A DEFINITION OF THE INFORMATION MANAGEMENT DISCIPLINE

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This paper provides a definition of a new discipline: Information Management. Paradigms of this discipline are: theory, architecture and design. A mission is defined as to effectively manage a solution or perception, to the appropriate degree anytime, anywhere in the synchronism of events. The discipline is divided in nine areas as follows: ecology of information, information science, programming languages, computing environment, networking environment, information engineering, application software engineering, information infrastructure engineering, information resource management. A curriculum model for each area is divided into the scope of theory, architecture, and design. A role of programming is provided.

INTRODUCTION

The present approach to a new emerging discipline -- information management (IM) -- is modeled on a definition of computing (formerly known as computer science) provided by a team of leaders from the Association for Computing Machinery (ACM). Computer science has roots in the 1940's and the first computer science department was created in the 1950's at the University of Ohio. Its long time chairman, Peter Denning, was a spiritus movens of a new definition of computer science, which is now just called computing (Denning et al., 1989).

Computer science was always perceived as a formal, mathematical discipline, which cared for precise definitions and solutions. On the other hand, "application computing" in business and institutions was opting for descriptive definitions and has rejected the language of mathematics as a tool of normalization inside its own discipline. Today, information management, having been in practice for more than 30 years, is almost taking over the computer world from the computer science domination, at least from the economic point of view. The task of the new leadership role for IM is enormous, yet this discipline is not yet ready for it. As in the past, today we still will look for the theoretical guidance to "computing."However, we will provide in this modeling a lot of specific solutions for IM. We hope that IM will develop its own awareness very soon, perhaps as soon as this discipline defines itself.

PARADIGMS FOR THE DISCIPLINE

The three major paradigms by which we approach work with mediated information systems, services, and infrastructure provide a context for our definition of a new discipline of information management. The first paradigm, theory, is rooted in philosophy, logic, and mathematics and consists of four steps which create a coherent, valid theory:

(1) define objects of study

(2) hypothesize possible relationships among them (theorem)

(3) determine whether the relationships are true (proof)

(4) interpret results.

An information management researcher expects to iterate these steps when errors or inconsistencies are discovered. The researcher seeks a new rule or law as a part of evolving knowledge.

The second paradigm, architecture (model), is rooted in the experimental scientific method and consists of four stages that are followed in the experimental prototyping of information constructs (systems, services, infrastructure):

(1) form a vision and assumptions

(2) plan a configuration and make a prediction

(3) design a prototype and verify with an user

(4) analyze results.

An information management scientist expects to iterate these steps (e.g.: when an architecture's predicted behavior does not meet assumptions).

The third paradigm design, is rooted in engineering and consists of the following four steps in the development of a system: information, software, infrastructure, management.. Its purpose is to manage a solution and/or perception within the appropriate degree anytime, anywhere in synchronism of events:

(1) define requirements

(2) define specification

(3) develop (design, integrate, and implement) the system

(4) test the system.

A developer expects to iterate these steps (e.g., when tests reveal that the last version of the system does not satisfactorily meet the requirements).

Theory is a foundation of any science which advances on sound logic, and eventually on mathematics. Theory is a conditio sine qua none of rational and humanistic progress in any discipline.

Modeling is a foundation of the social sciences and its derivative -- architecture is a method of modeling hybrid and space-time oriented information management systems, services, or infrastructure. Contrary to computer science modeling, which is based on mathematical algorithms, the information application modeling -- through architectural planning -- is based on graphical and cybernetic methods and tools. These methods and tools look for a solution map and consistency, generic correctness, completeness and feedback. The language of an IM model expression is graphic rather than mathematical.

Design is a foundation of engineering: engineers apply techniques (mainly graphic and computing, but not only) to solve problems or tasks through systematic analysis, design, testing, implementation, improvements, operations, and replacement).

These three processes are so intricately intertwined that it is impossible to say that any one is fundamental. Applications of theory appear at every stage of architectural modeling and design, applications of architectural modeling at every stage of theory and design, and applications of design at every stage of theory and architectural modeling.

Despite their inseparability, the three paradigms are distinct from one another because they represent separate areas of competence. Theory is concerned with the ability to describe and prove relationships among information management components. Architectural modeling is concerned with the ability to use those relationships and components to make operational predictions that can be compared with the world. Design is concerned with the ability to implement specific systems or subsystems of those components and relationships and apply them in practice. Thus information management theorists, information management scientists, and information management specialists do not have interchangeable skills. A theory without practice is dry, and practice without theory is blind.

In information management we tend to study telematic technology aids that support people engaged in information systems, services, and infrastructures. On the design side, for example, integrated enterprise-wide information management systems enable the effective management of organizational processes. On the architectural modeling side, telematic means simulate experiments with information solutions (processes, systems, services, infrastructures) and allow an evaluation of scientific results. On the theory side, computers help prove theorems, check the consistency of specification, check for counter-examples, and demonstrate test cases.

THE ROLE OF PROGRAMMING

Many activities in information management are not programming, some for examples include system analysis, design, implementation, design of database applications, application of Computer Aided Software Engineering (CASE), telematic means configuration planning, information strategy planning, and information resource management. Therefore, the notion that the information management discipline equals programming is misleading. What is the role of programming in the discipline? In the curriculum?

Clearly, programming is a part of the standard practice of the discipline and every information management major should achieve competence in it. This does not mean that the curriculum should be based on programming or that introductory courses should be programming courses. As productivity tools (e.g., CASE) and off shelf software packages are gaining acceptance in practice, programming will be replaced by automation and code assembling. However, there are billions of lines of code implemented and they need programming maintenance, now and in the distant future. Therefore, application programming is required in practice, but not as the essential skill. Furthermore, programming as such is a good general education method to teach information structures and logical thinking. Therefore, programming is recommended as a part of the curriculum.

DESCRIPTION OF INFORMATION MANAGEMENT

The description of information management as a discipline consists of four parts:

(1) Requirements,

(2) Short description,

(3) Division into sub-areas; and

(4) Elaboration of subareas.

A field of application computing and networking is a changing and dynamic field. The intention of this description is to provide a "living definition" that can be revised from time to time to reflect maturity and change in the field. At the moment, however, this description should consolidate specialists' efforts to direct further development into a more coherent discipline of science and practice. Otherwise, this change promoting discipline will implement unreliable and low quality solutions.

Requirements

There are many possible ways to formulate a definition. The following five requirements should shape the definition:

- It should be understandable by people outside the field
- It should be a rallying point for people inside the field
- It should be concrete and specific
- It should elucidate the roots in applications
- It should lead to the recognition of fundamental priciples and rules

In the process of formulating a description, we considered several other previous definitions and concluded that a description meeting these requirements must have several levels of complexity. The other definitions are briefly summarized here.

The roots of information management are in computer science, which was preoccupied with the use of computers as early as in the 1940's. In 1967, Nowell, Perils, and Simon stated that computer science is the study of computers. In 1968 the Association for Computer Machinery proclaimed The ACM Computer Science Curriculum. For a long time computer science was identified as a system programming discipline. In 1989, the ACM leaders redefined computer science as computing, which is broader than computer science (Denning et al.,1989). On the computer applications side, computer science was not accepted as a leading discipline, despite the fact that many applications courses are being taught as computer science classes.

In Europe during the 1960's and 1970's, a term l'informatique was initiated by the French and Poles (informatyka), which is a combination of information + automation. With the exception to medicine (medical informatics) this term has not been accepted in the United States. Instead, a term information technology is applied in applications. This term, today, is too narrow. First, it does not include new emerging communications and broadcasting technologies such as those which handle information. Second, this term puts too much emphasis on technology, while the applications world is predominantly preoccupied with information management. Today, technology is very often treated as a commodity. Other terms such as data processing, Computer Information Systems, or

Management Information Systems do not reflect the discipline's scope. Very often they are used at the community college level just to teach certain types of narrow program writing skills. In the emerging electronic enterprise, school, institution or global village, information technology's question of how to process is associated with the question of what to process?

Short Definition

The discipline of information management is the systematic study and practice of telematic (computers, telecommunications, television) technology applications (systems, services, infrastructure) in organizations and for individuals. The fundamental question underlying all of information management is, "What can be informated (automation with added value)?"

One mission of an information management discipline is to effectively manage a solution and/or perception, to the appropriate degree anytime, anywhere in the synchronism of events. Information management becomes a new organizational (business) function, which optimizes some other functions such as management, marketing, product development, production/service, finance, accounting, legal, interorganizational relations, and international relations.

Division into Areas

To qualify as an area, a segment of the discipline must satisfy four criteria:

- underlying unity of subject matter
- substantial theoretical component
- significant abstraction -- architecture
- important design and implementation issues.

Each area, should be defined in specifics and adapted by research and practitioners communities, and with what is also reflected in its own literature.

The following nine areas that cover the information discipline are selected:

1. Ecology of information
2. Information science
3. Programming languages
4. Computing environment
5. Networking environment
6. Information engineering
7. Application software engineering
8. Information infrastructure engineering
9. Information resource management

To present the content of areas, it useful to think of a 9 x 3 matrix, as shown in Table 1.

TABLE 1

COMPETENCE IN INFORMATION DISCIPLINE

#	Area	Theory	Architecture	Design
1	Ecology of Information			
2	Information Science			
3	Programming Languages			
4	Computing Environment			
5	Networking Environment			
6	Information Engineering			
7	Application Software Engineering			
8	Information Infrastructure Engineering			
9	Information Resource Management			

CURRICULUM MODEL

The goal of education is to develop competence in a discipline. Competence, the capability for effective action is an assessment of individual performance against the standard practice of the discipline. The educational process that leads to competence has five steps:

1. Motivate the discipline

2. Demonstrate what can be accomplished in the domain

3. Expose the distinction of the discipline

4. Ground the discipline evolution in history

5. Practice the distinction (Flores et al.).

In the educational process within the information management discipline the two following broad zones of competence should be sought:

Zone A: Discipline-oriented Thinking: The ability to invent new distinctions in the field, leading to new modes of action and new tools that make those distinctions available for others to use (the creative skills).

Zone B: Tool Use: The ability to use the tools of the field for active action in the information management and other disciplines (the professional skills).

As promoters of computing discipline (previously known as computer science) argue, I agree that discipline-oriented thinking is a primary goal of curriculum for information management majors. However, these majors should be familiar enough with the tools to work effectively with people and organizations in practice and research so they can participate in applications information management. Discipline-oriented thinking must be based on solid foundations of information ecology and science. The standard practices of information management discipline include planning, and development of architectures of systems, services and infrastructures. It also includes; testing prototypes, working in project teams, and administering information resources.

Again, taking a cue from computing, we should emphasize the motivation for lifelong learning. This should replace the teaching of actual skills only by the process of inquiry and orientation in information management literature and history.

This program of information management discipline cannot replace existing practices immediately. It should rather be seen as a plan for gradual reengineerng of the existing eclectic curricula.

A DEFINITION OF INFORMATION MANAGEMENT AREAS

My purpose is to provide a vision of the discipline by showing its main features, ot a detailed map. It is a framework within which a curriculum can be designed. It also is a framework of a permanently evolving discipline.

Ecology of Information (EoI)

This area explains the man/information relationship which replaces the man/material relationship as a central role in the development of human civilization and culture. By EoI we understand the relationship between the development of mankind with reference to information resources, and the consequent civilizational and cultural patterns.

Theory. Major elements of theory of EoI are:

a. Dynamics of information reservoir.

b. The theory of cognition.

c. Laws and rules of information.

d. Information ideology.

e. Information impact on organizations and individuals.

f. The Society and Information.

Architecture. Major elements of architecture in the area of EoI are:

a. Specific information reservoirs models.

b. Applicable measurements of cognition.

c. Information laws and rules in specific solutions.

d. Analysis of actual information ideologies

e. Measurements of information impact in specific domains.

f. Analysis and synthesis of actual societies.

Design. Major elements of design in the area of EoI are as follows:

a. Selection or development of applicable information reservoirs.

b. Application of cognition units in a specific solution.

c. Testing and interpretation of information laws and rules in specific solutions.

d. Testing and interpretation of actual and emerging information ideologies.

e. Testing and interpretation of the information impact in specific solutions.

f. Interpretation of the society's actual performance from the information point of view.

Information Science

This area explains a relationship between the information reservoir and telematic technology. Information science has roots in library science, data structures (computer science), data processing ('Data Division" of COBOL, and files management), information management (databases), and telematic (multi-media). The fundamental question includes: "For given classes of problems/solutions, what are the best information structures and procedures (algorithms)?"

Theory. Major elements of theory in the area of information science are as follows:

a. Relational algebra and relational calculus.

b. Dependency theory.

c. Concurrency theory, especially serializable transactions, deadlocks, and synchronized updates of multiple copies.

d. Statistical inference.

e. Sorting and searching strategies.

f. Performance analysis.

g. As supporting theory: cryptography.

h. Efficiency and effectiveness of information structures.

i. Optimization of information protocols and interfaces.

j. Optimization of information integration and sharing.

k. Optimization of information storing and retrieval.

l. Optimization of information access.

m. Optimization of information flows within the telematic environments.

Architecture. Major elements of architectural modeling in the area of information science are:

a. Modeling of information structures for given classes of problems/solutions,models for representing the logical structure of data and relations among the data elements, including the relational and entity-relationship models.

b. Representation of files for fast retrieval, such as indexes, trees, inversions, and associative stores.

c. Methods for assuring integrity (consistency) of the database under updates, including concurrent updates of multiple copies.

d. Methods for preventing unauthorized disclosure or alteration and for minimizing statistical inferference.

e. Modeling of integration and sharing for given classes of problems/solutions,languages for posing queries over databases of different kinds (e.g.: hypertext, text, spatial, pictures, images, video, rule-sets).

f. Modeling of information storing and retrieval for given classes of problems/solutions, such as hypertext, which allow documents to contain text at multiple levels and to include video, graphics, and voice.

g. Modeling of information access techniques for given classes of problems/solutions, including human-factors and interface issues.

h. Modeling of information flow for a given class of telematic environment.

Design. Major elements of design in the area of information science are as follows:

a. Develop an information structure (data, file, database) for a given problem/solution.

b. Develop a protocol and interface for a given problem/solution.

c. Develop a local solution for the information integration and sharing.

d. Develop a solution for information access.

e. Develop a solution for an information flow in a given technical environment: techniques for mapping large, read-only databases onto optical storage media).

Programming Languages

This area deals with programming languages for applications. The fundamental question includes: "What are the most effective languages for given classes of applications?"

Theory. Major elements of theory in the area of application programming languages are:

a. Formal semantics: methods of defining mathematical models of classes of applications.

b. Definition of programming rules.

c. Formalization of programming routines.

d. Formalization of programming interfaces.

Architecture. Major elements of architectural modeling in the area of programming languages include:

a. Classification of languages according to intended application area: transactions processing, information processing, concept processing, knowledge processing, wisdom processing.

b. Classification of major syntactic and semantic models for application program structures; e.g., procedure hierarchies, functional composition, abstract data types, and communicating parallel processing.

c. Methods for automatic generation of programming components.

Design. Major elements of design and experimentation in the area of application programming languages are the following:

a. Specific languages that bring together an integrated environment. Examples: procedural languages (COBOL, FORTRAN, ALGOL, Pascal, Ada, C), functional (LISP), dataflow (SISAL, VAL), object-oriented (Smalltalk, CLU), logic (Prolog), strings (SNOBOL), and concurrency (CSP, Occam, Concurent Pascal, Modula 2).

b. Specific implementation methods for particular classes of languages: run-time models, static and dynamic execution methods, typing checking, storage and register allocation, compilers, cross compilers, and interpreters, systems for finding parallelism in programs.

c. Programming environments.

d. Programs for syntactic and semantic error checking, profiling, debugging and tracing.

e. Applications of programming-language methods to document-processing functions such as creating tables, graphs, spreadsheets, input and output, and data handling.

Computing Environment

This area deals with hardware and software configuration management. The fundamental question is: "What is the most appropriate configuration of information resources for a given class of applications?"

Theory. Major elements of theory in the area of computing environments are:

a. Reliability of computing environments.

b. Quality of computing environments.

c. Security of computing environments.

d. Efficiency of computing environments.

e. Effectiveness of computing environments.

f. Feasibility of computing environments.

Architecture. Major elements of architectural modeling are as follows:

a. Classification of computing environments.

b. Generic architectures of computing environments.

c. Models of interconnectivity among different environments.

d. Models of interfaces.

e. Automation of computing environments.

f. Manageability of computing environments.

Design. Major elements of design in the area of computing environments are as follows:

a. Requirements of specific computing (hardware-software) environments.

b. Solution for a specific computing environment security.

c. Solution for a specific computing environment automation.

d. Solution for the specific computing environment interfaces.

e. Solution for a specific computing environment management.

f. Cost of designed computing environment.

Networking Environment

This area deals with multi-media networking environment. The fundamental question is: "What is the optimal configuration of telematic networks?"

Theory. Major elements of theory in the area of networking environment are the following:

a. Optimal topologies.

b. Optimal access methods.

c. Optimal conduits' capacities.

d. Optimal routings.

e. Optimal internetworking (protocols and interfaces).

f. Effective networks ("highways and oceans").

Architecture. Major elements of architectural modeling in the area of networking environment are as follows:

a. Classification of networking environments.

b. Classification of internetworking solutions.

c. Modeling of networking standards.

d. Modeling of networking interfaces.

e. Modeling of value added services.

f. Modeling of information highways and oceans.

Design. Major elements of architectural modeling in the area of networking environment are the following:

a. Requirements of the specific network environment.

b. Solution for a specific network environment security.

c. Solution for a specific network environment automation.

d. Solution for the specific network environment interfaces.

e. Solution for a specific network environment management.

f. Cost of designed network environment.

Information Engineering

This area deals with general methods of creating information systems and services. The fundamental question is; "What to process?"

Theory. Major elements of theory in the area of information engineering are the following:

a. Formalization of units of cognition.

b. Generic concepts of information systems.

c. Generic concepts of information services.

d. Generic concepts of communications services.

e. Generic concepts of telecommunications services.

f. Generic concepts of television services.

Architecture. Major elements of architectural modeling in the area of information engineering are as follows:

a. Classification of information systems architectures.

b. Classification of information services architectures.

c. Classification of communications services.

d. Classification of telecommunications services.

e. Classification of television services.

f. Modeling of composite systems and services architectures.

g. Modeling of life-cycle of telematic systems and services.

Design. Major elements of design in the area of networking environment are the following:

a. Requirements of multimedia telematic systems and services.

b. Solutions for specific telematic systems or services.

c. Life-cycle- oriented projects.

d. Cost-benefits analysis.

e. Marketing of telematic systems and services.

f. Delivery of telematic systems and services.

Application Software Engineering

This area deals with the design of programs and large software systems that meet specification and are safe, secure, reliable, and dependable. Fundamental questions include: "What are the principles behind the development of programs and programming systems?" "How does one develop specifications that do not omit important cases and can be analyzed for safety?" "How do software systems evolve through different generations?" "How can software be designed for understandability and modifiability?"

Theory. Major elements of theory in the area of software methodology and tools are:

a. Program verification and proof.

b. Temporal logic.

c. Reliability theory.

d. The supporting areas of predicate calculus, axiomatic semantics, and cognitive psychology.

Architecture. Major elements of architectural modeling in the area of software methodology and tools are:

a. Specification methods, such as predicate transformers, programming calculus, abstract data types, and Floyd-Hoare axiomatic notations.

b. Methodologies such as stepwise refinement, modular design, modules, separate compilation, information hiding, dataflow, and layers of abstraction.

c. Methods for automating program development, e.g., text editors, syntax- directed editors, and screen editors.

d. Methodologies for dependable computing, e.g., fault tolerance, security, reliability, recovery, N-version programming, multiple-way redundancy, and check-pointing.

e. Software tools and programming environment.

f. Matching problem domain through software systems to particular computing environment.

g. Life cycle models of software projects.

Design. Major elements of design and experimentation in the area of software methodology and tools are as follows:

a. Specification languages (e.g., PSL 2, IMA Jo), configuration management systems (e.g.: in Ada APSE), and revision control systems (e.g., RCS, SCCS).

b. Syntax directed editors, line editors, screen editors, and word processing systems.

c. Specific methodologies advocated and used in practice for software development, e.g., HDM and those advocated by Dijkstra, Jackson, Mills, Yourdan, or Targowski.

d. Procedures and practices for testing (e.g., walkthrough, hand simulation, checking of interfaces between modules, program path enumerations for test sets, and event tracing), quality assurance, and project management.

e. Software tools for program development and debugging, profiling, text formatting, and database manipulation.

f. Specification for criteria levels and validation procedures for secure computing systems, e.g., Department of Defense.

g. Methods for designing very large systems that are reliable, fault tolerant, and dependable.

Information Infrastructure Engineering

This area deals with large and small-scale information infrastructure which is composed of such elements as electronic money, electronic knowledge, information systems, telematic services, information utility (computers, telecommunications, television). On the large-scale, information infrastructure is provided for a city, region, nation, and the globe. On the small-scale, information infrastructure is provided for a school, company, governmental unit, and the citizen. The fundamental questions are these; "What is the scope of the information infrastructure?" "How should a user organization or individual adapt to this infrastructure?"

Theory. Major elements of theory in the area of information infrastructure are as follows:

a. Understanding of the infrastructure evolution.

b. Understanding of the social change.

c. Normative projection of the expected future solutions.

d. Analysis of infrastructure impact on individuals and organizations.

e. Provision of a theoretical foundation for rational applications of infrastructure.

f. Development of integrational theory of information infrastructure.

g. Rules of applying certain classes of infrastructure.

Architecture. Major elements of architectural modeling in the area of information infrastructure are as follows:

a. Methods of infrastructure definition.

b. Generic models of infrastructure for individuals.

c. Generic models of infrastructure for organizations.

d. Generic models of infrastructure for a city.

e. Generic models of infrastructure for a region.

f. Generic models of infrastructure for a nation.

g. Generic models of infrastructure for the globe.

h. Life-cycles of infrastructures.

i. Methods of designing infrastructures (for reliability, quality, throughput, easy to use).

j. Methods of maintaining infrastructures.

Design. Major elements of design in the area of information infrastructure are as follows:

a. Specific solutions of infrastructures.

b. Specific solutions for inter-structures.

c. Specific rules for applying infrastructures.

d. Reliability and quality of specific infrastructure.

e. Manageability of specific infrastructure.

f. Effectiveness of specific infrastructure

Information Resource Management (IRM)

This area deals with the organization and management of information resources in organizations. It is a new emerging organizational (business) function which requires professional management. The fundamental questions are these: "What is a content of information resources?" "What are the aims (mission, goal, strategy) of IRM?" "What are the processes of information resources management?"

Theory. Major elements of theory in the area of IRM are as follows:

a. Formalization of information resources (quantity and value).

b. Formalization of IRM phases of development.

c. Formalization of integration of business (institutional) strategy with information strategy.

d. Formalization of information strategic planning and control.

e. Formalization of information tactical planning and control.

f. Formalization of operational planning and control.

g. Formalization of information economics.

Architecture. Major elements of architectural modeling in the area of IRM are as follows:

a. Modeling of IRM function for given classes of organizations.

b. Modeling of information strategies for given classes of situations.

c. Development of systems architectures driven by information strategy.

d. Development of methods for information economics.

e. Development of strategy for the supportive culture.

f. Development of techniques for systems operational management.

Design. Major elements of design in the area of IRM are as follows:

a. Techniques for managing the information resources.

b. Techniques for planning information strategies.

c. Techniques for designing strategy-driven systems architectures.

d. Techniques for applying information economics.

e. Techniques for developing an information strategy for the supportive culture.

f. Techniques for applying systems operational management.

CONCLUSION

This concept of a new information management discipline does not contain such areas as artificial intelligence, since this area is heavily covered in computing. A domain of application expert systems is covered in information engineering, among other information systems.

It is not the author's intention to provide a detailed map of information management. This is a very dynamic discipline which consumes about 11 percent of the U.S. Gross National Product. This discipline is undergoing constant change if not an actual paradigm change. However, the information management discipline should begin a process of consolidation; otherwise, it will produce unreliable and ineffective systems, services, and infrastructure.

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