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On Defining Computer Science Terminology

A general problem with computer science terminology is that some terms are often used for different concepts and that the same concepts are denoted by different terms. To a great extent, this is due to the rapid advances in computer science where new concepts need new names.

We illustrate these issues by means of a special section in the August 1997 *Communications* that focused on the practical application and uses of health care information systems. These articles revealed some confusion with terminology in the area. For example, in one of the articles, a hospital information system is regarded as a particular type of product that only focuses on patient registration, admission, discharge, transfer, and other administrative functions, whereas a clinical information system is regarded as a product that focuses on physicians' use [1]. A personal communication with the author made clear that many hospital information systems contain both administrative and clinical components. However, reading this article, one can get the impression that hospital information systems and clinical information systems are regarded as disjoint systems. It is not so unusual for the term "hospital information system" to be used with this restricted functionality in mind (in particular by the hospital information systems vendors), despite the fact that the more appropriate term, "hospital administration system," was introduced more than 20 years ago [6].

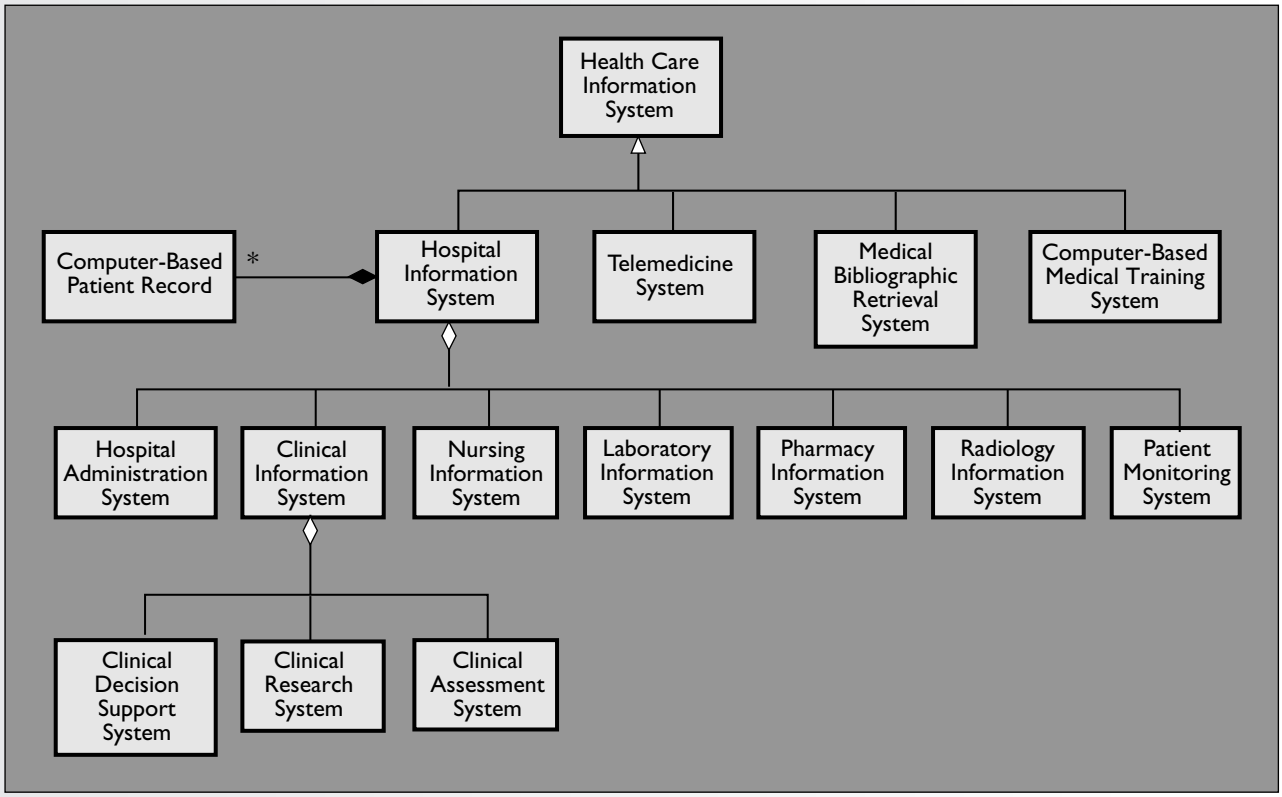
Saying a hospital information system contains a clinical information system is more appropriate; the term "hospital information system" should denote a broader concept of an information system for the hospital as a whole (which usually includes administrative and clinical components). Furthermore, a hospital information system is a kind of health care information system.

Some Problem-Solving Efforts

Collen [3] presents an early classification for a subdomain of computer science, namely medical information systems. This taxonomy distinguishes between a hospital information system and an office information system as being parts of a medical information system, whereby both hospital information systems and office information systems contain an administration system and a clinical information system. This redundancy seems unnecessary and not very intuitive since many functions offered by both contained administration systems are identical.

More than 250 terms were candidates for a European standard that defines a Medical Informatics Vocabulary (MIVoc) [2]. Different than Collen's taxonomy, the terms are organized into a generalization/specialization hierarchy (plus some additional links specified textually within a glossary). However, the final European standard defines and organizes only 59 of these terms into the tree structure, whereby only the 27 leaf nodes are defined in the core list of entries [2]. The remaining candidate terms are listed alphabetically in an appendix without

An Example Taxonomy for Health Care Information Systems



Rectangles are the UML symbols for classes. Inheritance for specialization and generalization is shown in the UML as a solid-line path from the subclass to the superclass, with a hollow triangle at the end of the path where it meets the superclass [4]. Hospital information systems, telemedicine systems, medical bibliographic retrieval systems and computer-based medical training systems are all specializations of health care information systems. We can also say that the term "health care information system" is a generalization of a hospital information system, telemedicine system, medical bibliographic retrieval system and computer-based medical training system (systems that transfer and process information to support health care).

The hollow diamonds in the figure indicate aggregation (part-of relations). A hospital information system is identified as an aggregation of specialized components. These components may be used without being integrated into a hospital information system. The UML also allows specification of composition through filled diamonds, whereby the parts are expected to live and die with the whole [4]. The computer-based patient records are included through composition into a hospital information system because their existence should be tied to the existence of containing systems (this does not exclude a migration or duplication to other systems).

In the UML, multiplicities for associations are specified through numerical ranges at the association links. The default multiplicity is 1. If the multiplicity specification comprises a single asterisk, then it denotes the unlimited non-negative integer range (zero or more). A hospital information system may contain many computer-based patient records.

Vocabulary

A ***computer-based patient record*** is a repository for all patient-related data arising during a patient's hospital stay or outpatient visit; it is an account of all patient encounters with the health care system. Computer-based patient records are not themselves health care information systems, but they are central components of a hospital information system, which is a kind of health care information system.

Additional components of a hospital information system are:

Hospital administration systems focus on patient registration, admission, discharge, transfer, and other administrative functions such as personnel and kitchen management, financing, and so forth.

Clinical information systems support physicians with their medical work. A clinical information system may include the following:

Clinical decision support systems that support physicians with knowledge processing capabilities for making diagnoses, for planning therapies, and so forth.

Clinical research systems that support the management and statistical evaluation of clinical studies.

Clinical assessment systems that support the examination of a presumably well person, for example, in geriatrics.

Nursing information systems support nurses' ability to assist individuals (sick or well) in the performance of those activities contributing to health.

Laboratory information systems support fundamental functions in both data processing and laboratory management.

Pharmacy information systems manage medical information related to drugs and to the use of drugs in patient care.

Radiology information systems support the acquisition and analysis of medical images and the management of radiology information and often include picture archiving and communication systems (PACS) that are able to store huge amounts of data for medical images. (As technical subsystems of radiology information systems, PACS are required to achieve non-functional requirements such as storage capacity and performance; thus, they are not included into our functional classification).

Patient monitoring systems watch for—and warn against—life-threatening events related to a critically ill patient, usually in an intensive-care unit.

Some other types of health care information systems are:

Telemedicine systems that connect geographically dispersed health care facilities via video and telecommunication.

Medical bibliographic retrieval systems that support search and access to medical literature.

Computer-based medical training systems that assist in medical training and education. This training may include virtual reality applications.

being given detailed definitions. In particular, the varieties of information systems classified in the accompanying box are only listed in the appendix of the standard and not classified within the tree structure.

An Object-Oriented Taxonomy for Health Care Information Systems

We propose systematizing the terminology by means of taxonomies and employing an object-oriented modeling notation to specify the taxonomy. As an example, the figure displays a taxonomy for health care information systems that has been modeled using the Unified Modeling Language (UML) notation for class diagrams [4]. The taxonomy provides a coarse classification of the functional requirements on such systems, not a decomposition into technical subsystems. This taxonomy is based on textbooks for medical informatics. The individual elements and the notation in the figure are explained in the figure box.

Logical Components vs. Physical Subsystems

The taxonomy presented corresponds to an assignment of functionality to specific functional components. In a particular setting, one such logical component may be realized through multiple physical systems, or one physical system may realize multiple logical components. The resulting requirements on system integration are not the subject of the taxonomy, which addresses the logical distribution of functionality. However, the dependencies and

required integration would be relevant for the actual implementation of a health care information system. For instance, access to computer-based patient records will be required by the other components of a hospital information system or by a telemedicine system (in our taxonomy, it is not explicit that some components may require access to each other). The overlapping areas of data among the components of a hospital information system are not modeled because this is not relevant for a taxonomy that classifies functionality. Refer to [5] for discussions of some problems and solutions to the integration of heterogeneous subsystems within a hospital environment.

Summary

We have shown how an object-oriented modeling notation can be used to present a taxonomy. The simple classification for medical information systems in [3] uses only aggregation, and the medical informatics vocabulary in [2] primarily uses a generalization/specialization hierarchy to relate terms to each other. The object-oriented modeling notation of the UML allows both generalization/specialization and aggregation/composition to be specified within a taxonomy in a visual way. To some extent, the presented taxonomy reflects our view on the domain, but it is based on previous research and on textbooks for medical informatics. Exemplary, a simple taxonomy for a small domain, namely health care information systems, is presented to illustrate the ideas. An important concern is the visual specification of the relationships among the defined terms.

Our central claims are:

- Systematizing the terminology in computer science by means of taxonomies is useful.
- Employing an object-oriented modeling notation to present the taxonomies is appropriate.

We consider such taxonomies important steps toward overcoming existing confusion with terminology in the area. Often, terminology is a problem for computer science because the development is so fast that people frequently use the same terms for different concepts or different terms for the same concept. A systematic terminology is useful to solve some of the resulting problems. C

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References

1. Anderson, J. Clearing the way for physicians' use of clinical information systems. *Commun. ACM 40*, 8 (Aug. 1997), 83–90.
2. CEN Technical Committee 251. *Medical Informatics—Vocabulary*. Approved European Standard in Healthcare Informatics ENV 12017, CEN Committee of European Normalization, 1995.
3. Collen, M. A brief historical overview of HIS evolution in the U.S.A. In *Hospital Information Systems: Scope—Design—Architecture*. A. Bakker, C.T. Ehlers, J. Bryant, and W. Hammond, Eds. North-Holland (1992), 29–34.
4. Fowler, M., and Scott, K. *UML Distilled: Applying the Standard Object Modeling Language*. Object Technology Series, Addison-Wesley, Reading, Mass., 1997.
5. Hasselbring, W. Federated integration of replicated information within hospitals. *Int. J. Digital Lib. 1*, 3 (Nov. 1997), 192–208.
6. Kennedy, T., and Facey, P. Experience with a mini-computer-based hospital administration system. *Int. J. Man-Machine Stud. 5*, 2 (1973), 237–266.