THE ENTERPRISE ENGINEERING DISCIPLINE

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ABSTRACT

Enterprise Engineering is defined as that body of knowledge, principles, and practices having to do with the analysis, design, implementation and operation of an enterprise. In a continually changing and unpredictable competitive environment, the Enterprise Engineer addresses a fundamental question: "how to design and improve all elements associated with the total enterprise through the use of engineering and analysis methods and tools to more effectively achieve its goals and objectives". Industrial Engineering provides an analytical approach to the design, improvement, and installation of integrated systems of people, material, information, equipment and energy. It thereby provides the holistic view of the enterprise necessary for successful implementation of Enterprise Engineering. This paper discusses the emerging discipline of Enterprise Engineering.

KEYWORDS

enterprise engineering, discipline components

WHAT IS A DISCIPLINE?

A discipline has six basic characteristics: (1) a focus of study, (2) a world view or paradigm, (3) a set of reference disciplines used to establish the discipline, (4) principles and practices associated with the discipline, (5) an active research or theory development agenda, and (6) the deployment of education and promotion of professionalism (Liles et al., 1995).

Figure 1. Components of discipline

A FOCUS OF STUDY

The needs of a changing society may be expressed as a unique fundamental question or focus of study. A discipline emerges to help answer the question through its goals and objectives (Denning, 1989; Doheny, 1987; Snodgrass, 1987). For a discipline to be established, the fundamental question must possess enough substance to evolve into a classical field of study. The discipline must offer something that remains meaningful as technology changes (Keen, 1980).

Enterprise Engineering has a well defined and unique focus of study defined by the Society for Enterprise Engineering's (SEE) fundamental question "how to design and improve all elements associated with the total enterprise through the use of engineering and analysis methods and tools to more effectively achieve its goals and objectives" (SEE, 1995). Knowledge Based Systems, Inc. uses the term Enterprise Engineering to "refer to the use of scientific methods and tools to analyze and design enterprises". (Benjamin et al., 1995) This definition of Enterprise Engineering is expanded by SEE to "a body of knowledge, principles, and practices having to do with the analysis, design, implementation, and operation of the enterprise" (SEE, 1995).

A WORLD VIEW

Establishing a world view is essential to a discipline; it defines the unique way in which it views the world. This world view or paradigm guides the development of the discipline through practice and research (Doheny, 1987). The viewpoint of a discipline needs to be complex and substantial enough to be divided into subdisciplines or subareas (Keen, 1980). For example, the industrial engineering discipline may be divided into subdisciplines such as ergonomics, plant layout, and engineering economy. Each subdiscipline is concerned and specialized primarily with a particular type of product, process, or industry (Smith, 1983).

Three world view assumptions reflect the depth of Enterprise Engineering:

1) the enterprise can be viewed as a complex system.

2) the enterprise is to be viewed as a system of processes that can be engineered both individually and holistically.

3) the use of engineering rigor in transforming the enterprise.

In the Enterprise Engineering paradigm, the enterprise is viewed as a complex system of processes that can be engineered to accomplish specific organizational objectives. Enterprise Engineering recognizes the ever-changing organic nature of the enterprise, and therefore has a valid world view or paradigm (Liles et al., 1995).

REFERENCE DISCIPLINES

Reference disciplines are existing bodies of knowledge that help establish the new discipline, that are a foundation of support for future work, and that are logical linkages to previous works. Throughout history, new disciplines have emerged from the need to solve new problems that are not fully addressed by existing disciplines. Emerging disciplines build upon the knowledge, subject matter, methods, tools, and theories of existing reference disciplines. At the same time, distinction from other disciplines is imperative to recognition. For a discipline to be unique, its traditional activities do not conform closely to those of any other discipline. To develop a recognized discipline, the contributions of supporting disciplines must be discovered and assessed, not merely adopted. Formally referencing disciplines recognizes the contributions of existing knowledge and provides a logical link to the new discipline. Other researchers can follow these links and develop a measure of acceptance and recognition for the new discipline. Without this linkage, researchers in existing disciplines may question the grounding theories of a new discipline and dismiss its importance (Liles et al., 1995).

Industrial Engineering
Systems Engineering/Systems Theory
Information Systems
Information Technology
Business Process Reengineering
Organizational Design/Human Systems

Figure 2. Enterprise Engineering Reference Disciplines

The discipline of Enterprise Engineering uniquely builds upon several reference disciplines in science, engineering, and humanities, shown in Figure 2. Industrial Engineering is an excellent reference discipline for Enterprise Engineering as it promotes a holistic approach to design, development, and implementation of integrated systems of people, machines, and materials (Badiru and Baxi, 1994). Davenport and Short (1990) linked Industrial Engineering to Business Process Redesign and Information Technology.

Enterprise Engineering has a history of referencing base disciplines to develop or enhance new tools, methods and theories. However, the scope of disciplines referenced has been limited. Currently, Enterprise Engineering has used engineering disciplines such as industrial engineering and systems engineering, but has mostly neglected rich fields of study in the humanities and in the sciences. Other reference disciplines need further investigation to determine their contributions to Enterprise Engineering. Lantzy and Moir (1992) show how Business Process Reengineering can be enhanced by drawing from engineering, management, and philosophy to develop new ideas in the same way as the English language incorporates words from other languages to express new ideas.

Research is vital to the growth and development of Enterprise Engineering as a discipline. Through the interest of research organizations and the support of sponsors, these reference disciplines may be investigated to determine the contributions applicable to Enterprise Engineering.

PRINCIPLES AND PRACTICES

Principles incorporate the world view and define the philosophical approach to solving problems. Practices are the methodologies, models, procedures, and theories used to apply the discipline's knowledge base. Together, principles and practices form the foundation of a discipline and promote further ordered study. In an engineering discipline, the body of abstract knowledge is developed by logical analysis and scientific research. The principles and practices of engineering are embodied in systems of theory, abstraction, design, and implementation. It is the activities which occur inside these systems that differentiates the many engineering disciplines (Liles et al., 1995).

Principles and practices must be arranged logically to facilitate decision-making, critical thinking and problem solving. The main elements of engineering practice are described below:

- *Theory* - Theory is important because it contributes a foundation of sound principles from which to advance the discipline. Theory sets the stage and gives focus to the development of principles and practices.

- *Abstraction* - Abstraction, or modeling, provides a way for engineers to represent the focus of study in a way that can be tested.

- *Design* - Design, or synthesis, is not merely selecting from alternatives, but is an iterative generation and evaluation of alternatives that meet identified needs.

- *Implementation* - Implementation is an integral part of the engineering process. The process of implementation must be designed just as carefully as the system to be implemented. During implementation, both the user and the designer can better analyze the design for improvements. Poor implementation is the cause of failure for many good designs.

Principles and practices incorporate the discipline's world view as well as the methodologies, models, and procedures necessary to advance the discipline. The identification of principles and practices needs to proceed if Enterprise Engineering is to become a recognized discipline.

AN ACTIVE RESEARCH AGENDA

An active research agenda implies that hypotheses are being generated which address the fundamental question of the discipline. The agenda stands the test of time, with many researchers and practitioners in the discipline continually expanding the research that builds upon itself. The research agenda is complex and substantial enough to be divided into subareas. Multiple subquestions are formulated to guide the research necessary to contribute to the body of knowledge which addresses the fundamental question asked by the discipline (Liles et al., 1995).

The development of an active research agenda is essential to establishing the concepts unique to Enterprise Engineering. The development of this agenda provides a mechanism to ground new theory and procedures to conduct Enterprise Engineering field studies. Enterprise Engineering needs to be in concert with practice, as both theory and practice enhance each other. Research agendas form a vital network between practitioners and researchers. Practitioners uncover new problems and communicate those problems to researchers. Researchers develop solutions through existing research agendas or through new veins of research, and communicate those solutions to practitioners. Practitioners and researchers working together form an iterative cycle that facilitates the enhancement of both theory and practice.

Enterprise Engineering has the beginnings of an active research agenda in both academia and industry. At ARRI, the authors and other researchers are investigating Enterprise Engineering models and methodologies. For example, a metric development methodology (Adams et al, 1995), a strategic justification methodology (Sarkis et al, 1995), enterprise transformation methodologies (Johnson et al, 1995; Underdown et al, 1995), and a virtual enterprise architecture (Barnett et al, 1994) are among recent publications. In addition to the research underway at ARRI, another example from academia is the University of Toronto where Enterprise Engineering research is being conducted to develop a virtual enterprise model (Gruninger and Fox, 1995). One example from industry is AT&T's Enterprise Design and Development Group that has constructed a commercial "comprehensive enterprise modeling system" (AT&T, 1995).

Effort is required to build a cumulative tradition. The current topics being addressed can be seen as possible lines of research for Enterprise Engineering, including: managing change, supporting technologies, methods, tools, and environments unique to the enterprise. Because the enterprise is a system of cultural, process, and technology components, all of these areas need to be researched to help answer the fundamental question.

EDUCATION AND PROFESSIONALISM

Education and professionalism are essential to the widespread recognition and deployment of a discipline. A discipline should be identifiable with a research community that sustains its own literature. The written record of knowledge and thought progression is valuable for future researchers and practitioners to reference when developing new theories and methodologies. Conferences and journals provide a forum for researchers and practitioners to exchange ideas, develop new knowledge and identify future lines of research. Separate curricula, professional societies, and journals advance professionalism and are necessary for a separate discipline (Maynard, 1971).

Whether Enterprise Engineering becomes a separate discipline or an extension of Industrial Engineering remains to be seen. At the present time, Industrial Engineering curricula need to encompass a more holistic view of the enterprise. This can be accomplished by advocating an interdisciplinary curriculum which links separate, but related subjects, to provide students with comprehensive skills (Badiru and Baxi, 1994).

Many conferences and journals regularly accept presentations and publications on Enterprise Engineering topics. Two conferences devoted entirely to Enterprise Engineering are held each year. However, to continue the development of Enterprise Engineering as a discipline, a refereed journal, university programs, and local interest groups need to be established.

CONCLUSION

The emerging discipline of Enterprise Engineering has been discussed in terms of six basic characteristics. Enterprise Engineering has a focus of study, a world view, several reference disciplines, sound principles and practices, an emerging research agenda, and an active professional society to promote education. See Figure 3. Although these characteristics of a discipline have been partially fulfilled, opportunities for the further development of this discipline are substantial. There is much more work needed in the further definition of a research agenda and in deploying education and promoting professionalism.

The Enterprise Engineer addresses a fundamental question: "how to design and improve all elements associated with the total enterprise through the use of engineering and analysis methods and tools to more effectively achieve its goals and objectives". Industrial Engineering provides an analytical approach to the design, improvement, and installation of integrated systems of people, material, information, equipment and energy. Industrial Engineering is an excellent reference discipline because it provides a holistic view of the

enterprise which is necessary for successful implementation of Enterprise Engineering. Because many of the skills required of Enterprise Engineers are those already possessed by many Industrial Engineers, IEs are well-positioned to take the lead role in developing this emerging discipline.

Enterprise Engineering Discipline	
Focus of Study	A well defined and unique focus of study is established.
World View	A world view or paradigm is firmly established.
Reference Disciplines	A solid, but narrow set of reference disciplines has been identified.
Principles & Practices	A set of principles and practices is emerging.
Active Research Agenda	A cumulative research tradition must be established.
Education & Professionalism	Specific journals, university programs and local chapters are needed.

Figure 3. Enterprise Engineering as a Discipline

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REFERENCES

Adams, S., J. Sarkis, and D. Liles, "The Development of Strategic Performance Metrics", *Engineering Management Journal*, Vol. 7, No. 1, pp. 24-32, 1995.

AT&T Enterprise Design and Development Group, *AT&T Enterprise Modeling Webpage*, http://www.edd.co.uk/em/print.html, Version 1.1, August, 1995.

Badiru, Adedeji B. and Herschel J. Baxi, "Industrial Engineering Education for the 21st Century", *Industrial Engineering*, Vol. 26, No. 7, pp. 66-68, July 1994.

Barnett, W., A. Presley, M. Johnson, and D. Liles, "An Architecture for the Virtual Enterprise", *Proceedings of the 1994 International Conference on Systems, Man, and Cybernetics*, San Antonio, pp. 506-511, October 1994.

Benjamin, Perakath C., Richard Mayer, Thomas Blinn, Charles Marshall, and Rich Tye, "Toward an Environment for Collaborative Enterprise Engineering", Presentation at the Society for Enterprise Engineering Conference, Orlando, 1995; Knowledge Based Systems, Inc., College Station, TX, 1995.

Davenport, Thomas H. and James E. Short, "The New Industrial Engineering: Information Technology and Business Process Redesign", *Sloan Management Review*, Summer 1990, pp. 11-27.

Denning, Peter J. et al., "Computing as a Discipline", *Communications of the ACM*, January 1989, Volume 32, No. 1. pp. 9-23.

Doheny, Margaret O., Christina Cook, and Mary Stopper, *The Discipline of Nursing: an introduction*, 2nd edition, Appleton & Lange, Norwalk, Connecticut, 1987.

Gruninger, M. and Mark Fox, "The Logic of Enterprise Modelling", Fourth IERC Proceedings, 1995, pp. 747-758.

Johnson, M., L. Meade, and J. Rogers, "Assessing the Impact of Enterprise Engineering", *Proceedings of the Society for Enterprise Engineering*, Orlando, June 1995.

Keen, Peter G. W., "MIS Research: "Reference Disciplines and Cumulative Tradition", *Proceedings of the First International Conference on Information Systems*, Philadelphia, Pennsylvania, December 1980, pp. 9-18.

Lantzy, Mark, and Bob Moir, "Business Process Re-engineering: Successfully Managing the Results", *IDEF Users Group Conference Proceedings*, October, 1992

Liles, D. H., Mary E. Johnson, Laura M. Meade, and D. Ryan Underdown, "Enterprise Engineering: A Discipline?", *Society for Enterprise Engineering Conference Proceedings*, June, 1995.

Maynard, H. B., *Industrial Engineering Handbook*, 3rd edition, McGraw Hill Book Co., New York, 1971.

Sarkis, J., A. Presley, and D. Liles, "Management of Technology within an Enterprise Engineering Framework", *Computers and Industrial Engineering special issue on Computer Integrated Manufacturing*, Vol. 28, No. 3, pp. 497-511, June 1995.

Society For Enterprise Engineering Conference Announcement, 1995

Smith, Butler, and Lebold, *Engineering as a Career* (4th ed.), McGraw-Hill Book Company, 1983.

Snodgrass, Anthony, *An Archaeology of Greece: the present state and future scope of a discipline*, University of California Press, Berkeley, CA, 1987.

Underdown, R., R. Wallace, J. Weddle, and J. Sarkis, "Grasping the Agile Opportunity: A Small Manufacturer's Perspective", *Proceedings of the Agile Manufacturing Enterprise Forum*, Atlanta, pp. 464-476, March 1995.

BIOGRAPHICAL SKETCHES

DONALD H. LILES - Dr. Liles is Professor of Industrial and Manufacturing Systems Engineering at The University of Texas at Arlington, and Associate Director of the Automation & Robotics Research Institute. His primary research interest is in the emerging discipline of Enterprise Engineering. He is principal investigator on numerous research projects including the "Agile Enterprise Templates" project funded by the State of Texas and the "Agile Aerospace Manufacturing Research Center" (Co-PI) funded by NSF. He is responsible for the development of ARRI's small enterprise program which has had significant impact in the local manufacturing community. Dr. Liles has supervised eleven Ph.D. students and has four more in progress. He and his students have authored numerous technical papers in manufacturing and related areas. Dr. Liles has a long history of working directly with industry on both industry and government funded projects. These projects have ranged from shop floor implementation of SPC to the development of a strategic justification methodology for investments in enterprise technology. Dr. Liles holds a B.S., M.S., and Ph.D. in Industrial Engineering from The University of Texas at Arlington. Dr. Liles is active in numerous technical and professional organizations. He is regional vice-president of Alpha Pi Mu, the National Industrial Engineering honor society. He has also served on the Steering Committee of the Society for Enterprise Engineering for six years, first as an industry observer and later as corporate support chair. He is currently Nominating Chair.

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