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LETTER FROM THE EDITOR

Welcome to the third edition of the *Academy of Information and Management Sciences Journal.* The Academy of Information and Management Sciences is an affiliate of the Allied Academies, Inc., a non profit association of scholars whose purpose is to encourage and support the advancement and exchange of knowledge, understanding and teaching throughout the world. The *AIMSJ* is a principal vehicle for achieving the objectives of the organization. The editorial mission of this journal is to publish empirical and theoretical manuscripts which advance the disciplines of Management Science and Information Systems.

As has been the case with the previous issues of the journals supported by the Allied Academies, the articles contained in this volume have been double blind refereed. The acceptance rate for manuscripts in this issue, 25%, conforms to our editorial policies.

The Editor of this Journal will continue to welcome different viewpoints because in differences we find learning; in differences we develop understanding; in differences we gain knowledge and in differences we develop the discipline into a more comprehensive, less esoteric, and dynamic metier.

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Chris Lee
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Manuscripts

THE IMPACT OF COMPUTER LITERACY ON STUDENT ACADEMIC PERFORMANCE IN THE INTRODUCTORY MANAGEMENT INFORMATION SYSTEMS COURSE

L. Richard Ye, California State University, Northridge

ABSTRACT

During the last decade, business school students have seen information technology being integrated into all aspects of their curricula at an ever-accelerating pace. Virtually all business schools now ask that their students meet certain computer literacy requirements before graduation, and these requirements are often part of the prerequisites for students enrolled in advanced courses of their majors, such as accounting, marketing, management science, and of course, information systems. There appears to be a strong belief, shared among the instructional faculty and prospective employers, that a higher level of computer literacy can lead to enhanced student academic performance, increased employment opportunities, and perhaps future success on the job (Jaderstrom, 1995; Tanyel, Mitchell, & McAlum, 1999; Trauth, Farwell, & Lee, 1993; Zhao, Ray, Dye, & David, 1998). Anecdotal evidence also seems to support such conventional wisdom: better computer skills should lead to more productive use of the technology, which in turn should lead to improved academic and job performance.

In this study, we examine empirically the correlation between students' level of computer literacy and their performance in an introductory information systems course. The research is seen as a first step in a series of studies designed to explore the predictive validity of the computer literacy requirement.

INTRODUCTION

During the last decade, business school students have seen information technology being integrated into all aspects of their curricula at an ever-accelerating pace. Virtually all business schools now ask that their students meet certain computer literacy requirements before graduation, and these requirements are often part of the prerequisites for students enrolled in advanced courses of their majors, such as accounting, marketing, management science, and of course, information systems. There appears to be a strong belief, shared among the instructional faculty and prospective employers, that a higher level of computer literacy can lead to enhanced student academic performance, increased employment opportunities, and perhaps future success on the job (Jaderstrom, 1995; Tanyel, Mitchell, & McAlum, 1999; Trauth, Farwell, & Lee, 1993; Zhao, Ray, Dye, & David, 1998). Anecdotal evidence also seems to support such conventional wisdom: better

computer skills should lead to more productive use of the technology, which in turn should lead to improved academic and job performance.

Surprisingly, there has been little formal research effort aimed at evaluating the effectiveness of the computer literacy requirement within academic settings. We do not know, for example, if students who have satisfied the requirement necessarily perform better than those who do not yet meet the requirement. Students may also question the validity of the requirement as a prerequisite for other courses. The problem appears to be twofold. First, there is no universal definition of what constitutes computer literacy (Jones & Pearson, 1996). As a result, we design our evaluative criteria based largely on individual judgments and group consensus. Second, we do not fully understand the process by which students' technology skills influence their academic performance and, ultimately, their job performance. Consequently, it is difficult to determine what specific performance indicators are most closely linked to an individual student's level of technology skills.

In this study, we examine empirically the correlation between students' level of computer literacy and their performance in an introductory information systems course. The research is seen as a first step in a series of studies designed to explore the predictive validity of the computer literacy requirement.

COMPUTER LITERACY AND PERFORMANCE

"Computer literacy" is a commonly used term in the business world, but it is not precisely defined. Computer literacy, in general, is being knowledgeable about the computer and its applications (Rochester & Rochester, 1991). Such knowledge appears to have two dimensions: conceptual, and operational (Winter, Chudoba, & Gutek,1997). The conceptual dimension includes an understanding of the inner workings of a computer or general computer terminology. Without such knowledge a user would find it difficult to figure out any system problems, or to learn to adapt quickly to new systems or software. The operational dimension refers to the necessary skills a user acquires, through training and practice, in order to operate specific systems to complete specific tasks.

While prior research did not evaluate the performance impact of computer literacy empirically, there is evidence that such a performance impact is likely to be task-dependent (Goodhue & Thompson, 1995; Lonstreet & Sorant, 1985; Rhodes, 1985; Thompson, Higgins, & Howell, 1994). For example, if we considered a student to be highly computer literate because s/he demonstrated a high level of proficiency in using a word processor or a spreadsheet program, we would also expect the student to perform well on tasks involving the use of a word processor or a spreadsheet program. We could not predict, however, how the student would perform on tasks involving the use of a database program, if s/he had not received training in database software. This leads us to the following hypothesis:

H1: Students' task performance will be positively correlated with their level of computer literacy, if the same type of software is involved in assessing their level of computer literacy and their task performance.

Winter, Chudoba, and Gutek (1997) use the notion of "functional computer literacy" to argue that a user needs both the conceptual and operational knowledge to perform effectively and productively in various white-collar work settings. A truly "computer fluent" user, they contend, does not simply memorize the correct sequence of keystrokes or mouse clicks. Rather, the user must form an internal representation of the system's structure and functions. Indeed, there is consistent research evidence that links a user's valid mental models of a system to better task performance (Foss & DeRidder, 1988; Booth, 1989; Sein & Bostrom, 1990; Weller, Repman, Lan, & Rooze, 1995). Within the context of computer literacy training, we would therefore expect students to form useful mental models of a computer system based on their conceptual knowledge of the system, and to be able to transfer that knowledge to tasks in an unfamiliar hardware/software environment. This leads us to a second hypothesis:

H2: Students' task performance will be positively correlated with their level of computer literacy, even if the task involves the use of unfamiliar software.

The foregoing arguments suggest that the performance impact of students' computer literacy depends on the nature of the task. More specifically, it depends on whether the task involves the transfer and application of the conceptual and operational knowledge obtained from their computer literacy training and practice. This gives rise to a third hypothesis:

H3: Students' task performance will have no correlation with their level of computer literacy, if the task does not require the use of their conceptual or operational knowledge of the computer hardware/software.

METHOD

A multiple regression analysis was applied to assess the significance of students' level of computer literacy in predicting their task performance. In addition to the primary independent variable, level of computer literacy, the analysis also included two other independent variables: gender, and grade point average.

A number of prior studies have investigated the impact of student gender as a predictor of academic performance, but the results appear inconclusive. Two earlier studies found that female students performed better than males in accounting (Mulchler, Turner, & Williams, 1987; Lipe, 1989), while others found males outperforming females in finance (Borde, Byrd, & Modani, 1996) and Economics (Heath, 1989), but no gender effect in marketing (Borde, 1998).

Extensive research also exists on gender-related computer attitudes and aptitude, with more consistent results. Several studies found that, compared to men, women tend to display lower computer aptitude (Rozell & Gardner, 1999; Smith & Necessary, 1996; Williams, Ogletree, Woodburn, & Raffeld, 1993) and higher levels of computer anxiety (Anderson, 1996; Bozionelos 1996; Igbaria and Chakrabarti 1990). Because the present study focuses on students' performance

in an information systems course, we include gender in the research model so its effect can also be explored.

Grade Point Average (GPA) as a predictor of academic performance is widely reported. Numerous studies have found GPA to be significantly correlated with student performance in accounting (Doran, Bouillon, & Smith, 1991; Eskew & Faley, 1988; Jenkins, 1998), marketing (Borde, 1998), and economics (Bellico, 1974; Cohn, 1972). However, because the predictive impact of GPA in an information system course is unknown, we believe it should also be included in the present research model.

This study was conducted among 92 business school students enrolled in four sections of an introductory information systems (IS) course at a public university. All sections were taught by the same instructor, under the same set of conditions. The use of information technology was an integral part of the course requirement. To complete the course successfully, students must complete two hands-on course projects, one hands-on mid-term examination, and a traditional paper-and-pencil final examination.

At the beginning of the course, we measured the students' level of business computer literacy with an existing examination instrument. This provided an individual numeric computer literacy score (CLS), data for the primary independent variable of the study. The instrument had been in use twice a year to determine if a student had met the business school's computer literacy requirement. The exam consisted of three parts: hardware and software concepts, word processing, and spreadsheet modeling. The concepts part was administered on paper in multiple-choices format, while the remaining two parts involved hands-on word-processing and spreadsheet problems to be completed on a computer. Over the course of five years since its first use, the exam had produced a consistent passing rate of 30 to 35 percent. This suggests that the instrument is fairly reliable.

A student information database was used to collect data for the other independent variables: gender, and student GPA prior to taking the IS course. A multiple regression model was run on four performance measures: project 1, project 2, mid-term exam, and final exam. Project 1 involved the development of a database application using a database management system (DBMS), to which the students had no prior exposure. This performance measure was designed to test Hypothesis 2. Project 2 involved the development of a production plan using spreadsheet modeling. The measure was used to test Hypothesis 1. Students completed the two projects individually, outside the classroom. The hands-on mid-term exam consisted of three parts: IS concept questions answered with a word processor, a database problem, and a spreadsheet problem. This measure was designed to test Hypotheses 1 and 2. The final exam consisted of entirely conceptual IS questions, conducted in paper-and-pencil format. The exam questions focused on traditional IS theories such as transaction processing, decision support, and systems development, which can be considered hardware/software-independent. The measure was used to test Hypothesis 3.

The general regression model was formulated as follows:

$$Ps_i = \$_0 + \$_1 CLS + \$_2 GEN + \$_3 GPA + \,_i$$

Where:

Ps_i = numeric score on the two projects and the two exams (100 possible on each),
CLS = numeric score on the computer literacy exam (100 possible),

GEN = subject's gender, coded 1 for male and 2 for female,
GPA = subject's cumulative grade point average prior to taking the course (4.0 scale),
β_0 = intercept,
β_{1-3} = slope coefficient, and
ε_i = error term.

RESULTS

Descriptive statistics for the various measures of independent and dependent variables are presented in Table 1. The relatively large standard deviation value for CLS suggests that there was a great degree of variation among students' computer literacy levels.

TABLE 1. Descriptive Statistics

Variable	*M*	*SD*	*N*
Dependent Variables			
Project 1 score	67.40	23.68	92
Project 2 score	80.67	15.11	92
Mid-term Exam score	56.43	11.25	92
Final Exam score	55.49	11.31	92
Independent Variables			
CLS	62.15	21.16	92
Gender	1.51	0.50	92*
GPA	2.67	0.48	92
* 45 males and 47 females			

Shown in Table 2 are simple pair-wise correlation coefficients among the independent variables. We found that gender and CLS were negatively correlated at the .05 probability level. This is not surprising. As discussed earlier, prior studies suggest that males tend to demonstrate a higher level of computer aptitude than females. We also found GPA and CLS to be positively correlated; this is consistent with the expectation that high-achieving students make greater efforts in acquiring the necessary knowledge and skills, including computer literacy.

The correlations found in Table 2 do not pose a serious multicollinearity problem. The correlation coefficients were relatively small. We also calculated the variance inflation factors (VIF) for each of the variables. While a VIF considerably larger than 1 would be indicative of serious multicollinearity problems, none of the VIF values calculated for this study was greater than 1.10.

TABLE 2: Correlation Coefficients			
Variable	CLS	Gender	GPA
CLS	1.00	-.24*	.24*
Gender		1.00	.10
GPA			1.00
* $p < 0.05$.			

In Table 3, we report the results of the regression analysis. The proposed model appeared to fit well in predicting performance for three of the four performance measures: Project 2, the Mid-term Exam, and the Final Exam. Reported coefficients of determination (R^2) were 0.21, 0.36, and 0.27, while F values were 9.33, 18.30, and 12.18, respectively, all at a significant 0.01 probability level.

Students' level of computer literacy, represented by CLS, proved to be significant in predicting student performance on Project 2 ($t = 2.79$, $p < 0.01$) and the Mid-term Exam ($t = 2.38$, $p < 0.05$). These results lend support to the hypothesis (H1) that students' level of computer literacy may influence their task performance, if the task involves the use of software familiar to them. We did not find CLS to be predictive of student performance on Project 1. Therefore there was no evidence to support the hypothesis (H2) that students might be able to transfer their computer literacy knowledge to tasks involving the use of an unfamiliar type of software. This also seems to explain the difference between the t statistic for Project 2 and the t statistic for the Mid-term Exam, since one part of the exam involved the use of database software. Finally, we found no CLS impact on student performance on the Final Exam. This result provides support for H3, that students' level of computer literacy will have no effect on their task performance, if the task requires neither conceptual nor operational knowledge of a computer system.

TABLE 3. Results for Regression Models for Various Performance Scores: Standardized Beta Coefficients (t Statistics) for Independent Variables				
Variable	**Project 1**	**Project 2**	**Mid-term Exam**	**Final Exam**
CLS	-0.12 (-1.05)	0.28 (2.79)**	0.24 (2.38)*	0.12 (-1.23)
Gender	0.05 (0.42)	0.27 (2.66)**	-0.09 (-1.04)	-0.04 (-0.47)
GPA	0.32 (2.96)**	0.20 (2.07)*	0.53 (6.03)**	0.50 (5.36)**
Intercept	30.92 (1.88)	34.83 (3.71)**	19.50 (3.13)**	21.52 (3.20)**
Model statistics Adj. R^2 F value	 0.07 3.33*	 0.21 9.33**	 0.36 18.30**	 0.27 12.18**
* $p < 0.05$. ** $p < 0.01$.				

Of the other two independent variables, we found GPA to be a significant predictor of performance across all four dependent measures. This is consistent with prior research asserting the validity of using students' past GPA as a strong predictor of future academic performance. To high academic achievers, an IS course, despite its heavy technological content, does not appear more difficult than courses in other subject areas.

Overall, gender was not a statistically significant performance predictor for an IS course. Gender's significant effect on Project 2 performance is worth further exploration, however. Because Project 2 involved the use of a spreadsheet program, the result seems to raise an interesting question: are females better at using a spreadsheet program than males? More research is needed to confirm and explain this observation.

DISCUSSION AND CONCLUSION

In this study we examined the performance impact of students' computer literacy in an information systems course. Results of multiple regression analysis found the predictive power of computer literacy to be task-dependent. As expected, if a task requires substantial uses of computers and a specific type of software, students with a higher level of computer literacy, as measured by their proficiency in using that specific combination of hardware/software, achieved significantly better performance. Conversely, if the task requires the use of unfamiliar software, or if the task requires neither the use of computers nor conceptual knowledge of computer hardware/software, students' level of computer literacy had no significant impact on their performance. Instead, students' GPA appeared to have far more predictive power for such tasks.

The study's failure to find support for H2 requires further explanation. Project 1, designed to test H2, required students to develop simple database applications. While the database software was unfamiliar to the students, we had expected them to use their mental models of a computer system to transfer existing knowledge to a new, novel task. What affected their performance, however, did not appear to be their operational knowledge of the software, but rather their understanding of the database concepts. A closer look at their submitted work revealed that many students had difficulty grasping fundamental concepts such as relationships and Boolean logic in complex database queries. While the graphical user interfaces in today's software environment provide great operational consistency across different applications, what seems to dictate task performance, as implied by this study, is an understanding of the task itself. Computers are only tools. A poor understanding of the task will lead to an ineffective use of tools.

The research reported here is limited by several factors. The participants were all from courses taught by one instructor at one university. In the absence of a standard test instrument, the computer literacy examination used in the study was a choice of convenience. While extraneous factors such as instructor styles and task designs were controlled, the results of the study may not be generalizable to different institutions. Further research is needed to overcome these limitations. First, a standard evaluation instrument for computer literacy must be developed and validated. Second, the current study needs to be replicated under different settings.

The findings from this study have important implications on teaching and learning. Despite the universal requirements for computer literacy among academic institutions, the performance impact of such requirements is far from clear-cut. The relationship between a technology-induced

increase in students' personal productivity and their academic performance appears, at best, indirect. The predictive power of computer literacy on performance does not depend on whether and how much information technology is *used* in the completion of a course. Rather, it depends on how much that technology is integrated into the *evaluation* of student performance. Unless we can demonstrate a clear relationship between computer literacy and performance, many students will continue to perceive the requirement as an unnecessary roadblock to their progress in their chosen academic programs.

Future research also needs to explore the linkage between computer literacy and personal productivity, and the linkage between productivity and academic performance. Establishing the predictive validity of computer literacy requirement is paramount. As information technology is further integrated into the educational process, we need evidence of such predictive validity to help influence students' attitude and behavior toward fulfilling the requirement. Meanwhile, this would also heighten the need for adequate student training in the uses of information technology, if we expect them to be successful.

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A DO-IT-YOURSELF FACULTY INFORMATION SYSTEM

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ABSTRACT

University administrators, like corporate managers, need information systems to support decision-making. Building internal systems for organizing, maintaining, and sharing information is a vital part of managing any organization. In an academic environment, faculty planning and reporting activities require access to timely, accurate information by deans and department heads.

This paper describes a project undertaken by one business school to implement a "do-it-yourself" faculty information system (FIS) to support the College's day-to-day operations, longer-term planning activities, and AACSB reaffirmation efforts. A data model was developed using a semantic object modeling approach. The data model was translated to a relational design for implementation. Three different sources were used to extract data for populating the database tables. The final system was implemented in a local area network environment to provide shared access.

INTRODUCTION

Management information systems (MIS) serve the management level of an organization by summarizing and reporting on the basic operations of an organization (Laudon and Laudon, 1999). MIS are characterized by:

- Support for structured decisions at the operational and management control levels, but are also useful for planning purposes,
- Reporting and control orientation,
- Use of existing corporate data and data flows,
- Use of past and present data,
- Internal orientation,
- Minimal flexibility and analytical ability.

University administrators, like corporate managers, need information systems to support decision-making. Building internal systems for organizing, maintaining, and sharing information is a vital part of managing any organization. In an academic environment, faculty planning and

reporting activities require access to timely, accurate information by deans and department heads. Although universities maintain human resource information systems, these systems typically provide institutional-level reports that do not address the managerial needs of mid-level administrators.

Like any IS problem, implementing a system for faculty planning and reporting can be accomplished using either a "build it" or "buy it" approach. For example, Vinsonhaler, Vinsonhaler, Bartholome, Stephens, and Wagner (1996) developed a knowledge-based system for tracking academic productivity called PERIS – Productivity Evaluation, Reward, and Improvement System. The system tracked activities for the components of teaching, research, and service. Using IF-THEN rules, point values were assigned to activities. Activity points were accumulated to calculate a productivity total for each component as well as for a faculty member overall. The traditional advantage to this "do-it-yourself" approach is that an application is developed that meets the specific information needs of its users. However, the approach can suffer from long implementation times and substantial development costs.

Off-the-shelf software packages, such as the Dean's Associate from Octagram, allow an institution to quickly implement a faculty information system solution. The Dean's Associate is specifically designed to meet the needs of schools seeking AACSB accreditation or reaffirmation through two types of reports: business school management and accreditation-related. Cost of the software is based upon the size of the faculty.

This paper describes a project undertaken by one business school to implement a "do-it-yourself" faculty information system to support management decision-making and AACSB reaffirmation efforts. Specific objectives of the system were to:

- eliminate duplication of records,
- improve organization of and access to data,
- enhance decision-making with relevant and timely information,
- increase faculty awareness of business school performance and productivity,
- generate AACSB reports.

Information provided by the system is used in the business school's day-to-day operations, longer-term planning activities, and AACSB reaffirmation efforts.

BACKGROUND OF THE PROBLEM

A combination of factors initiated the faculty information system (FIS) project in Fall 1997. The business school underwent a change in leadership the previous year followed by a change in office support personnel. Many of the paper and electronic record systems previously used were unavailable. Uncoordinated efforts among staff to recreate information were leading to redundant record systems. Addtionally, the school was two years away from the self-evaluation period of its AACSB reaffirmation.

Some information the business school required for decision-making and reaffirmation was available from institutional systems. However, reports were not timely and did not contain the appropriate level of detail needed for some types of decisions. Much of the data needed for AACSB reaffirmation surrounded faculty composition and intellectual activities. The personnel system maintained by the university did not capture this type of information.

The lack of appropriate information from university systems combined with the need for new internal record systems to support decision-making and AACSB reaffirmation triggered the FIS project in Fall 1997. Business school administrators examined the build versus buy options. The buy option was considered preferable, but funds could not be obtained to purchase an off-the-shelf solution. Since sufficient time and in-house expertise were available to implement a "do-it-yourself" solution, the school opted to build the faculty information system.

INFORMATION REQUIREMENTS

A subset of information requirements for the FIS is summarized in Table 1. The complete set of information requirements is too extensive to discuss comfortably in this paper. The requirements represent what information the FIS needed to generate for decision-making and external reporting activities.

Table 1
Sample Information Requirements for the FIS

Purpose	Type of Decision, Problem or Question	Type of FIS Output
Faculty Activity Tracking	Do faculty have appropriate course loads to achieve the school's mission?	Semester credit hours generated No. of course preparations
	Are faculty members intellectually active and are activities consistent with the mission?	No. of intellectual contributions Profile of intellectual contributions by type of outlet (journal, proceedings, etc.) and type of scholarship (basic, applied, instructional development)
Faculty Planning	Should the school request additional faculty positions?	No. of teaching positions generated by faculty
AACSB Reporting	Is the full-time faculty adequate?	Minimum full-time equivalent
	Is the faculty sufficiently diverse?	Ethnic origin, gender, rank
	Are faculty members academically qualified?	Terminal degree and year Profile of intellectual contributions

Faculty Activity Tracking. Since the school's mission should guide all activity, information is needed to verify that faculty teaching and scholarly activity is consistent with the mission. Information in this area is used for internal decision-making as well as AACSB reporting.

Faculty Planning. Each year, the school's dean must justify requests for new faculty positions. " Positions generated" is a key figure used to justify these requests. If a faculty of 50 is generating credit-hour production equivalent to 55 positions, then new faculty lines can be justified.

AACSB Reporting. Two AACSB standards, "Faculty Composition and Development" as well as "Intellectual Contributions," require substantial information about the size, make up, qualifications, and intellectual activity of faculty members (AACSB, 1999). The faculty information system should generate information that documents compliance with these standards.

A key concern in defining the initial information requirements was the level of detail required for tracking and reporting intellectual contributions (IC) activity. Recording IC activity can involve substantial data entry if complete citations for all contributions are maintained. A simple prototype was developed to test the feasibility of entering complete citations. The additional work required for data entry was impractical given the staff available. The primary objective was to establish an IC profile at the faculty member, department, and college levels that documented the quality of scholarship and the consistency of activity with the mission. Generating this information did not require capturing complete citations. Only a simple transaction representing each citation that could be tied back to a faculty member's vita was needed.

THE DATA MODEL

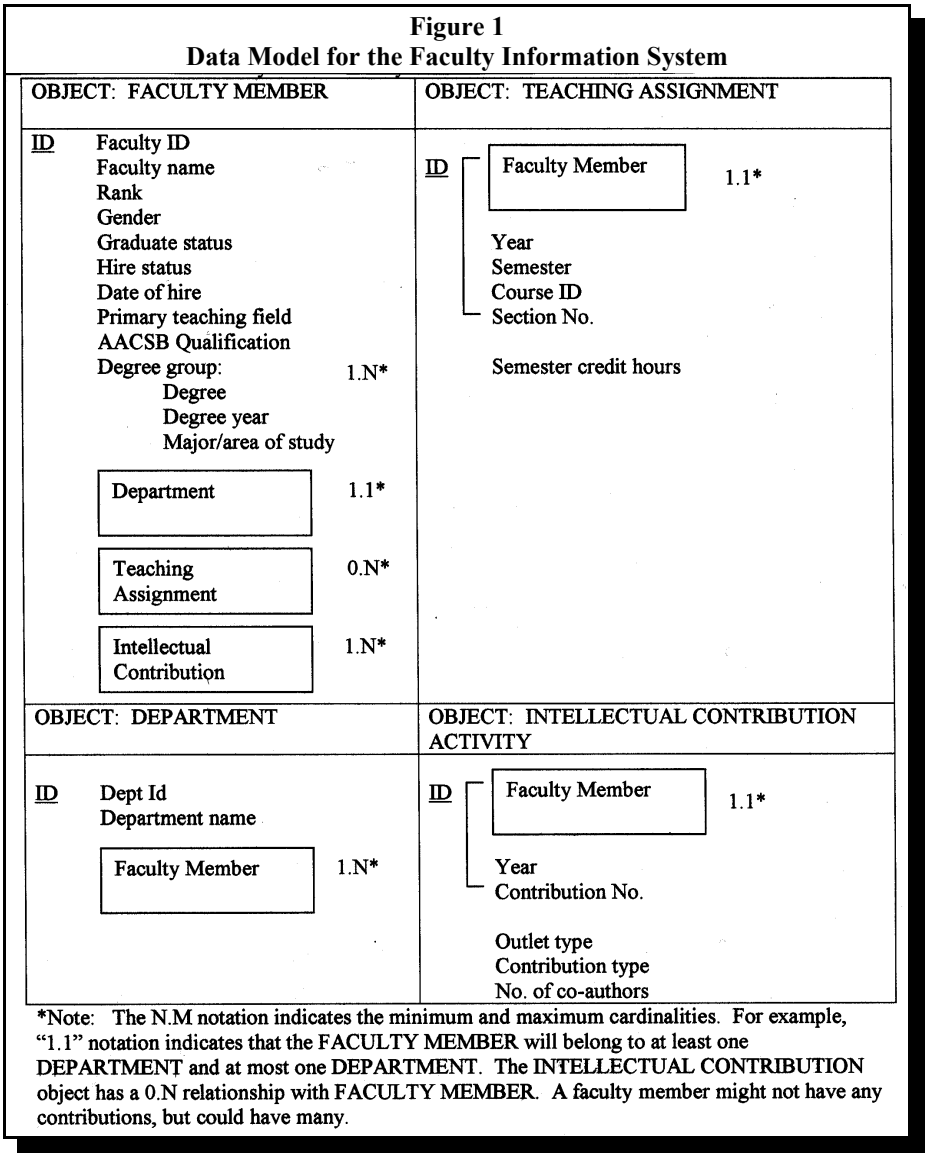
The data model was developed using a semantic object modeling approach. According to Kroenke (1998), "a semantic object is a named collection of attributes that sufficiently describes a distinct identity." Attributes can be simple (single-valued) or group (multiple attributes). Object`s can be simple, composite, compound or hybrid. Simple objects contain only single-valued , nonobject attributes. Composite objects contain one or more multi-valued, non-object attributes. Compound objects are made up of at least one object attribute. And hybrid, as the name suggests, are combinations of two different types. A completed semantic object model translates easily to a relational database design.

Four of the objects included in the data model are presented here: FACULTY MEMBER, DEPARTMENT, INTELLECTUAL CONTRIBUTION ACTIVITY, and TEACHING ASSIGNMENT. The data model assumed that faculty members belong to one department, but a department can have many faculty. A faculty member will have many teaching assignments and IC activities, but a teaching assignment or intellectual contribution activity belongs to only one faculty member. Figure 1 shows the semantic object diagram for the limited FIS.

Faculty Member Object. The FACULTY MEMBER object contains all attributes of a faculty member that are needed for satisfying the information requirements of the FIS. A faculty ID attribute uniquely identifies each member. FACULTY MEMBER has three object attributes that represent relationships with the objects. One group attribute, DEGREE GROUP, describes the attributes of the academic degrees earned by a faculty member. Since a faculty member can earn multiple degrees, the group is considered multi-valued.

Department Object. The DEPARTMENT object contains simple attributes department ID and name. The FACULTY MEMBER object attribute represents the multiple faculty members that are associated with a DEPARTMENT.

Figure 1
Data Model for the Faculty Information System



*Note: The N.M notation indicates the minimum and maximum cardinalities. For example, "1.1" notation indicates that the FACULTY MEMBER will belong to at least one DEPARTMENT and at most one DEPARTMENT. The INTELLECTUAL CONTRIBUTION object has a 0.N relationship with FACULTY MEMBER. A faculty member might not have any contributions, but could have many.

Teaching Assignment Object. TEACHING ASSIGNMENT contains attributes that describe a course taught by a faculty member during a specific term. If two faculty teach the same course, each is considered to have a unique TEACHING ASSIGNMENT. The semester credit hours represent the credit hours applied to the faculty member's teaching load.

Intellectual Contributions Activity Object. For the purpose of the faculty information system, the INTELLECTUAL CONTRIBUTIONS ACTIVITY of a FACULTY MEMBER must describe when (the year) the activity occurred, the type of outlet for the activity, and the type of scholarship. A contribution number is used to associate the activity with the corresponding citation on the faculty member's vita. If an intellectual contribution is authored by more than one faculty member, each individual will have an entry in the database. The attribute "number of co-authors" is used to

designate whether or not more than one FACULTY MEMBER contributed to the output. Availability of this attribute allows the FIS to produce a profile of activity that summarizes contributions with or without duplicate counts for co-authors.

THE DATA DESIGN

A semantic object model easily translates to a relational database design. The relational approach organizes all data in two-dimensional tables (or relations). Relationships between tables are created through common columns. Table 2 shows the table design for the FIS. Five tables are used to implement the four objects from Figure 1.

Table 2
The Data Design

Table Name	Table Columns
Faculty Member	Faculty ID, Faculty name, Rank, Gender, Graduate status, Date of hire, Hire status, Primary teaching field, Qualification
Degrees	Faculty ID, Degree, Degree Year, Major
Department	Dept ID, Name
Teaching Assignment	Faculty ID, Year, Semester, Course ID, Section No., Level, SCH
Intellectual Contribution	Faculty ID, Year, Contribution No., Outlet type, Contribution type, % of Contribution

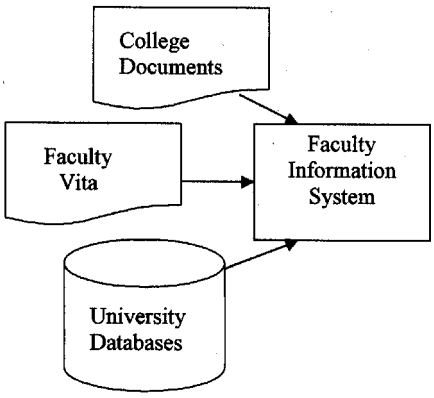
IMPLEMENTATION

According to Watson, Houdeshel, and Rainer (1997), two types of information are "generated and managed internally in the organization: information based on data records . . . and document-based information such as reports, opinions, memos, and estimates. (p. 272)" Both types of internal information were used to populate the FIS database. As shown in Figure 2, university information systems were used to extract data regarding instructional activity. College of Business documents provided faculty composition information (origin, status, and rank) while faculty vita were used to capture terminal degree and intellectual contributions input.

The database was implemented using Microsoft Access. Data captured from internal documents were entered manually into database tables while data extracted from university information systems were imported. Once the tables were in place, queries were developed to extract information for generating reports.

The database tables, queries, and reports were installed on the local area network (LAN) to allow for shared access. The LAN implementation allows multiple staff to use the information system, thus avoiding the redundancy problems that existed with former systems of record keeping.

Figure 2
Populating the Database



FUTURE DIRECTION

A Web-based version of the system has already been tested. However, because of concerns regarding confidentiality of some data, the Web-based FIS is still in test mode. Eventually, all faculty and staff should be able to view FIS reports using a Web browser. For now, the LAN version continues to meet the current needs of the business school.

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ONLINE TRADING: PROBLEMS AND CHALLENGES

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ABSTRACT

Despite the explosive growth and popularity of trading securities through the multitude of Internet brokerage firms, there are a number of problems and challenges associated with this venture. This study discusses and analyzes many of the problems and challenges plaguing the Internet trading sector. The main objective of this paper is to bring light to the "dark-side" of online trading as well as provide insight toward solving these dilemmas in an accurate and well-supported manner. Some of the items discussed include: hidden costs and deceptive advertising, independence, reliability, execution of trades, security issues, and the long-term outcome of online trading.

INTRODUCTION

Online trading is a practice that has exploded in growth and popularity. Currently, there are approximately 150 brokerage firms offering online trading (Future Banker, 2000). Societies use of the Internet has changed the entire concept of securities trading. In fact, Minkoff (2000) termed society=s use of online trading as "mainstream". In further support of this notion, he went on to add that by the year 2005, it is predicted that 81 percent of the households that own stocks will have an online account. Currently, 25 percent of the households that own stocks have an online account. Another study estimated that by the year 2003 approximately 9.7 million American households will manage more than $3 trillion in assets spread among some 20.4 million online accounts (Drummer, 1999). These are mind-boggling statistics compared to just three years ago when electronic trading was regarded a fad (Carroll, Lux, and Schack, 2000). Presently, in the U.S. one out of every six stock trades occurs over the Internet (Kassenaar, 1999). In 1999 online brokerage firms raised $1.76 billion in capital markets due to approximately five million online investors (*Economist*, 1999, and *Registered Representative*, 1999). Despite all of its growth and popularity, online investing possesses a host of problems and challenges for everyone involved. "You can make money fast and lose it faster," concluded Drummer's (1999, p.1).

LITERATURE REVIEW

There are several studies in the literature that attempt to discuss some of the problems and challenges associated with online trading. The first problem discussed in the literature is hidden costs and deceptive advertising associated with online trading. Atkinson (2000) supported this

contention that buried in all the online trading hype resides the fine print. This obscure data translates into a venture that is more costly than one was lead to believe. Another topic of discussion was that of the independence one comes to face when it comes to online trading. The fact that one must solely bear the overwhelming duties of research and investment decisions was supported through the studies conducted by Opdyke (2000) and Brackey (2000). Reliability was yet another area of concern discussed in these studies. The studies conducted by Patel (1999) and Opdyke (2000) confirmed that factors such as Internet congestion and erroneous data sites could prove costly to investors.

Delayed and varied execution speeds and self serving market makers were among the items responsible for this pitfall of online trading as was collaborated in the studies by McNamee (2000) and Patel (1999). Internet security is also a major concern to investors. Computer hackers and viruses plague every sector of the computer community and with certainty will continue to do so.

Finally, the long-term ill effect of online trading in regards to earnings was also discussed in the literature. McMillan's (1999) study found investors who outperformed the market by three percentage points before they began online trading, typically lag it by two points afterwards.

PROBLEMS AND CHALLENGES

Internet applications are endless and e-commerce companies are developing innovative business models and making advancements everyday. One of the fastest growing internet ventures is online trading. The first internet securities trading occurred in 1994. By 1997, it has been estimated that 17 percent of all trades occurred online via the internet (Goldberg, 1998). Online brokerage firms emerged and the wealth of information available to many investors have promoted the practice of investing through the internet. The opportunity that online investing present to investors is intriguing and returns often seem very promising. Within these opportunities lie many problems and challenges that are potential obstacles for the online investor. There are a variety of issues that online investors will face today and continue to do so in the future.

Hidden Costs and Deceptive Advertising

Since the mid 1990s, investors have been seeing advertisements by a multitudes of online brokerage firms bidding for customers. There are the endless stories and portrayals of the average person making thousands at the click of a mouse. Teaser advertisements boast of inexpensive or even free trades -"teaser rates"- in relation to the high dollar commissions one would pay a broker at a traditional full service firm (Atkinson, 2000). Now, even the traditional firms are offering online trading at discounted rates, whereas in 1998, none offered online trading (Bielski, 2000; Orr, 1999; *Economist*. 1999). So, why would anyone want to spend an exorbitant amount of money to trade securities using traditional off-line full service brokers when they can start an online account and do it themselves for a fraction of the cost (Brackey, 2000)? The choice appears clear-cut, or does it? For example, compare a trade costing $104 through a traditional full service firm versus $5 through an online brokerage. How can one go wrong? Well, buried in all this online trading hype is the fine print that Atkinson(2000) discussed in his study.

Unfortunately, the advertisements leave out a great deal of very important information regarding what all is involved in these accounts. As Morgenson (2000, p.1) stated, "Online investing is far costlier than most investors think." Nothing is ever mentioned about the large minimum balance one must maintain or initially deposit in order to qualify for these low advertised trading commissions (Kassenaar, 1999, and Financial Service Online, 1999). For example, Merrill Lynch, a traditional full service firm that recently began offering the online trading option through its Merrill Lynch Direct Account, offers trades for $29.95. However, the account requires a minimum account balance of $20,000 or $250 if the funds are applied to an Individual Retirement Account. American Express Brokerage, an Internet discount brokerage, has the following pricing guidelines: Investors who have account balances less than $25,000 must pay $14.95 for each buy and sell. Online buys cost nothing and sells cost $14.95 if investors have a minimum account balance of $25,000. Investors with account balances over $100,000 are entitled to free buys and sells. Brown and Co., a deep-discount online brokerage firm, offers trades for $5 each. It has the following guidelines: An investor must have at least five years= investment experience and have a minimum of $15,000 to open an account. Atkinson (2000) further warns that some firms even require that an investor make a certain amount of trades in order to qualify for the discounted trading fees. There are also the added costs of placing particular types of orders, such as limit, stop, or telephone orders (Atkinson, 2000). For example, Schwab, who requires an initial deposit of $5000, charges $29.95 if the trade is placed over the Internet, $49.50 if placed over the telephone using an automated service, and $55.00 if he or she personally gets a broker to place the trade. As one can see, an investor must possess a sizable sum of cash in order to qualify for some of the low trading fees offered by brokerages. In addition there are additional obscure fees that investors are required to pay when trading online.

In order for this area of concern to improve, everyone involved must do his or her part in facilitating change. Brokerages must strive to keep potential customers informed of the costs associated with this venture. Investors need to take it upon themselves to become educated on all the aspects of online trading (Gordon, 2000). They must investigate each brokerage in order to find out which one best suits his or her needs. Lastly, reading the fine print is imperative. As the old adage states, "if it is too good to be true, then it probably is." The Securities and Exchange Commission (SEC) and other pertinent Governmental entities play a role in online trading. Not only must they continue to monitor the industry, but they also need to increase regulation as well as step up enforcement efforts on the brokerages that facilitate inept marketing practices. As one can see there is much room for improvement in this area of concern in regards to online trading. Everyone must, especially the investor, must be cognizant of what he or she is getting into when it comes to trading online.

Independence

The term "do it yourself" is very much applicable in the case of online trading. Many investors who start online trading have no idea what this endeavor requires and the problems and challenges associated with it. The main problem and challenge that one must tackle is that of research. Without a broker to do this task, one is left to rummage through the endless and complicated amounts of data and information. This would include data sources such as financial

statements, stock reports, company profiles, and the like. This is a very time consuming, necessary and prudent task. One must possess the knowledge to understand the data and be able to ascertain its reliability and validity. (Research reliability is another topic in and of itself; that will be discussed later in this study).

The second dilemma faced by the "do-it-yourself" investor is that of investment advice. Without a broker, the decision to buy, sell, or hold a security is left up to the investor (Brackey, 2000). Also, investors who possess a portfolio must bear the responsibility of managing it on their own. Diversification issues and the like are matters that must be dealt with. They require extensive research, knowledge, and time. Therefore, one must truly understand the risk and return characteristics of the securities that they are buying and also have sufficient time to handle various issues involved with this task.

Unfortunately, very few people possess the time and knowledge required to handle this task responsibly and wisely, and therefore, it would be in his or her best interest to go through a full service broker. Online brokerages can improve this situation by offering more tools to assist their customers with investment decisions. Many brokerages are doing this and it appears to be a sign of the times (Fraser, 2000). However, one should not expect too many services to be offered because the lack thereof is the reason their trade commissions are low. It stands to reason that the more services available, the higher the trading fees.

Therefore investors get what they pay for. In order to be profitable, they must have ample time and knowledge to fill the gap that would ordinarily be filled by the duties of a full service broker. With the passage of time, hopefully the online brokerage community will provide investors with more account management tools.

Reliability

One is totally dependent on digital technology when it comes to online trading. After all, one cannot trade online if they are unable to establish a "connection" with the firm. There are a number of problems and challenges that can and do arise in association with computers and the Internet. The results can be devastating should a problem arise at the most inopportune moment. As investors are aware.... time is money. Computer crashes are inevitable, on the part of the firm as well as the investor. Heavy internet traffic or volume is another factor that one must eventually deal with (Patel, 1999). Connections and downloads can be delayed or stopped all together due to Internet or web site congestion. Online firms vary in their computer hardware just as investors. One can bet that there are brokerages that do not possess adequate backup servers or properly maintain them. On the same note, there is the potential of brokerages having faulty "backups" or the lack thereof. Some firms may not have an alternate means available for investors to conduct trades. Should investors be unable to conduct an online trade for any reason, he or she should also be able to place the order via the telephone or personally. Online investing requires that firms and the investors possess reliable computer equipment and measures in order to fulfill their intended purpose.

Another aspect of reliability is that of research materials. There are a number of sources available on the Internet that one can obtain free information regarding an array of investment topics. However, Opdyke (2000, p.1) warned in his study, "that the words, 'good' and 'free' usually

don't go together in the same sentence." Opdyke further asserted that within this plethora of information resides data that is stale, incorrect, and in some instances fraudulent (Hirschey, Richardson, and Scholz, 2000). Stale information includes out of date material and lagging stock quotes. Chat rooms, bulletin boards, and other like forums cannot be relied on as credible information sources. Opdyke's study stated that the information one really needs to effectively trade online is restricted largely to brokerage firm customers, institutional investors or those willing to pay handsomely for the research material. Of course this aspect relates back to the issue of "hidden costs". In short, unreliable data sources can provide devastating consequences.

Everyone involved in the online trading process can help improve reliability. Brokerages and investors must strive to improve their computer capabilities as well as keep their computer systems operating in an efficient manner (*Nikkei Weekly*, 1999). It is imperative that brokerages possess current as well as frequent backups of all data. They too must have a functional backup system available to investors, should the primary system fail or encounter problems. At the very least the firm should have an alternate server. A telephone system is another very beneficial backup alternative, where investors can phone in their orders should they be unable to place their orders via a computer. Investors must also keep up with their brokerages' computer capabilities as well as their own and make changes accordingly. Technology is constantly changing and it is up to both parties to ensure their systems are operating at optimum performance.

There are also steps that can be taken to improve the acquisition of reliable information. The Internet will always contain information that is inaccurate and sometimes criminal in nature. Sponsors of sites that contain securities data must monitor them frequently to ensure that only accurate and up to date material is provided. Disclaimers should be posted on every site that does not or cannot provide accurate information (Gordon, 2000). Online brokerage firms should provide enough data for investors to make sound decisions or provide a list of sites where one can go to obtain said data. Also, the SEC and other governmental bodies must continue to scan the Internet and step up enforcement efforts on those sites and sponsors who mislead its readers. Investors must educate themselves in regards to obtaining information from sites of this nature and be cognizant of the dangers involved in doing so. Hence, online trading can be very unreliable. Education, monitoring, regulation, and enforcement efforts can help reduce this stigma of online trading.

Execution of Trades

Many people are under the impression that a trade is executed the moment the mouse is "clicked" and at the amount expected. This is far from correct, as illustrated in Table 1. To understand how transactions occur, one must come to understand the online trading process (Hamilton, 1999 and McNamee, 2000). The process begins with the placement of an order. Once that order is placed with a brokerage firm, the firm then forwards the order to a Wall Street "market making" firm that actually executes the order. Brokerages often receive payments from market makers to get their business. This payment system is referred to as "payment for order flow" and is very controversial due to the potential of abuse. For instance, brokers may route orders where he or she is receiving the highest payments as opposed to where investors get the best execution. Routing and rerouting orders is inherently slow and result in poor executions. The market maker will match, but not necessarily beat the market's prevailing rate. A group of market makers may

control 30 percent or more of the market's volume. They in turn can use this information for their own gain.

Table 1: Comparison of Transaction Performance and Success Rate

	Week of June 12-16, 2000		Week of July 17-21, 2000	
	Transaction Performance (in seconds)	Transaction Rate (Rank)	Transaction Performance (in seconds)	Transaction Rate (Rank)
Market Index	13.87	91.3%	11.93	97.0%
DLJdirect	4.10	99.4%	4.5	99.9%
E*Trade	15.78	96.1%	NA*	NA*
Charles Schwab	8.29	99.3%	9.24	99.3%
Merrill Lynch	18.69	98.5%	22.24	91.7%

Source: www.keynote.com
Note: NA*: Not available

Online brokerages vary in their trade execution speeds as well as their trade execution success (Patel, 1999). As volatile as the market is, an online brokerage that takes twenty seconds to execute a market order can result in drastic expenses and losses. (*A market order is simply an order to buy or sell a specified amount of a security(s) at the prevailing market rate, whatever that may be at the time the order is 'filled' or executed*). What compounds this dilemma is when an online broker or another source contains lagging stock quotes, as opposed to "real time" stock quotes (Patel, 1999). (*Lagging stock quotes are quotes or prices that are not current with the actual market price. Real time quotes are those that follow the market second for second and change accordingly*). For example, an investor places a market order to buy 1000 shares of a "tech" stock. The stock is quoted at $5 a share from a source that has a twenty-second lag time. Unbeknownst to the investor, the actual value of the stock has increased to $6 at the time the order was placed. Now the online brokerage takes an additional thirty seconds to execute the order at which time the stock's price has escalated to $7 a share. This fifty-second time span - or "slippage" as Patel terms it - has ended up costing the investor an additional $2000. It is the risks and problems such as these that online investors experience everyday, but are seldom mentioned.

In the scenario discussed above, the investor could have placed a limit order on the buy; but there is no guarantee that his or her order would have been executed (McNamee, 2000). Recall that a limit order specifies that the investor will buy or sell shares at the price they specify. If their limit price beats the order offered by the dealer who gets their order, the dealer has to post their order where it will have a chance to be filled/executed. McNamee (2000) addressed this problem through a SEC report. The SEC report found "serious neglect" of these rules by many firms, including three mid-tier NASDAQ market makers that mishandled 46% to 92% of the orders examined. This translated into thousands of customers losing the chance to buy or sell stock at favorable prices. The

"execution" issue is a problem and challenge that plagues investors and brokerages with serious negative implications.

There are a number of ways in which everyone involved in the online trading process may address this concern. The SEC must continue to increase and improve regulation and enforcement efforts surrounding this dilemma (*Economist*, 2000). Brokerages must adhere to these various regulations and laws and make certain their affiliates are doing so as well. They must also remember that the customer is the main priority. Their actions must always be in the customers' best interest. Again, investors must educate themselves on the intricacies of online trading. From the results of time lags to the details of limit orders, investors must be cognizant of the business in order to protect themselves. Everyone involved can improve the process of trade execution if the correct steps are taken.

Security

Another area of major concern is security, which not only plagues online trading but the entire e-commerce industry. But, some argue that online investing is safe and secure. For instance, according to Anderson (1998), president of Ameritrade, online investing is secure mainly due to the fact that the only information being transferred over the internet are orders to buy or sell. Others disagree, because hackers or viruses are infiltrating investors' accounts. These accounts contain very pertinent as well as private information. However, there are times when very personal information is transferred over the Internet. Many online brokerages allow customers to apply for an account via the Internet. The information called for in these applications is very personal in nature (e.g., social security number, bank account(s) information, and credit card(s) numbers). While many firms have increased their security efforts by implementing complicated encryption techniques and various up to date anti-virus software applications, there are still online firms that are lacking in this area. Should these precautions be overlooked by a brokerage, the ramifications can be devastating to its customers. One can only imagine the damage that could occur should his or her personal information end up in the wrong hands.

Hence internet security is a serious problem that plagues the entire E-commerce community. Computer viruses and hackers are always going to be a threat in our society. It is up to online brokerages to maintain and strive to ensure that their computer systems are up to date in regards to anti-virus software and encryption techniques. It is also up to investors to investigate their brokerage firm to see what measures they are taking against this problem. Additionally, they need to see what can be done on their behalf to guard against breeches of security. This is a topic in which everyone needs to be abreast of and counter measures implemented. Failure to do so can result in devastating consequences.

Long Term Outcome

Over time, aggressive online trading can have a negative impact on investors= earnings. The studies by Minkoff (2000), Future Banker (2000) and Chidley (1999) supported this contention. They found that online investors make close to 10 trades a year, and by the year 2005 it is estimated that each investing household will possess an average of 4.5 accounts. On the same note, it is stated

that people with Internet accounts trade more often, as well as, trade more on margin. Furthermore, the Securities Industry Association (SIA) estimates that the average number of online trades per day now exceeds 500,000 (partly because of day-traders).

With all this excessive trades, one must contend with excessive trading fees, and lower earnings. McMillan (1999) and Levinsohn (1999) studies supports that excessive trading have resulted in investors's earnings to decrease. They found that investors increase their trading activity when they open an online account. Through aggressive trading, people get roughly two percentage points below what they would have achieved with a traditional "buy and hold" strategy. Levinsohn (1999) concurred with this argument in by stating that online investors are dismissing the rational strategy of buy-and-hold. McMillan's strongest point in his study was that investors, who outperformed the market by three percentage points before they began online trading, typically lag it by two points afterwards. Atkinson (2000) echoed the sentiments of this argument by stating that poor performance of a portfolio is directly attributed to active trading(i.e., it eats away at its gains). An investor that practices aggressive trading and is unwise to its long-range effects will undoubtedly suffer the financial consequences of such behavior.

Investors must be informed and educated regarding the online trading of securities. Securities trading simulation games which are offered through various sites, are excellent ways for investors to achieve this (Saunders, 1999). When it comes to the volatility of the market or the cumulative fees associated with aggressive trading, the investor must be cognizant of the ramifications of said factors (*Economist*, 1999). Patience and having an investment plan, such as a buy and hold strategy, are key to profitability. In conclusion, the typical investor who practices "buy and hold" stands to make more money than someone who ends up trading aggressively in an uncalculated manner.

SUMMARY AND CONCLUSION

The problems and challenges of online trading are deeply entrenched as discussed. There is no doubt that this practice can be very costly to an uneducated and uninformed investor. However, there are steps that must be taken to improve this dilemma. Investors must strive to better educate themselves through such mediums as investment simulation games in order to fully recognize the intricacies of online trading. To prosper from this endeavor, they must read the fine print in everything and posses the time and other requirements called for in this venture. Maintaining and keeping computers technologically up-to-date is imperative on everyone=s behalf. Brokerages must focus on the customer and keep them fully informed on all aspects of the business. Brokerage firms must ensure that their clients are capable of participating in this form of trading. The SEC and other governmental agencies must continue to increase its efforts in regulating and monitoring this sector of the market to insure that the customer=s best interest are being fulfilled. Online trading presents numerous problems and challenges to everyone involved. Investors must be prepared to work on this if they plan on reaping any benefits. With time, knowledge and continued effort the dangers of online trading can be minimized. Being informed and educated are the best safeguards in this ever-growing field of land mines.

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E-COMMERCE SECURITY STANDARDS AND LOOPHOLES

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ABSTRACT

Electronic commerce is enjoying a phenomenal growth at present. Until recently many people did not feel comfortable in using e-commerce. The principal reason for the initial reluctance of many people to accept the Internet transactions was the lack of confidence in the security measures of the Internet. The industry took serious note of people's concerns in this regard and committed to improve the Internet security. Several security standards were developed to facilitate e-commerce. This paper considers several methods available today for secure Internet transactions and addresses some of the loopholes in the system that could jeopardize the trust that needs to be established for the long term success of e-commerce.

INTRODUCTION

The Internet offers tremendous opportunity for merchants around the world to sell their products online. However, the anonymous and open nature of public communication networks has presented serious challenges for securing personal and bankcard information over the Internet. U.S. businesses are seeking opportunities worldwide by using the Internet to open up unreachable foreign markets. According to Internetstats.com, nearly 134 million Americans are online today compared to 118 million last year. Cap Gemini USA estimates that roughly 55,000 new users are going online every day. With this much growth in online use the natural beneficiary is online commerce. Industry's role in this regard then is to provide confidence for the customers that the transactions online are secure.

Standards play a significant role in securing the transactions on the Internet. Standards provide interoperability, connectivity, consistency of applications, transparent data exchange, distributed open environments, improved information sharing, security, and lower costs to users and software providers. The banking industry estimates that it costs approximately $1.07 per transaction. Surprisingly, without costly branches and human interaction, the cost per transaction using online will be one cent. With such a profound cost differential the businesses are slowly going to gravitate towards electronic transactions, with sufficient incentives to attract customers for online usage. U.S. Internet Council estimates that the capacity of the Internet backbone to carry information is doubling every 100 days in order to meet this added volume. Compared to a growth rate of only 10% in voice communications, the data traffic is rising at the rate of 125%. This phenomenal growth can be directly attributed to the expected $1.3 trillion e-commerce sales by 2003.

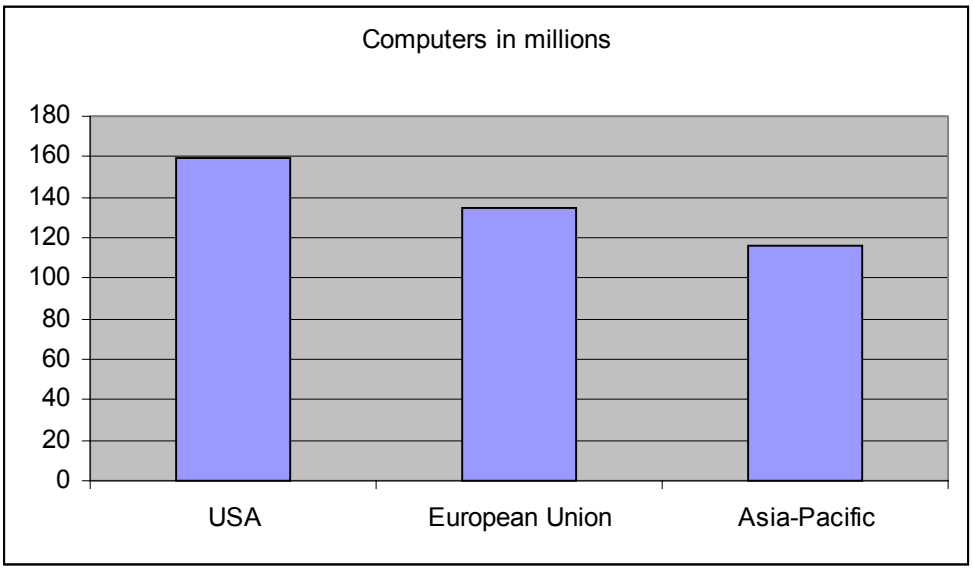
EMERGING INTERNET STANDARDS

Some of the newer and popular Internet standards include Secure Electronic Transactions (SET), Enhanced Data Encryption Standard (DES), Secure Sockets Layer (SSL), Secure HyperText Transfer Protocol (S-HTTP), and Secure Multipurpose Internet Mail Extensions (S/MIME).

Secure Electronic Transactions (SET)

Secure Electronic Transactions (SET) is a standardized, industry-wide protocol designed to safely transmit sensitive personal and financial information over public networks. Jointly developed by MasterCard and Visa International, SET uses RSA encryption and authentication technologies to enable secure payment transactions (RSA, 2000). SET uses RSA with 1024 bit keys. The RSA algorithm is the most scrutinized, tested, and trusted public key algorithm. The SET protocol contains state-of-the-art cryptographic technology that provides on-line transaction security that is equivalent or superior to the safeguards in present physical, mail and telephone card transactions.

To meet the security needs of bank card transactions over public networks, the Secure Electronic Transaction (SET) protocol uses cryptography and related technology to provide confidentiality of information about financial data, to ensure payment integrity, and to authenticate merchants, banks, and cardholders during SET transactions. The level of security incorporated into SET is based on RSA's Public-Key Cryptosystem, which has been proven over the last 10 years as the most commercially viable, widely used security technology available. The RSA Cryptosystem is used in over 100 million copies of messaging, groupware, email, and Internet-based applications. In this context it is worth noting the following.



With these many sources for online access around the world, the e-commerce industry has to guarantee security of transactions. Otherwise unscrupulous elements will try to take advantage and bring down the entire e-commerce industry. The stakes are enormous.

The SET protocol defines four main entities involved in a SET transaction: the Cardholder, the Merchant, the payment Gateway, and the Certificate Authority (Keen, 2000). Message integrity and authentication are achieved in the SET protocol through digital signatures. The confidentiality of messages in the SET payment environment is accomplished through encryption of the payment information using a combination of public key and secret key algorithms. The RSA Public Key Cryptosystem is the public-key algorithm used in SET and the symmetric key algorithm is DES (Data Encryption Standard). The SET protocol is also designed to allow for more complex transactions such as returning goods and obtaining a credit, or reversing an authorization for an amount when goods cannot be shipped. **The key aspect of SET is that no physical card is required for processing SET transactions.** Digital signatures help facilitate the transactions.

Data Encryption Standard (DES)

The Data Encryption Standard (DES) was published in 1977 as an encryption standard for U.S. Government applications. It was based on an encryption standard known as Lucifer cipher. When DES was adopted as a federal standard, its expected life was ten years. The DES is an U.S. national standard and de facto international standard. DES security is based on repeated bit permutations within a 64-bit block of text, where the permutations are derived from the specific DES key. Benchmarks have shown that a DES can encrypt about 300 kbps. The fastest DES chips are designed to encrypt data with one key and not to test many keys against the same block of cipher text.

Over the years, there have been several different attempts to crack DES. Although DES can only be cracked through brute force, the increasing speed and sophistication of computer processing power has rendered the standard insecure. Exhaustive key search remains the fastest known attack against the DES. But improvements in technology, leading to the potential for faster key search machines, now pose a greater threat to the use of single-key DES.

Triple-DES

Triple-DES is based on the existing DES, but has been enhanced by tripling the key length. The longer key will make it more difficult to use brute force to crack the code. Triple-DES, a strengthened version of the DES standard, is an alternative favored by banking and financial services industries. The new mode of multiple encryption is the triple-DES external feedback cipher block chaining with output feedback masking. The aim is to provide increased protection against certain attacks like dictionary attacks and matching cipher text attacks, which exploit the short message-block size of DES. The new mode is part of a suite of encryption modes proposed in the ANSI X9.F.1 triple-DES standard (X9.52) (Coppersmith, Johnson, & Matyas, 1996).

The use of triple encryption with multiple keys is generally accepted as the best and most practical method for increasing the strength of the DES against key search attacks. The two major concerns that are addressed when standardizing the triple-DES modes are matching ciphertext attack

and dictionary attack. The new method for increasing the strength of triple-DES mode against these attacks, without having to change the 64-bit block size of the DES algorithm, uses secret masking values. It also uses external feedback with Cipher Block Chaining (CBC).

Advanced Encryption Standard (AES)

NIST's Information Technology Laboratory has initiated a process to develop a Federal Information Processing Standard (FIPS) for Advanced Encryption Standard (AES) incorporating an Advanced Encryption Algorithm (AEA). It is initiated that the AES will specify an unclassified, publicly disclosed encryption algorithm capable of protecting sensitive government information well into the next century. The Advanced Encryption Standard will replace DES, which is more than 20 years old. They are looking for a 128-bit block cipher that supports keys of 128, 192, and 256 bits (NIST, 2000). NIST foresees that a multi-year transition period will be necessary to move forward any new encryption standard and that DES will continue to be sufficient strength for many applications.

RSA has delivered a proposal to the U.S. government for a new and more secure algorithm, designed by RSA laboratories team led by Ronald L. Rivest. According to NIST, Advanced Encryption Standard will be publicly defined, a symmetric block cipher designed so that the key length may be increased as needed and be implementable in both hardware and software. Algorithms submitted to NIST will be judged on security, computational efficiency, memory requirements, hardware and software suitability, simplicity, flexibility, and licensing requirements (Corman, 1998). The review process will take several years before the new standard is finally formalized. As the government's business on the public networks like Internet increased, the importance for more security, and higher standards of encryption is necessary.

These three standards together account for majority of the secure transactions online today. We need to keep in mind the rapid and sustained growth of the Internet over the years. The following table shows such a growth:

Year	Number of Americans online
1993	90,000
1997	19,000,000
1998	84,000,000
1999	118,400,000
2000	134,200,000

Source: www.internetstats.com

In this scenario the communication industry needs to reassure people that their transactions online are secure. The DES encryption schemes have stood the test of time and the newer open standards

makes it easy for the entire world to adopt this scheme. This is essential today because the electronic commerce is not limited to one country alone, rather the entire world.

Secure Sockets Layer (SSL)

Secure Sockets Layer (SSL) is a program layer created by Netscape for managing the security of message transmissions in a network. Netscape's idea is that the programming for keeping messages confidential ought to be contained in a program layer between an application, such as Web browser or HTTP and Internet's TCP/IP layers. The "sockets" refer to the sockets method of passing data between a client and a server program in a network or between program layers in the same computer. Netscape's SSL uses the public-and-private key encryption system from RSA, which also includes the use of a digital certificate. The prevalence of Netscape's servers and browsers in the marketplace today makes SSL easier to use and the most dominant technology for securing Web sessions.

The Secure Sockets Layer (SSL) is the defacto secure protocol for e-commerce transactions today. SSL is a layered approach to providing a secure channel. Although SSL does not provide mechanisms for handling payment, it offers confidentiality in Web sessions, authentication of Web servers, and data integrity of the message packet. The easiest method to test if the site supports SSL mode is by adding an "s" to the http portion of the URL. If the browser switches to secure mode, the encryption key will be activated in Netscape.

SSL secures the channel by providing end-to-end encryption of the data that is sent between a Web client and Web server. SSL provides authentication through a certification authority (CA). The CA endorses the identity of the Web site. Most Web browsers today come with a built-in box that contains a list of certification authorities. When one hits a Web site over the SSL session, the certificate of registration is downloaded to the user's Web browser. If the certificate signed matches the CA's corresponding public key in the browser, the Web site will be authenticated. SSL helps to detect Web spoofing by inspecting the certificate of the Web site (Thomas, 2000).

Secure HyperText Transfer Protocol (S-HTTP)

Secure HyperText Transfer Protocol (S-HTTP) is a secure extension to HTTP which provides a number of security features, including client/server authentication, spontaneous encryption, transaction confidentiality, and request/response nonrepudiation. The protocol was designed to be general enough to provide broad support for a number of different secure technologies, including symmetric encryption for data confidentiality, public key encryption for client/server authentication, and message digests for data integrity. S-HTTP was also designed to be interoperable with nonsecure HTTP services.

S-HTTP provides the user with the ability to communicate securely with a Web server by selecting the desired secure properties of the transaction. S-HTTP supports a vast array of options to enforce the secure properties, which make S-HTTP flexible, but more difficult to configure for the Web site developer.

Smart Cards

Smart cards can be used in many different applications, including electronic commerce; home banking; access to corporate intranets, networks, and E-mail programs; and computer and building security. The cards are also used by transit systems for fare payments on buses, subways, and toll roads. The new contactless smart card product called Practical Security can be read from a distance using an infrared signal. This product will automatically log computer users on or off as they approach or leave their terminals. Smart card technology will replace existing passwords and authentication methods in computers and on the Internet (Sandler, 1998). A serious limitation among proponents of general-purpose smart cards has been the lack of standards. With all the different manufacturers and types of cards, interoperability/functionality does not look like the central focus.

Smart cards are one technology the U.S does not lead because of the deregulated nature of the U.S. financial and telecommunications industries. A new blend of Java promises the ability to use a single card for multiple applications-such as electronic cash, credit, debit and buying-profile data (Chen, 2000). Java also allows hardware-independence, such that a single version of Java applet would run on any Java smart card, and of robust security, permitting a vendor to insert new applets into the card but minimizing the risk of criminals breaking into the card's data. The security algorithm in a smart card is in ROM.

The SSL and Secure HTTP technologies provide a source level encryption for data thereby assuring the consumer that no data leaves their computer until it is secured. The Smart Card technology on the other hand provides a means whereby the consumer an alternative means for paying for the products and services online and at the same time limit the potential loss in the event of a security breach. This alternative is required simply to guarantee faster transaction. The SSL and Secure HTTP inherently needs to perform additional functions before the data is transmitted and needs to reverse the process while receiving data. This requires additional processing time. However, Smart Card has the information encoded in the card itself thereby the processing time is reduced. The following table shows the growth of households online over the years, including a projection for 2004:

Year	Number of households in millions
1995	14.9
2000	46.5
2004	90

Source: www.internetstats.com

With an estimated 90 million households trying to send data online that needs to be secured, Smart Card indeed provides a cost-effective alternative. The liability reduction of Smart Card comes from the fact that the worth of a Smart Card at any one time is limited to a few hundred dollars and it is also well suited for micro-transactions involving small sums since we saw earlier that it costs a significant sum per transaction for offline processing.

LOOPHOLES

The loopholes exist in every technology that has been tried so far. This is inevitable in a fast changing technology. In the brick-and-mortar world people are able to observe and judge a business based on their location and size. In the e-commerce world this is not quite easy. For example, a con artist could easily develop a good web site similar to a well-known company's site and offer items for purchase. In the process the site could ask for people's credit card information and misuse that information. Along similar lines, a major corporation that wants to make available as much information as possible to the customers might inadvertently leave a hole in their computer system. This could be taken advantage of by people and cause hardship to genuine users as was the case in the recent 'denial of service attacks' on major web sites. These issues reinforce the need for building trust among the e-commerce partners (Keen, 2000).

Efforts are already underway to address some of these loopholes. A new tool called the Security Profile Inspector (SPI) is available to perform security assessment. This tool can analyze and point out potential loopholes in system configuration. In addition, this tool can alert the systems administrator when an intrusion is attempted. Another such software is Tripwire.

CONCLUSION

We have discussed several methods available for secure Internet transactions. Extensive deployment of fiber cables and the availability of high-speed access such as ADSL (Asymmetric Digital Subscriber Line) have made it possible for people to access the Internet in a secure way. Moreover, companies like Amazon.com and eBay have given the confidence to customers for online transactions. Recent trend in e-commerce indicates that several billion dollars worth of transactions are already taking place on the Internet. Enhancing security further only helps to do more business online.

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THIN CLIENT COMPUTING: BUSINESS SAVIOR TO THE HIGH COST OF COMPUTING?

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ABSTRACT

Business computing is attempting to come full circle with its interest in thin client computing. In the 1960's the mainframe computer, with its dumb terminals, was the only productive computing system available. Today, thin client network computing appears to be able to take business computing back towards this arrangement. The thin client ideal promoted over the last few years have, to date, not delivered on many of its promises.

INTRODUCTION

Business computing today comes in many different shapes, forms, and flavors. Businesses can rely on mainframe computers, mini computer platforms such as the IBM AS400 platform, Personal Computer (PC) networks, SUN SPARC platforms, or any combination there of. The computing choices available to business today are endless and at many times confusing. Many companies started out developing their systems with focus on a specific platform but then expanded to other platforms to provide specific functionality or cost savings not available on the original platform. Other businesses have allowed branch offices or divisions (especially larger organizations) to select their own platform as long as the functionality required was provided to their customer base, and networking issues were not a problem. Regardless of how most companies have ended up with numerous platforms the fact remains that having several different platforms to support is extremely expensive. Technical support from computing professionals with specific skill sets in each platform is a necessity, maintenance contracts with hardware vendors (most hardware platforms are proprietary, and thus very expensive) is also required in order to provide redundancy and high reliability, and software licensing and contracting to provide operating systems and applications for developers and end users. Add all these factors up and even a large corporation can send itself into bankruptcy if they don't manage their information systems efficiently (Ruley 1997).

TYPES OF NETWORKS

Most computer networks consist of combinations of platforms, operating systems, and applications. A small corporate network might consist of a mini-computer, several PC servers, and up to one hundred PC workstations scattered throughout the company. However, a large corporate

network can consist of a mainframe or several mainframe computers, dozens of mini-computers, hundreds of PC servers and literally thousands of PC workstations. The costs of operating and maintaining these large-scale information systems can run into the hundreds of millions of dollars.

With the costs associated with corporate computing continuing to escalate, organizations are looking for ways to reduce costs. In 1995, Oracle CEO Larry Ellison announced that an inexpensive Network Computer (NC) would soon be made available by Oracle that would not only provide an inexpensive hardware solution, but also run an operating system that was platform independent. "The Java VM (Virtual Machine) enables Java-based NC programs to be both operating-system and CPU-architecture independent." This was the first formal announcement of a thin client solution to network computing. With this announcement, many organizations began planning for the implementation of these new workstations with high hopes of reducing corporate computing costs. "The NC is coming, make no mistake about it, and it will be embraced by many managers as the solution to out-of-control costs associated with the conventional desktop computing paradigm. (Molta 1997)" Oracle, IBM and Sun are currently the main supporters of the NC.

A Network Computer terminal or NC is similar to a mainframe dumb terminal. Unlike a PC that can operate independently, a NC cannot function without a server to connect to. "An NC is basically an X terminal (think of it as a PC sans hard drive) enhanced just enough to run a Java virtual machine (VM) (Ruley 1997)."

The NC approach is very attractive to many organizations for several reasons. First, with a workstation that can support any platform, applications can now be run anywhere without being stored and run on the local workstation. "You don't have to be backing up your disk or upgrading your software or worrying about your software getting hit with a virus. All of that will be done for you on a professionally managed network." states Chris Gladwin of Cruise Technologies (Schwartz 1997). Second, with only one type of hardware configuration, corporate support can streamline their operations and support only that one platform. Third, security can be enhanced because the user cannot operate a NC independently. The server has complete control over access to network resources.

Proponents believe that NC's simply won't be accepted. "Very few front-line employees are ready for the roller-coaster ride associated with a radical makeover of their desktop environment, especially if the ticket for all the excitement is a loss of control, performance and flexibility (Molta 1997)". Also, JAVA has not yet proven itself to be reliable and efficient enough for today's high demand business computing. It requires considerable computing resources and is not stable enough for critical applications. Another factor hindering the NC is the fact that JAVA developers and resources are in very high demand, as well as relatively scarce, which is driving up costs. Vern Higberg, VP of IS for Atlanta-based delivery giant United Parcel Service stated, "We're not totally convinced that total cost of ownership of the NC environment is that much better than a well-managed PC environment.(Sweat 1997)" ". NCs process data locally, first downloading JAVA applications from the server, then processing the application, and finally storing data back on the server. After the tasks are completed, the NC deletes the application.

Another Network Computer platform is called the NetPC. The NetPC was introduced by Intel, Microsoft and Compaq as a Network Computer utilizing its own hardware and software but managed by a centralized server. "A NetPC, as defined by Intel and Microsoft, is essentially a Windows-based PC with local computing power and storage but optimized to be managed centrally

from a server. (Russel 1997).”” NetPCs offer the ability for the operating system and applications to reside on the NetPC or on the server. If the operating system and applications are on the server, the NetPC downloads both at startup, then deletes them on shutdown. The NetPC is designed to be centrally managed yet still provide the power of standard PCs and greater end user control and security. Also, end users have the choice of storing their data either on the server, or on the NetPC. However, the NetPC does not include floppy drives or CD-ROM drives, so end users cannot install software on their NetPC workstations.

A third category of Network Computers is called “Windows Terminals”. This Network Computer is the closest thing to a mainframe dumb terminal currently available. Windows Terminals do no local processing, but simply display graphics downloaded from a server. Windows Terminals offer the highest level of security, can be set up quickly in most cases, and are very inexpensive (since they do no local processing, less powerful hardware can be employed). This platform is also very attractive to large organizations looking to cut information systems overhead, and add additional reliability and security.

The main difference between the platforms is the direct levels of control that both network administrators and end users have over the workstation. Windows Terminals offer the highest levels of security, but the least user flexibility since they are basically dumb terminals, the end user has virtually no control. With an NC, the server maintains almost complete control, whereas with a NetPC, administrators have the ability to allow end users more control over their workstations, since the NetPC workstation can run its own operating system. "The NetPC can be configured as a NC or as a terminal and can alter or change the usage model for that particular device," said Ron Peck, director of network client marketing for Intel's Desktop Products Group.

The main similarity between the platforms is the hardware they use. All three platforms are based upon current PC architecture. Both typically have an Intel or compatible CPU, PC memory, motherboard and chassis, monitor, keyboard and mouse. The reasons for this are obvious: PCs are inexpensive. “The NC will gradually take more building blocks from the PC because it's the cheapest way to build a platform,” states Chris Gladwin. However, it must be noted that thin client computers do place high demand on a companies network infrastructure. Because these platforms are so dependent upon network data, they typically require a tremendous amount of bandwidth. This must be considered by any company looking to implement thin client technology with their organization. Additional benefits are that PCs are becoming more and more powerful and supporting enhanced functionality such as multi-media.

NETWORK STANDARDS

As of today, the current Network Computer standard is the Network Computer 1 (NC-1). IBM, Sun Microsystems, Netscape Communications, and Oracle described the NC-1 Reference Profile of minimum requirements for a device called a NC (Gilbertson 1997). According the NC reference file, the NC is not intended to replace PCs but to coexist with them in the workplace. Also, several attributes are expected such as the NC must be architecturally neutral, have a much lower total cost of ownership than personal computers, have a lower entry price than a typical personal computer, and be significantly easier to use and administer (Online 1999). NC-2 is currently being developed and has not been released, but is expected to have additional requirements such as an

overall emphasis on promoting network manageability, support for international environments, common cross-platform network booting system and more (Shah 1998).

The theory behind thin clients is a simple one. Provide distributed computing resources throughout the organization that is easily managed, inexpensive, flexible enough to support multiple platforms, and easily upgrade-able. There is a distinct need and market developing for thin client computing even with the PC dropping in price almost daily. “Unlike the PC, the thin client is purely an information-access device, with little of the overhead and few of the headaches of today's PCs.”, said Robert Gilbertson, president and CEO of Network Computing Devices Inc.

CONCLUSION

Business computing is attempting to come full circle with its interest in thin client computing. In the 1960’s the mainframe computer, with its dumb terminals, was the only productive computing system available. Today, thin client network computing appears to be able to take business computing back towards this arrangement. The thin client ideal promoted over the last few years have, to date, not delivered on many of its promises. Most companies that announced early on that they would be developing thin client workstations have fallen behind schedule and in some cases, not delivered at all. This is unsettling to corporate customers who want to see cost savings as soon as possible. "NCs were initially portrayed as $500 do-everything devices," says Zona analyst Greg Blatnik. "Quite frankly, announced products, technologies, and a whole series of things have not been delivered as predicted." (Hayes 1997).

As with any technology in today’s marketplace, these delays can only serve to damage the thin client platform. Other technologies are being produced that offer more functionality, similar costs, and at presently available. These delays are also causing the role of thin clients to narrow. They are primarily being used as terminal replacements in the retail, financial, and manufacturing industries (Hayes 1997).

Will end users accept the thin client platform? Will management reap all the benefits thin client distributed Network Computers have to offer? As with anything in the computer industry, thin client computing could be the wave of the future, or completely forgotten in a matter of months, only time and technology will tell.

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APPLYING THE TECHNOLOGY ACCEPTANCE MODEL TO THE WWW

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ABSTRACT

The WWW is one of the most critical information technologies of the new millennium. However, little is understood about the personal dynamics that affect its usage. In this study, the survey research method is used to explore the factors involved in the voluntary use of the WWW. The technology acceptance model (TAM) (Davis, 1989) is applied to WWW use to determine the relationships among perceived usefulness (U), perceived ease of use (EOU), and usage (USE) for a sample of n=295 university students. Structural equation modeling with LISREL software is used to evaluate the appropriateness of the TAM measurement scales and to estimate the strengths of the causal relationships in the TAM. Due to the unique nature of WWW use, several TAM items are found to be inadequate measures of perceived usefulness and perceived ease of use. Additionally, many of the relationships among TAM variables are found to be substantially different when compared to previous studies of end user computing systems.

INTRODUCTION

The WWW is a recently emerging and extremely important information technology. As evidence of the WWW's growth and influence, the value of goods and services provided via e-commerce was estimated at $3.0 billion in 1998 and is expected to mushroom to $75 billion in 2000 (Lieb, 1999). Online advertising expenditures in the U.S. alone will grow from $2.8 billion in 1999 to $22 billion by 2004 (Pastore, 1999). Two out of three American households now have access to the Internet at home, work, or school. Ninety-two million adults in North America (approximately 40% of the adult population) now use the Internet, with 55 million shopping online (Lieb, 1999). However, little research exists on understanding the psychological factors that contribute to the use of the WWW.

The technology acceptance model (TAM) (Davis, 1989) has experienced more than a decade of relative success in predicting and explaining the acceptance of many types of end user computing systems in work or school settings. However, it has not been rigorously applied to what may perhaps be the single-most important information technology of the new millennium—the WWW. It is vitally important to study the acceptance of the WWW since it is so far-reaching and should have a tremendous impact on the personal and economic lives of literally billions of individuals in the near and distant future (Hoffman et al., 1999; Graphic, Visualization, & Usability Center, 1999). Understanding more about the acceptance of the WWW can lead to significant improvements in the

design of both software and hardware to increase its usefulness and ease of use. Applying the TAM to the WWW can also lead to a better theoretical understanding of possible important differences between the WWW and of other types of end user systems.

The purpose of this study is to explore the relationships among the factors that may influence the voluntary, personal use of the WWW. In order to apply the TAM to the WWW, a survey instrument that includes the twelve standard TAM items was administered to n=295 college students at a large Midwestern university. A rigorous analysis of the measurement and structural equation models was conducted on the collected data using LISREL (version 8.3) software, yielding some very unexpected and interesting results. Background on the WWW and TAM are now presented followed by a discussion of the research methodology and results. The paper concludes with an exploration of the study's implications and a call for additional research.

APPENDIX I
Davis' (1989) U and EOU Items ("X" represents the target system)

Perceived Usefulness (U) Items	Perceived Ease of Use (EOU) Items
Using X in my job would enable me to accomplish tasks more quickly.	Learning to operate X would be easy for me.
Using X would improve my job performance.	I would find it easy to get X to do what I want it to do.
Using X in my job would increase my productivity.	My interaction with X would be clear and understandable.
Using X would enhance my effectiveness on the job.	I would find X to be flexible to interact with.
Using X would make it easier to do my job.	It would be easy for me to become skillful at using X.
I would find X useful in my job.	I would find X easy to use.

BACKGROUND

Usage of the WWW

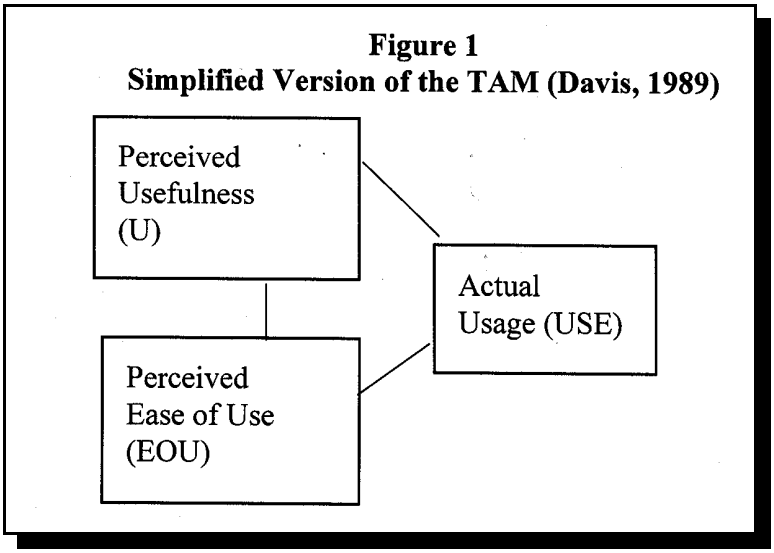
A recent comprehensive survey (GVU Center, 1999) has brought to light many interesting aspects of WWW usage. Nearly two-thirds of all WWW users are between the ages of 21 and 45 and two-thirds of all users are male. Some 85% of all users live in the U.S. with a nearly equal percentage having attended or graduated from college. About half of all users have been online for less than three years, and half of all users access the WWW from home with another 35% connecting at work. Two-thirds of all WWW users connect via a 56k or slower modem. The two most frequent problems cited with the WWW are slow speed (61%) and broken links (57%). The overuse of graphics (48%) and being unable to find needed information (45%) were also among the top five problems cited. Gathering information for personal needs was the most frequently cited reason for using the WWW followed by work, entertainment, and education. Nearly 90% of all

WWW users do so just to have fun and explore. There is no doubt that the WWW has already achieved a high rate of acceptance, but it is also clear that there is much room for improvement in both the quantity and quality of future use.

The Technology Acceptance Model (TAM)

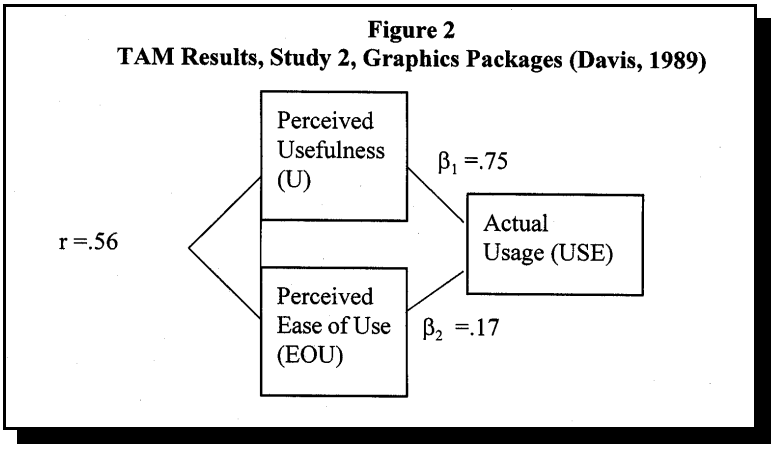
The TAM (Davis, 1989) was developed to predict and explain the voluntary use of any type of end user computing system used within the context of one's job. As Figure 1 illustrates, TAM postulates relationships among three constructs, perceived usefulness (U), perceived ease of use (EOU), and actual (or self-reported) usage (USE) of the system. The individual items that constitute the U and EOU scales are provided in Appendix I where "X" represents the target system under consideration (such as electronic spreadsheets, word processors, or email). U and EOU are expected to directly influence USE while U may also mediate the effect of EOU on USE.

Figure 1
Simplified Version of the TAM (Davis, 1989)



The original intent of the TAM was to explain and predict the voluntary usage of end user computing systems in a work environment. The results of nearly all previous studies indicate that U is the predominant determinant of USE, that EOU is usually a very weak or nonexistent influence on USE, but that EOU is a moderately strong influence on U. As a typical example, Davis (1989) uncovered the relationships shown in Figure 2 for use of a graphics package.

Figure 2
TAM Results, Study 2, Graphics Packages (Davis, 1989)



The voluntary use of the WWW may exhibit many characteristics that differ from those of the voluntary use of systems in a purely job-related or school-related environment. Using the WWW to search for specific information of personal interest (sports, weather, jobs, etc.) or to simply "browse" for entertainment may be quite different than using a system to schedule production in a factory or to complete a homework assignment. The goal of this research is to explore such differences, if they exist.

METHODOLOGY

The Instrument

The survey instrument (see Appendix II) consists of demographic items (age, gender, major) and questions concerning the extent of computer use in general and WWW use in particular. Questions about the use of the WWW include both the amount and purpose of WWW usage. The survey concludes with the twelve items that constitute the standard TAM scales for measuring perceived usefulness (U) and perceived ease of use (EOU). These twelve items were scrambled in order to avoid methods bias.

The wording of the TAM items in the survey differs from the original in two important ways. First, the term "the WWW" is substituted for the name of the target system, "X." It is a standard practice to replace "X" with the term used for the specific end user system under consideration. Second, references to the user's "job" are replaced with the user's "favorite activity" (an activity that the user can and does perform on the WWW, but can also be performed by conventional means, as explained in the survey instructions). Examples of such activities include searching for a job on the WWW instead of searching for one in the newspaper, or browsing for baseball cards on the WWW instead of at the card shop.

To help ensure content validity, the instrument was pilot tested on several faculty who teach WWW use and a class of 40 students who had recently been trained in WWW use. Several improvements were made in the original instrument prior to its final administration.

The Subjects

The subjects for this study originally consisted of 571 students from a large midwestern university. These students were nearing completion of their respective computer-related courses, thus ensuring that they were very computer literate. The students ranged from freshman to seniors and represented a wide cross-section of majors. The participants were requested to complete the survey to receive extra credit in their respective courses, and virtually all complied. Since the application of the TAM is predicated on the *voluntary* use of a system, a final sample of only n=295 subjects was used for analysis based on their response on the survey that at least 50% of their use of the WWW was to meet personal needs (as opposed to satisfying job or school requirements). Thus, the use of the WWW by these respondents was largely voluntary.

Analysis

The analysis method will involve first applying LISREL (version 8.3) structural equation modeling software to evaluate the appropriateness of the TAM measurement model for the three constructs under consideration (U, EOU, and USE) in a WWW context. After any required modifications of the measurement model, LISREL will be applied to the structural equation model as presented in Figure 1. The goodness of fit of the measurement and structural equation models will be evaluated using several standard measures provided by the LISREL output. Table 1 lists the specific measures to be used and their recommended cutoff values for satisfactory model fit (Bentler and Bonnet, 1980; Bollen, 1989; Hair et. al, 1992; Sharma, 1996).

Table 1
Goodness-of-fit Indicators and Recommended Cutoff Values

Goodness of fit (GFI)	> 0.90
Adjusted goodness of fit (AGFI)	> 0.80
Normed fit index (NFI)	> 0.90
Comparative fit index (CFI)	> 0.90
Incremental fit index (IFI)	> 0.90
Root mean square residual (RMR)	< 0.05

The recommended technique for improving the fit of either the measurement model or the structural equation model is to perform successive iterations with LISREL to identify offending estimates, such as item loadings on constructs or path coefficients in the structural model (Joreskog and Sorbom, 1993). Of course, a sound theoretical basis is required before eliminating paths from models (Hair et. al, 1992). The final resulting structural model should shed light on how the acceptance of the WWW for personal use may differ from the acceptance of end user systems for work-related use.

RESULTS

Demographics of the Respondents

Respondents to the survey were fairly equally divided among four groups: freshmen enrolled in a required introductory IT course, sophomore business majors enrolled in a required intermediate IT course, senior business majors (non-IS majors) enrolled in an MIS course, and sophomore/junior IS majors. Of the n=295 students who completed the survey, 47% were at least 21 years old and 53% were age 18-20. With respect to gender, 54% were male and 46% were female. Forty-eight percent of the respondents were business majors (non-IS), 23% were non-business majors, 19% were IS majors, and 10% reported no major. The subjects spend an average of 6.4 hours per week on the WWW. An average of 67% of these students' time on the WWW was for personal reasons (about half of that just browsing) with 30% to satisfy school requirements. About 50% of their time on the WWW was accessed from home, 45% from school. This sample gave an average rating of 5.8 to their overall satisfaction with the WWW.

Although the sample of undergraduate students was not random, the group provides a good cross-section from several different demographic segments of the undergraduate population of a large midwestern university. The sample represents both genders nearly equally, a wide variety of experience in both computer and WWW use, and a diversity of both age and major areas of study.

The Measurement Model

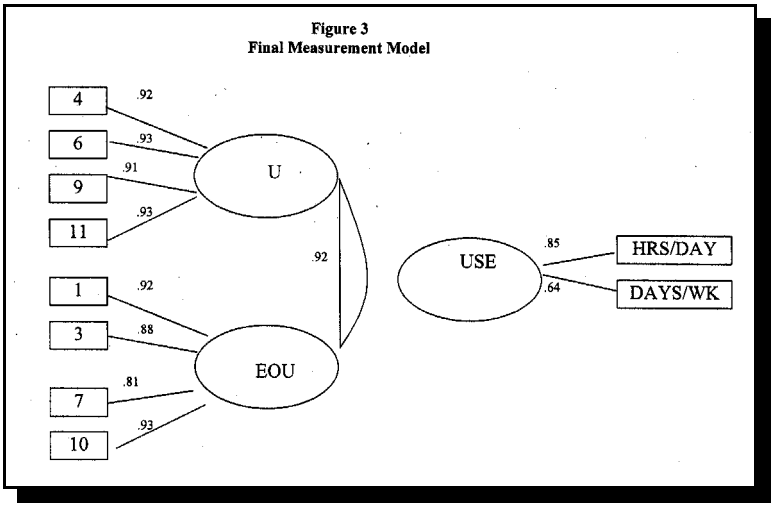
A rigorous application of LISREL software was performed on the data supplied by the final sample of n=295 students. First, the measurement model for the two variables U and EOU was evaluated. While the factor loadings of all items on their respective constructs were all quite high (ranging from 0.86 to 0.96), many of the goodness of fit indicators were far below the recommended cutoff levels. The LISREL output includes modification indices that identify which items are offending estimates and are thus candidates for removal from the model. Following the recommended process of successive refinement of the measurement model for U and EOU (Joreskog and Sorbom, 1993; Hair et. al, 1992), a total of four of the twelve TAM items were removed from the U/EOU model. Table 2 lists those items removed and the rationale for their removal.

Table 2
Offending Estimates in U/EOU Measurement Model

Items Removed (in order)	Rationale for Removal
12. It was easy for me to become skillful at using the WWW.	The concept of "skill" may not be especially germane in the context of personal WWW use.
8. Using the WWW makes it easier to perform my favorite activity.	Originally intended as a U item, the term "easier" may cause confusion with EOU issues.
5. I find the WWW flexible to interact with.	The "flexibility" concept has been noted as problematic in previous research.
2. Using the WWW enables me to perform my favorite activity more quickly.	The WWW is notorious for poor performance, especially when using slow modems.

The measurement model for USE originally consisted of three indicators: HOURS/DAY, DAYS/WEEK, and SESSIONS/DAY. A LISREL analysis of this model resulted in the removal of SESSIONS/DAY due to a relatively low factor loading of 0.42 (with a recommended cutoff of 0.5) (Pedhazur and Schmelkin, 1991). The complete measurement model is displayed in Figure 3 showing the survey items that serve as indicators of the three TAM constructs: U, EOU, and USE. The item loadings on their respective constructs are also shown.

Figure 3
Final Measurement Model

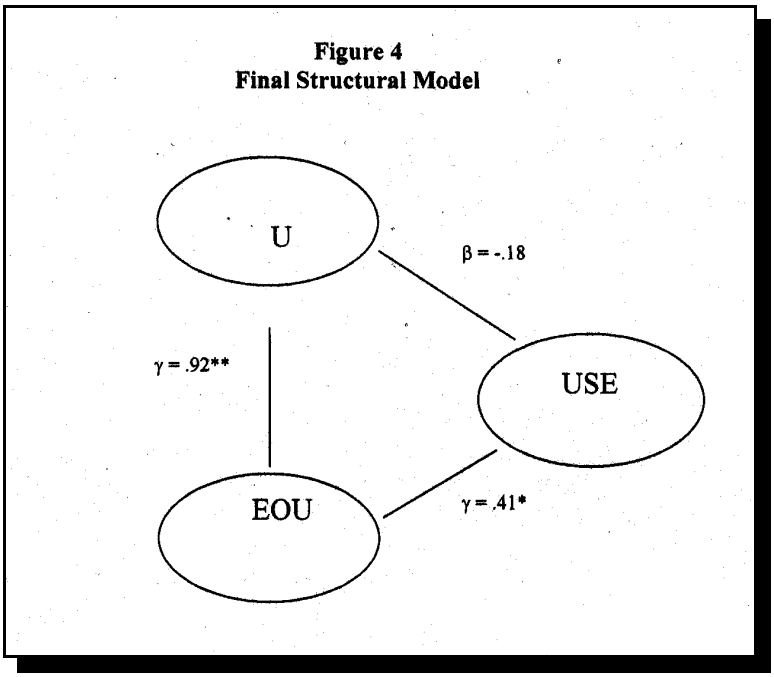


The Structural Equation Model

Once the best-fitting measurement model for WWW acceptance is established, the structural equation model may be analyzed to determine the relationships among model constructs. The very

first attempt to establish the relationships was quite successful resulting in the structural model in Figure 4. All goodness of fit indicators fell within their acceptable ranges. The final model indicates that there is no significant relationship between U and USE, but there are substantial and significant relationships between EOU and U, and between EOU and USE.

Figure 4
Final Structural Model



DISCUSSION

The Measurement Model

Obtaining a measurement model that fits the collected data, as explained in Table 2 and displayed in Figure 3, points to several important findings. First, consider the removal of Item 12 (easy to become skillful) from the TAM scale. The ease with which one becomes skillful at using the WWW may be a very distinct issue from the ease with which one uses the WWW once the skill is obtained. It is a common perception that navigating the WWW effectively by using search engines (e.g., Yahoo, AltaVista, Infoseek) and by following hyperlinks can be a daunting task to a beginner. Also, the concept of skill may not apply to recreational or personal use of the WWW as much as it does to the work-related use of an end user system. For example, one does not normally think of skill in the context of such recreational activities as watching movies or window-shopping.

The wording of Item 8 in the TAM scale ("Using X makes it easier to perform Y.") may be confusing since Item 8 was originally intended as a measure of U. The term "easier" may invoke thoughts of EOU from the respondent. Item 5 (flexibility of the system) has a history of measurement problems (Davis, 1989) as respondents may not have a clear idea of exactly what is meant by the term "flexibility" in the context of using a software package. Also, flexibility may be

considered a usefulness concept instead of an ease of use concept (as it was originally intended in the TAM). Finally, Item 2 ("Using X enables me to perform Y more quickly.") may not apply in the special case of the WWW, as it is known to be notoriously slow, especially when a slow modem is used as an access device (Overton, 2000).

The Structural Model

The structural model of Figure 4 also suggests many interesting relationships that may be unique to the WWW. The results of most applications of TAM are represented by Figure 2 where perceived usefulness (U) has a strong influence on actual use (USE), perceived ease of use (EOU) has a moderate influence on USE, and EOU has virtually no influence on USE. But the tables are turned dramatically when the WWW is considered, as evidenced in Figure 3. Perceived usefulness (U) has no significant influence on actual use. While one expects only a moderate influence of EOU on U, the WWW application exhibits a very strong influence of EOU on U. Finally, traditional TAM results predict virtually no effect of EOU on USE, but the WWW environment suggests that EOU is a moderately strong determinant of USE.

The question naturally arises as to why the results of applying the TAM to the WWW should be so decidedly contrary to the results of several other previous studies. The answer possibly lies in the focus on personal use of the WWW in contrast to the work-related use of end user systems in previous studies. If one's goal in using the WWW is primarily personal (browsing, entertainment, etc.), there may be little time or performance pressure involved. Additionally, "user comfort" may be of much higher concern. Therefore, the ease with which one is able to use the WWW should be a strong determinant of actual use. When a particular task is mandated (jobs must be scheduled or homework assignments must be completed), the usefulness of a system is of paramount importance and ease of use is secondary (Davis, 1989).

The perceived ease of use of the WWW has a very strong influence on perceived usefulness. Being able to quickly and easily navigate the WWW to accomplish personal goals is certainly a worthwhile objective. However, perceived usefulness has a very small (negative) influence on use, and cannot even be meaningfully addressed since the relationship is not statistically significant. Personal use of the WWW may be useful in the sense that it satisfies one's curiosity or entertains, while the use of end user systems in the workplace may be useful in the sense that they allow one to keep a job or get a promotion. The latter type of utility, where there are clear-cut goals and expected beneficial outcomes resulting from the achievement of such goals, should have a particularly strong influence on future use, as indicated in previous studies of TAM.

Implications

While it may be tempting to conclude that the personal use of the WWW is not as important as the work-related use of other types of end user systems, it is important to remember the tremendous economic impact that the WWW is now having and will continue to have in the future. This research suggests that in order to enhance the usage of the WWW, developers of Web sites, network administrators, and hardware providers must pay particular attention to the ease of use issue. Web sites must be well designed, network downtime must be minimized, and connection

speed must be improved. As recent surveys indicate (GVU Center, 1999), ease of use of the WWW is often a sore spot with users.

This study also suggests that enhancing perceived ease of use should have a very strong effect on perceived usefulness. Although perceived usefulness had no effect on use in this study, this situation may change in the future. As WWW users become more familiar with this new technology and use it to achieve more concrete and more economically vital personal goals (such as business-to-consumer e-commerce or job hunting), one would expect that perceived usefulness would have a more substantial impact on use.

Limitations and Future Research

One limitation of this study is the use of student subjects. Many students may not have the financial means to perform some important personal activities on the WWW, such as making credit card purchases. However, of all users of the WWW, a very sizable portion (nearly 25%) falls in the age range of 18-25 (GVU Center, 1999). The subjects were also not selected at random, so the results are not generalizable to the population of university students, let alone the general population of WWW users. However, the goal of this study is not to uncover TAM relationships for a general population, but simply to do so for a particular target group.

To overcome these limitations, a random sample of all WWW users should be surveyed. A distinction should be made between the uses of the WWW for personal, as opposed to work-related, reasons. The logistics of obtaining such a random sample could, however, be formidable, but worthwhile. A follow-up study on the personal use of the WWW would be able to confirm or refute the results obtained in this research.

The TAM could also be applied to the use of specific Web sites or to specific Internet hardware configurations. Such research could highlight conditions of good or poor site design, or the effect of connection speed on acceptance.

CONCLUSION

A survey of n=295 university students, who use the WWW primarily for personal reasons, revealed that the dynamics of WWW acceptance are very different from those of the acceptance of end user systems utilized for work-related purposes. Previous research involving the technology acceptance model (TAM) (Davis, 1989) has found that the perceived usefulness of a system has a strong effect on actual use and that perceived ease of use has little direct impact on actual use, although perceived ease of use wields moderate influence over perceived usefulness. In the case of personal use of the WWW, perceived ease of use has a moderate effect on actual use and a very strong effect on perceived usefulness. However, perceived usefulness has virtually no effect on actual use of the WWW. The major implication of these findings is that designers and developers in the field should strive to dramatically improve the perceived ease of use of the WWW to boost actual use in the future. This will also be increasingly important as users of the WWW begin to develop an enhanced perception of its usefulness in terms of e-commerce. Researchers should also realize that the dynamics of technology acceptance might depend heavily on the primary purpose of its application.

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APPENDIX II

Survey on Using the WWW

Please read each item *carefully* and respond to *all* items to the best of your ability. Thank you for your cooperation.

Name (optional, but required of students to receive extra course credit): _____

1. Age: _____ 2. Gender: M F 3. Major (if currently a student): _____

4. Amount of experience using the WWW: ____ years (____ months, if less than one year)

5. Approximately what percent of your total time on the WWW is spent using each of the following?

WWW Browsers You May Use	%
Netscape	
Microsoft Internet Explorer	
AOL	
CompuServe	
Other (please specify):	

Note: Your total should add to 100%.

6. About how many hours per week do you spend using a computer? _____

7. About how many hours per week do you spend writing or reading e-mail? _____

8. About how many hours per week do you currently spend using the WWW? _____

9. Approximately what percent of your total time using the WWW is spent for each of the following purposes?

Your Purpose in Using the WWW	%
Meet personal needs	
Satisfy job requirements	
Satisfy school requirements	
Other (please specify):	
Other (please specify):	

Note: Your total should add to 100%.

10. Approximately what percent of your total time using the WWW is spent on each of the following activities?

Your WWW Activities	%
Browsing (satisfying general curiosity about one or more subjects)	
Personal research on a specific subject (news, weather, sports, stock prices, etc.)	
Job-related research on a specific subject	
School-related research on a specific subject (if you are a student)	
Electronic commerce (actually buying and/or selling goods and/or services)	
Game playing	
Other (please specify):	
Other (please specify):	
Other (please specify):	
Other (please specify):	

Note: Your total should add to 100%.

11. Approximately how many days per week do you currently use the WWW? _____

12. On the days you use the WWW, about how many different sessions are involved? _____

13. Approximately what percent of your total time using the WWW is spent at each of the following locations?

Your Location When Using the WWW	%
Home	
Place of employment	
School	
Other (please specify):	
Other (please specify):	

Note: Your total should add to 100%.

14. Please circle *one* of the numbers (1 through 7) corresponding to your level of agreement or disagreement with each of the following statements. A *"favorite activity"* means one you can perform on the WWW, do perform on the WWW often, but can be performed in other ways. Examples would include reading news on the WWW instead of in a newspaper, chatting online instead of on the telephone, browsing a bookstore online instead of at the mall, doing school research on the WWW instead of at the library, buying tickets online instead of on the telephone, etc.

Statement About Using the WWW	Strongly Agree			Neither			Strongly Disagree
I find the WWW easy to use.	1	2	3	4	5	6	7
Using the WWW enables me to perform a favorite activity more quickly.	1	2	3	4	5	6	7
I find it easy to do what I want to do on the WWW.	1	2	3	4	5	6	7
Using the WWW improves the performance of a favorite activity.	1	2	3	4	5	6	7
I find the WWW flexible to interact with.	1	2	3	4	5	6	7
Using the WWW enhances my effectiveness in performing a favorite activity.	1	2	3	4	5	6	7
Learning to use the WWW was easy for me.	1	2	3	4	5	6	7
Using the WWW makes it easier to perform a favorite activity.	1	2	3	4	5	6	7
I find that the WWW is useful in performing a favorite activity.	1	2	3	4	5	6	7
My interaction with the WWW is clear and understandable.	1	2	3	4	5	6	7
Using the WWW increases my productivity in performing a favorite activity.	1	2	3	4	5	6	7
It was easy for me to become skillful at using the WWW.	1	2	3	4	5	6	7
I use the WWW more often than most of my peers.	1	2	3	4	5	6	7
Overall, I am satisfied with the WWW.	1	2	3	4	5	6	7

Please check to make sure you answered all items. Thanks again for your cooperation.

STUDY OF MODULATION USING GRAPHICAL PROGRAMMING AND VIRTUAL INSTRUMENTS

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ABSTRACT

Advanced electronics and computerization are revolutionizing today's industries and the engineering technology and science programs are under pressure to modernize their programs to meet the challenges of this changing technology or to maintain the accreditation of the programs. This requires upgrading laboratories with modern equipment and calls for increased funding and resources. But in recent years there is an increase in enrollment and decrease in resource allocation making it increasingly difficult to modernize the laboratories to provide adequate levels of laboratory and course work. This calls for alternative cost effective methods such as Graphical Programming and Virtual Instruments (VIs). These Virtual Instruments use graphical data flow programming and can contain any combination of industry standard hardware to acquire or output data. Because Virtual Instruments are PC based, the students can access them form any place at any time. This benefits non-traditional students who may have to work or take care of family. This will also help the regular students who need more time to complete an assignment. The goal of this paper is to discuss the design and development of a state-of-the art Computer Based Virtual Engineering Laboratory (CBVEL) and Analog Communication VIs.

INTRODUCTION

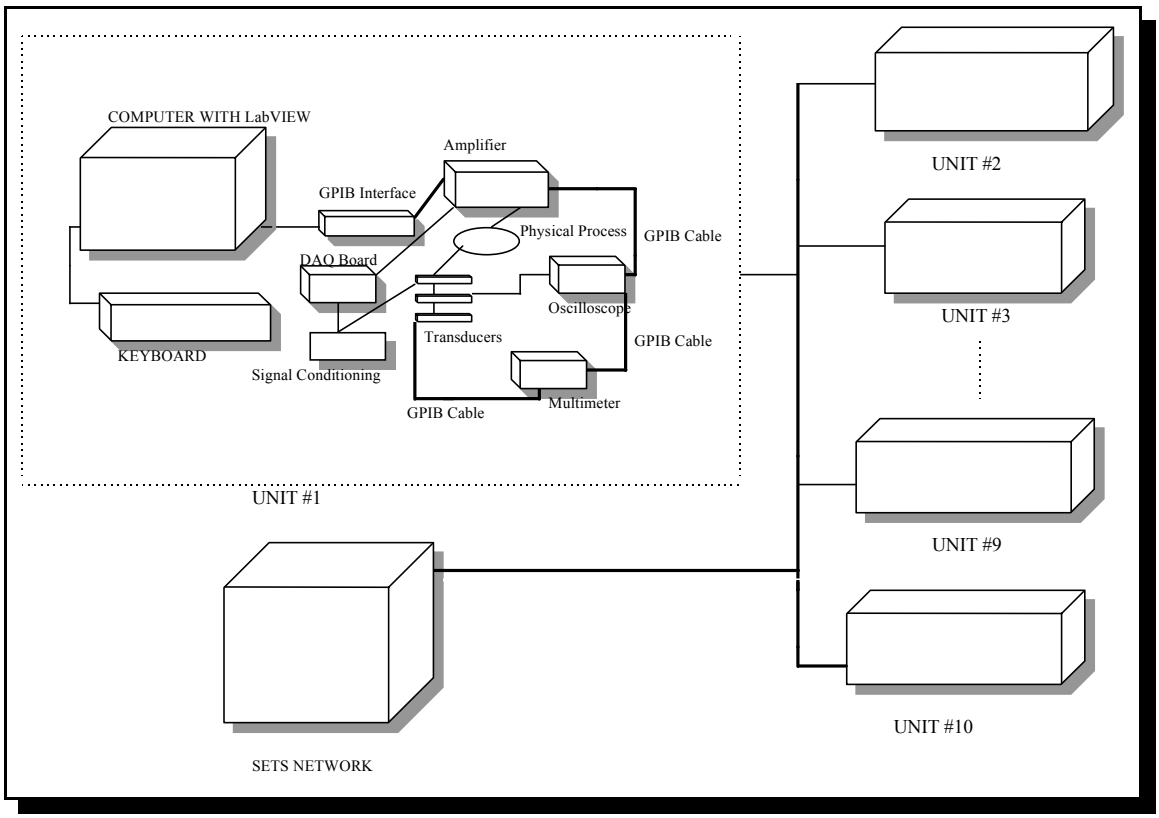
Technologies change fast. As these changes occur, industries need trained technologists and scientists to meet their new workforce requirements. Advanced electronics and computerization are revolutionizing today's industries and the engineering technology and science programs are under pressure to modernize their programs to meet the challenges of this changing technology or to maintain the accreditation of the programs. This requires upgrading laboratories with modern equipment and calls for increased funding and resources. But in recent years there is an increase in enrollment and decrease in resource allocation making it increasingly difficult to modernize the laboratories to provide adequate levels of laboratory and course work (Korrapati & Swain, 2000). This calls for alternative cost effective methods such as Computer Based Virtual Engineering Laboratory (CBVEL), which can be accomplished by using the following:

A	*Graphical Programming software (LabVIEW) and hardware (DAQ boards, GPIB interface etc.) from National Instrument.*
B	*Object Oriented Programming Software (Visual Basic, Java).*

We strongly believe that by modifying the existing laboratories through the addition of computers with appropriate DAQ and SCXI instrumentation, software (LabVIEW, Visual Basic, & Java) we can better educate and train our graduates to serve the needs of the technological and engineering community. Students will be skilled with hardware and software that is used throughout industry, at other undergraduate institutions, and graduate schools. Because of the flexibility of Visual Basic, LabVIEW and the associated interface, the system will be customized to suit the instructional and research needs of various departments. Virtual Instruments (VIs) relating to different courses will be integral part of this CBVEL. Examples of some of these VIs are Digital Electronics, Analog and Communications, Digital Signal processing, Digital Filters. These modules will be used to better train the engineering technology, sciences, and information technology graduates (Swain, Anderson, & Korrapati, 2000). This paper is arranged as follows:

BLOCK DIAGRAM OF CBVEL

The block diagram of CBVEL is presented below (Swain, Anderson & Korrapati, 1999):



The various component of this CBVEL are personal computers, LabVIEW software, programming languages like C++, Java, Visual Basic, DAQ cards, GPIB and other interfaces. These components can be purchased from National Instruments. The LabVIEW graphical

programming language is extremely versatile, and can be used to design and develop Virtual Instruments for various courses. The following are some of the application areas of LabVIEW:

Simulation - simulates physical processes

Data Acquisition - data acquisition from outside source

Data Processing - built in analysis library that includes signal generation, measurement, filters, windows, curve fitting, probability and statistics, linear algebra, and numerical methods,

Instrument and Control - Virtual Instruments (vi)

Program Development - Object oriented/graphical programming

Fuzzy Logic - fuzzy logic tool box

ANALOG COMMUNICATION VIs

This section describes in brief the underlying principles behind Amplitude Modulation, Frequency Modulation and Demodulation (Miller, 1996).

AM ANALYSIS

The frequency of human voice ranges from about 20 Hz to 3000 Hz. Transmission of such low frequencies as radio waves is impractical and useless because of a) interference problem and b) the largeness of antenna. The solution to this problem is Modulation. Modulation is a process of mixing a low frequency information and high frequency carrier through a nonlinear device. The transmission takes place at the high frequency (the carrier) which is modified to carry the low frequency information. Assume that the high frequency carrier is given by the following equation:

$$v = V_P \sin (wt+F) \qquad (1)$$

where

v = *instantaneous value,*
V_P = *peak value,*
w = *angular velocity = 2Õf,*
F = *phase angle*

Any one of these three terms could be varied to produce a modulated signal that contains intelligence. If the amplitude term V_P is varied, the resulting modulation is called as Amplitude Modulation (AM), if f term is varied, the resulting modulation is called as Frequency Modulation (FM), and if F is varied, the resulting modulation is called as Phase Modulation (PM). In reality, most of the transmission is carried out as a combination of all these three modulation techniques. In this paper we will concentrate on the Amplitude Modulation VI, Frequency Modulation VI and

Demodulation VI. The IT graduates encounter the modulation and demodulation concept (MoDem) in their networking and telecommunication classes. The modulation/demodulation VIs will help them to understand the subject matter better.

The amplitude for the AM wave form can be written as a sum of carrier amplitude E_c and intelligence amplitude e_i.

$$E = E_c + ei \quad (2)$$

$$\text{But } e_i = E_i \sin w_i t \quad (3)$$

$$E = E_c + E_i \sin w_i t \quad (4)$$

Let m be a measure of the extent to which carrier voltage is varied by intelligence, and m is defined as

$$m = \text{modulation index} = E_i / E_c \quad (5)$$

Equation 5 gives $E_i = m E_c$ *, and substituting* E_i *in equation 4 gives*

$$E = E_c + mEc \sin w_i t = E_c (1 + m \sin w_i t) \quad (6)$$

The instantaneous value of the AM wave is

$$e = E_c (1 + m \sin w_i t) \sin w_c t \quad (7)$$

Equation 7 can be written as

$$e = E_c \sin w_c t + (m E_c /2) \cos (w_c - w_i)t - (m E_c /2) \cos (w_c + w_i)t \quad (8)$$

Equation 8 shows that the AM waveform contains three terms:

1. *the upper side frequency* $f_c + f_i$
2. *the lower side frequency* $f_c - f_i$
3. *the carrier* f_c

In an AM, the carrier amplitude and frequency is always constant whereas the sidebands are usually changing in amplitude and frequency. The carrier contains most power since its amplitude is always approximately twice of the sideband's amplitude. The total power in an AM is given by

$$P_t = P_c (1 + m^2/2) \quad (9)$$

Where P_t = *total transmitted power (watts),*
P_c = *carrier power (watts),*
m = *modulation index*

FM ANALYSIS

Both frequency modulation and phase modulation fall under the general category of angle modulation. Frequency modulation is a special case of angle modulation where the instantaneous frequency of a carrier is varied by an amount proportional to the modulating signal amplitude. Noise and bandwidth are two basic limitations on the performance of a communication system. The performance of an amplitude modulated communication system degrades with the magnitude of the external noise, and they have limited bandwidth. FM was developed to address these limitations of

FM. The mathematical analysis of angle modulation is complex, and requires the use of high-level mathematics. In this paper we will use a formula to design our VI. The equivalent formula for FM is given by:

$$e = A \sin (w_c t + m_f \sin w_i t) \quad (10)$$

where

e = instantaneous voltage,
A = peak value of original carrier wave,
w_c = carrier angular velocity,
m_f = modulation index for FM, and
w_i = modulating signal angular velocity.

$$m_f = \text{modulation index for FM} = d/f_i \quad (11)$$

where

d = maximum frequency shift caused by the intelligence signal (deviation)
f_I = frequency of intelligence signal.

The VI for amplitude modulation is designed using equation 7 and is presented in Figure 1. Figure 2 presents a VI for modulation index and power. The VI for frequency modulation is designed using equation 10 and is presented in Figure 3. Figure 4 presents the VI for demodulation. It uses the AM VI of Figure1 and a Butterworth Filter to filter out the carrier. The students can use these VIs to study the AM, FM, and Demodulation concept. The interested reader may refer to Sokoloff (1998) to learn how to program in LabVIEW (Anderson, Korrapati, & Swain, 2000; Swain, Anderson, & Korrapati, 2000).

CONCLUSION AND DISCUSSION

The AM VI presented in Figure 1 is simulated with 50% modulation index, 150 Hz carrier frequency and 10 Hz signal frequency. The user can simulate this VI with different values for these three parameters and observe over modulation, under modulation, and 100% modulation. The Modulation Index and Power VI in Figure 2 is simulated with modulation index values of 0 to 1.5 with 0.25 increments in modulation index. The sideband power and total power is calculated and presented for each value of modulation index. This VI is helpful to decide the amount of modulation. Usually, in an AM most AM transmitters attempt to maintain between 90% to 95% modulation as a compromise between efficiency and the chance of drifting into overmodulation. Figure 2 represents the FM VI. This VI is simulated with signal frequency of 10 Hz and carrier frequency of 100 Hz. The lower sidebands are at frequencies less than carrier frequency (100 Hz) and the upper sidebands are at frequencies greater than carrier frequency. The demodulation VI is presented in Figure 4. This VI uses the modulation VI of Figure 1. The output of the modulation VI is passed through a Butterworth Filter VI to remove the carrier and recover the original signal.

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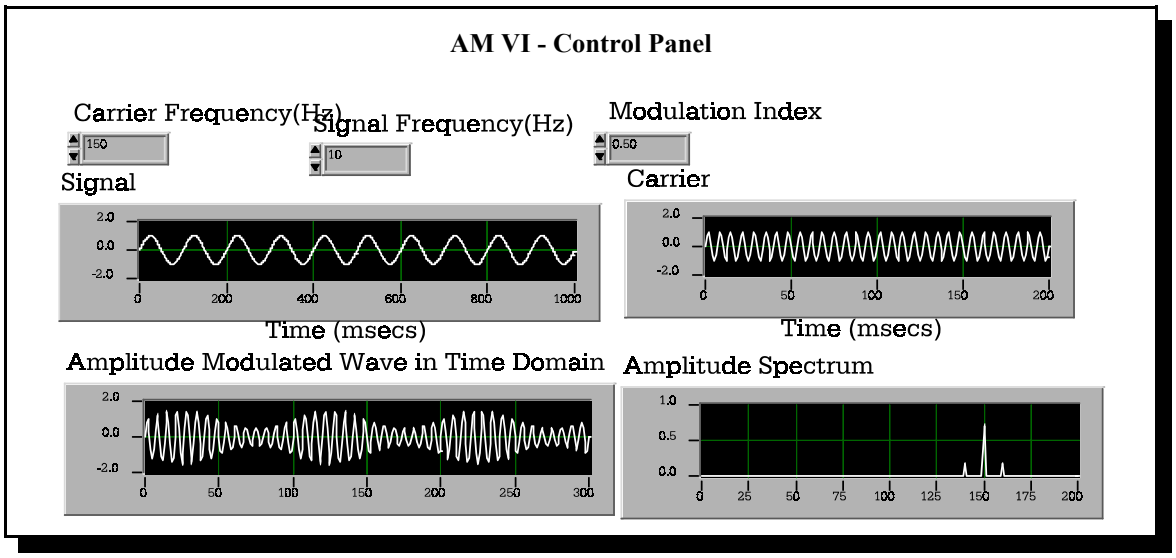
Figure 1: Amplitude Modulation VI



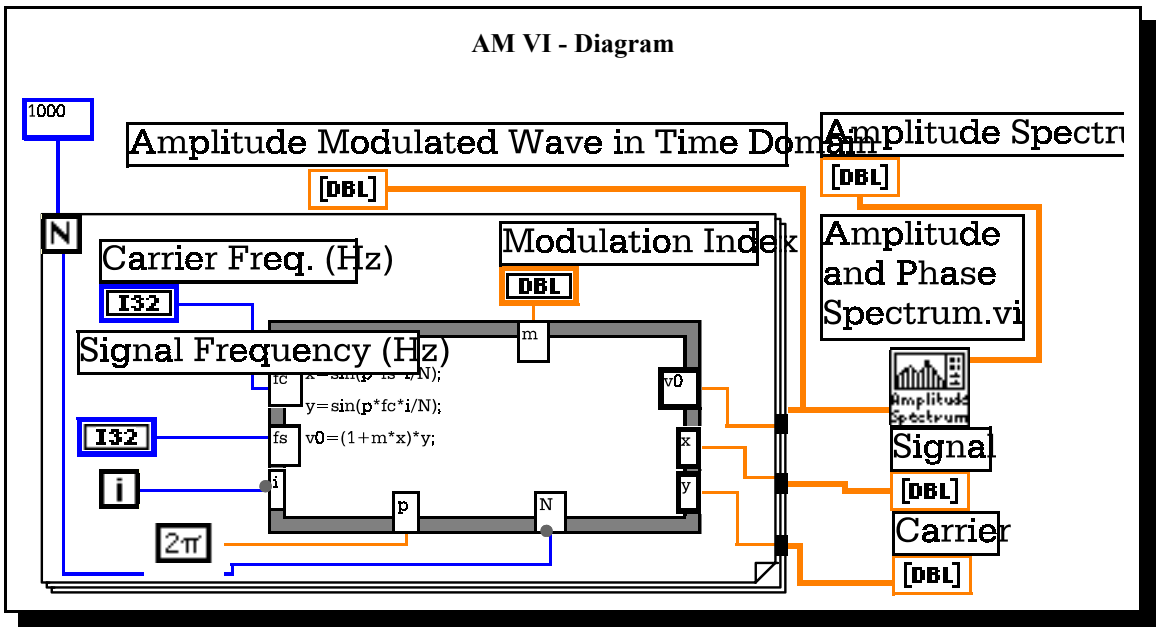


Figure 2: Modulation Index and Power VI

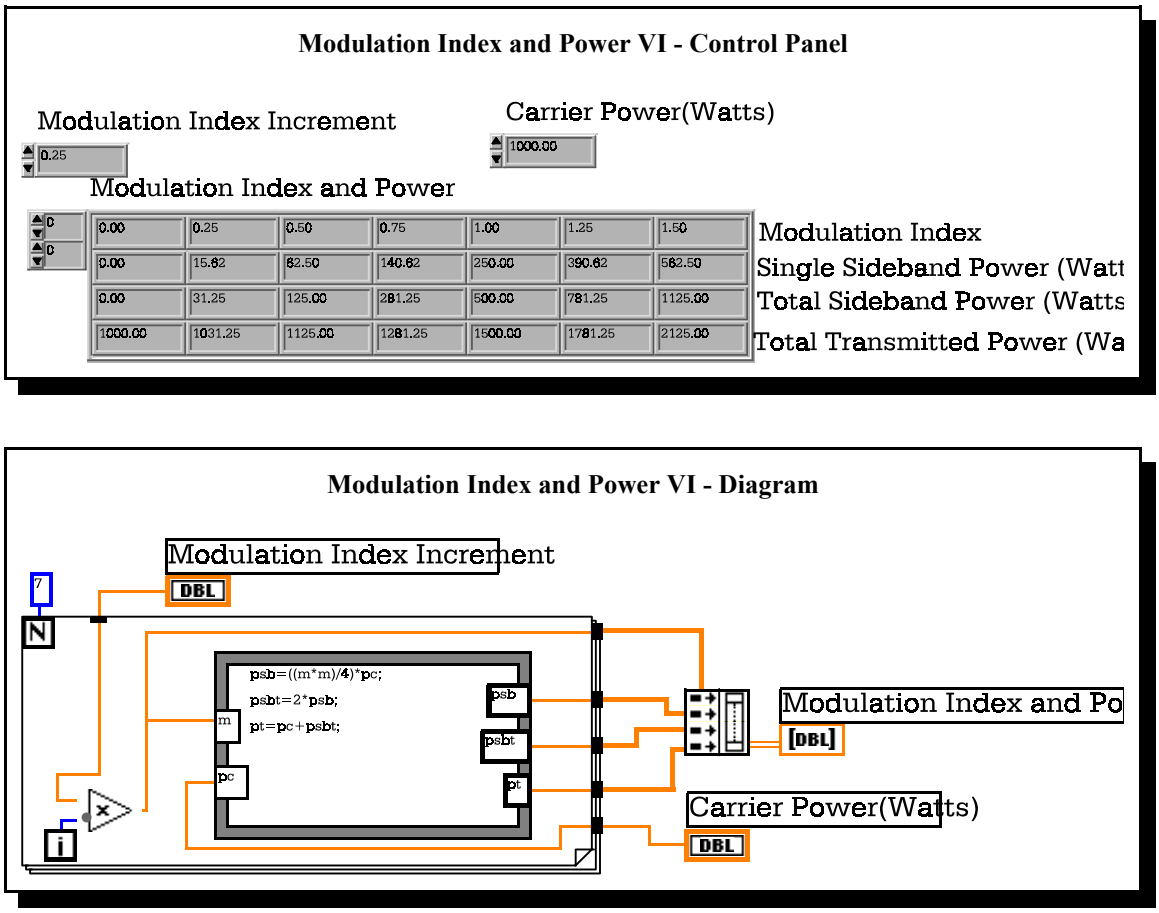
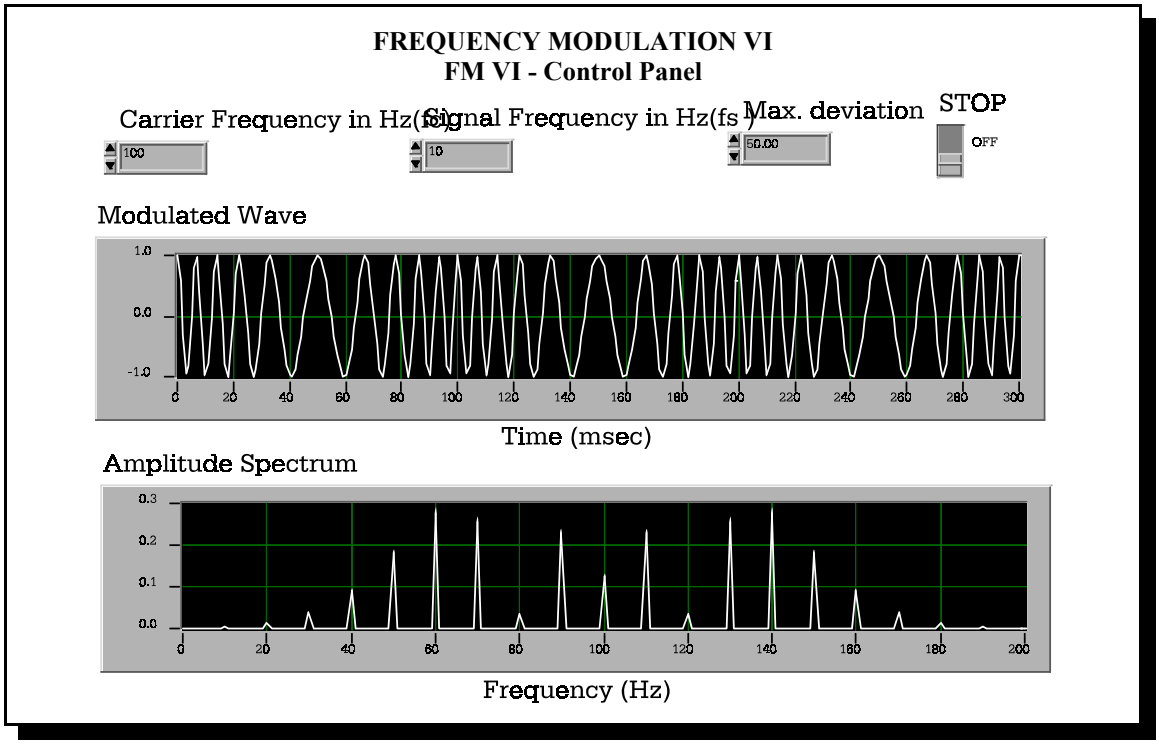


Figure 3: Frequency Modulation VI



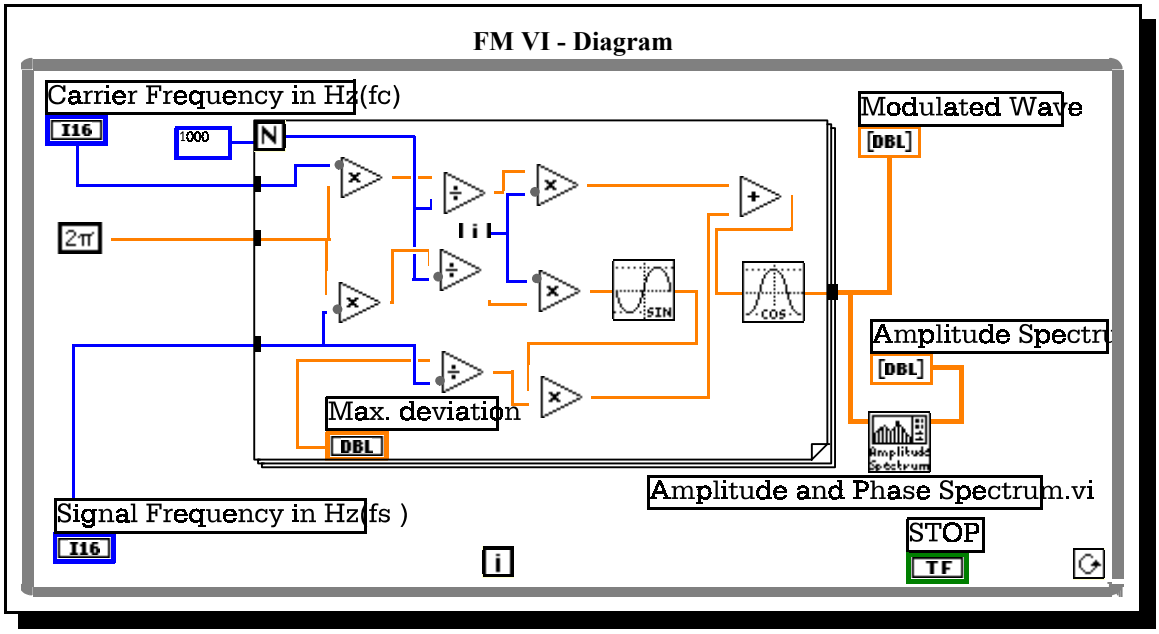
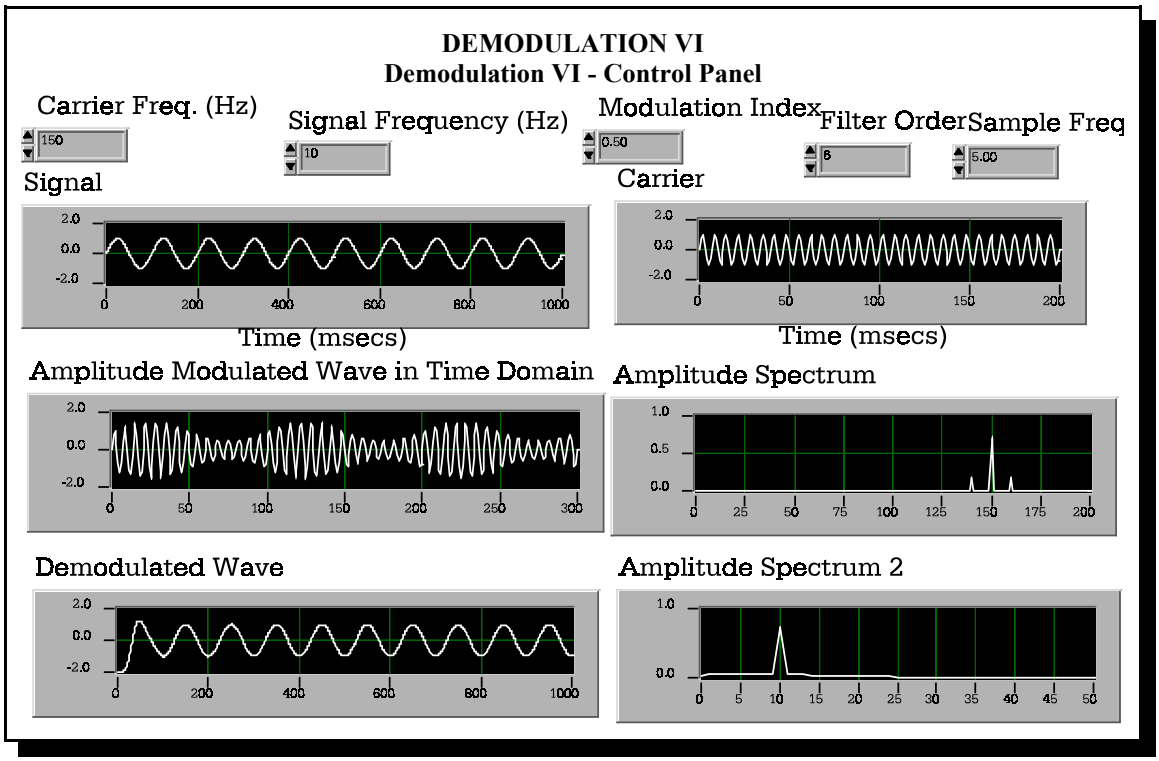
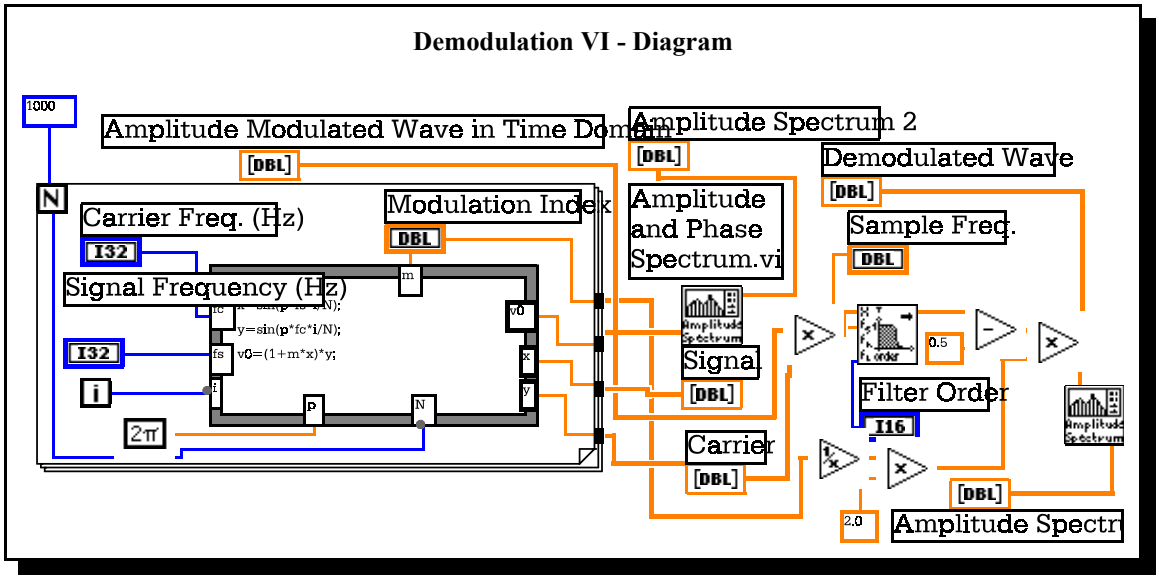


Figure 4: Demodulation VI





ARTIFICIAL INTELLIGENT SYSTEMS ARCHITECTURE FOR STRATEGIC BUSINESS DECISION MAKING: A PROTOTYPE NEURAL EXPERT SYSTEM WITH WHAT-IF FUNCTIONS

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Jae Ho Han, Pukyong National University
C. Christopher Lee, Central Washington University

ABSTRACT

This paper presents a neural expert system approach to designing an intelligent strategic planning system. The main recipe of the proposed neural expert system is an inference mechanism capable of performing forward inference. Four strategic planning portfolio models are considered such as BCG matrix, Growth/Gain matrix, GE matrix, and Product/Market Evolution Portfolio matrix. The proposed neural expert system could provide "what-if" functions, which prove to be very useful for unstructured decision making problems such as strategic planning problems. What-if functions are accomplished through the forward inference mechanism, enabling the neural expert system to provide appropriate outputs with respect to the given inputs. This study developed a prototype system, named StratPlanner, running on Windows 2000. Using the Korean automobile data, we performed experiments under experimentally designed competitive situations. Results support our supposition that the neural expert systems approach is useful for performing competitive analyses. Further research topics associated with the current research are discussed.

INTRODUCTION

Recently, a number of researchers in OR/MS (Operations Research/Management Science) have attempted to build intelligent expert systems for solving a wide variety of problems including production scheduling, finance, personnel, marketing, and accounting, etc (Waterman 1990). Common motivation underlying these researches is to intelligently assist decision-makers that have to solve poorly structured problems. The strategic planning problem is one of highly ill-structured OR/MS problems. Strategy, in effect, is the managerial action plan for achieving organizational objectives; it is mirrored in the pattern of moves and approaches devised by management to produce the desired performance. Strategy is therefore the how of pursuing the organization's mission and reaching target objectives (Thompson, Strickland III 1990). Today's managers have to think strategically about their company's position and about the impact of changing conditions. They have to monitor the external situation closely to know when the current strategy needs to be changed accordingly. The advantages of strategic thinking and conscious strategic planning activity include

(1) providing better guidance to the entire organization on the crucial point of "what it is we are trying to achieve," (2) making management more alert to change, new opportunities, and threatening developments, (3) providing managers with a much-needed rationale that argues strongly for steering resources into strategy-supportive, results-producing areas, (4) helping unify the numerous strategy-related decisions by managers across the organization, and (5) creating a more proactive management posture and counteracting tendencies for decisions to be reactive and defensive. The advantage of being proactive versus reactive is that long-term performance is enhanced. Business history shows that high-performing enterprises often initiate and lead, not just react and defend. They see strategy as a tool for securing a sustainable competitive advantage and for pushing performance to superior levels.

Computer-based strategic planning systems are playing an increasingly relevant role in assisting both diagnosis of strategic problems likely to threaten the organization's performance and suggesting strategic alternatives to solve those problems. When designing such systems, certain objectives must be considered carefully. First of all, strategy analysts or managers in organizations should be able to use reliable, low-cost, user-friendly instruments--for example, programs running on personal computers. Nevertheless, to meet strategy analysts' requirements, processing time should be relatively short. Since any failure of such systems could prove seriously harmful to an organization's competitive position and performance, both fault tolerance and reliability are the crucial properties to be satisfied by such computer-based strategic planning systems. At the same time, the strategy analysts must be provided with as much information as possible about how the processing is carried out.

In an effort to accomplish these objectives, developers of computer aids for strategy analysts face a variety of problems deriving from the complex nature of strategic planning-related data. Such data is characterized by an intrinsic variability, which is the result of spontaneous internal mechanisms or as a reaction to occasional external stimuli. Furthermore, most events related to the strategic planning result from the interaction of many factors and sub-factors whose different effects are almost indistinguishable.

Strategy analysts are accustomed to such problems, but their skills cannot easily be incorporated into computer programs. Most strategic planning decisions are based on experience as well as on complex inferences and extensive strategic knowledge. Such experience and/or knowledge cannot be condensed into a small set of relations or rules, and this limits the performance of algorithmic approaches or conventional expert systems approaches to many strategic planning tasks. The breadth of strategic planning knowledge is therefore an obstacle to the creation of symbolic knowledge bases (for example, IF-THEN rules) comprehensive enough to cope with the diverse exceptions that occur frequently in practice. Experience-based learning, fault tolerance, graceful degradation, and signal enhancement are properties of neural networks that make the neural network-assisted expert systems effective in solving the strategic planning problems. This points to a way for implementing reliable computer-based strategic planning systems that can closely emulate a strategy analyst's expertise.

This paper presents the basic part of a prototype system named StratPlanner (Strategy Planner), which is a neural expert system for diagnosing strategic problems and suggesting strategic alternatives that seem appropriate for the current competitive situations. We will mainly focus on two issues: (1) the design of a neural expert system which is suitable for performing the "what-if"

and/or "goal-seeking" analyses and (2) the competence of neural expert systems-driven strategic planning process in real strategic planning situations. Section 2 briefly discusses a basic theory of strategic planning and neural networks. Strategic planning techniques that are used in this paper are introduced in section 3. Inference mechanisms--forward inference and backward inference--are presented in section 4. In section 5, the performance of a prototype StratPlanner is illustrated with extensive experimental results. This paper is ended with concluding remarks in section 6.

STRATEGIC PLANNING AND NEURAL NETWORKS

A survey of the huge volume of contemporary practical and theoretical literature on neural network analysis yields the following three observations:

A	*There exists a great variety of viewpoints and approaches to neural network analysis.*
B	*A general design principle that will help determine an appropriate architecture of neural networks for a particular application does not exist. It varies with the characteristics of applications.*
C	*Major emphasis has been put upon experimental results obtained from extensive simulations, not upon rigorous theoretical derivations or proofs.*

These general observations also prevail in neural network applications to OR/MS topics. The neural network analysis has embraced a very broad scope, from early success with neuron-like models called perceptrons (Rosenblatt 1961) and Adalines (Widrow, Hoff 1960) in the 1960's to the cooperative-competitive neural networks in the 1970's. Hopfield (1982) suggested an iterative computational neural network for associative retrieval and optimization, triggering a current explosion of interests in neural networks. Its theoretical basis was provided by many researchers. Some significant contributions have been made to the memory and learning models using competitive learning for autonomous feature extraction (Rumelhart, Zipser 1985) and delta learning for generalized information storage (McClelland, Rumelhart 1985). By extending these contributions, Rumelhart and his colleagues (Rumelhart, Hinto, Williams 1986) revived the backpropagation (sometimes called generalized delta) learning algorithm for the multilayer perceptrons, which has been successfully used in many experimental works (Lippmann 1987). Literature reporting the neural network applications to the OR/MS problems has recently begun to appear. White (White 1988) suggested a neural network analysis for economic prediction using the IBM daily stock returns data. Some neural network studies were performed to analyze a stock market prediction. Nonetheless, there exist a few studies that use neural networks for solving the strategic planning problems.

Neural networks have useful properties as follows (Gallant 1988, Zeidenberg 1990):

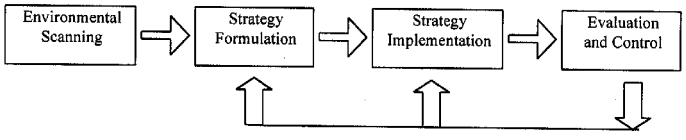
1	*Generalization capability: When the training set contains noisy or inconsistent examples, during the learning phase the neural network can extract the hidden regularities residing in the set. After learning, the neural network can generalize, giving correct responses even in the presence of examples that are not included in the training set.*
2	*Graceful degradation: In addition, due to the neural network's noise rejection capability, performance is widely insensitive to noise corrupting the input patterns. In the presence of very noisy or contradictory inputs, neural network performance decays gradually.*
3	*Heuristic mapping: Furthermore, when there exists a kind of mapping function among the input-output pairs which is difficult to be represented by some statistical forms, the neural network tends to discover the mapping function in a very heuristic manner.*
4	*Fault tolerance: In addition, their parallel and distributed processing characteristics (information is spread throughout the neural network) make the neural networks widely insensitive to neurons (or processing units) and/or connection weights deficiencies or disconnections.*
5	*Multiple inputs: Finally, the neural networks can treat Boolean and continuous entities simultaneously. Therefore, despite the type (discrete or continuous) or source of input patterns, the neural networks can receive multiple kind of input patterns and deal with them effectively.*

Because of all the properties mentioned above, the neural networks seem highly suitable for handling the strategic planning problems that are characterized by its unstructuredness and uncertainty.

STRATEGIC PLANNING TECHNIQUES

As is depicted in Figure 1, the process of strategic management consists of four basic elements: (1) environmental scanning, (2) strategy formulation, (3) strategy implementation, and (4) evaluation and control (Wheelen and Hunger, 1992). A number of strategic planning techniques have been proposed in previous researches (Abell, Hammond 1979, Glueck 1980, Larreche, Srinivasan 1982, Porter 1980, Rowe, Mason, Dickel 1982). Among them, the knowledge-based strategic planning approaches are well reviewed in Lee, Mockler and Dologite.

Figure 1
Basic Elements of the Strategic Management Process

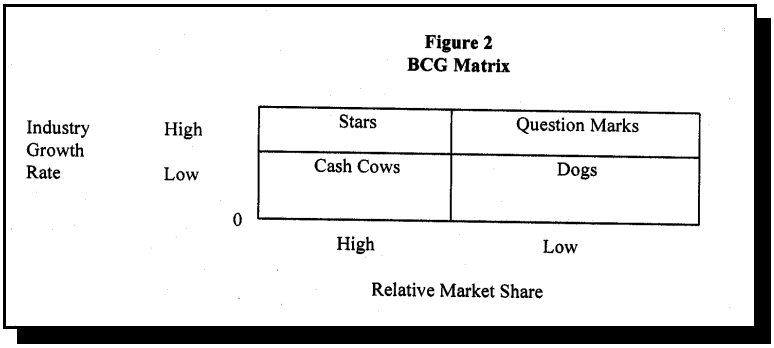


The available methods for strategic planning in the literature can be classified into three categories depending on their focuses: portfolio models, PIMS (Profit Impact of Market Strategy) analysis, and growth vector analysis. Refer to Lee (1992) for details about these three categories. Portfolio models assist managers in choosing the products that will comprise the portfolio and

allocating limited resource to them in a rational way. The PIMS analysis is designed not only to detect strategic factors influencing profitability but also to predict the future trend of return on investment (ROI) in response to the changes in strategy and in market conditions. Growth vector analysis adopts the idea of product alternatives and market scope to support the product development strategy; this results in three strategies that are penetrating a market further with its present products, imitating competitors or introducing product variants, and innovating entirely new products.

We choose four strategic evaluation methods from portfolio models: BCG matrix, Growth/Gain matrix, GE matrix, and Product/Market Evolution Portfolio matrix. The reasons are that (1) portfolio models have been widely acknowledged among researchers and practitioners and (2) four strategic methods selected can provide most of the information that might have been expected from the PIMS analysis and growth vector analysis. The BCG matrix is the single most popular method. It emphasizes the importance of a firm's relative market share, industry's growth rate, and displays the position of each product in a two-dimensional matrix. The products are called "Stars", "Cash Cows", "Question Marks", or "Dogs" by the position in the BCG matrix as shown in Figure 2.

Figure 2
BCG Matrix

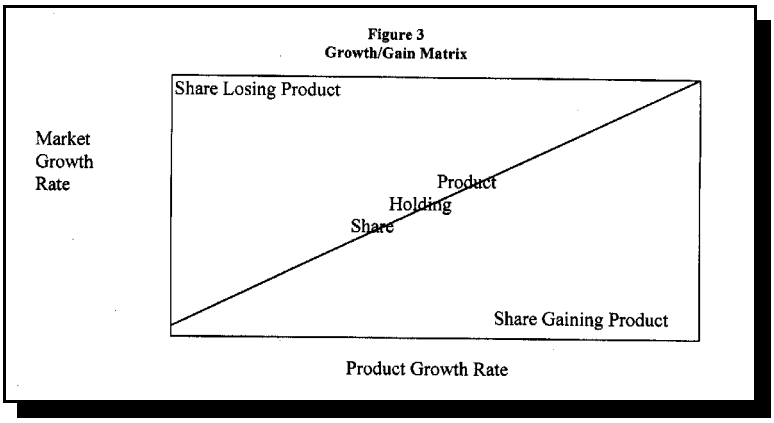


Usually the highest profit margins are expected from the "Stars", but they are also likely to require high net cash outflows in order to maintain their market shares. Eventually, the "Stars" will become "Cash Cows" as the growth slows down and the need for investment diminishes as it enters the maturity stage of the product life cycle. The "Question Marks" require large net cash outflows to increase the market share. If successful, these products will become new "Stars", which will in turn become the "Cash Cows" of the future. If unsuccessful, these products will become the "Dogs" to be excluded from the product portfolio. The BCG matrix alone is, however, not sufficient to make the investment decision because the model is too simple to cover the whole aspects of decision. In many circumstances, those factors other than relative market share and industry growth rate play a significant role in the production strategy formulation. To compensate the weakness of the BCG matrix, the Growth/Gain matrix, the GE matrix, and the Product/Market Evolution Portfolio matrix are used additionally.

The Growth/Gain matrix indicates the degree of growth of each product against the growth of market (See Figure 3). The product growth rate is plotted on the horizontal axis and the market growth rate on the vertical axis. Share gaining products appear below the diagonal line while share-losing products appear above it. The products on the diagonal line are interpreted as holding the

current market share. Alternatively, the graph displaying the trends of the products sales compared with the market size may replace the role of Growth/Gain matrix in a simpler way (Lee 1985).

Figure 3
Growth/Gain Matrix



The composite measures of the market attractiveness and the business (product) strength are plotted in the GE matrix. In order to construct the GE matrix, managers have to select the relevant factors having significant relationship with the industry attractiveness and the business (product) strength of the firm. Next they assess the relative weights of those factors depending on manager's judgment, combining the weights to depict composite measures on the GE matrix. Figure 4 shows 3 x 3 GE matrix chart depicting relative investment opportunity.

Figure 4
GE Matrix Chart

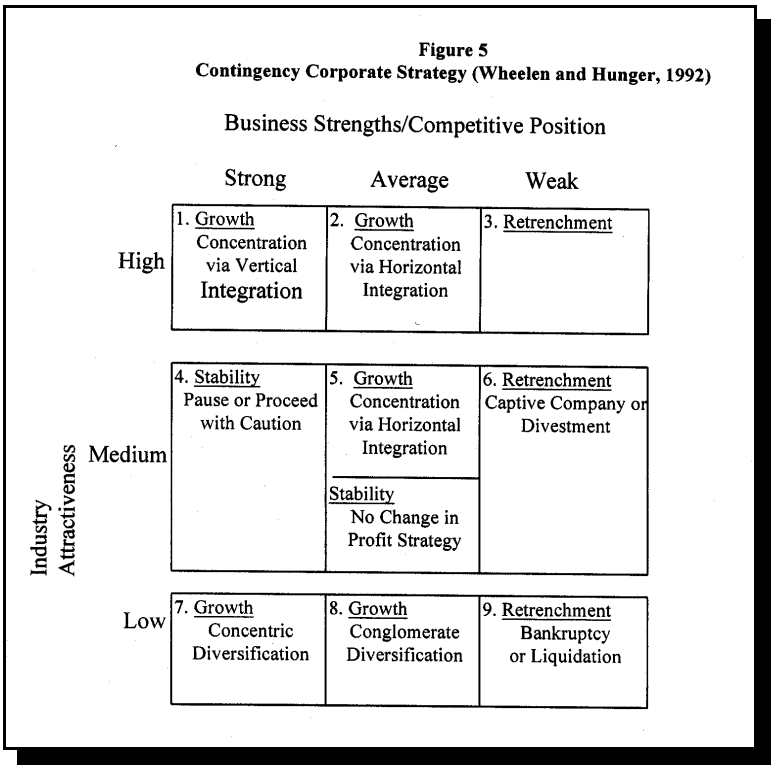
Industry Attractiveness				
	High	Winners	Winners	Question Marks
	Medium	Winners	Average Business	Losers
	Low	Profit Producers	Losers	Losers
		Strong	Medium	Weak

Business Strength/Competitive Position

Strategic managers can decide the overall direction of the firm through its corporate strategy by combining market attractiveness with the company's business strength/competitive position into a nine-cell matrix similar to the GE matrix. The resulting matrix, depicted in Figure 5, is used as a model to suggest some of the alternative corporate strategies that might fit the company's situation. Cell 1, 2, 5, 7, and 8 suggest growth strategies are either concentrated, which is expansion within

the firm's current industry, or diversified, where growth is generated outside of the firm's current industry. Cells 4 and 5 represent stability strategies--a firm's choice to retain its current mission and objectives without any significant change in strategic direction. Cell 3, 6, and 9 display retrenchment strategies, which are the reduction in scope and magnitude of the firm's efforts.

Figure 5
Contingency Corporate Strategy (Wheelen and Hunger, 1992)



GE matrix does not depict as effectively as it might the positions of new businesses that are just starting to grow in new industries. So, in that cases, Hofer and Schendel [9] proposed to use a Product/Market Evolution matrix in which businesses are plotted in terms of their relative competitive position and their stage of product/market evolution. They also recommended investment strategies at the business level (See Figure 6).

The combined use of these four strategic models can provide most of the functions necessary to effectively evaluate the corporate and/or business strategies.

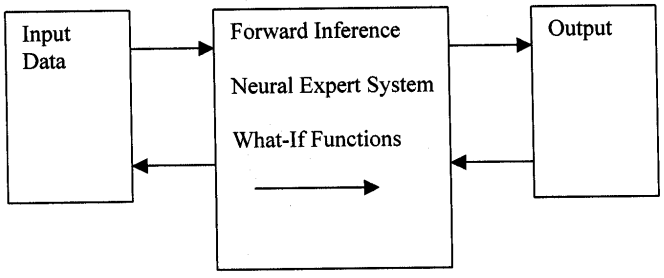
Figure 6
A Product/Market Evolution Portfolio Matrix and Recommended Investment Strategies at the Business Level (Hofer and Schendel, 1978)

		Relative Competitive Position			
		Strong	Average	Weak	Drop-Out
Stage of Market Evolution	Development Shake-Out	Share – Increasing Strategy			Turnaround Or Liquidation Or Divestiture Strategies
	Growth	Growth Strategy			
	Maturity Saturation Petrifaction	Profit Strategy		Market Concentration and…	
	Decline	Asset Reduction Strategy			

INFERENCE MECHANISM

The multi-phased aspects of strategic planning activities described above indicate that one-shot or wholesome approach is not appropriate for an effective strategic planning. Rather, to simulate a strategy analyst's reasoning as closely as possible, it would be better to divide the strategic planning-related decision-making processes into a relevant small number of subprocesses. In this respect, a forward inference mechanism suggests more robust strategies. Forward inference process helps decision-makers perform a "what-if" analysis that is essential for diagnosing the strategic problems and preparing strategic policies against the uncertain future.

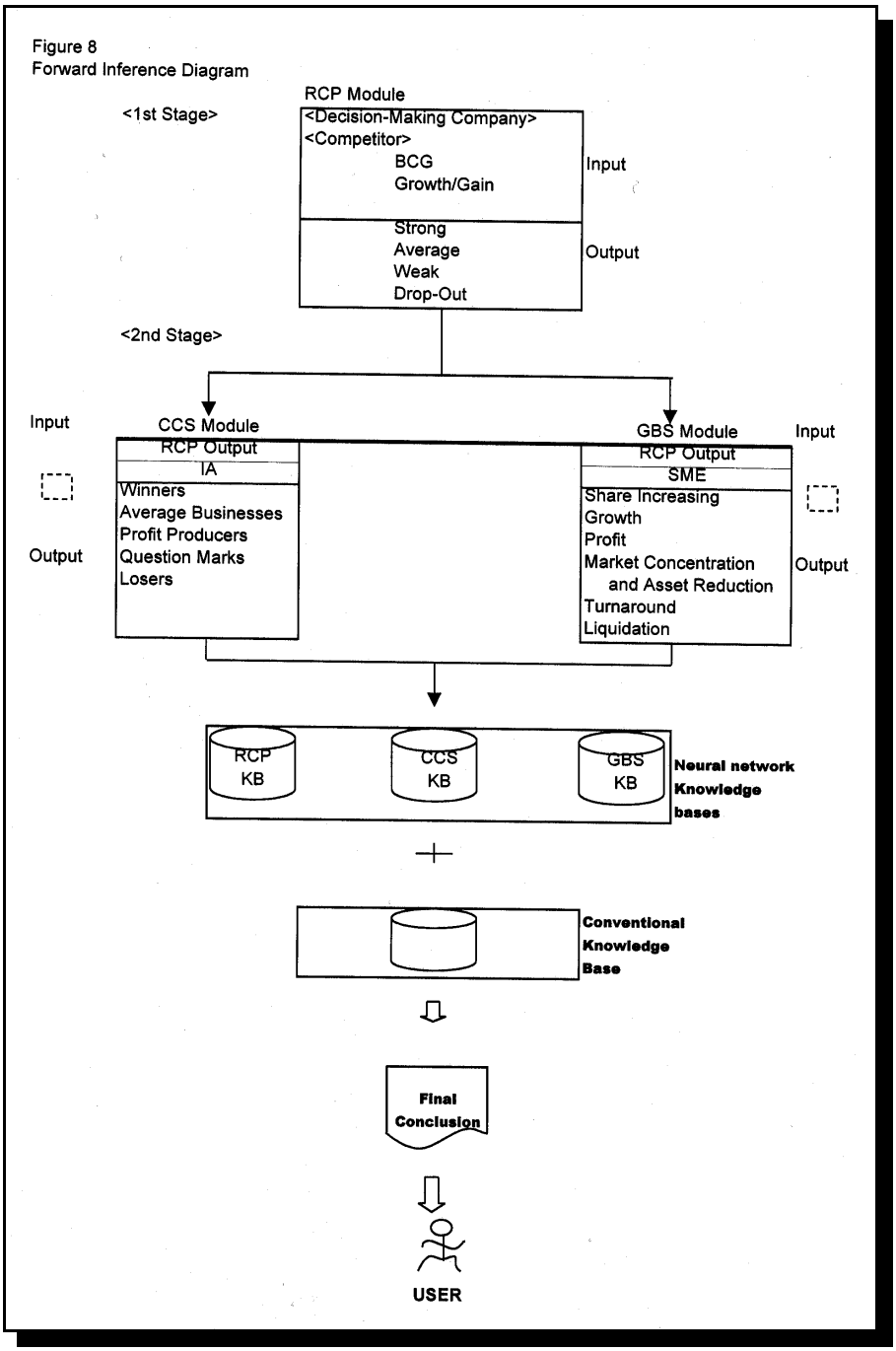
Figure 7
Overall diagram



The forward inference process is composed of two stages. The first stage uses a relative competitive position (RCP) neural network module, which suggests the competitive positions in a target market. The second stage uses both a generic business strategy (GBS) neural network module and a contingency corporate strategy (CCS) neural network module. Each module consists of one

feed-forward neural network trained by the backpropagation algorithm. Also, the stage of market evolution (SME) and industry attractiveness (IA) are also used as additional information to the CCS and GBS neural network module, as shown in Figure 8.

Figure 8
Forward Inference Diagram



In the first stage, the RCP neural network module provides information about the competitive position in the market relative to that of a target competitor. We considered two kinds of strategic planning models: BCG and Growth/Gain matrix. The architecture of the RCP neural network module has 22 neurons in the input layer and 4 neurons in the output layer (See List 1). For comparing relative competitive position between non-leading firms at the specific market, we modified the number of BCG matrix's cells from 4 to 8. The output value derived from this neural network module is used as the input value of RCP part of the CCS and GBS neural network modules. Following is a list of RCP neural network module architecture.

List 1
RCP Neural Network Module

Input Neurons:

< Decision Making Company >

BCG : Stars/Cash Cows/ H-Question Marks/ M-Question Marks/ L-Question Marks/ H-Dogs/ M-Dogs/ L-Dogs

Growth/Gain: Share Gainer/ Share Holder/ Share Loser

< Competitor >

BCG : Stars/ Cash Cows/ H-Question Marks/ M-Question Marks/ L-Question Marks/ H-Dogs/ M-Dogs/ L-Dogs

Growth/Gain: Share Gainer/ Share Holder/ Share Loser

Output Neurons:

Strong/ Average/ Weak/ Drop-Out

In the second stage, a choice is made between the GE and the Product/Market Evolution matrices according to the nature of the company's business. The criterion recommended by Hofer and Schendel (Hofer, Schendel 1978) is that if most of the businesses represent aggregations of several product/market segments, the GE matrix is more suitable; and if most businesses consist of individual or small groups of related product/market segments, a Product/Market Evolution matrix should be used. If the decision maker has difficulty making a decision based on these considerations, he should use both types of matrices to see which fits more appropriately to his own situation.

IA presents information about industry attractiveness. In this paper, to determine the degree of industry attractiveness being considered, decision-maker is prompted to select appropriate criteria, and determine their weights and ratings in five scales. According to the sum of weighted scores, one of 4 areas (High, Medium-High, Medium-Low, Low) is presented. Combining the results from RCP module and IA module, the CCS neural network module provides one of ten cells of GE matrix. The architecture of CCS neural network module is summarized in List 2.

SME presents information about the stage of the market for a product development stage, growth stage, shakeout stage, maturity stage, and decline stage. To determine an appropriate market stage of a product being considered in this paper, decision-maker is prompted to select one of the five stages.

List 2
CCS (Contingency Corporate Strategy) Neural Network Module

Input Neurons:

RCP Part : Strong/ Average/ Weak/ Drop-Out

IA Part : High/ Medium-High/ Medium-Low/ Low

Output Neurons :

H-S Winners/ H-A Winners/ M-S Winners/ H-Average

Businesses/ L-Average Businesses/ Profit Producers/ Question

Marks/ M-W Losers/ L-A Losers/ L-W Losers

Combining the RCP neural network module with SME information, GBS neural network module provides one of six types of generic business strategies that follow: share increasing strategy, growth strategy, profit strategy, market concentration/ asset reduction strategy, liquidation strategy, and turnaround strategy. The architecture of GBS neural network module is shown in List 3.

List 3
GBS Neural Network Module

Input Neurons :

RCP Part

Strong/ Average/ Weak/ Drop-Out

SME Part

Development/ Growth/ Shake-Out/ Maturity/ Decline

Output Neurons :

Share Increasing/ Growth/ Profit/ Market Concentration and Asset Reduction/Turnaround/ Liquidation or Divestiture

After training the RCP, CCS and GBS neural network modules with appropriate training data, three sets of neural network knowledge bases are generated. They are RCP knowledge base, CCS knowledge base, and GBS knowledge base.

Expert's knowledge is stored in a conventional knowledge base that may include information about various topics, for example, industry environments, socio-economic situations, contingency corporate strategies, competitive position objective, and investment strategy with respect to various strategic situations, etc. Especially, expert knowledge related to three kinds of areas--contingency corporate strategies, competitive position objective, and investment strategy--are considered. Contingency corporate strategies include nine types of strategies: "concentration via vertical integration", "concentration via horizontal integration", "concentric diversification", "conglomerate diversification", "pause or proceed with caution", "no change in profit strategy", "turnaround",

"captive company or divestment," and "bankruptcy or liquidation". Each of the six generic types of business strategies involves a different pattern of competitive position objectives, investment strategies, and competitive advantages, which are summarized in Table 1.

Table 1
Characteristics of the Six Generic Business Strategies (Hofer & Schendel, 1978)

Type of Generic Strategy	Competitive Position Objective	Investment Strategy
Share-increasing strategies		
Development stage	Increase position	Moderate investment
Shake-out stage	Increase position	High investment
Other stages	Increase position	Very high investment
Growth strategies	Maintain position	High investment
Profit strategies	Maintain position	Moderate investment
Market concentration and asset reduction strategies	Reduce (shift) position to smaller defendable level (niche)	Moderate to negative investment
Liquidation or divestiture strategies	Decrease position to zero	Negative investment
Turnaround strategies	Improve positions	Little to moderate investment

ILLUSTRATION

Architecture of StratPlanner

We developed a prototype StratPlanner running on Windows 2000. It is coded in Microsoft Visual C++ language. Its main menu is composed of five sub-menus as shown in Figures 9 and 10.

Figure 9
Structure of Main Menu

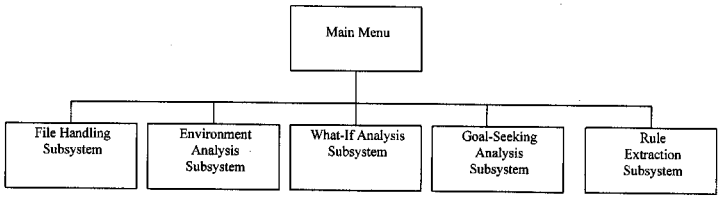
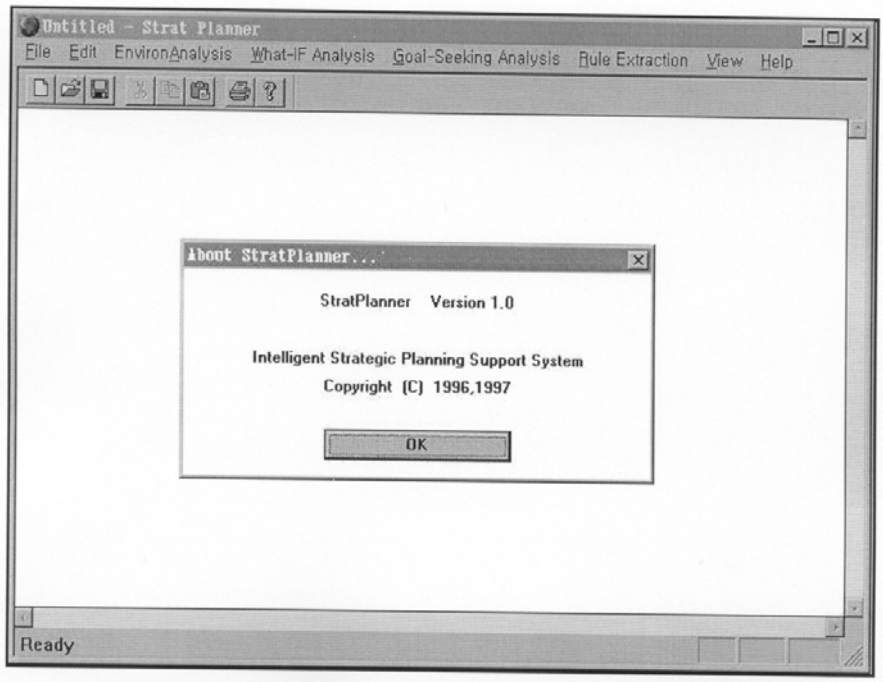


Figure 10

The Main Menu Screen



As mentioned in introduction, we will illustrate the performance of forward inference mechanisms: what-if analysis. For example, in StratPlanner, what-if analysis is performed in accordance with the steps shown in List 4.

Figure 11 illustrates showing the result from CCS neural network knowledge base.

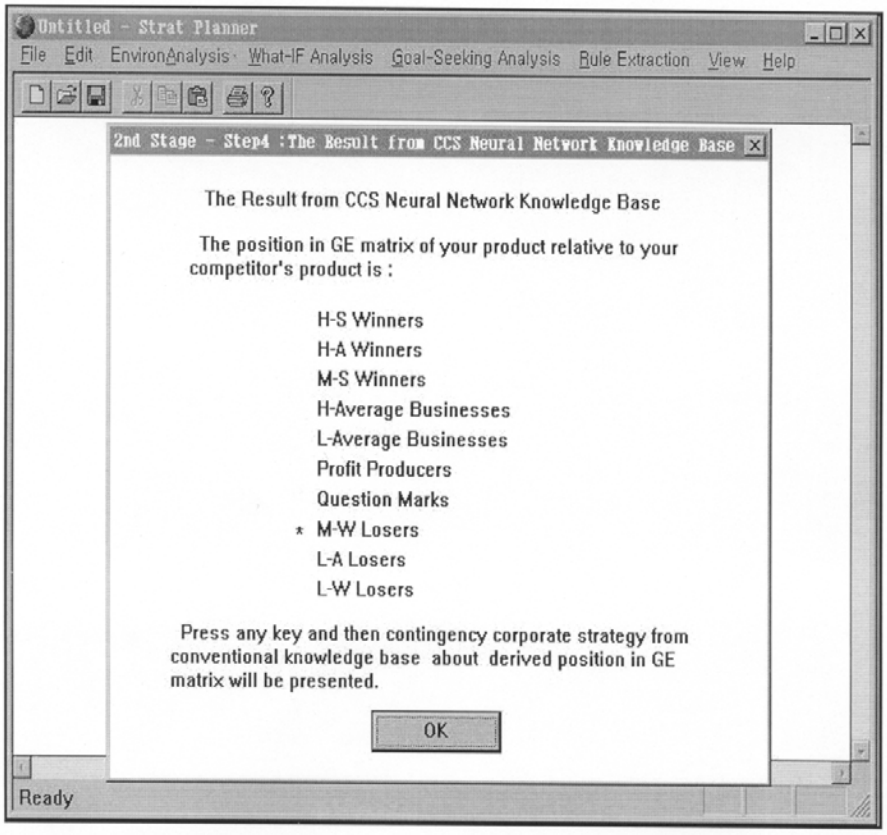
List 4
Steps of StratPlanner associated with What-If analysis.

Stage 1:	RCP Stage
	Step 1. Open the weight file of RCP neural network module.
	Step 2. Select a target product.
	Step 3. Input data about BCG and Growth/Gain matrix.
	Step 4. Get the result from RCP neural network knowledge base.

List 4 Steps of StratPlanner associated with What-If analysis.		
Stage 2:	GBS and/or CCS Stage	
	If GBS analysis is selected, then perform the following steps.	
		Step 1. Open the weight file of GBS neural network module.
		Step 2. Input data about stage of market evolution.
		Step 3. Get the result from GBS neural network knowledge base.
	If CCS analysis is selected, then perform the following steps.	
		Step 1. Open the weight file of CCS neural network module.
		Step 2. Input data about industry attractiveness.
		Step 3. Get the result from CCS neural network knowledge base.

Figure 11

A Sample Screen of What-If Analysis Subsystem



Data

Experiments were performed with Korean automobile data, which is fabricated as a strategically turbulent market designed to show the performance of StratPlanner in a turbulent strategic planning environment. Table 2 shows the categories of automobile data used in our experiments.

Table 2
Categories of Korean Automobile Data

	Company		
Type Car	KIA	HYUNDAI	DAEWOO
Small	Pride	Excel	Lemans
Compact	Capital Sephia	Elantra	Espero
Medium	Concord	Sonata	Prince
Large	Potentia	Grandeur	Super Salon

Monthly domestic sales data of three companies' passenger cars from May 1990 to August 1994 as well as miscellaneous strategic planning data from May 1990 to August 1994 was collected. The domain knowledge from two experts, a strategy analyst in 'K' automobile company and a strategy expert in university was also used in this experiment. Table 3 shows the type and description of data used in our experiments.

Table 3
Type and Description of Data Used in Experiments

	Type of Data	Description of Data
Quantitative Data	Monthly Sale Data	Market Growth Rate Relative Market Share Product Growth Rate
Qualitative Data	Expert Knowledge	Preparation of Input/Output Pairs used in Supervised Learning Preparation of Desired Output used in Test Knowledge related to three kinds of areas: Contingency corporate strategies Competitive position objective by type of generic strategy Investment strategies by type of competitive position objective
	Data Produced by Neural Network Modules	Relative Competitive Position Position in GE Matrix Position in Product/Market Portfolio Matrix Position in BCG Matrix Position in G/G Matrix

Table 3
Type and Description of Data Used in Experiments

	Type of Data	Description of Data
	User's Judgement	Determination of stage of market by car type Determination of industry attractiveness by car type Variable Selection Weight Determination

The data set consisted of 52 cases divided into 32 cases from May 1990 to December 1992 for the training set and 20 cases from January 1993 to August 1994 for the test set. Another data set is arranged for the differences in production periods. Based on this data, we trained and tested RCP, CCS, GBS, CCS_RCP, GBS_RCP, RMS_GG neural network modules. By using monthly data, this experiment is assumed to be a monthly one-shot.

Experiment for Forward Inference

For illustration of forward inference, consider KIA as a decision-making company. Suppose that KIA wants to build two kinds of strategies for its small type car "PRIDE" using data of Jan. of 1993: (1) competitive position strategy and (2) investment strategy. Analysis of the current period's data represents that current competitive positions of "PRIDE" compared to its major competitor, HYUNDAI's "EXCEL", are "High-Dogs" and "Share Loser", respectively. Similarly, the competitive position of HYUNDAI's "EXCEL" is analyzed to belong to "Cash Cows" in the BCG matrix and "Share Gainer" in the Growth/Gain matrix, respectively. Using this information, the RCP neural network knowledge base presents a "Weak" position. The stage of small car market evolution is analyzed as "Maturity". Based on the results from RCP neural network knowledge base and the stage of market evolution, the GBS neural network knowledge base provides "Market Concentration/Asset Reduction" strategy. The sample screen of this result is shown in Figure 12. This process by RCP and GBS neural network modules and other test cases are summarized in Table 4.

This generic business strategy is inputted to the conventional knowledge base, firing the following two rules.

```
IF      Generic_Business_Strategy = Market_Concentration/Asset_Reduction
        THEN    Competitive_Position_Objective = "Reduce position to smaller defensible position"
IF      Competitive_Position_Objective = "Reduce position to smaller defensible position"
        THEN    Investment_Strategy = "Moderate to negative investment"
        DISPLAY         "Usually some new assets are required, while others are sold off.  The net level of
                        investment depends upon the relative proportion of these two activities in each
                        specific case"
```

Table 4: Illustration of forward inferencing by RCP and GBS neural network modules

Test Set	Decision Making Company (KIA's "PRIDE")		Competitor (HYUNDAI's "EXCEL")		RCP	SME	GBS	
	BCG	G/G	BCG	G/G			Actual	Desired
93.01	High-Dogs	Share Loser	Cash Cows	Share Gainer	Weak	Maturity	Market Concentration	Market Concentration
02	High-Dogs	Share Gainer	Cash Cows	Share Holder	Weak	Maturity	Market Concentration	Market Concentration
03	High-Dogs	Share Loser	Cash Cows	Share Gainer	Weak	Maturity	Market Concentration	Market Concentration
04	High-Dogs	Share Gainer	Cash Cows	Share Gainer	Weak	Maturity	Market Concentration	Market Concentration
05	Cash Cows	Share Gainer	High-Dogs	Share Loser	Strong	Maturity	Profit Strategies	Profit Strategies
06	Cash Cows	Share Loser	High-Dogs	Share Holder	Strong	Maturity	Profit Strategies	Profit Strategies
07	Cash Cows	Share Gainer	High-Dogs	Share Loser	Strong	Maturity	Profit Strategies	Profit Strategies
08	High-Dogs	Share Loser	Cash Cows	Share Gainer	Weak	Maturity	Market Concentration	Market Concentration
09	High-Dogs	Share Gainer	Cash Cows	Share Loser	Weak	Maturity	Market Concentration	Market Concentration
10	High-Dogs	Share Loser	Cash Cows	Share Holder	Weak	Maturity	Market Concentration	Market Concentration
11	Middle-Dogs	Share Loser	Cash Cows	Share Loser	Weak	Maturity	Market Concentration	Market Concentration
12	Middle-Dogs	Share Loser	Cash Cows	Share Loser	Weak	Maturity	Market Concentration	Market Concentration
94.01	Middle-Dogs	Share Loser	Cash Cows	Share Loser	Weak	Maturity	Market Concentration	Market Concentration
02	High-Dogs	Share Gainer	High-Dogs	Share Loser	Strong	Maturity	Profit Strategies	Profit Strategies
03	Middle-QM	Share Loser	Stars	Share Gainer	Weak	Maturity	Market Concentration	Market Concentration
04	Stars	Share Holder	Low-Question Marks	Share Loser	Strong	Maturity	Profit Strategies	Profit Strategies
05	Cash Cows	Share Loser	Low-Dogs	Share Loser	Strong	Maturity	Profit Strategies	Profit Strategies
06	Low-QM	Share Loser	Low-Question Marks	Share Loser	Drop-out	Maturity	Liquidation or Divestiture Strategies	Profit Strategies
07	Cash Cows	Share Gainer	Low-Dogs	Share Loser	Strong	Maturity	Profit Strategies	Profit Strategies
08	Low-Dogs	Share Loser	Low-Dogs	Share Loser	Strong	Maturity	Profit Strategies	Profit Strategies

Figure 13 depicts the result of forward inference. In response to the current market situations of KIA's PRIDE, StratPlanner provides "Reduce position to smaller defensible position" strategy as a competitive position objective and "Moderate to negative investment" strategy as an investment strategy.

Figure 12

The Result Screen of GBS Neural Network Knowledge Base in What-If Analysis

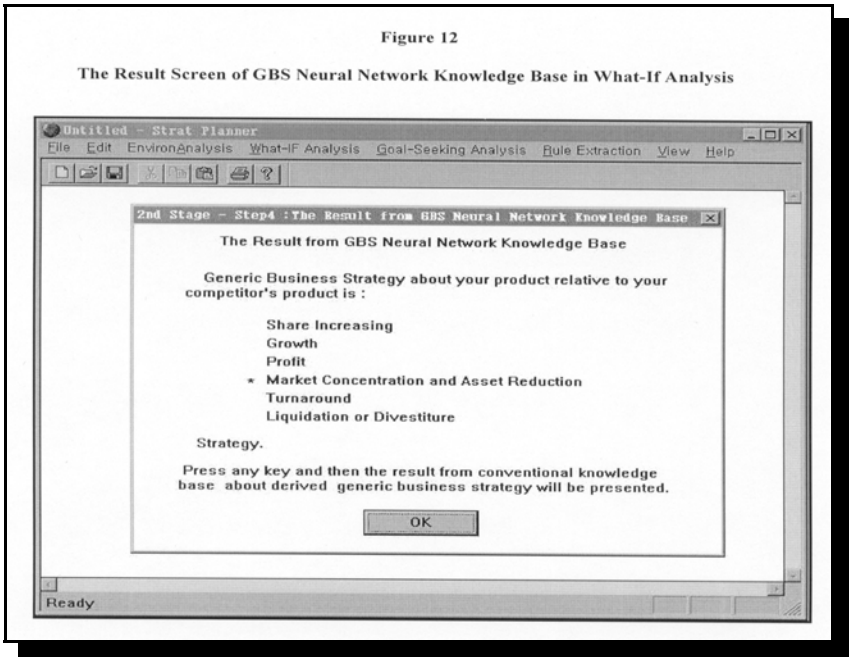
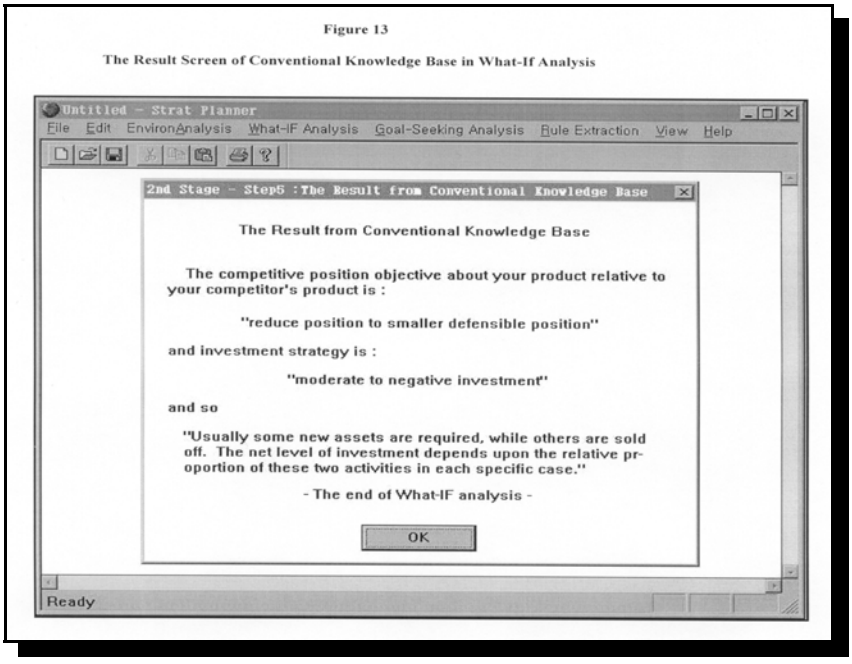


Figure 13

The Result Screen of Conventional Knowledge Base in What-If Analysis



CONCLUDING REMARKS

In this paper, we proposed a neural expert system capable of performing a forward inference so that strategic planning problems may be solved more effectively. The proposed neural expert system is designed to provide "what-if" inference function, based on combining the generalization capability of neural networks with expert system. A prototype system StratPlanner was proposed to prove our approach. Its performance was illustrated with real competitive data of Korea Automobile Industry. However, there exist much room for further research. First, "goal-seeking" function can be added to a future system development to make the system capable of performing a bi-directional inference. Goal seeking functions are realized through the backward inference mechanism, enabling the neural expert system to show the appropriate inputs (or conditions) to guarantee the desired level of outputs. Second, an improved version of StratPlanner can incorporate refined mechanisms of environmental analysis, competitor analysis, and advanced strategic planning models.

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