The MIS Research Program at the University of Arizona

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During the past fifteen years the University of Arizona has fostered an environment of strong research programs and has emphasized programs in the physical sciences. Signals from the administration have been very clear—build a strong research program and stress doctoral education. Within this research environment, the department of management information systems has followed the research model found in Schools of Science and Engineering.

The Management Information Systems Department

The Department of Management Information Systems (MIS) was founded in 1974 as an adjunct to the Department of Accounting; it became a separate department in 1976. The long-range strategy was to develop three major areas, which embrace much of the MIS field: information systems (IS), decision support and policy. Initial departmental strengths were in the IS area which had a technical and design orientation. A dominant theme in the department is that design is the key to MIS and the emphasis is on rigorous technical IS design and application.

The MIS Department consists of 21 faculty members, twelve professional staff and 90 graduate assistants. The number of research positions is a function of the amount of grant support. The MIS Department has 625 undergraduate majors, 125 master’s candidates in MIS, 40 M.B.A. students with majors in MIS, and 42 Ph.D. students. Research support in the department has exceeded $2 million per year since 1984.

The MIS Department research program has thrived as a result of support from the university, college and external sources. The MIS Research Group, through external research grants and support from the university, provides access to research facilities, liaison with students from throughout the university, contacts with funding sources, and clerical support. What makes this work is 45 exceptional doctoral students.

Continued internal support from university administrators depended on development of a strategy to establish the credibility of MIS. The faculty pursued grants for technically oriented projects from the National Science Foundation, Army Information Systems Command, Office of Naval Research, Electrical Power Research Institute, Digital Equipment Corporation, IBM, NCR and AT&T. The department has received six National Science Foundation grants since 1976.

A turning point in terms of research productivity and faculty and graduate student recruiting was the acquisition of dedicated computer systems for the MIS Department in 1980. Since 1980 the department has received over $10,000,000 in equipment support to build 11 laboratories and 2 decision rooms.

Structure of the Ph.D. Program in Management Information Systems

The Ph.D. program is the key to the research thrust of the department. The genesis of ideas at the university level consistently has provided the raw material for commercially viable information technologies. The Arizona doctoral program in Management Informations Systems (MIS) prepares students to perform the pioneering analysis and design that will shape future generations of information systems.

The MIS doctoral program emphasizes the analysis, design and development of information systems, ranging from artificial intelligence-based expert systems to the latest in collaborative group support systems, as well as the organizational and behavioral aspects of information systems impacts, management and planning. While the major encourages the integration of information systems and decision sciences in coursework and research, other areas of minor study can also be profitably combined with the MIS major. Doctoral study is determined by an area of specialization selected by the student.

MIS focuses on systems analysis and design methodologies, decision support systems for individuals and for groups, expert systems, database management, data communications networks, office automation systems, and information system impacts.

The first courses students take at Arizona are devoted to research topics and issues in MIS. MIS 611A is a research readings course and MIS 797 is a continuing research seminar. In their second semester, doctoral students begin a three course
sequence of research design courses. The first, MIS 611B, is a
general overview of the research methodologies most common
in MIS research. The other
two courses may be selected from
a list of methodology courses offered across the University.

Most MIS doctoral students are expected to have some back-
ground in MIS, so it is not anticipated that a student will have
to take all seven of the basic core courses. These courses cover
basic areas of MIS, including analysis and design, database, ex-
pert systems, and computer architecture. Students are directed
to take as many of these courses as the Department believes
they need.

In addition to the core courses discussed above, students are
required to take four courses in the MIS specialty area of their
choice, and in a minor area of study. The specialty courses
may be satisfied by an MIS 699 with the student’s major
professor, or any other 500 or 600 level courses approved by
the Department. The minor courses must be jointly agreed upon
by the Department and the student’s minor committee.

Research Activities

Research activities in the MIS Department emphasize formal-
izing the processes of defining analyzing, designing, building,
and operating (using) management information systems. Other
research concerns are the improvement of MIS operations and
Management of Information by increased application of quan-
titative techniques, expert systems and support systems of var-
ious types.

Research in the department integrates a variety of topics in
related fields: (1) Electronic Meeting Systems. Development
and operation of facilities for group problem solving. Exper-
imentation and field site work; (2) an IS focus on systems
analysis and design methodology, data base management, data
communications networks, decision support systems, and of-
vice automation; (3) decision sciences, particularly large-scale
optimization problems, scheduling, and simulation; (4) man-
agement policy in IS, including issues of centralization versus
decentralization, cost allocation and pricing, and management
of computing facilities; and (5) Technology transfer, tracking
soviet and eastern bloc countries computer technology.

A key strategy has been to employ multiple reference disci-
plines in undertaking research projects. This is accomplished
by building intellectual and organizational bridges to other disci-
nines in the university. Recent dissertations in MIS have
been based in management science, organizational behavior,
computer engineering, artificial intelligence and other related
areas.

The MIS program at Arizona was founded essentially as a pro-
gram built upon the Engineering School model of research.
This tradition has had a strong influence in shaping the char-
acter of the MIS research program. The research program has
stressed problem solving, technical skills and underlying root
disciplines of computer science, economics, management sci-
ence and organizational behavior.

The research methodology in this area is thus heavily oriented
toward the engineering paradigm of “build it, test it experimen-
tally, test it in the field, and report the results.” Much of early
work in the department was performed on the effectiveness of
software systems for requirements definition and analysis and
automation of the systems building process. However, it is
clear that at Arizona we do not use only one research method.
Rather, we use the “appropriate methodology” for a particular
research project to support the systems building emphasis. The
approach taken depends on the research problem and the indi-
vidual researcher. An entirely new research topic starts with
the researcher’s “concept.” Initial field tests are used to vali-
date the model’s appropriateness and validate the researcher’s
understanding of the problem. The result of the field testing is a
richer, improved model ready for testing through structured ob-
servation, laboratory experiments and field experiments. There
is a emphasis to use a balanced portfolio of research meth-
ods in the department. This change in emphasis has occurred
gradually over the past 10 years.

Most of our research on the engineering approach employs
laboratory-based building and testing of systems. Most of the
work starts with a rough model and continues through the devel-
ment of improved models, which are usually further refined
by field studies, field experiments, or laboratory experiments.

The Arizona faculty provides considerable guidance in the se-
lection of a topic for doctoral students. We discourage top-
ics for which there is inadequate faculty support. The faculty
does permit systems development projects, mathematical and
simulation models, experiments, case studies, field studies and
comparative case studies.

The department fosters a team approach to research. Senior
faculty provide direction for projects. Each project then has
an associate project director to provide support. The project
teams are composed of senior doctoral students along with first
and second year doctoral students. Thus a team is structured
such that senior faculty provide mentoring to both faculty and
doctoral student on the project.

The following projects are currently active in the department.

- PLEXSYS
  - Systems Development
  - Electronic Meeting Systems
  - Planning Systems
- Studies of Soviet Technology
- Office of Future
- Information Center
  - Expert Systems
  - Consultation, Help, Distribution
Two key projects are described as representative of work in the department.

The History and Foundation of PLEXSYS Information Systems Development

Research at University of Arizona

The systems building process has been and continues to be the foundation of the research effort. Recently we started extensive efforts with respect to laboratory and field experiments. PLEXSYS is an umbrella concept that encompasses much of the software development in the department. The underlying concept for PLEXSYS had its beginning in 1965 with the development of Problem Statement Language/Problem Statement Analyzer (PSL/PSA) as part of the ISDOS (Information System Design and Optimization System) project at Case Institute of Technology [25, 26, 24]. Nunamaker was involved in the project that led to PSL/PSA from its inception. The PSL/PSA process started with the assumption that the requirements were known, or the individual or group responsible for the systems building project was capable of stating the requirements. There was no emphasis on developing an organizational consensus on the "correct" set of requirements, because at the time, it was assumed that the systems analyst was in charge and would be able to satisfactorily define the systems requirements. The emphasis on involving the user in requirements analysis was not to develop for another ten years. The collective wisdom of the ISDOS project at that time decided that it was more important to develop methods to reduce the time to build a system, starting with "the assumption of correct requirements" as a given. The rationale was that the "correct requirements" are not constant; they change with changes in the organization. The users themselves change with respect to what they think they need to do their job. The basic objective was to reduce the time from the initial statement of requirements until the target system was operational. Automation or computer support was envisioned for each task in the systems life cycle.

From this conceptual framework, developed by five doctoral students under the direction of Professor Daniel Teichroew at Case Institute of Technology, evolved a number of software tools for automating the systems building process. This approach utilizing computer support for the systems building process resulted in PSL/PSA in 1965 and later in PLEXSYS [16].

In 1975–1968, three activities shaped the development of PSL/PSA and eventually the development of PLEXSYS: (1) The first version of the problem statement language and problem statement analyzer was developed by Nunamaker [18] as input to a computer aided systems analysis and design software package called SODA (Systems Optimization and Design Algorithm); (2) the prototype for the problem statement language was developed by John Paul Tremblay; (3) the prototype for the problem statement analyzer was developed by Paul Stephan. These three developments lead to the PSL/PSA version which was used by well over 100 organizations for documenting and analyzing the set of requirements for an information system.

PSL/PSA is a tool for describing requirements of a system, recording the descriptions in machine processable form, and storing them in data base. With the PSL/PSA approach, data is expressed in a formal language called PSL. As PSL statements are entered into the data base, PSA analyzes the statements for correctness, completeness and consistency with data and information already present in the data base. PSA then would produce a set of reports that represented the combined views of the many analysts or problem definers working on the requirements. These reports described the inputs, outputs and system flow along with system structure, data structure, data derivation, size, volume and systems dynamics.

Next, Pat Blosser [3] and Benn Konynski [15], doctoral students at Purdue University in the early 70's, added procedural definitions to PSL to facilitate automatic code generation from PSL/PSA. This served to facilitate code generation.

Nunamaker and Konynski moved on to Arizona in 1974. During the process of using SODA/PSL, SODA/PSA and ADS/PSA (Accurately Defined Systems) (early prototypes of PSL/PSA) on a large project for the U.S. Navy, a change took place in their thinking [24]. There were problems in depending on end users to utilize a formal language for requirements specifications. The end users at the Navy would not write their specifications in a PSL/PSA like system, so an accounting firm was hired to sit with the end users and write the specifications in the language. Insights gained from the deficiencies in this solution led to the development of the PLEXSYS concept. The idea was to develop a phase that came before the use of PSL/PSA, i.e., develop software to assist the users with the determination of requirements [16]. This phase would help developers determine what was needed in addition to the software in order to develop systems that would be used by the end users of the information system.

In many of the organizations, Nunamaker and Konynski worked with, the user group was represented by a steering committee or task force consisting of 10–20 people. It became clear in 1979 that what was needed was a special meeting room for the task force to use, or a place for the user group to meet to address the information requirements of an organization. The function of the room would be to display the system flows, data structures and information requirements on a large screen projection system and permit each user seated at a Workstation to interact with the set of requirements and the proposed design of the system. The PLEXSYS–84 system, which was an extension of the PSL/PSA/ISDOS project, was a workbench/workstation environment for the system development team. A collection of integrated tools, procedures, transformations and models were available to the systems developer to analyze and design systems. It was expected that PLEXSYS would shorten the life of system development.

1PLEXSYS is derived from the word "plexus," which is defined by Webster's as "an interwoven combination of parts or elements in a structure or system." The "sys" in PLEXSYS is short for system.
cycle of development by facilitating a fast implementation of a prototype system. It was recognized that the design process could not be completely automated and that PLEXSYS would be a computer aided support system with database, knowledge bases, model management and inquiry facilities.

History of Arizona's Electronic Meeting Facilities

1st Facility – PlexCenter

Construction of the first computer assisted group meeting facility at the University of Arizona began in 1984. The facility, which opened in March 1985, was conceived as a meeting room for end users, systems analysts, systems designers and project leaders to review and analyze system specifications and designs. As usage of the system progressed over the first 18 months of operation we found that the software was valuable in planning efforts of all types not just information systems planning. In fact the usage of the room shifted from requirements and design review to initial discussion of issues and problems. The participants in each session became the group responsible for decision making regarding the organization's goals and objectives relative to the task. The system was built for one particular audience but was found to be useful in a broader context.

The first facility, called the PlexCenter, houses a large U-shaped conference table with 16 computer workstations. Each workstation is recessed for line-of-sight considerations and to facilitate interaction among the participants when appropriate. A BARCO large screen (10 ft.) projection system can display screens of individual PCs. In addition, a video switcher facilitates the movement of screen images from PC to PC or downloads the public screen (facilitator's) display to each workstation. The facility includes four breakout rooms, also equipped with PCs, for small group discussion. PLEXSYS software consists of a large number of tools, including tools for brainstorming, issue analysis, voting, stakeholder identification, assumption surfacing, and recording what happened during a meeting. The facilitator's station provides access to and control over the group support tools. The facilitator helps the group get the most out of the GDSS process by both guiding the meeting and running the software. The interfaces have been set up so that the user can understand the screens that appear even if they have not seen a particular screen previously.

2nd Facility – CMI

The second Arizona facility designed to support group work with information technology was opened in November, 1987. The room was designed to accommodate 24 workstations with space for two persons per workstation. In addition, gallery seating for 18 observers was included in the back of the room. The room has a distinct legislative feel to it but it also facilitates talk across the room, if appropriate. The 24 workstations house IBM PS/2 model 50's with high resolution color monitors. The room is equipped with 38 audio pick up microphones and six video cameras with stereo audio capability. In addition to the two large screen displays, a high resolution video projector with a remote control unit displays computer (analog and TTL) and NTSC video signals. This system permits display of laser disc, transparencies, videotapes, 33mm slides and Videoshow 160, a computer graphics presentation system with special effects.

A separate control room was built to house TV monitors, audio mixers and video editing equipment for monitoring and processing session recordings. The capability exists to capture the computer inputs from all participants as well as audio and video recording of a session. Years later, one could reproduce a replay of a key corporate discussion or decision. This capability would provide tremendous insight for changes to corporate strategy, planning, etc., in the future.

Future Plans – PLEXSYS Facilities

The result of our experiences has led us to consider the next phase in the development of information technology to support meetings, which is to distribute some of the functions of the collaborative meeting room to a participant's office. It is necessary to bring everyone together in the electronic meeting room for each task. We are also planning to support groups distributed around the country and the world.

In the near future, we will integrate PLEXSYS software tools with a videoconferencing system in order to test the concept of distributed meeting room facilities. The first step is to connect our two GDSS facilities with electronic and video links.
We envision a facility in which the scenarios are the same as found in our first and second rooms, but participants are located thousands of miles away. Imagine a facility in which your group is sitting in the center of a circular room. The walls of the room are covered with screens of the participants from around the world. Each local group would find themselves in the center of all participants.

**Study of Computer Technology in Soviet Bloc Countries**

The MOSAIC Group of the Management Information Systems Department at the University of Arizona was formed by Professor S.E. Goodman in 1981 to study computer-related technologies of the Soviet Union and other socialist countries. The group can be divided into two major categories: analysis of these computing technologies and development of the means to support this analysis. The bulk of funding for projects in support of both aspects of MOSAIC'S research comes from Los Alamos National Laboratories, the National Council for Soviet and Eastern European Research and the National Science Foundation.

Current major analysis projects include research into software development in the CMEA countries, evaluation of the state of high-speed computing in the Soviet Union (Peter Wolcott, Ph.D. student), analysis of policy trends in high technology within Eastern Europe (A. Tom Jarmoszko, Ph.D. student, and Gary Geipel, MS student), and development of an overall picture of the state of computing in the People’s Republic of China (Ethel Masland, MS student).

A focal point of the MOSAIC Group’s work and the main support mechanism for its foreign technology assessment is the Arizona Analyst Information System (AAIS). A major project for the future will be the redevelopment of this system to take full advantage of state-of-the-art research techniques (CARAT).

**AAIS**

The AAIS was developed to support the diverse tasks of analysts and researchers working with large volumes of “messy” textual data. Over the last six years approximately 100 analysts have used the system, including many advanced users at the Ph.D. research level. The AAIS has helped to produce a steady stream of analytic work including dissertations at all degree levels, academic papers, and custom reports of all sizes for a number of U.S. Government organizations. We are arguably one of the most productive (qualitatively and quantitatively) groups studying international technological developments, and the AAIS has been critically important in achieving that status.

The AAIS supports three principal activities: (1) the input of information into the system, (2) the output of the indexed information in various formats; and (3) extensive intra-group communications. The AAIS is not just a text search system, but a system that supports the entire life-cycle of research and analysis—from “raw” data to complete reports.

The AAIS is a general system for the automation of research and may simultaneously support any number of different databases. At this time, the largest of three databases that use the AAIS is the original MOSAIC database on Soviet and East European computing and related information. It currently consists of over 30,000 “text atoms” (each the size of a paragraph or two of text) derived from over 12,000 sources. In addition to text, information concerning some 7,000 organizations and 15,000 persons is contained in the MOSAIC database, which is growing at a rate of roughly 150 text atoms per week.

While the database is freely searchable on persons, organizations, keywords and bibliographic information, “analysis files” are also used to group text atoms for a more careful study. Analysis files act like file folders for the collection and structuring of information and have been used in the past to form detailed technical assessments of Soviet and East European computer hardware, to compile profiles of important Soviet officials and organizations. In addition they are used to route particularly useful text atoms to appropriate analysis “in-baskets” or directly to analysts. Analysis files are used for both long- and short-term purposes.

The AAIS is deeply embedded in the activities of the MOSAIC group. Most team members spend over 50% of their working time on the system. In addition to its short-term research value, it has developed great value as an institutional memory and as a vehicle for group communication, technical support, and discipline.

**The Proposed Carat System**

While the ASIS has proven invaluable both as a research tool and as a test bed for information system research, a number of limitations are apparent. The MOSAIC database has grown enormously, far exceeding initial expectations. The group is now considering a project for replacement of the AAIS both to correct these limitations and to take advantage of the many new technologies that have emerged since the inception of the AAIS project.

Over the years, the MOSAIC group has accumulated valuable experience in planning, implementing, maintaining and using the AAIS as a sophisticated analysis tool. With this experience, as well as an understanding of complex information systems, we have the capability to build a system for the 1990s. The Computer-Aided Research and Analysis Tool (CARAT) is intended to be the system to replace the AAIS.

All information currently contained in the AAIS—supported databases will be transferred to CARAT—supported databases. While
the resulting databases will continue to grow as before, it will also be possible to further structure old information within the richer CARAT environment. In addition to matching all of the current functions of the AAIS, the CARAT system will improve a researcher’s ability to organize information and will provide better support for remote users, whether functioning on- or off-line from the main database.

The CARAT system will support multiple “MOSAIC-like” databases, a feature which is expected to attract users from different fields.

The following is a list of the main characteristics of the proposed CARAT system:

1. The system will have new “collaborative work” capabilities, enabling a group of professionals to make comments and decisions based on common information.

2. Advanced man–machine interface techniques will be implemented to make the system more “user friendly”. With these techniques, the system will be accessible to users of all experience levels.

3. The system will support multimedia information such as text–English as well as foreign-language text–and images.

4. Features of so-called “hypertext” systems will be incorporated.

5. There will be improved access for remote users.

6. The system will supply the users with an extensive variety of tools for compiling and refining information from the database.

7. The system will support various forms of output, including standardized and user-defined reports. Reports now produced under the AAIS system, including textual reports with cross-indexing and bibliographic lists, will be preserved and substantially augmented.

**Research Philosophy**

The MIS requirements for system development as a research methodology are defined since it is clearly a different approach than that taken in the majority of business schools. A system development research process is presented from a methodological perspective. System development as a research methodology falls into the category of applied science and belongs to the engineering, developmental, and formative type of research.

The system development methodology is an age-old method and process that human beings use to study nature and to create new entities. System development has contributed to many research domains. The following is presented as an example of the systems building process.

Consider airplane design, the Wright brothers built the first airplane before the aerodynamics field had been created. From the experiences gained through building real airplanes and by studying model airplanes built in the laboratory and wind tunnels the theory of aerodynamics and aerostatics was created. The aircraft industry is now using the most advanced CAD/CAM tools to design the next generation of airplanes. These CAD/CAM tools have encoded theories developed in aerodynamics and heuristics derived from building real systems. The use of CAD/CAM tools has resulted in savings of millions of dollars through the improvement of the performance of new airplanes.

The research approach is:

1) build a system, 2) develop theories and principles from observing behavior, 3) encode expertise in computer software, and 4) use tools to assist in the development of new systems. Table 1 describes four examples of the contribution of systems development to theory building and research [4].

**Guidelines for Research in Systems Development:**

1. Do not assume that you already know everything about a problem domain. Building a prototype system will provide new insight. A prototype system is a model of the real world system and can be used to study the domain.

2. The process of building systems leads to an understanding of the system building process as well as of the product of the process, i.e., a good understanding of a domain. This will result in a successive refinement and improvement of both the product and the process.

3. The development of new systems may change the processes and concepts within a domain and thus expand the horizon of human knowledge about their environment.

4. System development methodology can be used in conjunction with other methodologies, such as laboratory experiment, field experiments, and case studies. Empirical research can provide valuable feedback. The result can lead to the further development of the system and a better understanding of the domain.

**Systems Development Perspectives**

**Research Domain and Research Methodology**

System development is a research domain as well as a research methodology. The question is often asked, "Does the Development of a software system constitute research?"

A research domain is the subject matter under study in a research project. A research methodology consists of the com-
Domain | Progress
--- | ---
Airplane Design | The Wright brothers designed the first airplane (1903)
| Development of aerodynamics and aerostatis
| CAD/CAM for airplane design and manufacturing (1980s)
Memory Management in Computer Systems | Real memory management
| Simulation of memory usage
| Virtual memory management
| Mathematical models of memory usage
Software Development Methods and Tools | Structured programming (Early 1970s)
| Structured design (Mid 1970s)
| Structured analysis (Late 1970s)
| Automated techniques (Early 1980s)
| Empirical studies of system development methods (1980s)
| CASE techniques (Late 1980s)
Electronic Meeting Systems | Electronic mail (late 1960s)
| Teleconferencing (1970s)
| Group decision support systems (GDSS) (Early 1980s)
| Evaluation of GDSS (Mid 1980s)
| Intelligent E-Mail (Mid 1980s)
| Integrated Electronic Meeting Systems (1990s)

Table 1: Examples of the Contribution of System Development to Theory Building and Research

Combination of the process, methods, and tools which are used in conducting research in a research domain. Developing system development tools (i.e., a special case of system development) is the research domain. Just as statistics provide a method for conducting empirical research, software engineering is a generally agreed-upon method for conducting software development research.

Comments or the use of research methodologies follow at Arizona:

1. **The research method is not more important than the research question.**

   The research method is a means of finding truth in a research domain. Without an understanding of a research domain, researchers could ask the wrong question or formulate a meaningless hypothesis. No matter which research method is applied, wrong or irrelevant questions can only lead to wrong conclusions. System building as a research methodology not only can be used as a means of better understanding a research domain, it can change the process and product in a research domain. It must be remembered that system development research is often used in conjunction with other methodologies.

2. **A valid methodology is necessary, but not sufficient for good research.**

   A sound research methodology provides methods and tools for the systematic study of a subject area, but does not guarantee good research results. A critical component of a successful research process is a sound understanding of the research domain. If the researcher does not understand the domain, how can the researcher intelligently interpret the results. The statement is obvious, but often researchers get involved in domains in which they are not expert. They rely too heavily on the methodologies to produce good results.

In Figure 1, a framework is proposed to explain the relationship between research domain and research methodology. The body of knowledge includes both research domain and research methodology [4]. The research process involves understanding the research domain, determining meaningful research questions, and applying valid research methodology to address the research question. Results from a research project can contribute to the body of knowledge both by expanding knowledge in a given domain and by enriching the methodology applied in a domain.

The research process in social and behavioral science can be summarized as follows: 1) choosing the research problem(s), 2) stating hypotheses, 3) formulating the research design, 4) gathering data, 5) analyzing data, and 6) interpreting the results so as to test hypotheses. There is a parallelism between the social (behavioral) and engineering (development) types of research, although the detailed methods and tools used may differ.

Figure 2 illustrates the system building process model from a research methodology viewpoint. Research issues which should be addressed in each phase are also identified. A system building process (with emphasis on software development) consists of the following steps:
Research Process

Apply Valid Research Methodologies + Understand the Research Domains

Research results contribute to the body of knowledge

Body of Knowledge

Knowledge of Research Methodologies + Knowledge of Research Domains

Figure 1: Research Domains and Research Methodologies

System Development

Research Process

Construct a Conceptual Framework

Develop a System Architecture

Analyze & Design the System

Build the System

Observe & Evaluate the System

Research Issues

* State a meaningful research question
* Investigate the system functionalities and requirements
* Understand the processes/procedures of the system building
* Study relevant disciplines for new approaches and ideas

* Develop a unique architecture design for assembly, modularity, etc.
* Define functionalities of system components and how they interact with each other

* Design the data structures and processes to carry out the system functions
* Develop alternatives solutions to design problems and choose one solution

* Learn about the concepts, framework, and design through the system-building process
* Gain insight about the problems and complexity of the system

* Observe the use of the system by case study and field study
* Evaluate the system by lab, experiment and field experiment
* Develop new theories/models based on the study of the system built
* Synthesize experiences learned

Figure 2: The Process of System Development Research
   The researcher should justify the significance of the research question pursued. An ideal research problem is one that is new, creative, and important in the field. When the proposed solution of the research problem cannot be verified mathematically and tested empirically, the researcher must develop a system to demonstrate the validity of the solution. Once the system has been built, the researcher can study its performance and the phenomena related to its use in order to gain insight into the research problem. A clear definition of the research problem provides focus for the research throughout the development process. The research question should be discussed in the context of an appropriate conceptual framework.

2. Develop a system architecture.
   A good system architecture provides a road map for the system building process. It puts the system components into the correct perspective, specifies the system functionality, and defines the structure of the relationships and dynamic interactions among system components. In the systems building research, it is necessary to identify the constraints of the environment, the objectives of the development effort (i.e., the focus of the research), and the functionality of the resulting system. Requirements should be defined so that they are measurable and thus can be validated. The system requirements, constraints, and assumptions should be stated in order to guide the system design and implementation.

3. Analyze and design the system.
   Analysis and design is an important part of a system development process. Design involves the understanding of the domain studied, the application of relevant scientific and technical knowledge, the creation of various alternatives, and the synthesis and evaluation of proposed alternative solutions. Design specifications will be used as a blueprint for the implementation of the system. For a software development project, design of data structures, database, or knowledge base should be determined at this phase. The program modules and functions should also be specified at this stage after alternatives have been proposed and explored and final design decisions been made.

4. Build the system.
   Implementation of a system is used to demonstrate the feasibility of the design. The process of implementing a working system can provide research insight into the advantages and disadvantages of the concept, framework, and design chosen. The experience and knowledge accumulated will be helpful in re-designing the system. Empirical studies of the functionality and the usability can only be performed after the system has been built.

5. Observe and evaluate the system.
   Once the system is built, researchers can test its performance and usability as stated in the requirement definition phase. The impact on individuals or organizations can be observed. The test results should be interpreted and evaluated based on the conceptual framework and the requirements of the system. Development is an evolutionary process. Experience gained from developing the system usually will lead to the re-design and continuing development of the system, or even discovery of a new theory for explaining observed new phenomena.

The use of system development as a research methodology in information systems should conform to the following criteria: 1) The purpose is to study an important phenomenon in areas of information systems through system building, 2) The results have significant contributions to the domain, 3) The system is testable subject to the objectives and requirements stated, 4) The new system can perform the stated function better than other systems, and 5) Experience and design expertise derived from building the system can be generalized.

In every phase of the system development process, researchers gain insight concerning the domain that leads to changing design decisions made in previous phases.

Selected Accomplishments

Requirements Definition and Analysis

Research in the department has led to several major breakthroughs in the understanding of the requirements definition process. The requirements definition work followed the efforts of Teichroew, Hershey, Nunamaker and Konsynski on the development of PSL/PSA and lead to on the development of the PLEXSYS software. For example, AT&T used the concepts to design its accounting and billing systems and TRW adapted the concepts for the SREM approach.

Decision Support Systems

The decision support systems work at Arizona had its beginning at Purdue with the development of generalized planning systems. The research conducted by Andy Whinston and Jay Nunamaker was on the integration of models and databases to support the decision-making process in analyzing water pollution problems. Application of these ideas to specific pollution problems in Indiana was carried out in the early 1970s. David Pingry and Jay Nunamaker continued the work at Arizona through support from the Electrical Power Research Institute from 1975–1983. "This research led to what are now referred to as Decision Support Systems". [32]
Electronic Meeting Systems (Facilities and Software)

The requirements definition and DSS work provided the foundation for the GDSS efforts that developed in the early 1980s. This work resulted in the development of software and a facility that was opened in March 1985. Grants from DEC, NCR, IBM, and the US Army made possible the development of the DIC laboratory where a network of personal computers, audio-visual equipment, and decision support software permitted computer-aided brainstorming in an anonymous, non-threatening environment that encourages creativity and frankness among the participants. Although originally conceived in the context of planning for the development of information systems, it was soon apparent that the DIC methodology was applicable to decision making and planning in general. The DIC laboratory was used by many groups to make "real" group decisions on a wide variety of issues facing their organizations. The laboratory proved to be a very valuable new way of approaching the problem of group decision making, and an environment for research on that process. Three Arizona research papers describing this project were designated "best paper" of DSS Track at the 1986 [17], 1987 [19] and 1988 [23] Hawaii International Conferences on System Sciences.

The success of the DIC led to the construction of a much more ambitious second-generation laboratory, the Center for Management of Information (CMI) Room which opened in November, 1987. The CMI room is one of the few facilities of its kind in the world. It combines the very latest in computer, communications, and audio-visual technology with the group decision support software that has been under development for eight years. Both the DIC and CMI electronic meeting facilities have attracted national attention both as a new tool for group decision making, and as a research environment. IBM is building replicas of the Decision Center at six of its locations around the country, to be used as an alternative to the traditional committee meeting method of decision making.

Conclusion

This paper is just a beginning in terms of explaining the research philosophy at Arizona. It is clear that there are a number of models that can be taken in research. We need to understand the advantages and disadvantages of each approach. MIS is still in its formative stage of development and we all have much to learn about the research process.

References


