Representing a Body of Knowledge

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Overview

There are two basic, useful strategies for representing a field's body of knowledge. One enumerates the technologies of the field, the other its principles. They are different interpretations of the same knowledge space. But they lead to different actions.

Representing a Body of Knowledge

A body of knowledge (BOK) is an organized description of the knowledge of a field. Curriculum developers often work with a BOK so that they can be sure that they are covering the essential knowledge of their field. The ACM includes a computing BOK in its Curriculum 2001 recommendation.[1] That BOK is a list of core technologies of the computing field, the ones every computing professional should know. The ACM has been cooperating with the Computing Ontology Project to describe the BOK as a set of topics with links connecting each topic to others closely related.[2]

The ACM BOK and the Ontology are both technology-oriented BOKs. Their main headings are topics such as core technologies, methods, devices, processes, or important concepts.

A principles framework is orthogonal to a technology-oriented framework. The same principle may appear in several technologies, and a particular technology relies on several principles. The set of active principles (those used in at least one technology) evolves much more slowly than the technologies.

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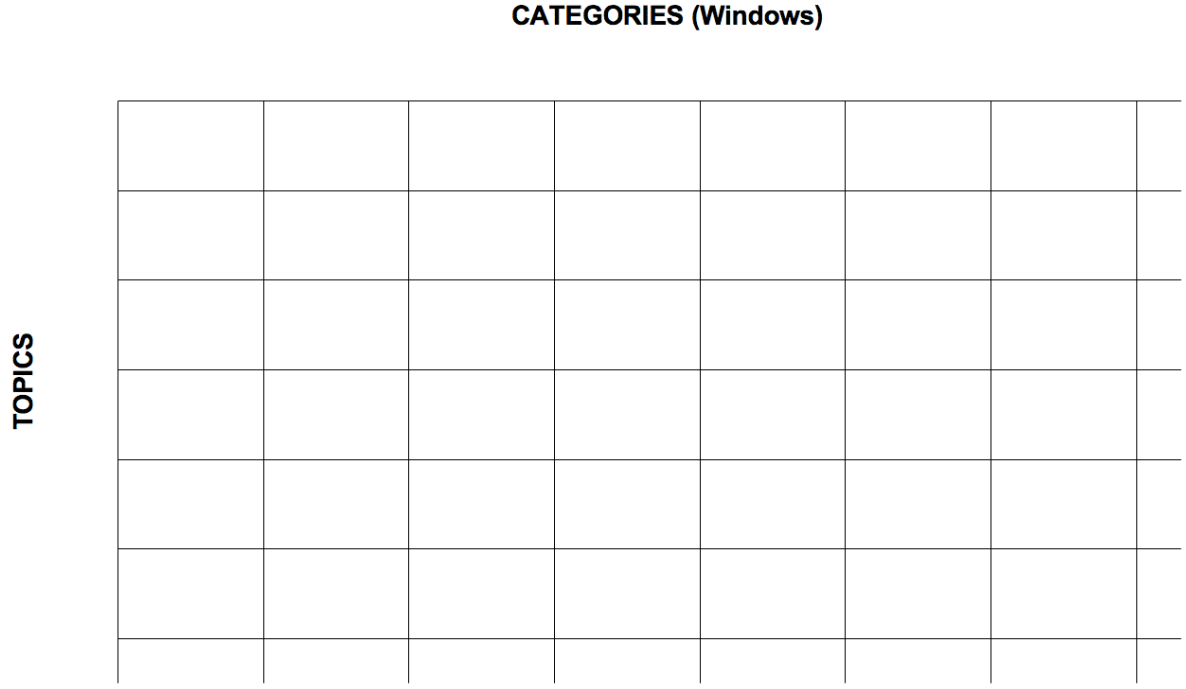
[1] http://www.acm.org/education/curric_vols/cc2001.pdf

[2] Davies, Gordon, Lillian Cassel, and Keikki Topi. Using a computing ontology for educational purposes. *Proc. 11th SIGCSE Conf. on Innovatin and Technology in Computer Science Education* (2006), 334. Download from acm.org/dl with search keywords "computing ontology davies" or use the bookmark: http://doi.acm.org/10.1145/1140124.1140242

While the two styles of framework are different, they are strongly connected. To see the connection, imagine a two-dimension matrix. The rows are the topics from a technology-oriented framework, and the columns are the categories of principles. (We sometimes refer to the categories as windows because each category represents a distinctive way of viewing technologies.) The interior of the matrix is the knowledge space of the field.



Under topics, we can list the technologies from the ACM BOK. Under categories, we can list the seven windows of the GP framework. A box in the matrix can be inscribed with the principles from the category (column) expressed through technology the technology (row). The figure below illustrates a matrix and a few of the many technology names; security technology is showing two principles in the coordination category. (They are key distribution protocols and zero knowledge proofs.)

	computation	communication	coordination	recollection	automation	evaluation	design	
architecture								
Internet								
security			key distr protocol zero knowl proof					
virtual memory								
database								
programming language								

Thus the technology-oriented BOK enumerates the knowledge by rows of the matrix, while the principles-oriented BOK enumerates by columns. The important point is that they see the same knowledge -- from different perspectives and interpretations.

To illustrate this further, imagine someone who wants to enumerate all the principles involved with a technology. The answer is obtained simply by reading the principles from the row of the matrix. Or, if the matrix is not filled in, by analyzing the technology for its principles in each of the seven categories. In the example below, the security topic is showing that it draws principles from all seven of the categories.

	computation	communication	coordination	recollection	automation	evaluation	design	
security	O(.) of encryption functions	secrecy authentication covert channels	key distr protocol zero knowl proof	confinement partitioning for MLS reference monitor	intrusion detection biometric id	protocol perform under various loads	end-to-end layered functions virtual machines	

The GP framework allows new kinds of questions to be explored within the context of the principles. For example, someone can enumerate all the technologies that employ a particular principle, or category of principles, as indicated in the figure below. In this example, we see that the coordination category contributes principles to all the technologies listed.

	computation	communication	coordination	recollection	automation	evaluation	design	
architecture			hardware handshake					
Internet			TCP and IP protocols					
security			key distr protocol zero knowl proof					
virtual memory			page fault interrupt					
database			locking protocol					
programming language			semaphores monitors					

Actions Enabled

Among the many likely users for a GP framework, three groups stand out:

Interested outside observers. These are people in other fields, or newcomers to the computing field, who would like a conceptual roadmap for the science of the field, expressed in the traditional style of science. With a GP framework, they can explore the breadth and scope of the field, learn about the powers and limitations of all computing technologies, and find out how various aspects of computation work.

Technology designers. These are people who are designing or refining technologies, including innovators who seek new technologies. With a GP framework they can

1. see the guiding principles of a technology;
2. see the limitations of a technology (imposed by principles);
3. see ways to simplify and reduce the perceived complexity of a technology; and
4. find connections with other technologies that share the same principles.

Educators. These are people who teach computing and design curricula. With a GP framework they can

1. check the completeness of a BOK;
2. given a topic for a course, determine the principles that must be brought out in the course;
3. given a principle, find examples of technologies that exemplify it;
4. design a course or series of lectures around a principle and the technologies that exploit it; and
5. design a science map of the field.

Summary

A principles-oriented framework is orthogonal to a technology-oriented framework. Each major technology is based on principles from several (usually all!) of the seven categories. Just as each technology manifests multiple principles, each principle is expressed in multiple technologies.

A future task is to completely fill in the matrix for all the technologies listed in the ACM BOK. We expect that this will reveal a small set of frequently occurring base principles. Current examples: (1) Design steps transform representations while preserving information. (2) Names are bound dynamically to the objects they denote.