedical literature. It is maintained by the National Library of Medicine in the United States. MeSH contains about 15,500 main MeSH concepts and about 50,000 MeSH chemical terms. Several American terminologies are mapped to MeSH through the Unified Medical Language System (UMLS) (see "Unifying Terminology in the United States" below).

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The *Read Clinical Codes*, or RCC, is a nomenclature collection of some two hundred thousand terms used in health care in the United Kingdom. [8] Included are ICD9-CM, OPCS (Classification of Occupations and Coding Index), and BNF (British National Formulary). RCC was designed with computer use in mind. Its main object is to identify similar objects by a short unique code. About 80 percent of general practitioners in the United Kingdom use the Read Codes; hospitals do not, as yet. Several expert groups are expanding the specialist terminology. There are plans to include multiple hierarchies and a topography (anatomy) axis. The New Zealand health department has recently decided to use the Read Codes as a national standard. Australia is examining the Read Codes as an option and possible standard for primary care.

International Classification of Disease, 9th Revision: Chinese Classification of Disease, or ICD9:CCD, is a Chinese approach to disease classification. [9] The ICD9:CCD contains all the ICD9 terms, plus many others, including procedures and traditional Chinese medicine, which are mapped to ICD9. It uses a unique coding system containing topographic and etiologic information, lending itself to SNOMED (*Systematized Nomenclature of Medicine*) mapping. This mapping is currently underway, together with ICD9-CM and ICD10 extensions. There is a published translation into Japanese and English. [10] ICD9:CCD contains about twelve thousand concepts.

In Belgium, there are extensions to the ICD9-CM codes to produce a finer granularity of classification called *Adaption Hospitalière de la Classification Internationale des Maladies et des Opérations* (HCIMO). [11] Alternative descriptions and additional terms have been added, with the aim of producing a useful and detailed clinical terminology. HCIMO could be truncated for hospital management (ICD9-CM) and DRG (Diagnosis Related Grouping) use, and truncated still further for international statistics (ICD9). Versions are available in Dutch, French, and Flemish. An orthopedic subclassification has been developed using an additional topographic axis. This grades the HCIMO terms in order of frequency, and enables access to them via an anatomic structure. Relationships between procedures and diagnoses have been developed to assist coding accuracy. The HCIMO contains about 22,500 concepts.

In Germany the thesaurus of the *Befunddokumentation und Arztbriefschreibung im Krankenhaus*, or BAIK, has evolved to contain more than eighty thousand terms with about twenty-two thousand defined nodes. [12] Several European hospitals use this terminology for clinical medicine. BAIK is mapped to ICD9.

Kaihara, Kiuchi, and Satomura in Japan have compiled a large Japanese-English translation dictionary for health care. This has been partly mapped to ICD9 and SNOMED. (See "Processing Natural Languages at Chiba University Hospital," page 6.)

There are very many terminologies used locally. An example is the Medicare Benefit Schedule (MBS) of the Commonwealth Government of Australia, used to calculate the payment of Australian doctors. [13]

The Explosion in Health-Care Terminology

It is reasonable to construct a classification—for example ICD9 or ICPC—using a single axis. This results in a single list of terms and codes. If increased detail is required, terms must be added, thus increasing the size of the list.

When using a single-axis terminology for coding clinical descriptions, an explosion of terms results from the combination of simpler concepts. For example, a terminology could contain a separate code for every possible fracture of every bone in the body. Thus, the simple (or atomic) concept of "fracture" would be combined with the simple (or atomic) concept of a "bone."

If two axes are used in the above example, two codes would be combined, one from the "fracture" axis and one from the "bone" axis to form a more complex (molecular) concept of a particular fracture. The "fracture" term could be replaced with "infection" or "bruise" or "cancer" and these could be combined with each "bone" to form a large list of concepts. All these could be coded using two axes (two codes) with very little increase in the size of the coding system.

The *Systematized Nomenclature of Medicine* (SNOMED), produced by the College of American Pathologists, employs several axes which may be combined. [14] The axes of SNOMED-3 and the number of contained terms in each are shown in table 1.

Axis	*Terms*
Topography	12,000
Morphology	6,000
Chemicals/Drugs	10,000
Function	10,000
Occupation	2,000
Diagnosis	40,000
Procedure	15,000
Living Organisms	25,000
Physical agents, forces and activities	10,000
Linkage/modifier	4,000

Table 1. The axes of SNOMED-3.

Figure 3 shows a SNOMED-2 browser with several axes (diagnosis, etiology, and topography) combined to code a complex concept. [15] Related information such as synonyms and laboratory modifiers is displayed also. Translations of this nomenclature exist in a number of languages. One author even refers to a "MUMPS" translation. [16]

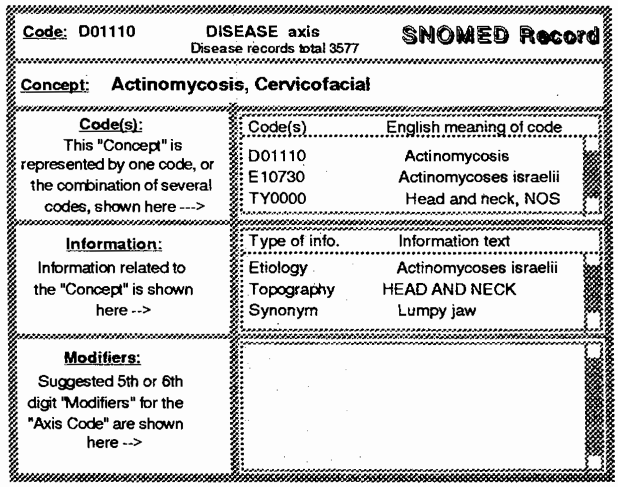

Figure 3. A SNOMED-2 browser.

New Developments

There is increasing interest in coding clinical details because the process of coding offers unique identification and access to various hierarchies and associated information. The computer is thus on the verge of some basic "understanding" of a "coded" concept. Deeper understanding evolves as the coded concept becomes used in databases and knowledge bases. Computer processing of "free text" requires similar computer "understanding."

The GALEN Project of the European Community is an initiative of Advanced Informatics in Medicine (AIM). [17] GALEN stands for "Generalised Architecture for Languages Encyclopaedias and Nomenclatures" in medicine. It is aiming at a formal representation for medical concepts.

The European Standards Working Group 2 (CEN TC251) on Medical Terminology and Coding Systems and its Project Team 3 (PT03) on Models of Semantics are analyzing the problems and needs for the future. CEN PT03 is developing an overall framework to describe medical coding and concept systems to underlie the emerging standards. It is particularly concerned with concept-modeling to describe the contents and structure of coding systems and the division of responsibility between coding systems and the information models using those coding systems.

Experts from several countries recently have formed an "interest group" based in the United States called "Canon." [18] This group is examining the "atomic particles" necessary to form the "complex molecules" used to describe clinical details. They are currently working to great depth in the narrow domain of chest X-ray reports. [19]

SNOMED with its various axes is capable of coding detailed description. In its current form, however, it is possible to combine terms to create "SNOMED nonsense" (e.g., "fractured eyebrow"). It is therefore necessary to develop computer rules so only appropriate terms may be combined. These have been referred to as "conceptual graphs." Plans are underway in the United States to develop "conceptual graphs" for SNOMED-3 axes.

Mapping Terminologies

A major disadvantage of the multiplicity of terminologies is the lack of connections between the concepts in each, so data collected using one terminology cannot be compiled directly by the computer with information compiled from a different terminology. The concepts in one terminology, although present in others, are often not explicitly "linked" or "mapped" one to the other. To link each concept by word-matching is not adequate, as the underlying clinical meaning needs to be determined.

There are, however, some links between concepts in different terminologies. Some are inherently linked if one is a subset or extension of another. Often, if one terminology is an extension of another, mappings can only be usefully constructed in the many-to-one direction. Sometimes there are concepts in one terminology that are not able to be linked to those in another terminology because they are unique to one. Figure 4 shows mappings between concepts in different terminologies.

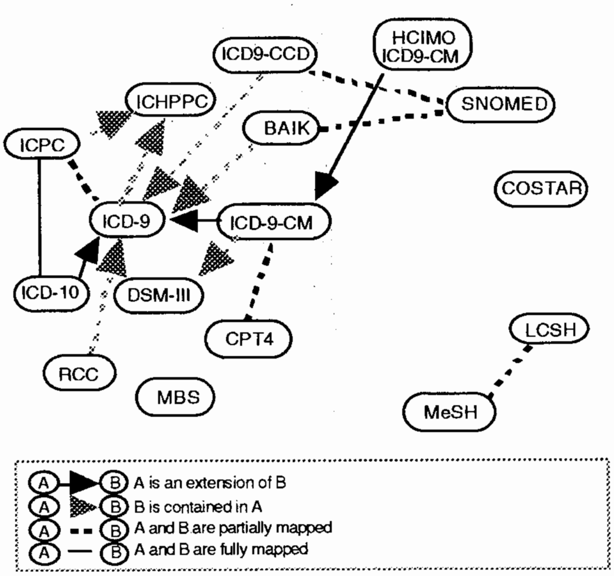

Figure 4. Mappings between terminologies.

Unifying Terminology in the United States

There are several machine-readable biomedical information sources in the USA. They include biomedical literature, clinical records databanks, knowledge-based systems, and directories of people and organizations. Various terminologies are used to create them. A researcher requires a seamless terminology interface to these resources, which is achieved by the Unified Medical Language System (UMLS) sponsored by the National Library of Medicine in Washington, DC. [20] The UMLS has three knowledge sources, all of which are used by system developers: the "Metathesaurus," the "Semantic Network," and the "Information Sources Map." [21,22, 23].

The Metathesaurus (edition 3) is a collection of 130,000 distinct concepts and 243,131 lexically unique terms, contained on 155,254 "cards." [24,25] All these are derived from seventeen sources. They include all terms from MeSH 1992 (Medical Subject Headings), AI/Rheum (National Library of Medicine, Bethesda, Maryland), DSM-IIIR (*Diagnostic and Statistical Manual of Mental Disorders 3rd edition Revised*), and selected terms from ACR (Index for Radiological Diagnosis, including Diagnostic Ultrasound), COSTAR (COmputer STored Ambulatory Record), COSTART (Coding Symbols for Thesaurus of Adverse Reaction Terms), CPT4 1989 (*Current Procedural Terminology, 4th Revision*), CRISP (Crisp Thesaurus, Bethesda, Maryland, National Institutes of Health, Division of Research Grants, Research Documentation Section), DXplain (an online diagnostic decision-support program from Massachusetts General Hospital; see "Translating English into German Using VA File Manager," page 18), ICD9-CM (*International Classification of Disease, 9th Revision with Clinical Modifications*), LCSH (Library of Congress Subject Headings), MeSH 1992 Supplementary Chemicals, NANDA (Classification of Nursing Diagnoses - Carroll-Johnson), NIC (Nursing Interventions Classification - McClosky), SNOMED-2 (*Systematized Nomenclature of Medicine*), and UMDNS (Universal Medical Device Nomenclature System). The terms from these sources have been mapped to MeSH headings, and to each other, as well as to a "semantic network." Several resources in which a term occurs have been identified in the Metathesaurus. There is also a French version of the Metathesaurus. See figure 5.

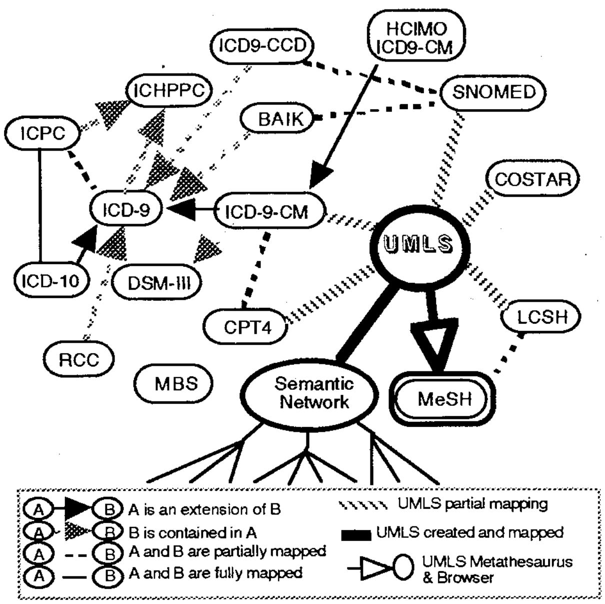

Figure 5. The unifying effect of the Metathesaurus of the UMLS.

The UMLS produces browsers to enable visualization of the Metathesaurus—the "MetaCard Browser" for the Apple Macintosh computer (see figure 6), and the "Coach Metathesaurus Browser" for MS-DOS. [26] Both run directly off a CD-ROM.

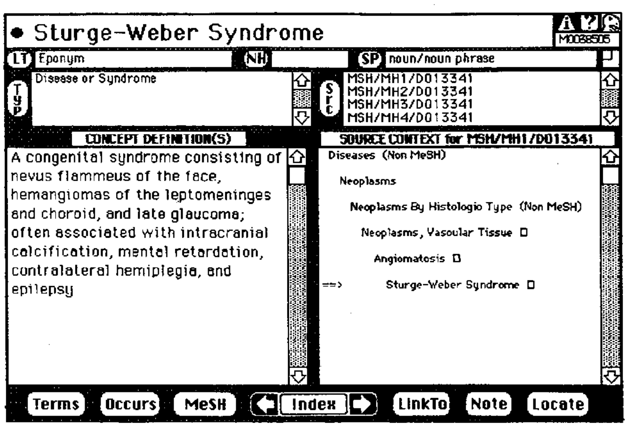

Figure 6. The MetaCard Metathesaurus browser.

The semantic network consists of some 134 "semantic types" with 46 nonhierarchical relations, of which the primary one is the heritable "is a" relationship. [27,28] These and other relationships (e.g., "exhibited by," "carried out by," "forms," or "is an evaluation of," etc.) form a network. The relationships on a semantic network can be as complex and detailed as imaginable. They could include such relationships as "is a symptom of." This would open up the domain of clinical medicine. But the UMLS confines itself to developing better access to biomedical information. The Information Sources Map is composed of a "descriptive" and a "procedural" component. [29] These contain such elements as scope, location, vocabulary, syntax, rules, and access conditions. They enable access to some sixty-six publicly available biomedical information resources in the United States, including: literature (MEDLINE), consultation systems (AI/Rheum, ILIAD, PDQ, QMR), genome project (GenBank, OMIM), patient records (HELP, COSTAR), and chemical databases (CHEMLINE, TOXLINE, Chem Abstracts). The UMLS project is a good example of a cooperative and coordinated effort to achieve a complex and otherwise unobtainable goal, which is at the very heart of health informatics.

Unifying Terminology Internationally

Most health-care problems are worldwide. Diseases know no boundaries. Biomedical research is expensive. The standards of health care are improving and the expectations of patients are increasing. The cost of health-care delivery is an ever-enlarging proportion of national budgets. Information technology is expected to help in the maintenance of high-quality care, in the avoidance of errors and omissions, and in the health-care cost containment. There is a need for the world to collaborate in computerized medical research, and share in the use of knowledge-based systems and databases. For this to occur, the terminologies from various countries in various languages will need to be unified. The methods used by the UMLS may serve as a guide. This system was (and is being) developed as a terminology interface to information resources created using largely unrelated terminologies. A multilingual index that can access the many health-care terminologies used throughout the world would appear to be a requirement. [30] This is illustrated in figure 7.

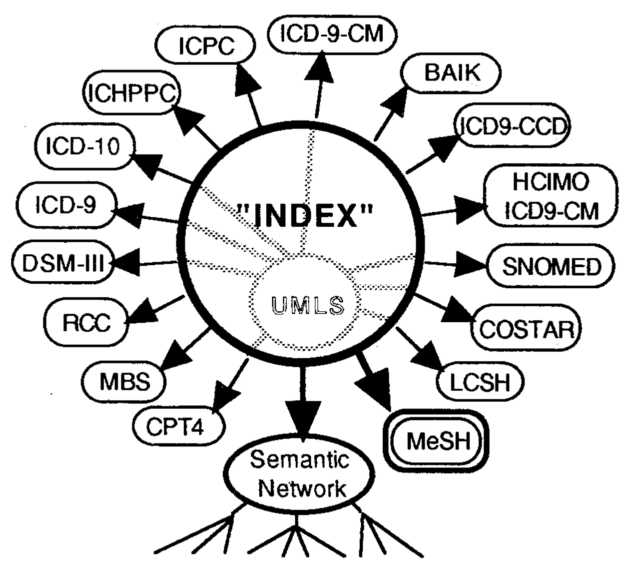

Figure 7. A multilingual index accessing (not mapping) various terminologies.

Considerations for a Multilingual Index

Accessing different terminologies from different languages requires mechanisms for coordinating the individual terminologies and relating these terminologies to the natural languages used in health care. To achieve this the authors currently believe that two "engines" associated with each natural language are required: an "input conversion engine," and an "output generation engine." This approach follows a trend in machine-aided natural language translation.

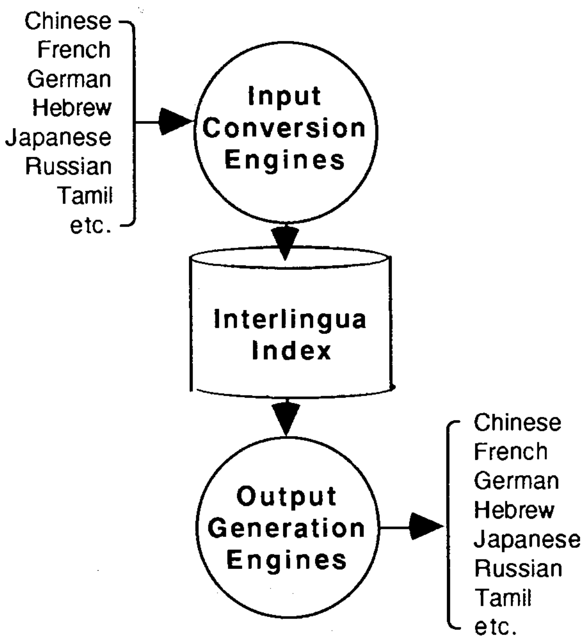

Figure 8. An interlingua index approach to accessing terminologies in multiple languages.

The original input from a given language is converted by its input engine into a language-independent internal representation, or "interlingua" (figure 8). By preserving enough knowledge about the input of a given terminology, but storing it in a language-independent form, the system can (in conjunction with an output engine) generate appropriate natural-language representations in whatever language is targeted for that application.

The techniques for input, actual storage, and output are addressed in companion research which has been described elsewhere. [31]

The Significance of Internationalization Extensions to M

M has been used to support bilingual medical systems for some years. Giere's work with medical records is well known to the M community. [32] Moore et al. have shown that it is possible to use existing forms of M to support bilingual machine translation of texts in a number of languages, including English-German, English-Japanese, and English-Spanish. [33] New extensions, however, offer a number of features that will greatly enhance M's ability to meet the needs of medical researchers using multilingual databases. (These extensions were recently incorporated into the M standard currently being submitted by the MDC for ISO and ANSI approval.) Zhang et al. showed how M could be extended to solve some of the internationalization concerns, but those extensions were nonstandard stopgap measures awaiting MDC's adoption of more formal syntax. [34]

The process described in the previous section can be supported in part with high-level programming languages such as M and C. Several functions, however, are not achievable in any current programming system, including effective processing of mixed-character-set strings and automated collation suitable for a number of natural languages and cultural environments. Although the new extensions to M do not afford all of the functionality desirable for multilingual processing, they will greatly facilitate multilingual information-processing in this and in other domains.

One of the most important extensions to M is that for alternate collation sequences. Structured system variables allow assignment of a specific collation algorithm to a single global variable. Once this algorithm is assigned, all subscripts (keys) in that global will be inserted in the proper location according to that algorithm. Updates to the global will retain the correct collation sequence, making it possible at any time to obtain an "alphabetized list" of the keys in that global.

This feature is essential to efficient processing of the classification schemes described in this article. With the new extensions to M, it will be possible to use the interlingua representation of a concept to cross-reference a given natural-language code equivalent, then create a separate cross-reference for that language alphabetized according to the natural language used. This feature is not available as standard syntax in any other high-level programming language, and it is unlikely that languages such as C will have it available for many years into the future.

The second major multilingual processing element relates to text manipulation in different languages. M extensions permit specification for an active process of a user-selected character set (within the sets available on that system from the vendor). They also permit redefining the pattern match operator to meet the special requirements of different character sets (once again, these features are facilitated by structured system variables that will be standard across different M implementations). With better text manipulation, it will be possible to create two separate windows, each operating with its own character set, in which classifications from different languages can be viewed, compared, and analyzed. These extensions (in addition to standardization) enable a deeper understanding of the texts the user is translating. By immeasurably enhancing expert-system development in the health-care terminology domain, this capacity will augment the power of browsing and other understanding systems proposed in this article.

M's new internationalization will offer other features. But these two examples give a foretaste of M's forthcoming standardized power to generate meaningful clinical research. True, still more features are needed—the MDC recognizes that the new features represent only a start toward full internationalization of M. For instance, override capability (e.g., the ability to use alternate pattern match codes) will be helpful in many multilingual applications. The adage of learning to crawl before one walks, however, makes sense in this environment. We look forward with confidence to the addition of these features to M in the years ahead.

The authors believe that it is both possible and worthwhile to develop a prototype index to access health-care terminologies in multiple languages. The interlingua approach described in this paper is an adaptation of one used in machine-aided translation. [35] New extensions to M recently submitted for ANSI and ISO approval will greatly facilitate programming these concepts. By making ours the only high-level programming language with standard features suitable for multilingual processing, these new extensions place M ahead of other programming languages for years.

This work has been supported in part by Sony Microsystems, Inc., Sun Microsystems, Inc., and the General Electric Corporation. The authors also wish to express their sincere thanks to the many individuals who are collaborating on this project around the world, notably J.J Cimino, P. Dujols, W. Giere, T. Kiuchi, H. Lamberts, E-S. Li, W.G. Moore, Y. Satomura, F.W. Stitt, I. Wakai, and C. Zhang.

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