A SYSTEMS MODEL FOR THE FIELD OF INFORMATICS

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EXTENDED ABSTRACT

This paper proposes a structure for the material that makes up the whole field of informatics, based on the approach that this field has similar scope to the domain of Information Systems Engineering, as this term is used by the British Computer Society (BCS) to define the field for which it has professional responsibility. This professional scope means that in the UK the BCS is responsible for accrediting degree programs in the disciplines that are usually identified internationally as Computer Science, Computer Engineering, Software Engineering, Information Systems, Information Technology and Artificial Intelligence, and that hence comprise the whole field of informatics (or Computing, as it is usually termed in the UK).

Underlying this definition of Information Systems Engineering is the recognition that all of the activities in this field are concerned with different forms of information systems, and the activities that relate to them, so that it is appropriate to apply the concepts of general systems theory to the problem of structuring this field. In the specific context of Software Engineering this has led to the recognition of three main components to the discipline, namely products, processes and people, and the generalization from software systems to the various kinds of information systems and the disciplines that deal with them simply emphasizes the importance of these three components, since the differences between them arise primarily from the different amounts of emphasis that each puts on these three components.

The model that is proposed in this paper treats each of these three components as though it were a separate dimension, so that in principle any given topic can be identified by its position within the resulting three-dimensional space of concepts. In practice, though, some topics (and particularly fundamental theoretical ones) are almost independent of one or even two of the dimensions, and so their position can be identified just in terms of those dimensions on which they do depend (for instance, by dependence on other more basic topics). Also, one consequence of applying general systems theory to these components is that each of these three dimensions has a hierarchical rather than a linear structure, and so the overall structure of the concept space is actually one of three intersecting hierarchies. Within this the structures of the individual levels of the hierarchies may then introduce further sub-dimensions, particularly for different variants of similar concepts.

This approach contrasts with the one that has nearly always been used in creating curriculum models for the individual disciplines, where in each case an appropriate collection of topics from the three components has been flattened into a single hierarchy of knowledge areas and knowledge units. This latter approach obscures the inherent relationships between the three components, which have to be captured instead by cross-referencing between the different knowledge units. Also, the different views that have been taken within the various disciplines for how topics should be organized into groups have then further obscured the relationships between the topics. For this model, though, an important aim is to illustrate these relationships between topics, and this multi-dimensional approach is intended to achieve this, by ensuring that related topics are located close to each other in at least one of the dimensions. This feature is particularly significant where curricula are to be designed for programs that try to link different disciplines, as it means that the coherence of a curriculum will be indicated by the extent to which the topics cluster together in this space of concepts.

Given this underlying philosophy for the proposed model, the core of the paper is concerned with describing the structures of the three dimensions of the model, and illustrating this with examples of where different groups of topics would be placed within this model. For the products dimension, this structure is derived primarily from the relevant concepts of general systems theory as applied to information systems, namely that any information system has a purpose (ie the processing and storage of information), it has a boundary across which inputs and outputs must flow (ie the

communication of information), and it has a structure derived from the way in which sub-systems are assembled to construct it. Thus the primary hierarchical structure is given by the different levels of abstraction that define the kinds of components or sub-systems with which each level is concerned, as these are determined by the forms of processing, storage and communication carried out by the components, and the paradigm used to construct them. The most primitive level of abstraction is therefore concerned with analogue circuits, and on top of this the successive levels correspond to digital circuits, digital components (such as processors and memories), computers, operating system services, fundamental programming constructions, programming abstractions, applications programming interfaces, and complete software systems. The different aspects of the systems at each level of abstraction then provide the secondary structure, so that this sub-dimension identifies the storage concepts used in the systems, the processing concepts used, the paradigm for assembling elements of the systems, the form of internal communication between elements, and the form of external communication with the environment in which the elements exist. At the lower levels of the hierarchy this means that the individual topics then correspond to the varieties of available components, but at the higher levels the relationships with the people dimension mean that these broaden out into the whole variety of application domains for information systems.

For the process dimension, which is concerned with the activities that must be carried out in order to develop any kind of information system, the hierarchical structure of the dimension results from the application of two different concepts. One, which relates to the processing that must be carried out during the development, reflects the need to compose smaller activities into larger ones. The other, which relates to the information about the system that must be manipulated by the different activities, reflects the different layers of abstraction that characterize this knowledge itself. Since the activities involve manipulating all the abstract layers of this information, though, it is not necessary to keep these two structuring concepts separate, and so the model treats them as a single hierarchy, in which the lowest level is provided by notations, and the levels above this correspond to models and resources, activities, processes, and methodologies. Then, within the levels the structure of the higher ones derives primarily from the fact that the components within them are various scales of activities, which therefore have purposes, but also require two kinds of inputs. One kind of input is the information that the activity must process, and the other is the physical resources (ie people plus tools) that are needed to undertake this processing.

For the people dimension, it is common in curriculum models to make a distinction between the two possible roles that people have in connection with information systems, either as users of the products or as participants in the processes, but within this model these simply appear as the relationships between the people dimension and the products or process dimensions respectively. Hence, the hierarchical structure of this dimension simply needs to reflect the typical structure of human organizations, with individuals at the lowest level, small groups or teams at the next level, and complete business units or equivalent organizations at the highest level. Within each of these levels the primary structure then arises from the different purposes that the various systems (ie people or groups of them) may have, since it is these that result in the different application domains within which information systems may be constructed, and which therefore have to be reflected in the higher levels of the products dimension.

The final part of the paper then compares this model with the other main model that has been proposed for the whole field of informatics, namely Denning's "Great Principles" model. His model is also multi-dimensional, with two main dimensions: "principles" and "practice", where the "principles" dimension has two elements. One of these is the "mechanics" element, which corresponds precisely to the general properties of information systems, as these provide the sub-structure for the products dimension, and the other is the "design" element, which similarly corresponds to the desirable properties of the systems (ie products) and the relationships between the components of these systems that give rise to these properties. His "practice" dimension corresponds precisely to the various kinds of activities that form the process dimension in this model, and then within his two-dimensional space he identifies two components: "core technologies" and "applications". The first of these corresponds precisely to the different layers of abstraction in the products dimension of this model, while the "applications" component corresponds to the different domains that result in this model from the sub-structure of the people dimension, and that are reflected in the higher levels of the products dimension.