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LETTER FROM THE EDITOR

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DERIVING A CAPABILITY MATURITY MODEL FOR ELECTRIC UTILITY SECURITY ASSESSMENT

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Diane L. Lockwood, Seattle University

ABSTRACT

The pressures of "better, faster, cheaper" have driven electric utilities to find new, more efficient, cost-cutting approaches to doing business such as using low cost public networks like the Internet for data communications. While many utilities have rushed to take advantage of the apparent benefits, the new security vulnerabilities these technologies introduce have not been fully appreciated. As a result, many utilities are not aware of the potential threats and impacts such vulnerabilities may introduce, nor are they prepared to assess these risks fully. This paper describes a security assessment tool, the Critical Infrastructure Capability Maturity Model (CI-CMM), which is designed to assist the power industry in determining whether their security processes are adequate, including those that address the threats posed by potential electronic intrusion. This proposed new model is based on a derivative of the Software Engineering Institute's Capability Maturity Model (CMM), which has become a well-established tool for assessing the effectiveness of a firm's software development processes. Use of this proposed new tool should not only identify potential security problems, but also provide needed education and awareness to utilities submitting to the assessment process.

INTRODUCTION

While physical destruction due to natural occurrences is still the greatest threat facing North American electric utilities, the growing vulnerability to electronic intrusion has been well documented. The White House report by the National Security Telecommunications Advisory Committee (NSTAC) states that "the security of electric power control networks represents a significant emerging risk to the electric power grid" (NSTACIA, 1997), (Oman, Schweitzer & Frincke, 2000). These systems are increasingly vulnerable to hackers, disgruntled insiders and terrorists; yet, at the same time, traditional security assessment models used by electric utilities have continued to emphasize physical threats (IEEE-PES, 2000).

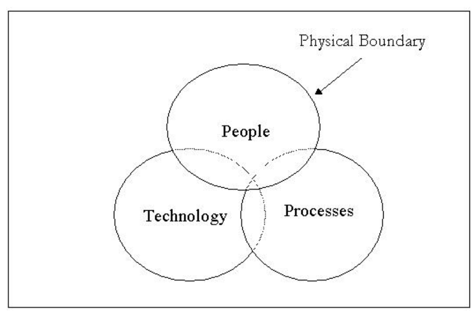
Recent research has shown the validity of applying tools and techniques from the Infosec community to the safeguarding of critical components of electric utility infrastructures (Oman, Risley, Roberts & Schweitzer, 2002). Likewise, by drawing from techniques used by the InfoSec community to assess the effectiveness of computer security processes, this paper provides an approach for assisting utilities in assessing security risks to their critical infrastructure, including those posed by potential electronic intrusion. Realizing that education and awareness is an important first step to recognizing security risks, this process will also provide valuable learning experiences for those undertaking it (IEEE-PES, 2000).

We begin with a description of what is included in the definition of a critical infrastructure system, then provide an overview of the kinds of assessment models available to the InfoSec community. We discuss how to adapt these models to evaluating security at electric utilities and then make recommendations about how to apply and interpret them during an onsite assessment.

SCOPE OF CRITICAL INFRASTURE SYSTEMS

We have broadened the definition of critical infrastructure to include not only technology, but also the people and processes necessary to run it and the physical boundary that offers the first level of protection.

Figure 1. Major Components of Critical Infrastructure



People

According to IEEE1402, ignorance is a significant vulnerability in the face of intrusion threats (IEEE-PES, 2000). If individuals working for a public utility are unaware of security vulnerabilities, they might ignore security practices that they perceive as being of no value other than making work more difficult.

The level of security awareness, and the skills and training in security of the people working with a critical infrastructure system, affect its level of vulnerability. Lack of knowledge and awareness of security threats on the part of users make systems more susceptible to intrusion. If we want to assess the security of a critical infrastructure, we must include assessment of the knowledge and skills of the people running it.

Processes

In addition, certain processes must be in place and followed to assure critical infrastructure system security. A component secured by some form of authentication might as well have none if the factory-set default password is not changed upon installation. A surprising majority of utilities leave default passwords in place making systems vulnerable to easy intrusion (Oman, 2003).

Password management is another good example. Firms need to develop processes for creating strong passwords and changing them on a periodic basis. Hacking tools have become increasingly effective. Password models, considered good protection a few years ago, are now vulnerable to cracking in a reasonable period of time (Oman, Schweitzer & Fricnke, 2000). Organizations seeking to secure their systems should develop processes to harden passwords and to gain the cooperation and support of users to follow them.

Technology

Technology is the centerpiece of critical infrastructure; however, security cannot be achieved by just buying a technology. If the technology is not managed using the right processes, it will not achieve its desired end. Technologies must be used properly, and this proper use must be monitored and enforced. An authentication system, turned off because it takes users too long to gain entrance to a system (causing complaints to a system administrator) provides no protection.

Physical Boundary

The first line of defense of any critical infrastructure is the physical facility in which it is located. If the system in question is a network of distant components, we might investigate whether the facility is protected by adequate lighting, fences, or guarded gates. If the system is housed entirely in a single building, we might check whether there are cipher locks on doors or coded entry systems requiring more than one vector of authentication (IEEE-PES, 2000). Security of physical boundaries affects the vulnerability of the entire system and will be included in our assessment model; however, since physical security at electric utilities is covered in other sources, this paper will not elaborate further on this dimension other than to include it in the CI-CMM (IEEE-PES, 2000).

In summary, when assessing the security level of critical infrastructure systems, it is not enough to look at technology. The people, processes and physical boundaries of such systems will also affect the level of security. Any assessment model that purports to evaluate the security of critical infrastructures must also take into account the people, processes and physical boundaries of the system in question.

THE CRITICAL MATURITY MODEL APPROACH

The Software Engineering Institute's (SEI's) original Capability Maturity Model (CMM) is a framework describing the key elements of an effective software development process (Paulk, Curtis, Chrissis & Weber, 1993; Paulk, Weber, Garcia, Chrissis & Bush, 1993). In the ten years since it was first published, the framework has proved to be a strong theoretical base for developing other process maturity models for other domains. With its focus on processes and the proficiency of the people executing them, the CMM makes a good candidate assessment model to adapt for critical infrastructure assessments.

SEI, itself, has adapted the CMM to a number of different domains. Table 1 describes derivative CMM models that SEI has under current development. They range from a People Capability Maturity Model that addresses the maturity of the human resources infrastructure of an organization, to a Software Acquisition Capability and Maturity Model that proposes best practices for software purchases based on benchmarking government and military procurement practices.

Table 1: CMM Derivative Models Under Development at SEI (CMU, 2003)

CMM Derivative	Domain	Function
SW-CMM Capability Maturity Model for Software	Processes used by software professionals	Judges the maturity of software processes of an organization Identifies key practices required to increase process maturity
P-CMM People Capability Maturity Model	Human Resources Knowledge Management Organizational Development	Addresses critical people issues Improves processes for managing and developing a workforce
SA-CMM Software Acquisition Capability Maturity Model	Software Acquisition	Benchmarks software acquisition processes of the government and military Improves software acquisition processes
SE-CMM Systems Engineering Capability Maturity Model	Systems Engineering	Ensures good systems engineering Analog to the software engineering CMM
IPD-CMM Integrated Product Development Capability Maturity Model	Product Development	Guides IPD design, development, appraisal and improvement Achieves timely collaboration of necessary disciplines throughout the product life cycle

Other organizations in other domains have exploited the versatility of the CMM, as well. The International Institute for Learning and its leading practitioner, Harold Kerzner, have developed the Project Management Maturity Model designed to assist firms in evaluating the maturity level of their project management infrastructure (Kerzner, 2001). Other, similar models have been developed by groups like the International Standards Organization (SPICE, 1995).

Of greater interest to the researchers is the NSA-developed CMM derivative, the INFOSEC Assessment Capability Maturity Model (IA-CMM), which is used to appraise the ability of an organization that conducts the INFOSEC Assessment Process, to support its assessors. This version of the CMM served as a template for the development of the CI-CMM.

The CMM Meta Structure

A Capability Maturity Model is built using a step-by-step process that begins by identifying distinguishing capabilities that an organization has when it is at one of several specific maturity levels proscribed in the model. The maturity levels for the original CMM (for software development) are shown below in Table 2.

Table 2: CMM Maturity Levels (Paulk, Curtis, Chrissis & Weber 1993; Paulk, Weber, Garcia, Chrissis & Bush, 1993)

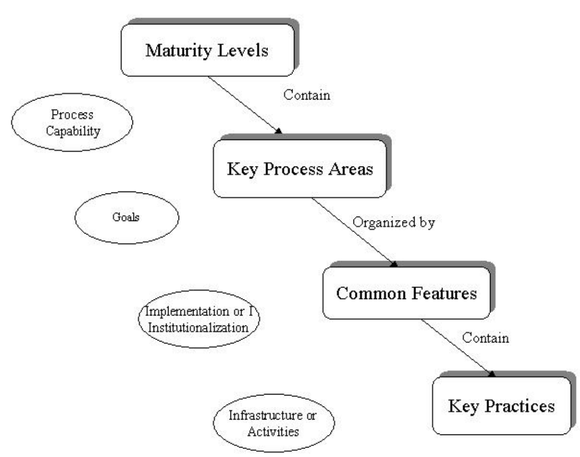
Maturity Level	Name	Description
Level 1	Initial Level	The organization does not provide a stable environment for software development. Project success depends on having good software managers or teams.
Level 2	Repeatable Level	At the repeatable level, the organization establishes basic guidelines for managing the software project and its various procedures
Level 3	Defined Level	The organization has a formally documented standard process for developing and maintaining software engineering and management.
Level 4	Managed Level	At the managed level, the organization sets quantitative goals for both software products and processes. They have a predictable process.
Level 5	Optimizing Level	The entire organization is focused on continuous process improvement. Software processes are evaluated to prevent known types of defects from recurring and lessons learned are spread to other projects.

According to the model, organizations must pass through all levels, sequentially, from lowest to highest in number, on their way toward Level 5, continuous process improvement. At Level 1, chaos reigns. To get anything done requires the push and persistence of strong personalities. At a Level 2, the organization has described processes for developing software that are regarded as guidelines for managing software development. At a Level 3, processes established at Level 2 are now considered standards that must be followed. At a Level 4, the organization establishes and collects metrics for managing these standard processes so that they become predictable. At a Level 5, processes are managed proactively. They are evaluated periodically and the feedback is used to upgrade and improve processes, continuously. The journey toward continuous process improvement is relevant in any domain and is one of the main architectural building blocks of any Capability Maturity Model.

Referring to Figure 2, once capabilities are assigned to each maturity level, key process areas are identified, together with goals that can be attained using these process areas. In the next step, common features characterizing the successful implementation of these process areas are determined. Finally, key practices that indicate successful implementation of the common features (defined as infrastructure in place or activities performed) are described. Once key practices are defined, it is relatively easy to formulate questions that, when asked, would determine the presence of that key practice.

This analytical process, outlined in Figure 2, is common to each version of the CMM mentioned previously and is another major architectural building block of a Capability Maturity Model. The questions tied to each key practice that fall out of this analysis become an ideal assessment tool for determining the maturity level of an organization's processes, in other words, how reliable a firm's process infrastructure is.

Figure 2: CMM Development Process (Paulk, Curtis, Chrissis & Weber, 1993)



The CMM Maturity Levels and the CMM Development Process are the basic architectural components of any Capability Maturity Model and were employed in the development of the CI-CMM, the Critical Infrastructure Capability Maturity Model.

DEVELOPMENT OF THE CI-CMM

The Critical Infrastructure Capability and Maturity Model (CI-CMM) was developed in order to evaluate the state of security of organizations in the critical infrastructure domain. It is a collection of best practices an organization should adopt in order to secure its critical infrastructure.

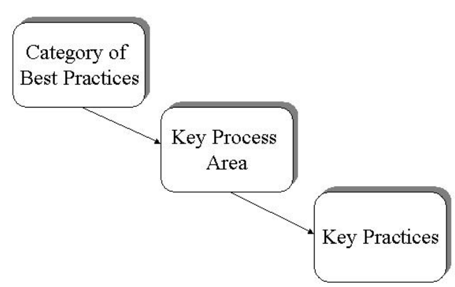
The CI-CMM draws upon a CMM derivative model, the INFOSEC Assessment-CMM (IA-CMM), that appeared to be the best analog for a CI-CMM (SPICE, 1995). Additional sources included 1) the IEEE1402, which documents methods and designs to mitigate intrusions, (NSA-INFOSEC, 2003) and several recent publications that provide technical solutions for security problems in the critical infrastructure of electrical utilities (Oman, 2003; Oman, 2001; Oman, Risley, Roberts & Schweitzer, 2002; Oman, Schweitzer & Roberts 2002; Oman, Schweitzer & Frincke, 2000).

Best practices for security in critical infrastructure, defined for this initial version of the CI-CMM, were grouped into process areas, by categories that correspond to the basic components of critical infrastructure identified earlier:

People
Processes
Computer Technology
Boundary Defense

Within each category a set of processes was defined, each containing a series of key practices describing how a critical infrastructure would be managed, ideally, for optimal security. The steps taken to produce Version 1.0 are shown in Figure 3.

Figure 3 Steps to Develop the CI-CMM



Process Areas

The CI-CMM contains 7 process areas, each of which is composed of key practices that map to questions that can help the assessor determine the organization's appropriate capability level for that process. An analysis of the answers will lead to making recommendations for closing security vulnerabilities discovered in the assessment process. The 7 CI-CMM process areas are listed in Table 3 below by category.

Table 3: CI-CMM Key Process Areas by Category

Category	People	Processes	Computer Technology	Boundaries and Surroundings
Process	PA01--	PA03--	PA05--	PA07--
Areas	Provide ongoing skills and knowledge to support security	Planning for a secure environment	Establish a secure architecture	Establish secure perimeters, buildings and surroundings
	PA02--	PA04--	PA06--	
	Provide Company- wide security awareness	Enforcing security policies	Manage authentication	

Maturity Levels

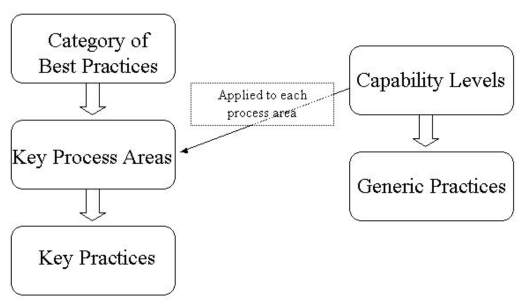
The CI-CMM contains 6 levels of maturity as defined in Table 4.

Table 4: CI-CMM Maturity Levels (NSA-INFOSEC, 2003)

Maturity Level	Name	Description
Level 0	Not Performed	Practice is not conducted
Level 1	Performed Informally	Base practices performed.
Level 2	Planned and Tracked	Commitment to perform Performance planned, disciplined, tracked and verified.
Level 3	Well Defined	Standard process defined and tailored Data used to measure performance.
Level 4	Quantitatively Controlled	Measurable quantity goals established Process capability determined to achieve goals Performance objectively managed
Level 5	Continuously Improving	Quantitative process effectiveness goals established Effectiveness improved continuously

Each maturity (capability) level was applied to each process area in order to define the common features that would describe an organization at that particular maturity level. For example, an organization at a Level 1, where chaos reigns, would have different features than an organization at a Level 5, where processes are under control and managed proactively, anticipating problems before they happen. At Level 1, an assessor would not expect to find any repeatable processes. At a Level 5, an assessor would expect to see not only standardized processes being followed, but also metrics being collected from these processes and being used to determine what process improvement projects an organization might undertake. Describing generic practices expected at each capability level, first, assisted in defining key practices associated with each process area. That approach is shown in Figure 4.

Figure 4: Components of the CMM Development Precess (NSA-INFOSEC, 2003)



From key practices, questions were developed for a CI-CMM assessment questionnaire to be used as an assessment tool for evaluating the level of security at an electric utility. Grouped by Domain Category, Key Practices by Key Process Area and related questions are provided in Appendix A.

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

We have presented a new Capability Maturity Model, the Critical Infrastructure Capability Maturity Model (CI-CMM) which is based on the basic architecture of the Software Engineering Institute's Capability Maturity Model. While this model was developed as an assessment tool to evaluate critical infrastructure security in the electric utility, it could be applied to assessing critical infrastructure in other industries, as well.

What remains is employing this tool during an assessment at an actual utility. The original CMM has been honed and refined over years of application. The CI-CMM is only in its first version. It is anticipated that, with use, it will be updated and changed over time. Honing this tool through application in the electric utility should lead to understanding how it might be used in other industries such as water, natural gas, oil, and transportation. It is anticipated that this single tool can be employed within any industry having critical infrastructures to protect.

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APPENDIX A ASSESSMENT QUESTIONS

PEOPLE CATEGORY

Within this category are those processes required to assure that the people who are managing and working within a secured environment are properly prepared to adhere to best security practices. While the purpose of the CI-CMM model is to assist in assessing the relative security of critical infrastructure systems, the boundary of those systems must be drawn to include the people and processes used to run them.

As an example, if individuals working for a public utility are unaware of security vulnerabilities, they might ignore security practices that they perceive as being of no value other than making their work more difficult. According to IEEE1402, ignorance is a significant vulnerability in the face of intrusion threats.

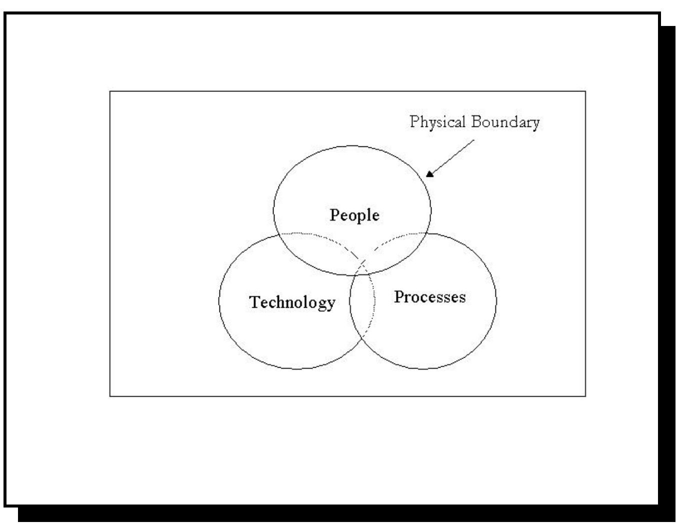

Figure 5. Scope of Critical Infrastructure System

The process areas/key practices within the People Category include:

PA01--Provide ongoing skills and knowledge to support security
- Identify security training needs
- Select/Develop training opportunities
- Train
- Assess the effectiveness of training

PA02--Provide company-wide security awareness
- Develop awareness program
- Disseminate awareness information
- Measure the effectiveness of awareness program

QUESTIONS: PEOPLE CATEGORY

PA01-- Provide ongoing skills and knowledge to support security
- PA01.1--Identify security training needs
- PA01.2--Select/Develop training opportunities
- PA01.3--Train
- PA01.4--Assess the effectiveness of training

Has there been security training of any kind?
If no,
Are there any future plans to hold security training? (ask for documents)
If yes,
Did you develop a training plan? (ask for documents)
Did you do a needs assessment for the training? (ask for documents)
Did you develop in-house training? (ask for documents)
Did you hire outside trainers? (ask for documents)
Did they have adequate credentials? (ask for documents)
Was training conducted across all job categories? (ask for job categories)
Were all employees trained? (ask for the specific number trained)
Was training offered more than once? (ask how frequently)
Have you conducted training assessments?
Was the training effective?

PA02--Provide company-wide security awareness
- PA02.1--Develop awareness program
- PA02.2--Disseminate awareness information
- PA02.3--Measure the effectiveness of awareness program

Do you have a security awareness program?
If no,
Are there any future plans for a security awareness program? (ask for documents)
If yes,
Did you develop a security awareness program plan? (ask for documents)
Did you do a needs assessment? (ask for documents)
Did you receive outside assistance to develop your program?

Did they have adequate credentials? (ask for documents)
Was the security awareness program directed to all job categories? (which ones)?
Were all employees exposed to the program? (if not, why?)
Was the awareness program conducted over a given time period? (what time period)
Have you conducted assessments of any kind?
Was the security awareness program effective?

PROCESS CATEGORY

Within this category are those processes required to assure that the processes operating security within the organization are in place and followed to assure best security practices. While some may believe that security can be achieved by buying a technology, if the technology is not managed using the right processes, it will not achieve its desired end. An example is an authentication system that is turned off because it takes too long to gain entrance to a system when it's activated.

The process areas/key practices within the Process Category include:

PA03--Planning for a secure environment
Understand the criticality of the mission, information and systems of the organization
Identify security reporting and regulatory requirements
Assess security threats
Assess security vulnerabilities
Assess potential impacts
Perform risk analysis
Develop security plan
Maintain all security plans
Monitor plans
Update plans
PA04--Enforcing security policies
Develop security policies
Develop Code of Conduct
Establish security policies
Disseminate security policies
Enforce security policies

QUESTIONS: PROCESS CATEGORY

PA03--Planning for a secure environment
PA03.1--Understand the criticality of the mission, information and systems of the organization
PA03.2--Identify security reporting and regulatory requirements
PA03.3--Assess security threats
PA03.4--Assess security vulnerabilities
PA03.5--Assess potential impacts
PA03.6--Perform risk analysis
PA03.7--Develop security plan
PA03.8--Maintain all security plans
PA03.9--Monitor plans
PA03.10--Update plans

Do you have a security plan for your organization?
If yes, ask for documents.
Do you have an incident response plan?
Do you have a computer survivability plan?
Do you have a computer crime reporting/forensics plan?
Are these plans appropriately disseminated in your firm? (who received the plan/s?)
Do you update the plans on a regular basis? (how often to you update the plan/s?)
Is/are the plan/s followed and enforced?
Have you identified the criticality of the organization's mission, information and systems? (ask for documents)
Have you identified the organization's security reporting and regulatory requirements? (ask for documents)
Have you identified the security threats to your systems? (what are they?)
Have you ever assessed those threats? (ask for documents)
Have you identified the vulnerabilities of your systems? (what are they?)
Have you ever assessed those vulnerabilities? (ask for documents)
Have you identified the potential impacts of threats to your systems? (what are they?)
Have you ever assessed those potential impacts? (ask for documents)
Have you ever performed risk analysis based on security threats you have identified? (what are the levels of risk you have identified?-ask for documents)

PA04--Enforcing security policies
PA04.1--Develop security policies
PA04.2--Develop Code of Conduct
PA04.3--Establish security policies
PA04.4--Disseminate security policies
PA04.5--Enforce security policies

Have you developed security policies?
If no,
Do you have plans to develop security policies?
If yes, ask for documents
Have your security policies become established?
Are they widely disseminated to all appropriate employees?
Do you enforce the security policies? (If yes, ask for examples)
Do you have a Code of Conduct for computer usage?
Is the Code visible, readily available, to all employees?
Is the Code enforced? (If yes, ask for examples)
Do you have a password attack defense? (what is it?)
Do you have a modem attack defense? (what is it?)
Do you have a public network attack defense? (what is it?)
Do you have a wireless network attack defense? (what is it?)
Do you have a telecom attack defense? (what is it?)
Do you have a private network attack defense? (what is it?)

COMPUTER TECHNOLOGY CATEGORY

Within this category are those processes required to assure that computer technology is operated using the appropriate levels of security required to assure best security practices. While technology by itself will not provide security, it is often the solution most firm's rely upon to meet their security needs.

The process areas/key practices within the Computer Technology Category include:

PA05--Establish a secure architecture
- Develop an architecture plan
- Establish architectural standards
- Enforce architectural standards

PA06--Manage authentication
- Develop authentication strategies
- Implement authentication strategies
- Monitor authentication implementations
- Enforce authentication procedures

QUESTIONS: COMPUTER TECHNOLOGY CATEGORY

PA05--Establish a secure architecture
- PA05.1--Develop an architecture plan
- PA05.2--Establish architectural standards
- PA05.3--Enforce architectural standards

Do you have a computer systems architecture plan? (ask for documents)
Does the architecture plan establish standards? (ask for documents)
Does the architecture plan address program security?
Does the architecture plan address network security--topologies/subnetting?
Does the architecture plan address OS design from a security perspective?
Does the architecture plan address memory protection?
Does the architecture plan address file protection?
Does the architecture plan establish network controls?
Does the architecture plan address firewalls?
Does the architecture plan address Intrusion Detection Systems
Does the architecture plan address secured modems, modem key/locks?
Does the architecture plan address secure e-mail?
Does the architecture plan address VPN's?
Does the architecture plan address database security?
Does the architecture plan address multi-level security in databases
Does the architecture plan address sensitive data in databases?
Does the architecture plan address data integrity/reliability issues?
Does the architecture plan address encryption?
Does the architecture plan address anti-virus protection software?

PA06--Manage authentication
- PA06.1--Develop authentication strategies
- PA06.2--Implement authentication strategies

PA06.3--Monitor authentication implementations
PA06.4--Enforce authentication procedures
Have you implemented access control techniques?
Do you impose user authentication on your systems? (Which systems?)
Do you use:

- Biometric authentication?
- ID devices?
- Dial back modems?
- Password generators?
- Device-based passwords?
- Two- or three-vector authentication?

Do you use password generators or device-based passwords?
Do you employ audit logs?
Are they reviewed and analyzed frequently? (how frequently?)
Have you established password strategies?
Do you regularly review the effectiveness of your authentication implementations?
Do you enforce authentication procedures?

BOUNDARY AND SURROUNDINGS CATEGORY

Within this category are those processes required to protect critical infrastructures properly at their boundaries in order to assure best security practices. While people, processes and computer technology are components of secured systems, as defined in this approach, it is often easiest to intrude physically by breaching physical boundaries at plants and substations.

The process areas/key practices within the Boundary Category include:

PA07-- Establish secure perimeters, buildings and surroundings
Develop plans for secure perimeters, buildings and surroundings
Assess vulnerabilities
Plan mitigations
Implement the plan
Monitor the implementations
Assess the effectiveness
Make additions/corrections

QUESTIONS: BUILDINGS AND SURROUNDINGS CATEGORY

PA07-- Establish secure perimeters, buildings and surroundings
PA07.1-- Develop plans for secure perimeters, buildings and surroundings
PA07.2-- Assess vulnerabilities
PA07.3-- Plan mitigations
PA07.4-- Implement the plan
PA07.5-- Monitor the implementations
PA07.6-- Assess the effectiveness
PA07.7-- Make additions/corrections

Do you have facilities plans for secure perimeters, buildings and surroundings?
If yes, ask for documents
If no,

> Do you intend to develop such facilities plans?
> Have you assessed perimeters, buildings and surroundings for vulnerabilities?
> Have you planned mitigation for these vulnerabilities?
> Have you implemented any of these planned mitigations?

Do you have fences surrounding the property?
Are any poles or towers suitably far away from fences?
Do your buildings have reinforced secure walls and/or doors?
Do doors have entrance locks? Computers have equipment locks?
Have you set up photoelectric / motion-sensing devices on the premises?
Have you set up a video surveillance system?
Do buildings have alarm systems?
Has outdoor lighting been designed to eliminate vulnerabilities?
Has landscaping been designed to eliminate vulnerabilities?
Are sewers / manhole covers suitable distanced from the facility?
Have guardrails been established?
Are warning signs posted appropriately?
Are the premises and buildings patrolled? (how frequently?, by whom?)
Are there any other barriers established on the property to ward off intruders?
Are security measures monitored and reviewed for effectiveness on a regular basis?
Are these assessments the basis for making improvements?

APPENDIX B EXAMPLE ASSESSMENT QUESTIONNAIRE

The following questionnaire is an example of the form to be used when evaluating the security levels of an electric utility. The questions were prepared for the process PA01-Provide Ongoing Skills and Knowledge To Support Security. One of these questionnaires is required for each PA.

Each question can be answered, 'yes,' 'no,' 'I don't know,' or 'I'm not sure.' Capabilities that an organization has when it functions at each level of maturity indicated on the questionnaire have been determined. This will allow the assessor to probe further to determine at what level the organization is functioning.

APPENDIX B EXAMPLE ASSESSMENT QUESTIONNAIRE

Example Data Sheet PA01	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
Has there been security training of any kind?						
If no,						
Are there any future plans to hold security training? (ask for documents)						
If yes,						
Did you develop a training plan? (ask for documents)						
Did you do a needs assessment for the training? (ask for documents)						
Did you develop in-house training? (ask for documents)						
Did you hire outside trainers? (ask for documents)						
Did they have adequate credentials? (ask for documents)						
Was training conducted across all job categories? (ask for job categories)?						
Were all employees trained? (ask for the specific number trained)						
Was training offered more than once? (ask how frequently)						
Have you conducted training assessments? (ask for documents)						
Was the training effective?						

INFORMATION DIFFUSION IN ELECTRONIC POOLWRITING MEETINGS

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ABSTRACT

Electronic poolwriting is used in many group support system meetings, but the brainwriting technique has several limitations. Most of its disadvantages as compared to other idea generation methods stem from the limited diffusion of information throughout the group in the form of typed comments. Through simulations of electronic poolwriting meetings with varying group sizes and meeting durations, this paper illustrates an asymptotic information diffusion surface. That is, as group size increases or meeting time decreases, the percentage of comments viewed by participants decreases.

INTRODUCTION

Group support systems have been used in meetings to enhance negotiations and decision making, and many studies indicate that they provide greater process satisfaction, reduce session time, and increase participation when compared to traditional, oral meetings (Dennis, Heminger, Nunamaker, & Vogel, 1990). Most of these electronic meetings involve some form of group idea generation through typed comments (brainwriting), typically electronic poolwriting (EPW) (Aiken & Carlisle, 1992), but different techniques result in different group processes and outcomes such as decision quality, satisfaction, and the number of comments generated (Benbasat & Lim, 1993; Easton, George, Nunamaker, & Pendergast, 1990).

Although groups continue to use EPW, the technique has several disadvantages. Perhaps most importantly, this brainwriting method does not allow all comments to be shared among all individuals in the meeting, severely limiting the exchange of ideas. The purpose of this paper is to investigate the nature of this information diffusion through mathematical simulations of EPW meetings with different group sizes and session durations. Results show that the percentage of comments viewed increases as session length increases and group size decreases following a rough, asymptotic information diffusion surface mapping.

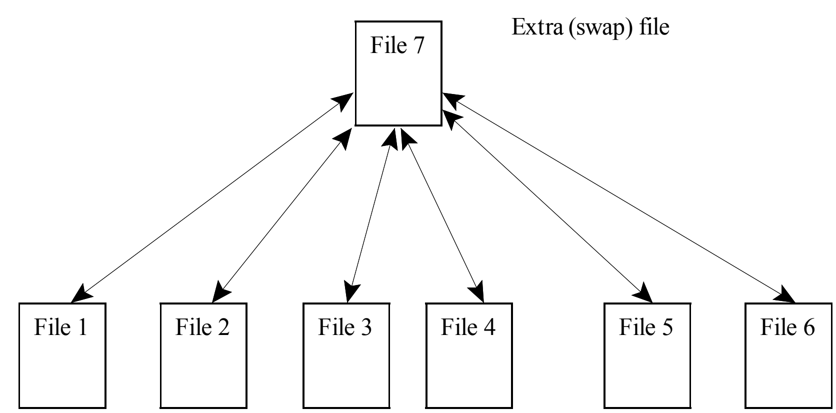
ELECTRONIC POOLWRITING

Definition

EPW is based upon individual poolwriting (see Figure 1) in which group members (Van Gundy, 1992):

1.	Write down ideas about the problem on a sheet of paper.
2.	Place their sheets in the center of the table (a pool of paper) and exchange it for another one.
3.	Read the ideas on the new sheet and use them to stimulate new ideas.
4.	Write down any new ideas on the sheet and exchange it for a new sheet from the pool when they need additional stimulation.
5.	Continue writing down ideas and exchanging sheets for the duration of the meeting.

Figure 1: Electronic poolwriting comment file exchange (group size=6)



EPW simply substitutes disk files for papers. Thus, for a group of N people, there are N+1 files (including the swap file) to be exchanged. All ideas are recorded and comments are nearly anonymous. Lapses in anonymity may be caused by group members recognizing phraseology or pet ideas or looking at each other's terminals, for example.

Mathematical model

Assuming that the time a user spends to process (reading old comments/typing a new comment) a file follows a truncated Normal distribution, the expected frequency of file viewings by each individual can be expressed as:

$$F = D/(N+1) * \int 1/t * f(t)dt \qquad (1)$$

where:

F = Frequency a file is seen by each user
D = meeting duration
N = group size [number of files = group size + 1]
$f(t)$ = Normal probability density function with a finite minimum and maximum

Each participant takes a different amount of time compared to other participants (typing, reading, and comprehending speeds), and the amount of time spent on one particular file also varies because of complexity, length, etc., affecting the file viewing frequency.

EPW allows all participants to type at the same time, but the complete set of comments cannot be viewed at the same time (Vogel & Nunamaker, 1990). In addition, by definition, all comments cannot be seen during the course of the meeting. At a minimum:

$$\neg C_i = N - 1 \qquad (2)$$

Expressed in terms of total comments:

$$C_i = \sum_{i=1}^{N} C_i - (N - 1) \qquad (3)$$

or

$$C_i = \sum_{i=1}^{N} C_i - N + 1 \qquad (4)$$

where

C = number of comments in file seen by each individual at time *t*
i = individual group member
N = group size

At the close of the meeting, one file of comments will be at each terminal. Subtracting the comment written by the individual, he or she will not have seen all of the others' new files plus the swap file.

Each exchange of files represents one comment written, i.e., the number of comments in a particular file increases by one with each file viewing.

$$C_f(t) = C_f(t\text{-}1) + 1 \qquad (5)$$

where

C = number of comments in file
f = file identifier
t = time interval

After 5 minutes and 20 exchanges in a 9-person group, 20 comments might have been written, and on average, only 20/10 comments are in any particular comment file. That is:

$$C_f(t) = \sum_{f=1}^{N+1} C_f \; / \; (N+1) \qquad (6)$$

Thus, at any given time, only a small fraction of all comments is available for viewing by each individual. Some files may have far more of less than the average number of comments, however. Using this average, if the individual processing rates are constant, the percentage of comments viewed per individual should also remain constant, as shown in Figure 2. However, this assumes a fixed group size and meeting duration.

The total number of comments viewed by each individual over the course of the meeting varies by group size and time. Also, because of asynchronous comment processing, redundant comments (those stating essentially the same idea) are generated, and comments are viewed multiple times (files are re-read with each exchange). The total comments viewed by each individual during the meeting can be expressed as:

$$V_i = \sum_{t=1}^{D} C_i(t) \; - E_i \qquad (7)$$

where

V = number of comments viewed
E = extra viewings of comments

The number of unique comments generated per individual is:

$$U_i = \sum_{t=1}^{D} C_i(t) - R_i \qquad (8)$$

where

U = unique comments

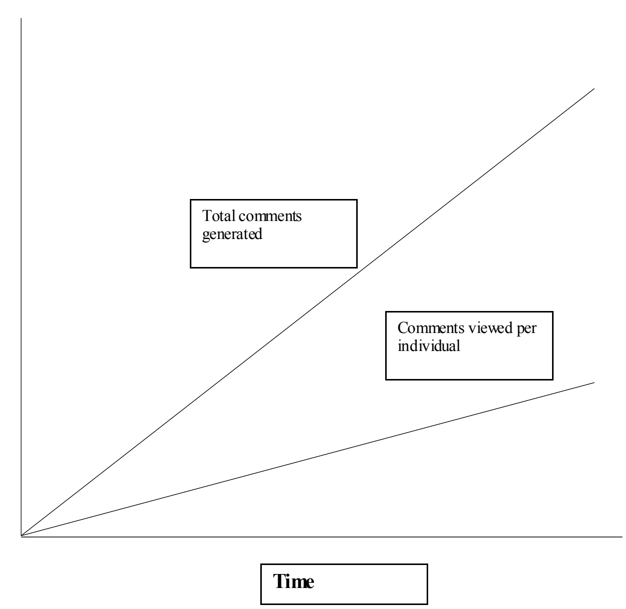
R = redundant comments

Therefore, the number of unique viewings of non-redundant ideas (I) for the group (information diffusion) is:

$$I = \sum_{i=1}^{N} \sum_{t=1}^{D} C_i(t) - R_i(t) - E_i(t) \qquad (9)$$

The terms R_i and E_i represent the amount of slack or overhead in an EPW meeting. This inefficiency consumes valuable meeting time and increases participant frustration with the process (Aiken, Sloan, Paolillo, & Motiwalla, 1997).

Figure 2: Comments viewed over time in an EPW meeting



Finally, the percentage of comments viewed by each group member increases for smaller groups and longer meetings, as shown in Figure 3 and described by:

$$P = \sum_{t=1}^{D} \sum_{i=1}^{N} C(t) / C_i(t) = \min[1, \exp(k + b * D + c * N)] \qquad (10)$$

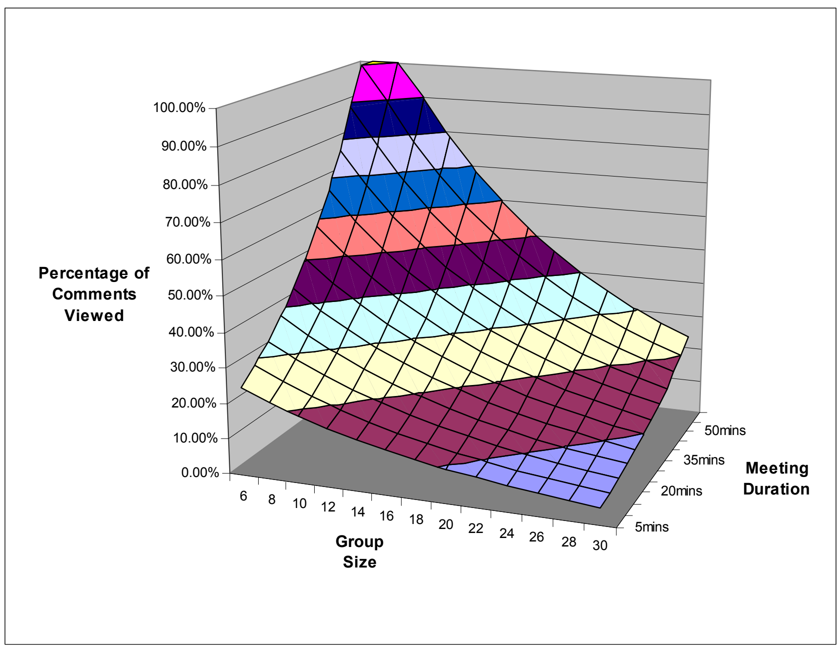
where:

P = percentage of comments viewed

k = constant

a, b = coefficients

Figure 3: Percentage of comments viewed in an EPW meeting



However, group meetings generally benefit from more participants as more people can add more, unique insights to the topic (Dennis & Valacich, 1993), and extending the meeting solely for increased swapping of files is likely to cause greater boredom and more off-topic comments (Reinig, Briggs, & Nunamaker,1998). Thus, larger, longer meetings can be expected to reduce the percentage of total information viewed by each individual.

Several studies comparing EPW with alternative meeting techniques have shown that subjects want to see all comments over the course of the meeting and at any particular time (Aiken, Vanjani, & Paolillo, 1996). However, this is impossible using EPW due to the limitations described above. Another study of six-person, 10-minute EPW meetings (Aiken, 2001) showed that on average, only 50% of all comments were viewed by meeting participants, and each participant had no idea which comments he or she was missing. The study also showed that participants who wrote more comments than the group average using EPW were able to view a greater percentage of total public comments (because of more file exchanges).

EPW Simulation

In addition to the loss of information in an EPW meeting, described in the prior study, the sequence of file swapping can be erratic because of different human information processing speeds described in (1). This erratic behavior has been noted in several EPW meetings (Vogel and Nunamaker 1990):

> *Experience with use of electronic brainstorming [EPW], including monitoring of file use, suggests that periods of extreme non-randomness can occur in file interchange between group members. As such, a group member may not see all of the files during a session and/or may see a small group of files an abnormally high percentage of the time. ... It would be helpful to have a mathematical model of electronic brainstorming that would model alternative file dynamics, which could be examined in live groups.*

Simulation is one of 11 IS research methodologies (Galliers & Land, 1987), and a dynamic social process such as a group support system meeting provides a fertile research area for the use of the technique for theory construction and verification (Garson, 1994; Liebrand, 1998). Simulation is especially useful due to time and subject availability limitations, and it can be used to test the boundaries of a hypothesized model (Stasser, 1992).

In a prior simulation of EPW meetings with a group size of 10 and meeting durations from 10 to 60 minutes (Aiken, Li, & Vanjani, 2001), results showed that for each participant, the file swapping process was statistically random but not uniform. That is, some files were viewed more often than expected while others were viewed less often. However, the researchers suggested that other group sizes and meeting durations should be investigated to determine how file exchanges occur at upper and lower boundaries.

SIMULATION

Methodology

A simulation study was conducted to investigate the effect of group size and meeting time on the percentage of comments seen by each participant. The amount of time spent by each simulated participant with each comment (file) was set to follow a truncated Normal distribution with a minimum of 97.67 seconds, a maximum of 154.67 seconds, and a mean of 116.67 seconds based upon a study of historical EPW meetings (Aiken, Aljumaih, Reithel, & Conlon, 1997) and the theoretical formula described in (2.1). In addition, repeated viewings of the same comment were not counted. A total of 2000 simulations were conducted by varying the group size from 10 to 40 and the meeting time from 5 to 60 minutes in increments of 5 minutes.

RESULTS

Table 1 shows a sample simulation of a 10-member EPW meeting over 50 minutes. In the table, the sequence of file viewings per individual show the file number and the number of seconds spent on each file. Each group member starts the meeting with a file (the user numbers and file numbers are the same), and each file is swapped with the extra file (file #11) at a different time. The table shows that user 9 finished first after 88 seconds and thus, swapped with file 11 first.

Table 2 shows sample file viewing frequencies for a simulation of a 10-member group over 50 minutes. As shown, some files were viewed more than others, and some files were not seen at all by some group members.

Table 3 shows the average comment viewing frequency for each group size and meeting time, and Figure 4 is a graphical representation. As expected, the viewing frequency increased with a smaller group size and a longer meeting time.

Table 1: File viewing sequence in a sample simulation (file # / time viewed in seconds)
(Group size=10, number of comment files=11, meeting time = 50 mins)

	Files									
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
user 1	1/107s	8/99s	4/107s	10/122s	9/135s	10/118s	11/127s	8/116s	10/108s	7/98s
user 2	2/123s	6/111s	1/132s	7/130s	6/98s	4/125s	3/105s	11/119s	5/103s	2/121s
user 3	3/118s	5/125s	6/109s	3/105s	11/118s	3/141s	9/120s	4/120s	3/108s	5/112s
user 4	4/89s	9/110s	10/107s	9/123s	8/135s	1/97s	2/133s	10/130s	2/116s	10/124s
user 5	5/116s	1/116s	3/115s	11/104s	4/125s	11/111s	8/116s	5/135s	8/133s	3/118s
user 6	6/120s	3/109s	7/130s	2/145s	7/110s	6/123s	4/97s	3/116s	11/121s	8/103s
user 7	7/123s	2/87s	8/115s	4/123s	10/120s	8/111s	1/106s	7/119s	6/100s	9/124s
user 8	8/93s	4/109s	9/91s	5/129s	1/128s	5/140s	10/96s	1/132s	7/118s	1/107s
user 9	9/88s	11/123s	2/142s	6/128s	3/89s	9/125s	5/106s	2/122s	1/101s	6/97s
user 10	10/124s	7/94s	11/113s	8/94s	5/101s	2/94s	7/131s	6/118s	9/128s	4/112s

Table 2: File viewing frequency in a sample simulation (Group size=10, number of comment files=11, meeting time = 50 mins)

	file1	file2	file3	file4	file5	file6	file7	file8	file9	file10	file11
user 1	2	1	2	2	1	2	2	4	3	5	2
user 2	2	2	3	2	3	3	2	1	3	1	4
user 3	0	3	7	1	3	2	3	2	2	1	1
user 4	4	3	1	2	1	1	1	3	4	4	1
user 5	2	2	2	3	3	2	1	4	1	2	3
user 6	2	2	3	3	0	4	2	2	2	2	3
user 7	3	2	1	2	2	3	3	2	1	2	3
user 8	4	1	1	3	3	2	3	2	4	2	0
user 9	1	5	3	1	4	3	1	2	2	2	1
user 10	3	2	1	3	3	1	2	3	2	1	3

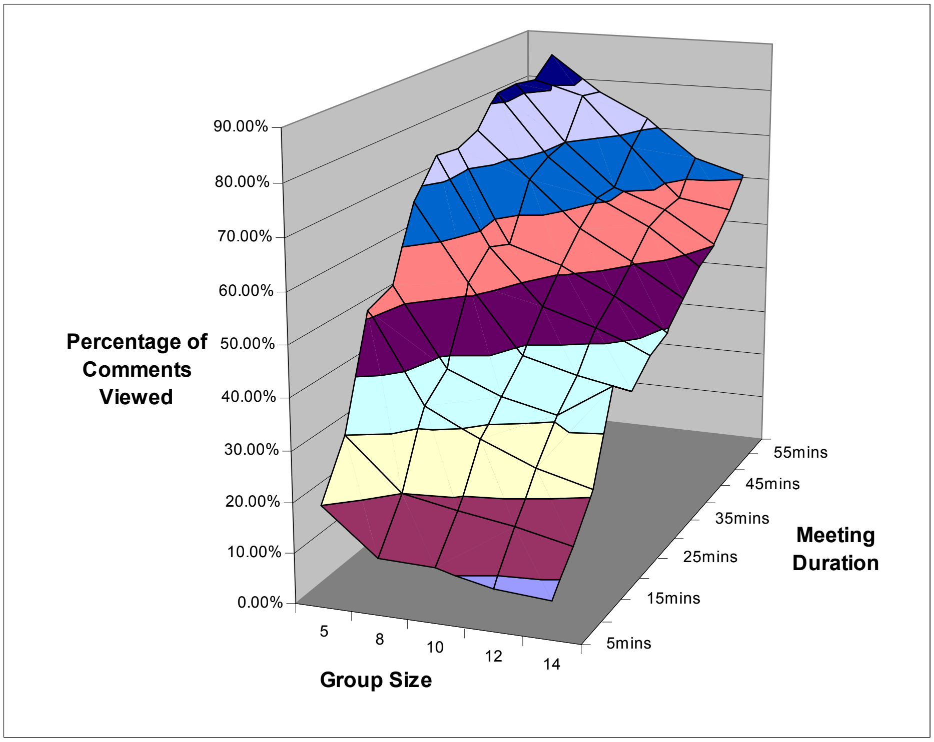
Table 3: Simulated percentage of comments viewed by group size and meeting duration

	Duration											
group size	5min	10mins	15mins	20mins	25mins	30mins	35mins	40mins	45mins	50mins	55mins	60mins
5	0.2	0.3	0.5128	0.5358	0.675	0.7481	0.7383	0.7573	0.8191	0.8195	0.8111	0.8503
8	0.1131	0.2	0.3362	0.378	0.5217	0.5685	0.5486	0.6623	0.6894	0.6994	0.781	0.7722
10	0.1091	0.1793	0.2829	0.3329	0.3845	0.4561	0.5126	0.5667	0.6082	0.607	0.6731	0.7195
12	0.0833	0.1637	0.2402	0.3097	0.3572	0.4231	0.4608	0.5044	0.5551	0.5667	0.5684	0.6384
14	0.0758	0.1398	0.211	0.3793	0.3362	0.3776	0.3936	0.4365	0.4786	0.5016	0.5528	0.6056

A linear approximation of the simulated results was more accurate than an exponential approximation (R^2 = 0.923 and R^2 = 0.813, respectively) because the outer boundaries of the mapping surface were not explored sufficiently. The viewing frequency surface cannot intercept the axes, and non-linear behavior is expected to be more pronounced for a group of 3 over 60 minutes and a group of 30 over 3 minutes, for example.

The Chi-square statistic was used to investigate the comment viewing distribution by each participant in the simulated meetings. Ideally, each participant should see each file with the same frequency (a uniform distribution). For example, if 100 comments are written by a nine-person group (10 files), each group member should see each of the 10 files 10 times, as described in (6). At the 90% confidence level, all viewing frequencies were found to be uniform with the exceptions of meetings with group size/meeting times of 12/30, 14/30, 10/40, 14/40, 12/40, and 14/40.

Figure 4: Percentage of comments viewed in simulations (raw data)



A one-sample runs test for randomness also was conducted. In addition to uniform distribution, files are expected to be distributed among meeting participants randomly. Results showed that for each participant, the file swapping process was statistically random at the 95% confidence interval with the exception of group size/meeting time 10/60.

DISCUSSION

The study has a few limitations. Although the comment viewing time per individual was based upon real-life groups, other times should be used in further simulations to investigate its effect on the percentage of public comments viewed. As participants spend less time per comment, they should be able to view more comments during the meeting, increasing the percentage viewed.

While this simulation used only one dummy file as specified in the traditional model of poolwriting, some researchers have suggested that extra dummy files may improve the file distribution. However, in one study (Herniter & Gargeya, 1995), the extra files did not increase the percentage viewed significantly. Nevertheless, due to the asynchronous nature of file handling in EPW, 100% comment viewing cannot be achieved during the meeting.

CONCLUSION

Information should be exchanged equally and completely in a meeting to foster feelings of ownership and fairness. Due to the fundamental design of electronic poolwriting, equal and complete distribution of comments is impossible during the meeting, although transcripts can be disseminated afterward. This simulation study has demonstrated that the percentage of comments viewed decreases with group size and increases with meeting time.

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INTEGRATING SAP R/3 APPLICATIONS INTO A TOTAL QUALITY MANAGEMENT COURSE

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ABSTRACT

Recent trends in business school curricula have focused on incorporating technology and integrating subject matter across functional areas. With the advent of enterprise resource planning (ERP) systems such as SAP R/3, and the willingness of vendors to partner with universities as in SAP R/3's American University Alliance, a means for facilitating the achievement of these curricular objectives has emerged. In this paper we explore how such software can be used in the teaching of Total Quality Management (TQM). We first discuss how enterprise resource planning systems allow an organization to integrate quality with other business processes such as purchasing, production, sales and accounting. We then make some suggestions on how SAP R/3 can be used in a TQM course for MBA students.

INTRODUCTION

One of the primary reasons cited by universities for developing alliances with SAP, the largest ERP vendor, is the "rich environment for teaching" provided by the SAP R/3 system (Gable and Rosemann, 1999). University faculty note how such software provides students with an active learning experience that enables them to understand business processes and how they are interrelated. ERP software can also be used to illustrate the idea of best practice and why businesses must move away from functional silos and towards functional integration (Stewart and Rosemann, 1999). Moreover, faculty note the importance of teaching students about SAP R/3 in its own right. As the adoption of ERP software among companies becomes widespread, this technology will undoubtedly become increasingly more important in the future. ERP systems provide a means to teach business students real-world applications in areas such as accounting and inventory management, which allows them to almost immediately provide a positive impact to their employers upon graduation (Gloede, 1999).

In developing a technology-integrated "real-world" curriculum, most schools concentrate first on linking together the core functional areas of business. While linking may be accomplished in several ways, one approach is to design a course that focuses on the interrelationships within and between business processes using SAP R/3. At our university, an SAP Alliance school, just such a course (Integrated Enterprise Management Systems) using SAP R/3 was designed for the MBA program. This interdisciplinary, team-taught course provided opportunities for cooperation between functional area faculty and the cross-functional integration of subject matter.

Aside from being used as the basis for interdisciplinary team-taught courses, SAP R/3 can be used to teach specialized MBA elective courses. One elective course that lends itself to becoming "SAP-enabled" is Total Quality Management. In this paper, we focus on how incorporating SAP R/3 applications into a TQM course can help students make important linkages between quality management and other business processes. Interestingly, a review of the literature that reports on the use of ERP systems in university teaching indicates that quality is not one of the areas apt to involve SAP R/3 applications. Yet, industry implementation of ERP does include the Quality Management (QM) module (Mabert, Soni & Venkataramanan, 2000). The purpose of this paper, therefore, is to bridge this apparent gap between academia and business by exploring how the Quality Management (QM) module of SAP R/3 can be used in the teaching of quality. Moreover, this paper illustrates how incorporating SAP R/3 applications in a quality management course can help students understand how quality relates to all business functions of the enterprise. The methodology used is a case study approach in which SAP R/3 applications are incorporated into an existing MBA level elective course in Total Quality Management.

REVIEW OF RELEVANT LITERATURE

Universities have approached the incorporation of ERP systems into the curriculum in a variety of ways. Esteves and Pastor (2001) provide an annotated bibliography of ERP research, including ERP in education. Of the twenty-six articles cited, ten focused on ERP courses, ten on the usage of ERP in universities, and six focused on information systems (IS) curricula. Faculty are further aided in their quest to use ERP in the classroom by other published sources of support and references (Watson et al., 1999; Gable & Rosemann, 1999), guides for case use and research methodology in an ERP environment (Stewart & Gable, 1999; Stewart, et al., 2000).

Within IS programs, ERP has been developed as independent tracks as well as being integrated into existing IS courses (Watson & Shneider, 1999; Stewart et al., 1999). Within the business area, Foote (1999) describes an accounting information systems curriculum developed around SAP-related courses, Shoemaker (1999) discusses a six-hour introductory ERP course for sales and marketing, and Sedera and Sedera (2000) describe a process engineering course using SAP R/3 to design process models for a local firm. ERP has been integrated into MBA programs as a stand-alone option or as a component of existing MBA courses (Becerra-Fernandez, 2000; Blackwood & Snidvongs, 2000) and suggested as a theme for organizing MBA curricula (Rivetti, Schneider, & Bruton, 1999). Traditional business school subjects such as financial accounting, materials management and human resource management are being taught in the context of ERP. ERP systems are also robust enough to accommodate inter-organizational subjects such as supply chain management and customer relationship management. However, there is virtually no reference in the literature to using ERP to teach quality concepts.

Stewart and Rosemann (1999) proposed a model for collaborative ERP education among universities, preferably across countries and via distance education, as these universities face the challenges of launching entire ERP curricula with limited resources. In an effort to support their model, they present the business, technology, strategy, and information technology management course offerings of eight universities (two each from Australia, U.S., Europe, and Southeast Asia) involved with or exploring the SAP University Alliance Program. In so doing, they found that the most common business course offerings using SAP R/3 are accounting and manufacturing related. None of the eight universities listed a course in quality management.

In a more comprehensive study conducted in cooperation with SAP, Gable and Rosemann (1999) surveyed universities from 14 different countries that were using or considering using SAP R/3 in teaching and research. At the time of their report, the largest number of responses had come from universities in the U.S., Germany and Australia. They received details on 158 SAP-related subjects. Based on the survey data, they found that the Materials Management (MM) module was the most popular, used in 61% of all subjects. The Financials and Asset Management (FI/AM) and Sales and Distribution (SD) modules were a close second and third. A little more than half of all subjects referenced the Production Planning and Control (PP) and Controlling (CO) modules, and about one third of the subjects referenced the Human Resources Management (HR) module. When asked about the intensity with which they accessed these modules in their courses, again the MM module ranked first. Intensity was defined on a five-point scale (1=casual review to 5=in-depth review). Although the PP module was referenced less frequently than the FI/AM or SD modules, it was accessed with more intensity. It appears that the use of SAP R/3 in production management courses is quite extensive, based on both the frequency and intensity scores for the MM and PP modules. However, the Quality Management (QM) module of SAP R/3 was not referenced once in this study. The QM module is part of the SAP R/3 Logistics subset that also includes PP, MM, SD and Plant Maintenance (PM).

While there is no indication in the literature that universities are using ERP to teach quality, a recent survey of U.S. manufacturing firms found that industry implementation of ERP does include the module on Quality Management (Mabert, Soni, & Venkataramanan, 2000). In that survey, 44.6% of the firms responding indicated that they had already implemented the Quality Management module. While its implementation may not be as widespread as some of the other modules, such as Financial Accounting (91.5%) or Materials Management (89.2%), its use among firms is as common as the Personnel/Human Resources Management module (a module referenced as being taught by one third of the universities surveyed in the Gable and Rosemann study cited above).

Since firms are implementing ERP for quality management purposes, it seems that business curricula already incorporating ERP applications should expand to include quality. ERP systems, such as SAP R/3, support TQM by offering a means to measure and monitor quality performance outcomes. Likewise, SAP R/3 can support the teaching of total quality management by emphasizing continuous improvement based on knowledge of the system. Another important reason why SAP R/3 should be used to teach quality is to help demonstrate to students how quality is incorporated throughout the enterprise. This can be accomplished by either teaching the quality functionality represented in the QM module, or by illustrating how the QM module integrates with other business functions. The ultimate goal is to help students understand business processes and how the business functions must be integrated to support and automate these processes. The remainder of this paper will present the linkages between quality and other functional areas, illustrating how these are integrated within an ERP system, and will provide some examples of exercises using SAP R/3 that can be assigned as part of a quality course to enhance students' understanding of these concepts.

THE INTEGRATION OF QUALITY

An ERP system provides students with a means to experience the integration of business processes throughout the firm. By focusing on TQM, the impact of one process on other areas of the business, such as production, inventory control, and accounting can be illustrated easily. For example, quality data entered into the system for incoming material can be accessed by production for decision-making purposes. Likewise, sales and customer service can access quality data generated by the production process. Although the functionality and configurability of ERP systems may vary, each system will have some level of capability for integrating quality with other business processes within the firm.

Quality and Production

A firm typically employs measurement limits to determine the quality of materials it purchases, the product throughout the production process, and the finished good. Quality control tests with measurement limits and testing frequency can be incorporated into the ERP system for any item or stage in the production process. This enables a firm to integrate purchasing and production directly with the quality assurance system. As material is purchased or work-in-progress is produced, the actual quality measurements are entered into the system and compared to the measurement limits. If the actual measurements fall outside the limits, the status of the item is automatically flagged as requiring attention by quality control (QC) and the inventory is not available for further processing or sale until a designated employee takes the appropriate action.

Quality is integrated within the production planning process when material availability is checked. If a production run requires material with specific quality attributes (e.g., grade, potency, or pH level), the requirements can be matched to the attributes of the material in inventory and production scheduled according to its availability. Within a process industry such as chemicals, the recipe used to create the batch is adjusted according to the quality attributes of the input materials. The planning process uses this information to determine the input quantities required to yield a specific output quantity with certain quality characteristics.

Many ERP systems have lot traceability functionality. This is particularly important for firms in the food and pharmaceutical industries. A lot can be traced from the finished good back through the production process and material input. Many federal regulatory agencies require this capability. An ERP system integrates quality with purchasing, production, and distribution by allowing a lot to be tracked automatically throughout the system. In addition, the system can often be configured to prevent inventory movements and lot combinations that might compromise quality according to industry regulations.

Quality is easily integrated into the inventory control system by an ERP system. Each lot or batch in inventory has quality characteristics and dates associated with it. As inventory is created and moved within the system, these characteristics and dates can be updated to help track and control inventory. As stated above, the system can help the firm determine whether lots can be combined in inventory based on these characteristics and dates. Relevant dates may include a shelf-life date, an expiration date, or a quality re-testing date. The ERP system can be configured to flag inventory within the system that exceeds these dates so the appropriate action can be taken.

Quality and Sales

The quality characteristics and dates are also used as a link between quality and sales order processing. An ERP system can be used very effectively to provide good customer service by matching the lot to the quality level desired by the customer. When an order is placed, the ERP system will match the quality characteristics of the lot with the quality attributes required by the customer. When the lots matching the customer's criteria are located, the system can prioritize which lot should be used to fill the order based on lot selection criteria such as oldest, largest, smallest, or expiration date. Lot selection criteria can also be used to control inventory by turning inventory in a manner desired by the firm. If the customer has a question about the lot, the lot traceability functionality allows the firm to provide more data about the lot or determine whether a quality problem exists. Therefore, the firm can also take the appropriate action with the remaining inventory or product that has been distributed to other customers. In addition, the problem can be more easily traced to the source, whether it is in production or with material supplied by the vendor.

Quality and Accounting

An ERP system ties the activities occurring throughout the firm, including quality activities, directly with the accounting system through the general ledger. Scrap and rework data as well as quality testing costs are automatically captured in the general ledger and can be used for analysis. Inventory held in a QC status is valued and reflected in the accounting system. A credit note issued to a customer for product returned due to a quality problem is immediately reflected in the general ledger and can be tracked for analysis. The ERP system can be configured to link quality related cost data directly to the general ledger and accounting function. These data can be further used for analysis and control of quality within the firm.

The ability to conduct analysis and generate documentation is enhanced by an ERP system. Quality activities, trends, and costs can be analyzed in an effort to become more efficient and effective in purchasing and production. The availability of these data is made possible by the integration within the system of quality, purchasing, production, and accounting activities. In addition, many systems utilize the production and quality data for statistical process control. The quality results of purchased materials can be tracked to evaluate the quality performance of vendors and aid in vendor selection. Lot traceability provides a firm with a means to generate the appropriate documentation for regulatory agencies. The ERP system enhances the ability of the firm, through documentation, to track and control its inventory movement to and from an available status and QC. Inventory may go into a QC status as material is purchased and inspected, during the production process, or as a result of a customer driven return. In some systems, the inventory can only be restored to an available status through a QC function. This functionality gives the firm better tracking and control of its inventory, as well as any necessary documentation.

Quality and Human Resources

TQM within the firm incorporates aspects of quality other than product quality. A human resource (HR) component of an ERP system includes system security. Access to the overall ERP system, or just one computer screen of the system, is controlled by the system security setup. This aids a firm in maintaining quality and data integrity within the system by allowing only trained, qualified people limited access to the system. The security level established for individuals or groups may include read-only capability for specific screens, processing capability for specific modules, or the ability to change specified parameters.

Quality throughout the firm can also be improved when the HR function utilizes the ERP system to help reduce costs, which in turn leads to increases in efficiency and productivity. Managers can use the ERP system to effectively recruit employees with attitudes and values more closely aligned with the corporate culture. This, in addition to an enhanced ability to tailor training, compensation, benefits and incentives to each individual employee, results in satisfied employees. Hence, the firm benefits by having improved employee retention which contributes to a higher quality workforce. Not only is there a direct impact on the quality of the workforce itself, but the HR function can improve the quality of its processes by being able to more effectively monitor actual employee performance relative to plan, maintain employee skill profiles, match company needs to available knowledge and skills, manage career and succession planning objectives and track progress against these objectives, administer payroll, and handle regulatory compliance needs. Other ways in which the HR function can improve quality throughout the firm is by communicating the company's vision and policies in a timely and effective manner to all employees, quickly disseminating information about changes in strategy or processes to the appropriate people, and providing access for all employees to their skills profile, assessment, training plans, salary, bank information and tax withholding. Overall, the quality of life within the firm improves because employees are more satisfied and the firm gets the most out of its human capital (www.sap.com).

SAP R/3 IN A TQM COURSE

In a course on TQM, a logical point at which to introduce students to SAP R/3 applications is during discussion of an organization's quality assurance system. A quality assurance system includes well-designed and documented procedures for product and process control, inspection and testing, control of measuring and test equipment, corrective and preventative action, and the use of appropriate statistical techniques. In most situations it is appropriate to identify and trace products during all stages, from purchasing through production to delivery and installation, even down to individual parts or batches. Data for process control come from some type of inspection, and inspection activities must be integrated throughout the production process (at receipt of incoming materials, during the manufacturing process, and upon completion of production). Through hands-on SAP R/3 applications, students can gain an appreciation of the complexities inherent in keeping track of these data, making decisions based on these data, and seeing the impact of these decisions on the rest of the organization.

Hands-On Exercises

The QM module in SAP/R3 consists of five elements: Quality planning, Quality inspection, Quality certificates, Quality notification, and Information system. In teaching TQM, an instructor may choose to incorporate any or all of these areas into her/his course. We focus on the elements of Quality planning and Quality inspection as they most easily fit with our course content. In creating an "SAP-enabled TQM course," a subset of exercises taken from the SAP R/3 training course LO705 - Basics in Quality Management can be adapted and introduced into the course. These exercises are briefly described in Table 1.

Many of these exercises have students create the files necessary to execute the inspection of some specific incoming material. Indeed, the first six exercises listed in Table 1 all deal with the building of such files: setting up the parameters and answering the types of questions that will drive the inspection process. Because inspection is material-based, the students' first step is to create a material master for a specific incoming part (e.g., batteries). In SAP R/3, this is accomplished using the MM (Materials Management) module from a QM (Quality Management) view. In creating the material master, students learn what basic information must be provided, such as what is being inspected (e.g., batteries), what will trigger an inspection (e.g., at goods receipt), and what type of results will be recorded in this master record after inspection (e.g., quality score).

Table 1
SAP/R3 Exercises Using the QM Module

Task	Description
Create a material master	Contains all necessary data including what material is being inspected, what is the base unit of measure, and what will trigger an inspection.
Create an inspection plan	Specifies the inspection operations and the characteristics (e.g., packaging, length, life expectancy) to be inspected for each operation.
Create an inspection method.	Describes how the inspection is to be carried out for an inspection characteristic.
Dynamic modification.	Involves adjusting the sample size and severity of inspection on the basis of current quality level.
Create inspection characteristics.	Describes the inspection requirements for materials, parts or products (e.g., tolerance limits for a quantitative characteristic).
Create inspection catalogs.	Enables standard definitions of qualitative attributes to be maintained through coding and facilitates the recording and later evaluation of descriptive data.
Results recording.	Executes the inspection plan and records results with reference to an inspection lot.
Usage decision.	Completes the inspection and affects other areas of the enterprise dependent on the decision.

Source: SAP AG Training and Education Participant Guide, LO705: Basics of Quality Management (NA), R/3 System Release 3.0F, May 1997.

Students begin to use the QM module with the second exercise. In creating an inspection plan, students are required to describe inspection operations (e.g., check material packaging, measure voltage), classify the characteristics being inspected (e.g., packaging is qualitative, voltage is quantitative), and set various controls (e.g., the type of results recording desired). At this point students also have the option of assigning a work center to the inspection operation that would enable the system to keep track of quality costs, hence an opportunity to show the link between quality and accounting. Closely related is the third exercise, creating an inspection method, in which students describe how the inspection is to be carried out for each inspection characteristic (e.g., lift and turn the pack of batteries to make sure that the packaging is not damaged).

The exercise on dynamic modification involves putting into place a mechanism for adjusting the sample size and severity of inspection for the material on the basis of changes in its quality level. This exercise underscores how results from inspection are fed back into the system allowing for adjustments to be made to future inspections. In completing this exercise, students are required to make decisions regarding sampling procedure (SAP R/3 supplies sampling procedures based on ISO

9000 standards), sampling plan (i.e., sample size and acceptance number), how ongoing quality levels should be monitored, and rules for changing inspection severities in the event that quality levels change (i.e., increased, normal, reduced).

In the next exercise, students determine specifics about each inspection characteristic and learn how they can create and use a master record to maintain this information. They are asked to determine the inspection requirements for each quantitative characteristic (e.g., upper and lower tolerance limits for voltage), to input formulas for any calculated characteristics (e.g., volume from length and diameter), and to specify whether a given characteristic was critical or optional to the acceptance decision. Use of a master record facilitates standardization of the inspection planning process. The next exercise has students create and use inspection catalogs. Inspection catalogs contain definitions for qualitative attributes that are added to the master record. Students can then code descriptions for qualitative attributes (e.g., damaged packaging) to facilitate the recording and later evaluation of inspection data.

After successfully building the files needed, and dealing with the myriad of decisions throughout the process, students are then ready to execute their inspection plans and record results. This exercise, coupled with the final exercise on usage decisions, provide students with an excellent opportunity to see how inspection results affect other areas of the enterprise. Students create an inspection lot, and then have each characteristic in all operations of the inspection plan evaluated (e.g., packaging, voltage). Results can include measured values, attribute codes, nonconforming units, number of defects, valuation code (accepted or rejected) and a quality score. The usage decision step is important in establishing linkages with other business processes. After inspection results are recorded, what will be done with the material? Will the material be made available to other areas of the enterprise? Should the material be posted to inventory, reworked or scrapped? Inventory control and the production planning process are obviously affected. In addition, the resulting quality score affects vendor evaluation and control. The current quality level also has implications for how future inspections of the material will be carried out based on the dynamic modification rule. By working through these exercises, students can see how quality fits into the logistical process. They can experience first-hand how the continuation of other business processes depends on the quality management function.

CONCLUDING REMARKS

SAP R/3 cannot only be used to support interdisciplinary cross-functional business courses, but it can also provide a means with which to link more specialized elective courses (such as TQM) to other business areas. While there has been virtually no account in the literature on using SAP R/3 in the teaching of quality, we believe that many opportunities exist to incorporate SAP R/3 applications into a quality course resulting in beneficial student outcomes. We also recognize that particular challenges may present themselves. Students whose first introduction to SAP R/3 comes in a specialized elective course may understandably have some difficulty understanding the system and its capabilities. As such, careful curriculum planning with regard to prerequisites and course sequencing is necessary to support "SAP-enabled" electives in either an MBA or undergraduate business program.

Future research should address the effectiveness of using SAP R/3 to teach quality. Specifically, pre-test versus post-test results could be used to assess whether SAP R/3 applications in a TQM course help students understand the linkages between quality and other business functions. Other types of general feedback, such as student satisfaction, could also be used to improve the pedagogy and design of "SAP-enabled" courses. Finally, course embedded assessment techniques could be employed to determine whether incorporating SAP R/3 applications in a TQM course helps to achieve desired student learning outcomes.

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THE DEVELOPMENT OF TELCSIM: AN INTERACTIVE TOOL TO ENHANCE STUDENT'S UNDERSTANDING OF TELECOMMUNICATION PRINCIPLES

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ABSTRACT

This paper presents the need, requirements and issues considered in the design and development of an interactive simulation software package intended to enhance the understanding of basic telecommunications principles by typical business students seeking to master the concepts of information technology. This paper focuses on the design and implementation of the first module of a Telecommunications Simulation package - TelcSim, specifically designed to meet the needs of today's students. This first module is an interactive visual learning tool that uses Fourier series analysis to animate a signal displaying it on a Frequency-Domain plot as well as on a Time-Domain-plot for various harmonics of the signal as chosen by a student. In addition, TelcSim provides features that enable students to observe damping and noise effects on a signal on real-time bases.

An experiment was conducted to measure the effectiveness of TelcSim. The analysis of data obtained reveals that TelcSim had significant impact on students' learning ability and their comprehension of concepts such as amplitude, and frequency or period of electromagnetic signals.

INTRODUCTION

In response to industry needs and requests, many colleges and universities have created technical Management of Information Systems or Information Technology Management (ITM) programs within the school of business rather than in the school of engineering or school of science. These programs attempt to provide individuals with business skills and the technical skills required to succeed in the information technology profession. The combined knowledge in both areas can be used to conduct businesses in more productive, economic, and efficient way. These individuals usually focus on the design, integration and use of existing technology to solve business problems, rather than basic research and the development of new technologies. These ITM programs typically teach a series of technical courses that lead to the understanding and mastery of information technology skills such as analysis and design, programming, database and telecommunications. In addition, these students are required to take the school of business core courses to develop an understanding of business processes.

The introduction of information technology, which includes many concepts from engineering and science, poses a dilemma for many business students. There is the false impression that business students do not require the depth of mathematical skills required in more technical areas. Most business curricula require only a cursory overview of mathematical concepts usually far less than required in either the typical engineering school or school of science.

In a basic telecommunications course, mathematics is the language typically used to present advanced technical concepts such as signaling methods, encoding techniques and general networking. Mastering topics taught in this manner requires an understanding of fundamental mathematical concepts. These concepts provide a student with the ability to see the application of an equation clearly from the expression itself. For example, Fourier series analysis is used to show how complex signals are constructed and can be decomposed for analysis. Without a strong mathematical foundation mastering these concepts is very difficult.

In most engineering classes, there is a laboratory component where the concepts discussed in lecture can be explored in a physical environment. The student can use an oscilloscope to view signals and see the effect of adding harmonics or noise components. These resources that reinforce and enhance the learning of theoretical concepts are typically not available to business students.

TelcSim was developed to bridge this gap. It provides a series of interactive simulations that assist students in understanding telecommunications concepts by presenting them in a visual manner. These simulations allow the student to use parametric analysis to study signal behavior.

REACHING TODAY'S STUDENT

We seem to be experiencing two fundamental changes in a typical college student. Today's new traditional students are typically less prepared by their high school experiences to respond to the methods of teaching and learning that most of today's instructor experienced. A report published by (Community College Week 1999) shows what is obvious to the casual observer - university faculty are aging in respect to students. This is creating a significant gap in our learning styles and world experiences

We live in a rapidly changing, highly connected, visually oriented, digital world. There are new expectations on the part of students. The technical environment today is far different from the environment that existed when most people teaching these courses were attending college. Teaching methods must change to meet the needs of today's students.

Teachers need to reexamine their strategies to present material by alternative methods. Practical learning experiences should be provided which emphasize hands-on activities. They can no longer emulate the methods used by instructors of the past to introduce complex ideas and principles.

Today's students have been raised with computer games and television as their primary media. They respond to and expect the use of technology in the learning environment. It is harder to entice them to study purely complex theoretical concepts. Their expectations are that the instructor will come up with creative methods to enhance their comprehension of the material presented. They are expecting the interactive world of the play station to provide their learning needs.

Co-existent with the needs of the younger students, there is an increase in the number of adult students returning to colleges to learn technical skills such as information technology. Adult students present a slightly different challenge as many of them have forgotten most of the mathematical concepts and principles that they may have once mastered. In addition, (Tomlin,1997) has shown that adults learn better by interactive hands-on experiences rather than by the traditional lecture approach to presenting materials.

Personal experience suggests that a high percentage of students seeking to master ITM lack the necessary background in mathematics to grasp the concepts as they are traditionally presented. Both new younger students and returning adults are expecting an interactive hands-on educational experience. Educators need to develop methods to satisfy both of these constituents and deliver a quality program. The development of *TelcSim* is an attempt to provide an interactive learning experience to meet the needs of these constituencies. The requirements, design, development and testing of a simulation tool - *TelcSim* - is outlined below.

NEED FOR INTERACTIVE VISUAL SIMULATION ENVIRONMENT

Flight simulator is used to successfully teach students to fly without the risk and expense of using an airplane. Visual simulations such as the *TelcSim* program help students master the basic concepts of signal theory as well as network and protocol simulations without the expense of maintaining a laboratory. Research by (Vidal-Madjar 1993) confirms that simulation enhances students' learning. Another study (Peter Li Inc., 1993) finds that the use of interactive simulation material leads to increased student motivation as well as a faster and deeper understanding of the principles being presented. These studies seem to indicate that there is a real value in the use of computer simulation in student learning environments.

DESIGN ISSUES AND REQUIREMENTS

Operating and Development Environment Selection

It was decided that the *TelcSim* tool must run in an environment that is readily available in most business schools. Today that environment is the Microsoft Windows operating system family running on PC based workstations. Development environments such as C++, Java and Visual Basic were considered. Visual Basic was selected due to it flexibility and interactive graphics capabilities.

Module 1: Fourier Series Analysis

One of the hardest concepts for beginning students to grasp is the creation of complex signals by the summation of sine waves differing in amplitude and frequency. Creation of an analog sine wave by summation is often used to introduce and reinforce these basic principles. Building on these concepts, we show how delay distortion and signal distortion occur during propagation.

A typical mathematical expression for constructing a square wave using Fourier series is shown below.

$$S(t) = \sin(2\pi ft) + \frac{1}{3}\sin(2\pi 3ft) + \frac{1}{5}\sin(2\pi 5ft) + \frac{1}{7}\sin(2\pi 7ft) + \ldots$$

Faced with mastering this equation, students often enter a glossy eyed trance never to recover.

Figure 1 shows the *TelcSim* screen showing a sign wave in time-domain plot. We have tried to present the display in the same manner as a student working in a laboratory would see the sine wave on an oscilloscope.

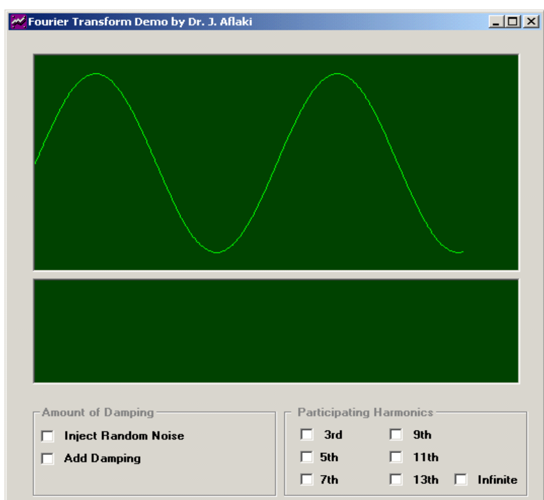

Figure 1. Screen print of *TelcSim* (Time-Domain Plot)

Figure 2 shows a Screen print of *TelcSim* module 1 Time and Frequency Domain Plots. A student is able to visualize the construction of different signals by adding harmonics to create a square wave. Visualizing how complex signals are created is an important concept that is valuable in understanding digital transmission over analog medium. The student is introduced to the concepts of period and frequency. *TelcSim* simulates an electronics lab project which uses a frequency generator and oscilloscope to introduce a student to equivalent concepts.

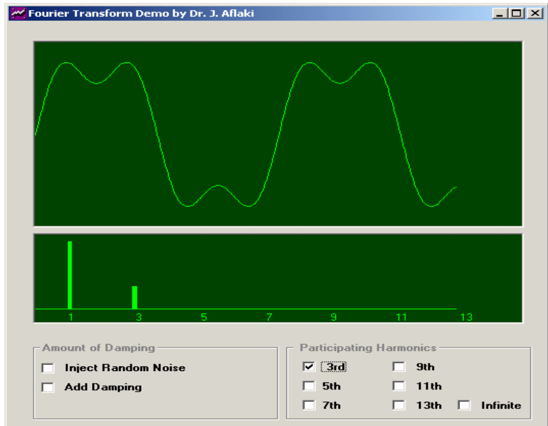

Figure 2. Screen print of *TelcSim* module 1 Time and Frequency Domain Plot

Module 2: Attenuation

As a signal travels from the transmitting device to the receiving device some of its power is absorbed by the medium. This loss of power over a distance is called attenuation. If the signal's power drops too much, then the receiving device may not be able to interpret the data correctly. The *TelcSim* tool has a module which uses a damping function to show the effect of attenuation on the signal power. A screen shot of this is shown in Figure 3. This module can also be used to show the concepts of delay distortion. Again, the simulation is modeled to emulate the environment a student would find in an electronics laboratory.

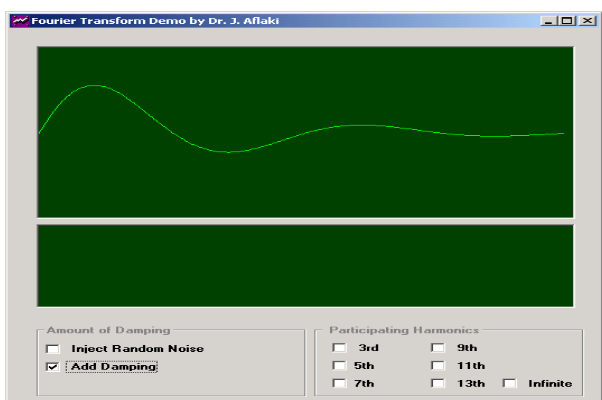

Figure 3. Screen print of *TelcSim* showing attenuation

Module 3: Noise

A signal in transmission is subjected to various factors such as attenuation and noise that affect the quality of the signal. Various types of noise such as thermal noise, cross-talk noise, inter-modulation noise, and impulse noise are discussed in our telecommunications course. The *TelcSim* tool has a module that uses a random noise generation function to show the noise effects on a signal. A screen shot of this is shown in Figure 4.

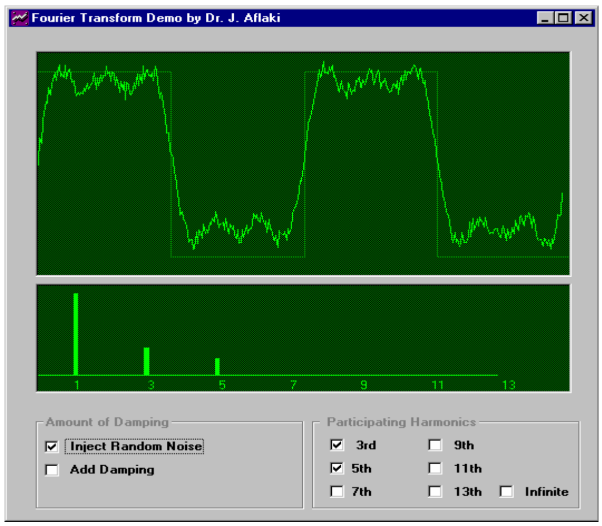

Figure 4. Screen print of *TelcSim* showing noise effects on a signal

DISCUSSION

TelcSim has been utilized in introductory telecommunications classes to supplement the teaching of basic signal concepts. To evaluate the effectiveness of *TelcSim* as a tool to teach fundamental concepts of electromagnetic signals the following experiment was designed. Two groups were selected from classes teaching the introductory telecommunication course. Thirty-eight students utilized *TelcSim* in their class and thirty studied the same concepts using only traditional methods.

To evaluate the effectiveness of *TelcSim*, four questions covering the basic concepts of the material covered were created. The same basic questions with different numeric values were included on each student's module examination. The four areas used to measure mastery of the material are categorized as follows:

Q1 - Amplitude
Q2 - Period/Frequency

Q3 - Phase
Q4 - Bandwidth

The results of this evaluation are shown in Figure 5 and Table 1. The raw scores show that with *TelcSim* 82% answered Q1 correctly versus 20% without *TelcSim*,. With *TelcSim* 50% answered Q2 correctly and without only 23% answered the question correctly. With *TelcSim*, 82% answered Q3 correctly versus 63% of those who did not use *TelcSim*. On Q4, 55% of those using *TelcSim* answered correctly versus 37% without *TelcSim*. The raw data shows that generally the use of *TelcSim* improved the student's performance.

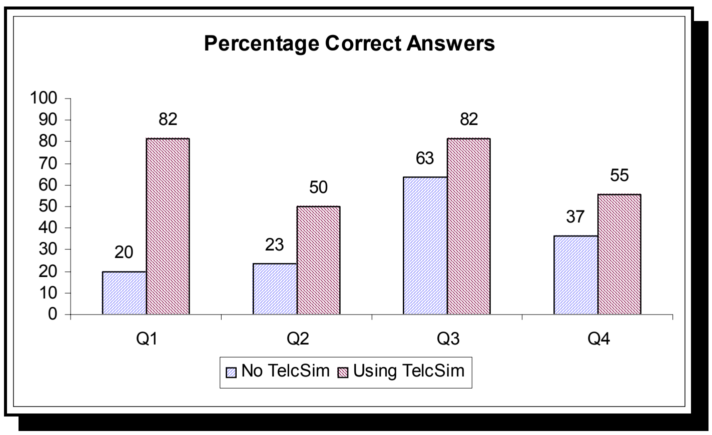

Figure 5 Comparison of correct answers given by students who used *TelcSim* with correct answers given by students who did not use *TelcSim*

Table 1: T Test - Group Statistics

	TELSSIM	N	Mean	Std. Deviation	Std. Error Mean
Q1 - Amplitude	No *TelcSim*	30	.20	.407	.074
	TelcSim	38	.82	.393	.064
Q2 - Period/Frequency	No *TelcSim*	30	.23	.430	.079
	TelcSim	*38*	*.50*	*.507*	*.082*
Q3 - Phase	*No TelcSim*	*30*	*.63*	*.490*	*.089*
	TelcSim	*38*	*.82*	*.393*	*.064*
Q4 - Bandwidth	*No TelcSim*	*30*	*.37*	*.490*	*.089*
	TelcSim	*38*	*.55*	*.504*	*.082*

SPSS 11.5 was used to analyze the results presented and the following hypotheses were tested:

$$H_0: \; P_{NoTelcSim} = P_{TelcSim}$$
$$H_1: \; _{PnoTelcSim} \neq P_{TelcSim}$$

Essentially, H_0, the null hypotheses states that there is no statistically significant difference between the student's performance using *TelcSim* and those that did not. H_1 states that there is in fact a statistically significant difference between the performance of the students using *TelcSim* and those that did not.

A T-Test was performed as this experiment is concerned with comparing the mean performance of two independent randomly selected groups of students on mastering the subject matter. Table 1 also shows that we cannot make the assumption of equal variance of the samples in this analysis. The results of the T-Test are presented in Table 2.

Table 2: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	*Sig.*	*t*	*df*	*Sig.* (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Q1 Amplitude	Equal variances assumed	.104	.748	-6.318	66	.000	-.62	.097	-.810	-.421
	Equal variances not assumed			**-6.292**	**61.353**	**.000***	**-.62**	**.098**	**-.811**	**-.420**
Q2 Period /Frequency	Equal variances assumed	14.661	.000	-2.301	66	.025	-.27	.116	-.498	-.035
	Equal variances not assumed			**-2.346**	**65.618**	**.022***	**-.27**	**.114**	**-.494**	**-.040**
Q3 Phase	Equal variances assumed	10.716	.002	-1.705	66	.093	-.18	.107	-.396	.031
	Equal variances not assumed			-1.661	54.824	.102	-.18	.110	-.403	.038
Q4 Bandwidth	Equal variances assumed	1.663	.202	-1.529	66	.131	-.19	.122	-.429	.057
	Equal variances not assumed			-1.534	63.135	.130	-.19	.121	-.428	.056

Table 2 shows that while students did better on all questions that were used to indicate mastery of the subject using *TelcSim,* only Q1 and Q2 showed significantly different results. This indicates that the *TelcSim* had significant impact on students' learning and their comprehension of concepts such as amplitude, and frequency or period of electromagnetic signals.

These results indicate that the use of *TelcSim* is worthwhile as a teaching tool but it should be enhanced to ensure that students master the concepts of phase and bandwidth.

It appears that students gain a better understanding of signal concepts by using *TelcSim* than by solving mathematical problems meant to help them master the same principles. Feedback was obtained from students about additional features they would like to see incorporated into the product and some interface changes were requested. These comments were compiled and may be incorporated in future releases of TelcSim.

The perceived need among faculty and students for some hands-on experiences to supplement the typical lecture-only format of ITM classes was the primary motivation for exploring methods of providing a laboratory experience to supplement technical classes such as telecommunications. *TelcSim* was initially conceived as a complement for the laboratory experience needed by ITM majors.

It appears that with continued development, this tool will provide an effective substitute for some of the needed laboratory experiences. There still exists a need for students to gain experience using real equipment in addition to simulations. The savings in physical laboratory space and equipment will more than justify the effort needed to continue development of this tool.

CONCLUSION

An experiment was conducted to measure the effectiveness of TelcSim. The analysis of data obtained from our experiment reveals that *TelcSim* had significant impact on students' learning ability and their comprehension of concepts such as amplitude, and frequency or period of electromagnetic signals. In addition, *TelcSim* provided students with a virtual hands-on laboratory experiment. It appears that this tool has been effective in teaching some of the more technical materials, required by industry, in our classes without being two concerned with students' lack of mathematical and technical background.

Furthermore, in the past, we received numerous complaints from students that they did not understand the related concepts being taught in introductory telecommunications classes. This tool seems to have created more interest and motivation to learn these concepts and has alleviated some of our students' concerns.

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PUBLISHER'S NOTE

The figures did not translate well into the journal in the publication process. The authors may be contacted for the better visuals.

LENGTH OF TERM AND LEVELS OF STATISTICS ANXIETY: A COMPARISON OF TYPES OF OFFERINGS

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ABSTRACT

Does the way a course in Business Statistics is offered affect the levels of statistics anxiety of the students in the class? The Statistics Anxiety Rating Scale (STARS) was administered to students during the first week of four different types of offerings: MWF (fifteen week semester, 50 minutes in length); MW (fifteen week semester, 75 minutes in length; MTWRF (summer session, 90 minutes in length); and MTWRF (intersession, 180 minutes in length). There were 95 subjects in the first group, 57 subjects in the second group, 33 subjects in the intersession class, and 46 subjects taking statistics in summer school. One-way ANOVA was used to see if there was any difference in the four groups. If a significant difference existed, Fisher's LSD was then used to determine which group or groups differed. Results, in general, showed that the length of the class affected the level of statistics anxiety in three of the six factors identified by STARS. Further examination showed that the accelerated courses, either in the summer session or in the intersession, resulted in significantly higher levels of statistics anxiety courses than either type of offering during the regular semester.

BACKGROUND

In the spirit of Corey's "Action Research" of the 1950s, the Statistics Anxiety Rating Scale (STARS) was administered at the beginning of the course in four different types of offerings, namely MWF (regular semester), MW (regular semester), summer session, and intersession. The classes were taught by the same instructor, used the same textbook and utilized similar methods of instruction. What is "Action Research"? It is defined by Corey to be "deliberate, solution-oriented investigation which is designed, conducted, and implemented by teachers themselves in order to improve teaching in the classroom" (Corey, 1954). Previous research found that the length of the term affected the levels of statistics anxiety (Bell, 2001). This study expands on the sample size as well as adding a different type of offering, namely a traditional MWF class. An earlier study found that international students scored significantly higher, indicating more anxiety, on several of the factors identified by the instrument (Bell, 1998). Other studies found that nontraditional students also scored significantly higher on some factors identified by STARS (Bell, 2002 & Bell, 2003).

Will students who opt for business statistics in an accelerated time frame exhibit higher levels of statistics anxiety?

METHOD

Participants in this longitudinal study included ninety-five students in a regular semester MWF class (fifty minutes), fifty-seven in a regular semester MW class (seventy-five minutes), thirty-three students in an intersession class (one hundred-eighty minutes), and forty-six studying statistics in summer school (ninety minutes). One-way ANOVA was used to determine differences in the anxiety levels of the various offerings, then Fisher's LSD was used to determine where the differences were. The data analysis features of Excel were used throughout. The data were gathered from 1998 to 2002.

INSTRUMENT

STARS consists of two parts. The first part presents twenty-eight situations often associated with statistics anxiety. These items are scored on a Likert-type scale from one to five, with a "one" indicating no anxiety with that situation while a "five" indicates considerable anxiety. The second part consists of twenty-eight statements dealing with statistics, with responses recorded on a Likert-type scale from one (no anxiety) to five (considerable anxiety). Hence, the lower the score, the lower the anxiety level. Six factors are revealed in STARS: worth of statistics, interpretation anxiety, test and class anxiety, computation self-concept, fear of asking for help, and fear of statistics teachers (Cruise, 1985).

Factor 1 - Worth of Statistics - This factor deals with a student's perception of the value of a statistics course. A person scoring high on this factor sees little or no value in a statistics course. A student scoring high on this factor also feels that statistics does not "fit" their personality, thus indicating a negative attitude toward statistics (Cruise, 1985).

Factor 2 - Interpretation Anxiety - This factor is concerned with anxiety rising from interpreting statistical data. This could arise from deciding which statistical test to use or what to do with the null hypothesis (Cruise, 1985).

Factor 3 - Test and Class Anxiety - The factor deals with anxiety related to taking a statistics course or examination. The student that scores high on this factor experiences anxiety when enrolling in or taking a statistics course, solving statistical problems, or taking an actual statistics test (Cruise, 1985).

Factor 4 - Computation Self-concept - This factor reveals anxiety associated with actual mathematical computations, thus relating to classical mathematics anxiety. The student that scores high on this factor experiences anxiety because it involves mathematical calculations and the student feels inadequate when comprehending statistics (Cruise, 1985).

Factor 5 - Fear of Asking for Help - A high score on this factor reveals a fear of asking a fellow student or the professor for assistance with statistics problems (Cruise, 1985).

Factor 6 - Fear of Statistics Teachers - This factor deals with the perception of the statistics teacher. A person scoring high on this factor questions “the humanness of the teacher”. This person views the statistics teacher as “lacking the ability to relate to the student as a human being” (Cruise, 1985).

DISCUSSION

Factor 1 - Worth of Statistics - One-way ANOVA revealed no significant differences in the four types of offerings .The means and percentiles of the four groups are shown below.

Table 1: Factor I - Worth of Statistics

Type of Class	Mean	Percentile
MWF	34.26	58th
MW	34.35	58th
Intersession	35.96	66th
Summer	38.00	66th

Factor 2 - Interpretation Anxiety - The groups differed significantly on this factor ($F = 2.994$, $p = .032$). Subsequent pair-wise comparisons using Fisher’s LSD revealed that summer session students scored significantly higher, indicating more anxiety, than either the MWF regular semester students ($t = -2.728$, $p < .01$) or the MW regular semester students ($t = -2.366$, $p < .01$) (Anderson, 1996). The means and percentiles are shown below.

Table 2: Factor 2 - Interpretation Anxiety

Type of Class	Mean	Percentile
MWF	26.00	61st
MW	26.14	61st
Intersession	27.88	70th
Summer	29.24	73rd

Factor 3 - Test and Class anxiety - Differences were noted on this factor ($F = 6.610$, $p = .0003$). Subsequent pair-wise comparisons revealed several significant differences. Regular semester MWF students exhibited lower levels of anxiety than either intersession students ($t = -3.92$, $p < .001$) or summer students ($t = -3.54$, $p < .001$). Regular semester MWF students also had lower anxiety levels than regular semester MW students ($t = -1.69$, $p < .05$). Intersession students had higher anxiety levels than regular semester MW students ($t = 1.97$, $p < .05$). Students opting for the summer course also had significantly higher levels of statistics anxiety than regular semester MW students. Means and percentiles for the four groups are shown below.

Table 3: Factor 3 - Test and Class Anxiety		
Type of Class	Mean	Percentile
MWF	24.15	55th
MW	25.84	64th
Intersession	28.33	72nd
Summer	27.85	72nd

Factor 4 - Computation Self-concept - One-way ANOVA found significant differences between the four groups on this factor also. Pair-wise comparisons revealed that summer students had significantly higher levels of statistics anxiety than regular semester MWF students ($t = -2.903$, $p < .005$), regular semester MW students ($t = -2.76$, $p < .005$), and intersession students ($t = -1.829$, $p < .05$). The table that follows shows the respective means and percentiles.

Table 4: Factor 4 - Computation Self-concept		
Type of Class	Mean	Percentile
MWF	14.71	56th
MW	14.73	56th
Intersession	15.12	56th
Summer	17.41	64th

Factor 5 - Fear of Asking for Help - No significant differences were observed for this factor. Means and percentiles for the four groups are shown below.

Table 5: Factor 5 - Fear of Asking for Help		
Type of Class	Mean	Percentile
MWF	8.96	42nd
MW	8.28	60th
Intersession	9.39	70th
Summer	9.83	77th

Factor 6 - Fear of the Statistics Teacher - No significant differences were noted for this factor. The mean and percentiles are shown below.

Table 6: Factor 6 - Fear of the Statistics Teacher		
Type of Class	Mean	Percentile
MWF	9.97	42nd
MW	9.82	42nd
Intersession	10.06	42nd
Summer	10.17	42nd

CONCLUSIONS

The length of the course appears to have some relationship to the anxiety levels experienced by the respective students in those classes. The length of the individual class, ranging from fifty minutes to 180 minutes, appears to be of utmost importance. Students taking business statistics in an accelerated format, such as a summer session or an intersession have significantly higher levels of statistics anxiety than those students who take statistics during the regular session. The better offering appears to be those with shorter class times, or in other words, more class meetings. The traditional MWF (three times a week) or MW (twice a week) have lower levels of statistics anxiety. Should these results be interpreted to mean that statistics should not be offered in accelerated time formats? Absolutely not. The instructor should only be aware that the students in these classes face more difficult challenges than those in traditional classes. Could the student be "forced" into such classes due to dropping a course? It might be pointed out that statistics is one of the prerequisites for upper division courses. Perhaps anxiety may be higher for all such classes. Techniques such as open books/notes, posting solved copies outside the classroom, collaborative testing, and extensive use of calculators were successful in lowering anxiety levels, but more so for better prepared students, namely those with a background in calculus (Bell, 2001). A recent trend for teaching business statistics has been to incorporate personal computers. Will this approach lower levels of statistics anxiety, or will the cyber phobia further complicate matters?

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INTERPRETATION OF SHIFTED BINARY INTERPRETIVE FRAMEWORK COEFFICIENTS USING A CLASSICAL REGRESSION PROBLEM

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ABSTRACT

In regression analysis, dummy variables are usually introduced by using binary coding and the designation of a single reference group for the purpose of interpretation. Other interpretive frameworks are available that allow comparison of designated category coefficients to an "average" value for the overall sample dependent variable. These shifted interpretive framework coefficients are usually easier to understand and interpret than the coefficients based on the binary-coded framework. Utilizing the processes suggested (1) by Suits and (2) by Sweeney-Ulveling, the binary framework coefficients can be shifted to allow for comparison about an "average" value. Each framework shifting process is accomplished without the assistance of a computer statistical package.

The purpose of this paper is to use binary framework coefficients, taken from a classical regression problem presented by Chatterjee and Price, 1977, to illustrate the two shifted interpretive frameworks and to discuss the interpretation of the resultant coefficients.

INTRODUCTION

In most introductory courses in statistics, the binary interpretive framework is the framework of choice when introducing the topic of dummy variables in regression analysis (Chatterjee and Price, 1977; Daniel and Terrell, 1992; Weiers, 2002). A recent Internet search for "dummy variable interpretation" resulted in access to hundreds of links for the request. A majority of these links emphasized interpretations based on the binary-coded framework.

The binary interpretive framework uses binary coding and the omission of one category of the dummy variable. The interpretation of each category coefficient is made relative to the omitted category. When a regression model has two or more dummy variables, the interpretation of the binary dummy coefficients is even more complex to interpret. Simplifying the interpretation of the binary interpretive framework coefficients can be addressed by utilizing the shifting of the binary-coded framework. The shifted interpretive frameworks allow interpretations of the coefficients for every dummy classification relative to an "average" for the dependent variable. The shifted interpretive frameworks are preferable particularly when the regression analysis is being employed by practitioners who are not accomplished statisticians, or when the results of the analysis are to be disseminated to individuals who are heterogeneous in regard to their various dummy classification membership. The shifted interpretive processes are accomplished without the use of a statistical computer package. The purpose of this paper is to use existing binary interpretive framework coefficients, taken from a classical regression problem, to illustrate two interpretive framework shifting processes and to discuss the interpretation of the resulting coefficients.

A CLASSICAL PROBLEM

In 1977, Chatterjee and Price presented a problem utilizing the binary interpretive framework and included two dummy variables. A few years later, Berenson, Levine and Goldstein (1983) used the Chatterjee-Price problem in their presentation of the binary interpretive framework. The authors considered the Chatterjee-Price problem as a standard in regard to the presentation and discussion of the binary interpretive frameworks of two or more dummy variables. This paper utilizes the Chatterjee-Price binary interpretive framework coefficients to illustrate and discuss two delineated shifted binary interpretive frameworks. Thus, the Chatterjee-Price problem is designated as a classical problem.

The Chatterjee-Price problem was developed from a salary survey of computer professionals in a large corporation. The objective of the survey was to identify and quantify those factors that determine salary differential. The salary variable was measured in dollars per annum. The explanatory variables included such factors as education, years of experience, and management responsibilities. The years of experience variable was measured in years. Education and management responsibilities were treated as categorical variables. Education was coded as 1, for completion of high school, 2 for completion of a college degree, and 3 for completion of an advanced degree. Management responsibility was coded as 1 for a person with such responsibility and 0 otherwise. The binary interpretive framework was used in the coding of the two categorical variables: with advanced degree the omitted category for education and without management responsibility the omitted category for management experience.

The binary interpretive framework dummy variables for education were D1 = (1,0) for high school graduate (HS), D2 = (0,1) for bachelor's degree (BS), and D3 = (0,0) for advanced degree (AD). The management responsibility dummy variables were D4 = (1,0) for management responsibility and D5 = (0,0) otherwise. The codes used in the computer solution are presented in Table 1.

For this study, the experience variable was recoded as deviations from the mean of experience. The deviations are denoted as X. The effects of all three variables on salary were measured using linear regression analysis performed on a computer and are presented in Table 2.

Table 1: Computer Coding for the Binary Interpretive Framework						
	Dummy Variable			Management	Dummy Variable	
Education	D1	D2	D3	Responsibility	D4	D5
High School	1	0	0	Yes	1	0
Bachelor's Degree	0	1	0	No	0	1
Advanced Degree	0	0	1			

Table 2: Binary Interpretive Framework Fitted Model			
Variable Name	Coefficient Estimate	Standard Error	t
(Intercept)	15128.2	349.6	43.28
Experience (X)	546.2	30.52	17.9
High School Graduate (D1)	-2996.2	411.8	-7.28
Bachelor's degree (D2)	147.8	387.7	0.38
Management Responsibility (D4)	6883.5	313.9	21.93
R^2 = 95.7% S = 1027			

The general regression model for the Chatterjee-Price classical problem is as follows:

$$Y = b_0 + b_1 * X + b_2 * D1 + b_3 * D2 + b_5 * D4 \quad (1)$$

where b_0 is the intercept or constant for the model. The fitted regression model for the Chatterjee-Price problem is stated as:

$$Y = 15128.2 + 546.2 * X - 2996.2 * D1 + 147.8 * D2 + 6883.5 * D4. \quad (2)$$

Appropriate residual and influence analyses should be applied to the fitted model in order to satisfy the use and interpretation of the model's estimated coefficients. For this study, the fitted model is assumed to be satisfactory.

BINARY INTERPRETIVE FRAMEWORK INTERPRETATION

In terms of salary for computer professionals, the coefficients for Equation (2) are interpreted as follows:

1. The experience coefficient, b1, is $546.16, meaning that each additional year of experience is estimated to be worth an annual salary increment of $546.16;
2. The coefficient of the management responsibility dummy variable, b5, is estimated to be $6,883.50. This amount is interpreted to be the average incremental value in annual salary associated with a management position;
3. a) The HS education coefficient, b2, is $-2,996.2, measures the salary differential for the HS category relative to the AD category;
   b) The BS education coefficient, b3, is $147.8, measuring the salary differential for the BS category relative to the AD category; and
   c) The difference, b3 - b2, is $3,144.00, measures the differential salary for the HS category relative to the BS category.

The salary differentials may be restated as follows: AD is worth $2,996.20 more than HS, whereas BS is worth $147.80 more than AD, and BS is worth about $3,144.00 more than HS. The fitted regression model represented by Equation (2) assumes that these salary differentials hold for all fixed levels of experience.

SHIFTED BINARY INTERPRETIVE FRAMEWORKS

The choice of a middle category as a reference category rather than one of the extreme categories for a categorical variable is sometimes considered a way of constructing a form of group comparison that contrasts the categories to middle or "average" groups. However, this procedure does not address the complexity of coefficient interpretations because the interpretations remain relative to an omitted category. Perhaps a better way of constructing category comparisons is to shift the interpretive framework to an "average" of the dependent variable. The shift in the interpretative framework is such that the contrast of a regression coefficient for a designated category is made to an "average" value for the dependent variable and not to a specified zero-coded category. While the shifting processes will yield numerically different coefficients, the overall fit and significance of the regression model remain unchanged. A main advantage of shifting the interpretative framework of binary-coded dummy variables to an "average" is that the coefficients are no longer sensitive to which class is treated as the omitted class.

The process of shifting the interpretive framework of binary-coded coefficients can be made without the use of a computer program by adding a constant, k, to the coefficients within each set of coefficients for a qualitative variable and subtracting k from the regression equation constant or intercept. The general relationship for determining k is

$$\text{Sum}\ (b_i^*) = \text{Sum}\ (w\ (b_i + k)) = 0 \qquad (3)$$

where b_i represent the binary-coded regression coefficients, b_i^* represent the shifted regression coefficients, and w represents a weight for the importance of each coefficient within a set of regression coefficients for a qualitative variable. The resulting value of k yields the condition that the new set of coefficients, b_i*, will average zero.

The two shifting processes used in this study are (1) the Suits process (Suits, 1983) and (2) the Sweeney-Ulveling process (Sweeney and Ulveling, 1972). Starting with binary-coded coefficients, usually generated with the assistance of a statistical computer package, the shifting process can be accomplished with or without the assistance of a computer program. Each process uses the extended regression model. The extended model includes dummy variables for the omitted categories. The general extended regression model is stated as:

$$Y = b_0 + b_1 * X + b_2 * D1 + b_3 * D2 + b_4 * D3 + b_5 * D4 + b_6 * D5. \quad (4)$$

The fitted extended binary model for Equation (4) is stated as:

$$Y = 15128.2 + 546.2 * X - 2996.2 * D1 + 147.8 * D2 + 0 * D3 + 6883.5 * D4 + 0 * D5. \quad (5)$$

The coefficients b_4 and b_6 are for the omitted category dummy variables, D3 and D5, respectively. For the binary interpretive framework, these coefficients have a value of zero.

Suits (1983) suggested a shifting process, Shifting Process I, which expresses the category regression coefficients as deviations from an "average," where the "average" is the unweighted mean of the dependent variable across all categories for a categorical variable. In calculating the unweighted mean of means, each category receives an equal weight of 1, regardless of the number of cases in that category. Thus, when binary-coded coefficients are shifted using Shifting Process I, the value of w in Equation (3) is set at 1. The unweighted mean of all group means is reported as the regression equation constant, b_0, and is the reference point from which all category differences can be calculated. Since two sets of dummy variables are included in the Chatterjee-Price problem, a constant must be computed for each set and added to the coefficients of the respective sets, k_1 and k_2. The sum of the constants, k, is subtracted from b_0. Referring to Equation (5), the dummy variables representing education are D1, D2 and D3, and the constant k1 is computed as - (-2996.2 + 147.8 + 0) / 3. Likewise, for the dummy variables representing management responsibility, the constant k_2 is computed as - (6883.5 + 0) / 2. The required constants are k_1 = 949.5 and k_2 = -3441.8. The sum of the constants, k, is -2492.3.

To shift the interpretation framework of the coefficients to an "average" that is the overall mean of the dependent variable, referred to as Shifting Process II, Sweeney and Ulveling (1972) suggested using the sample proportions for categories of each qualitative variable as weights in Equation (3). For the Chatterjee-Price problem, a summary of the qualitative variables, education level and management responsibility, is presented in Table 3.

Using Table 3 and Equation (5), for education level, k_1 is computed as - (0.30435 * -2996.2 + 0.41304 * 147.8) and k_2 is computed as - (0.43478 * 6883.5). The required constants are k_1 = +850.8 and k_2 = - 2992.8. The sum of the constants, k, is - 2142. As in Shifting Process I, k is subtracted from the constant and each constant, k_1 and k_2, is added to the coefficients of their respective dummy regression coefficients in Equation (5). For a more complete discussion and illustration of these processes see Gober (2003).

Table 3: Summary of the Cases (n = 46) for the Qualitative Variables and Categories					
Cases	Education Level			Management Responsibility	
	High School	Bachelor's Degree	Advanced Degree	Yes	No
Frequency	14	19	13	20	26
Proportion	0.30435	0.41304	0.28261	0.43478	0.56522

The adjustment terms for the delineated interpretive frameworks are presented in Table 4. The Suits process yields coefficients that estimate the difference between the mean value of annual salary for a category and the unweighted mean of the means of annual salary across all categories. The Sweeney-Ulveling process yields coefficients that estimate the difference between the mean value of annual salary for a category and the weighted mean for annual salary.

Table 4: Adjustments for Shifted Frameworks			
Coefficients		Suits	Sweeney-Ulveling
(Intercept)	(-)	-2492.3	-2142
Education	(+)	949.5	850.8
Management	(+)	-3441.8	-2992.8

From Table 4, the shifted interpretive framework adjustments for the Suits process are \$949.50 for each level of education, \$-3,441.80 for each management level, and \$2,492.30 for the intercept. Likewise, the adjustments for the Sweeney-Ulveling process are \$850.80 for education levels, \$-2,992.80 for management levels and \$2,142.00 for the intercept. The extended binary framework coefficients and the shifted framework coefficients are presented in Table 5.

The Suits interpretive framework model is stated as:

$$Y = 17620.5 + 546.2\,X - 2046.7\,D1 + 1097.3\,D2 + 949.5\,D3 + 3441.8\,D4 - 3441.8\,D5, \quad (6)$$

and the Sweeney-Ulveling interpretive framework model is stated as:

$$Y = 17270.2 + 546.2\,X - 2145.4\,D1 + 998.7\,D2 + 850.8\,D3 + 3890.7\,D4 - 2992.8\,D5. \quad (7)$$

Table 5: Interpretive Framework Coefficients

	Framework		
Variable Name	Binary	Suits	Sweeney-Ulveling
(Intercept)	15128.2	17620.5	17270.2
Experience (X)	546.2	546.2	546.2
High School Graduate (D1)	-2996.2	-2046.7	-2145.4
Bachelor's Degree (D2)	147.8	1097.3	998.7
Advanced Degree (D3)	0.0	949.5	850.8
Management Responsibility (D4)	6883.5	3441.8	3890.7
No Management Responsibility (D5)	0.0	-3441.8	-2992.8

INTERPRETATION OF SHIFTED INTERPRETIVE FRAMEWORK MODELS

The Suits and Sweeney-Ulveling models yield the same coefficient for the quantitative variable, experience, as the binary interpretive model. The Suits shifted coefficients for the categorical variables are interpreted as follows:

1. a) Management responsibility, b5, adds $3,441.80 to the "unweighted average" of annual salary (averaged over all subgroups);
   b) Without management responsibility, b6, subtracts $3,441.80 from the "unweighted average" of annual salary (averaged over all subgroups);
2. a) The HS education category, b2, $-2,046.7, measures the salary differential for the HS category relative to the "unweighted average" of annual salary;
   b) The BS education category, b3, $1097.3, measures the salary differential for the BS category relative to the "unweighted average" of annual salary; and
   c) The AD education variable, b4, $949.5, measures the salary differential for the advanced degree category relative to the "unweighted average" of annual salary.

The Suits coefficients yield salary differentials for the categorical variables as follows: AD is worth $2,996.20 (2046.7 + 949.5) more than HS. BS is worth $147.80 (1097.3 - 949.5) more than an AD, and BS is worth about $3,144.00 (2046.7 + 1097.3) more than HS. These salary differentials are the same as the differentials using the binary framework.

The Sweeney-Ulveling's model coefficients are interpreted as follows:

1. a) Management responsibility, b5, adds $3,890.7 to the "weighted average" of annual salary (averaged over all subgroups);
   b) Without management responsibility, b6, subtracts $3,890.7 from the "weighted average" of annual salary (averaged over all subgroups);
2. a) The HS education category, b2, $-2,145.4, measures the salary differential for the HS category relative to the "weighted average" of annual salary;

b) The BS education category, b3, $998.7, measures the salary differential for the BS category relative to the "weighted average" of annual salary; and

c) The AD education variable, b4, $850.8, measures the salary differential for the advanced degree category relative to the "weighted average" of annual salary.

The Sweeney-Ulveling's coefficients yield the following salary differentials for the categorical variables: AD is worth $2,996.20 (2145.4 + 850.8) more than HS diploma, BS is worth $147.90 (998.7 - 850.8) more than AD, and BS is worth about $3,144.10 (2145.4 + 998.7) more than HS. Except for differences due to rounding, these salary differentials are the same as the differentials for the binary and Suits frameworks.

Equations (5), (6), and (7) differ in appearance, but all have the same coefficient of determination and the same standard error of estimate. The three frameworks allow for interpretations that are viewed from different angles. Rather than assessing each category relative to a particular omitted category that sometimes is chosen arbitrarily, the shifted interpretive frameworks show the extent to which management and education level salary coefficients deviate from the company "average" salary. An approximation of the salary of any individual or group of individuals can be computed by simply determining to which classifications the individual or group belongs, and then summing the increments (positive or negative) associated with these classifications with the "average" salary. The exactness of the approximation depends upon the degree of interaction that exists between the explanatory variables, because the equations assume no interaction among the explanatory variables.

As an additional note, when Equation (2) coefficients are generated, the variances for the coefficients are generally available. Thus, a t test applied to one of the coefficients will test salary in the selected category from the salary for the omitted category for that particular dummy variable. Whereas, a t test applied to one of the coefficients of Equations (6) or (7) will test the salary level for that category against the "average" salary for the company. A significant t test for any selected category indicates the selected category is significantly different from the "average" of the response variable. The variances of the coefficients for Equations (6) or (7) are different from those for Equation (2) and may be calculated from the variance-covariance matrix for Equation (2). When using a computer statistical package, dummy variable coding schemes are available which yield the shifted interpretive coefficients and their variances.

SUMMARY

Regression models that contain dummy variables are economically fitted by using the binary interpretive framework, Equation (2). Once Equation (2) is available, shifted interpretive frameworks (6) and (7) can be used to form coefficients that are more easily interpreted. For the Chatterjee-Price problem, the salary differentials for the categorical variables were shown to have the same values and interpretations for each of the three equations.

The Suits process of shifting the interpretive framework is quickly accomplished with just the knowledge of the binary interpretive framework coefficients. However, the Sweeney-Ulveling framework requires the frequency of occurrence for the categories within each categorical variable. When available, the Sweeney-Ulveling framework should be chosen to simplify the interpretation of coefficients because the coefficients are conveniently interpreted as deviations about the average of the dependent variable. The Suits framework provides coefficients that are interpreted as deviations about the unweighted average of the dependent variable when averaged across all subcategory averages. When the Sweeney-Ulveling framework is not available, the Suits framework is suggested as the framework of choice to simplify the interpretation of coefficients when compared to the binary interpretive framework.

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ISSUES AFFECTING THE INTEGRATION OF EMERGING INFORMATION TECHNOLOGIES INTO CORPORATE INFORMATION TECHNOLOGY STRATEGY: A DELPHI STUDY

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ABSTRACT

The accelerating evolutionary pace of technology creates a heretofore-unseen dilemma for the information technology executive charged with the responsibility of developing an IT strategy. Specifically, an executive who plans an IT strategy using only currently available commercial technologies must accept the prospect that some, or perhaps all, of the technologies may become obsolete prior to implementation. A potential remedy for the aforementioned problem exists in the form of emerging information technologies. By considering emerging information technologies as potential components of IT strategy, executives may be able to minimize the impact of the rate of technological evolution on IT strategy. This process requires the executive to evaluate technologies earlier in the product development life cycle. Accordingly, there are additional issues that executives must address with respect to emerging information technologies and IT strategy planning. This paper reports the findings of a four round web-based Delphi Study designed to elicit a cohesive set of issues that affect an IT executive's decision to integrate emerging information technologies into corporate IT strategy.

INTRODUCTION

In the competitive business arena that is the global marketplace, a strategy may be the single discriminating factor between the success or failure of an organization. Information technology executives recognize the importance of an effective organizational information technology strategy (Brancheau & Janz, 1996; Niederman et al., 1991). However, the rapid evolution of information technology (IT) injects an additional degree of complexity into the formulation and implementation of corporate IT strategy (Gordon, 2002; Low, 2001; Varon, 2000). Specifically, the innovation rate of IT has reached such a frenzied pace that organizations face the dilemma of planning a technology-based strategy with currently available commercial technologies that are often obsolete by the time of implementation (Benamati & Lederer, 2001; Davenport, 2001). Using emerging information technologies, strategists may diminish the evolutionary effects of technology on IT strategy. However, research suggests most technology executives charged with the responsibility of developing and implementing corporate information technology strategies do not employ plans that rely on emerging information technologies and therefore detrimentally affect the useful life of newly crafted strategies (Cegielski, 2001).

The research described herein utilized a web-based Delphi method to solicit, from information technology executives, a cohesive set of issues that significantly affect the integration of emerging information technologies into corporate technology strategy. Additionally, an online chat session with the participating executives provided a forum through which the practitioners were able to express additional qualitative sentiments regarding the adoption of emerging information technologies into corporate strategy.

The general implications of the current study are two-fold. First, the findings of the study provide significant insights for practitioners attempting to develop more timely information technology strategies. More importantly, the issues elicited during the Delphi rounds of the study offer an initial perspective from which researchers may populate decision models such as the Theory of Planned Behavior or the Theory of Reasoned Action to explain the adoption-decisions of IT executives regarding emerging information technologies.

INNOVATION DIFFUSION AND EMERGING INFORMATION TECHNOLOGIES

The most appropriate theoretical perspective from which to extend the current study is the sociological research domain of innovation diffusion. For this reason, the following sections include a brief overview of the research tradition of innovation diffusion.

An innovation is an idea, practice, or an object perceived as new by an individual (Rogers, 1995). It is important to note that it does not matter whether the idea, practice, or object is new by the measure of time that has lapsed since its discovery (Katz, 1961). The perception of newness by the potential adopter determines the reaction to the idea, practice, or object. Thus, if an individual perceives an idea, practice, or object, as new, it is innovation. Generalized knowledge regarding an innovation is one common measure of newness (Katz & Levin, 1959).

In many instances, innovation assumes the form of technology. Technology is a design for action that reduces the level of uncertainty in the cause and effect relationship involved in achieving a desired result (Rogers, 1995). Technology has two potential forms - hardware and software (Rogers, 1995). In innovation diffusion research, hardware and software have much more encompassing definitions that those definitions popularly employed in information systems research. Hardware is the tool that embodies the technology in physical form. Software is the information basis of the tool. Examples of hardware as technology, like the airplane or the television, are very common, as they manifest in tangible form. Technology embodied as software may be less obvious to casual observation. Political theories like Marxism and religious ideologies such as Calvinism are examples of technologies that are composed exclusively of information, and thus described in innovation diffusion research as software. Most often, technology is a combination of hardware and software. Because generalized information technology is the artifact of interest in the current study it is important to understand that both information technology hardware (i.e. workstations, routers, servers, printers) and information technology software (any coded program) are, in the broader constructs of innovation diffusion research, forms of hardware.

Emerging information technologies (EIT) represent a distinct category of IT innovation. For the purposes of this discussion, EITs are innovations that are in the early stages of development. Defining characteristics of EITs often include incomplete product standardization and limited availability (i.e. beta versions of software and prototypes of hardware). There are two distinct categories of emerging information technologies: 1) evolutionary extensions of existing technologies or 2) revolutionary new technologies, heretofore, unknown. Regardless of how an EIT is classified, the explicit business application of the EIT is the same: the capability of achieving a practical purpose more effectively or more efficiently than an existing technology. During the past decade, organizations have integrated a multitude of emerging information technologies into the ordinary course of business. Currently pervasive business applications of information technology such as e-mail, data warehousing, and client/server computing were, at one time, emerging information technologies.

CORPORATE STRATEGY AND INFORMATION TECHNOLOGY

Corporate IT strategy derives direction from the overall organizational strategy (Segars, Gover & Teng, 1998; King, 1988). Many organizations have well-developed IT strategies that complement the organizational strategy (Segars & Grover, 1998). However, most corporate IT strategist base future IT strategies upon currently available information technologies (egielski, 2001; Satish & Ritu, 1999). Simply stated, information technology executives focus on integrating today's commercially available technologies into tomorrow's IT strategy. In doing so, most executives develop corporate IT strategies that dramatically lag behind the evolution of technology. To remedy the problem of dated IT strategy, IT executives should focus some attention on emerging information technologies. Examining EITs during strategy planning affords the IT executive the opportunity to anticipate tomorrow's business applications of IT today. The inclusions of EITs in corporate IT strategy planning results in the development of a proactive, forward-looking, IT strategy.

THE DELPHI METHOD

The qualitative nature of the current study dictated the use of a non-traditional information systems research methodology. Specifically, the current study utilized the Delphi Method, a survey research technique developed by the Rand Corporation in the early 1950s (Dalkey & Helmer, 1963).

Because of the unique characteristics (Table 1) of the methodology, the Delphi technique is applicable for highly multi-dimensional research questions that deal with uncertainty in a domain of imperfect knowledge (Churchman & Schamblatt, 1965; Paliwoda, 1983). The objective of the technique is to achieve consensus among experts regarding a specific topic (Taylor & Meinhardt, 1985). In previous comparative analysis of group survey techniques, Riggs, (1983) and Rohrbaugh (1979) reported that the Delphi technique achieved a greater level of accuracy than other group consensus techniques.

Operationally, the application of the Delphi Method involves three phases: 1) the selection of expert panelist, 2) the collection of topic-relevant issues, and 3) the ranking of reported issues. The term "expert" is subjective therefore, a researcher must quantify, in some measurable terms, exactly what constitutes an expert for the purposes of the study. Of the Delphi studies published in MIS journals, researcher typically quantify experts based upon factors such as years of professional experience, job or position title, level of education, and professional certifications. To collect topic-relevant issues, the initial round of the Delphi questionnaire is open-ended (Delbecq, Van de Ven & Gustafson, 1975). The purpose of the first questionnaire round is to aggregate information for subsequent the ranking rounds of the study (Brancheau & Wetherbe, 1987). In the first round, the panel of experts contribute input that they feel pertinent to the focus question of the study (Nambisan & Agarwal, 1999). In the second round of the study, the panelists rank each of the issues from the first round (Paliwoda, 1983). From the data gathered in the second Delphi round, the study administrator scores the issues (typically using weighted average method) and redistributes the results to the panelist (Nambisan & Agarwal, 1999). In the third round, as well as any subsequent rounds of the study, the experts review the group rankings and to re-rank the issues given of the aggregated responses of the group. The process of ranking and re-ranking continues until the panelist achieve a consensus (Delbecq, Van de Ven & Gustafson, 1975).

Table 1: Characteristics of the Delphi Method

Characteristic	Description
Anonymity	By interacting only with the administrator, the panelist remain anonymous to one another.
Controlled feedback	Information is gathered and redistributed via the administrator.
Group response	Individuals contribute information to form a group response.
Expert opinion	Panelists are selected based on knowledge of the topic.
Reduced cost/ time	There is no need for the to arrange costly and time-consuming face to-face meetings

THE CURRENT STUDY

The current study utilized a Delphi process to aggregate and assess the relative importance of the issues that affect the integration of emerging information technologies into corporate information technology strategy. As part of the process, each potential panelist received an email solicitation for participation that included 1) the purpose of the study, 2) the definition of emerging information technologies advanced in the current study (EITs), and 3) three short summaries describing three different current emerging information technologies. Each of the three EITs used in the study is radically different - a telecommunications protocol, a programming language, and personal video technology. All three of the EITs chosen for the study meet the criteria of the definition of EIT advanced in this paper. Furthermore, the three EITs chosen for use in the study exhibit the property of *generalizability* - they are not technologies that are industry or application specific. For example, the telecommunications technology *Bluetooth* has as many potential applications in the automobile industry as it does in the financial services industry. Likewise, *XML* holds value for any organization with the desire to standardize web page applications, document transfer, or any number of other uses. Finally, virtual retinal display (VRD) is a technology that is applicable by end-users regardless of the industry or organization. The descriptions of the technologies selected for use in the current study, along with the aforementioned definition, provided the participants a common point of reference regarding EITs and the impact on IT strategy.

SUBJECTS

A review of Delphi studies published in MIS journals during the past 15 years revealed most studies utilize between 10 and 30 expert participants (Nambisan & Argarwal, 1996; Dekleva & Zupancic, 1996; Doke & Swanson, 1995; de Hann & Peters, 1993; Cougar, 1988). Only the SIM Delphi studies conducted by Brancheau et. al (1996, 1987) and a 1996 study by Malhota et al. included more than 50 participants throughout each round of the study. From the cursory analysis of previously published MIS Delphi studies, an initial number of 30 expert participants seemed appropriate for the current study. In order to obtain the desired number of participants, 212 CIOs from Fortune 1000 firms received the aforementioned email soliciting participation for the current study. Of the 212 individuals contacted, 75 individuals registered to participate in the current study.

Because of the diversity of the individuals who participated in the current study, it is important to report some associated information for the respondents. Geographically, there was representation from all major regions of the United States. Compared to 2000 census data, the South (46% of the respondents) was over-represented. This occurred mostly at the expense of the Midwest (11%). The West (19%) and Northeast (24%) were represented in proportions expected by their respective populations. The over-representation of the South is a function of the geographic proximity of the researcher conducting the current study. The Delphi respondents represented six industries. Information technology (25%) was the most represented industry followed by financial services (16%) and healthcare (16%). The employers of the respondents ranged in size from 3700 employees to over 65,000 employees. Seventy-eight percent of the respondents in the current study had 15 years of professional experience or more. Additionally, 81% of the respondents held the position of VP of Information Technology/Chief Information Officer/Chief Technology Officer. Finally, all respondents had an undergraduate degree and 35% had earned an advanced degree.

PARTICIPATION BY ROUND

The initial round of the study required the panelist to review the definition of EIT and read the three EIT summaries. Based on the definition and descriptions of the EITs, each participating executive submitted his or her perceptions of potential issues regarding the integration of each EIT into respective corporate strategy. In the first round, 37 of the 75 (49.33%) registered participants contributed 63 issues. After submitting comments regarding each of the three EITs, each executive classified the commonalities in his or her comments regarding the three EITs. Twenty-four of the original 63 issues were unique (Table 2). The unique issues provided the basis for the first ranking (round 2). In the second round of the study, 33 of the initial group of 75 (44%) registered participants ranked the issues (Table 3). All second round participants also participated in the first round of the study. Additionally, the computation of Kendall's Coefficient of Concordance was not significant therefore, a third round of the study was necessary to achieve a consensus.

Table 2: Unique Issues from Round One

1. Cost of the technology to deploy	2. Security of the technology
3. Ability to support the technology with current IT staff	4. Cost to maintain the technology
5. Acceptance of the technology by end-users	6. Current uses for the technology
7. Acceptance of technology by customers/clients	8. Reliability of the technology
9. Perceived future uses of the technology	10. Standardization of the technology
11. External support for technology	12. Use of technology by competitors
13. Commercial access to the technology	14. Training for users of technology
15 Compatibility with knowledge management practices	16. Performance aspects of technology
17. Potential measurable return on investment in technology	18. Technology development life cycle
19. Ability to integrate technology over time	
20. Integration of technology with organizations outside the firm	
21. Ability to gain competitive advantage through use of technology	
22. Ability to sustain competitive advantage using technology	
23. Compatibility of technology with current business operations	
24. Compatibility of technology with future business operations	

Table 3: Rank of Issues from Round Two		
Issue	Rank	% of Participants who Ranked the Issue Equal to The Group Rank
Ability to gain competitive advantage through the use of technology	1	48.48
Ability to sustain competitive advantage using technology	2	39.39
Security of the technology	3	33.33
Acceptance of technology by customers/clients	4	36.36
Current uses for the technology	5	48.48
Perceived future uses of the technology	6	51.52
Reliability of the technology	7	30.30
Performance aspects of technology	8	33.33
Compatibility of technology with current business operations	9	27.27
Compatibility of technology with future business operations	10	39.39
Cost to maintain the technology	11	42.42
Integration of the technology with organizations outside the firm	12	33.33
Compatibility with knowledge management practices	13	36.36
Cost of the technology to deploy	14	54.55
Acceptance of the technology by end-users	15	36.36
Standardization of the technology	16	69.70
Ability to support the technology with current IT staff	17	54.55
Commercial access to the technology	18	42.42
Training for users of technology	19	60.61
Ability to integrate technology over time	20	69.70
Potential measurable return on investment in technology	21	63.64
External support for technology	22	69.70
Use of technology by competitors	23	81.82
Technology development life cycle time	24	87.88

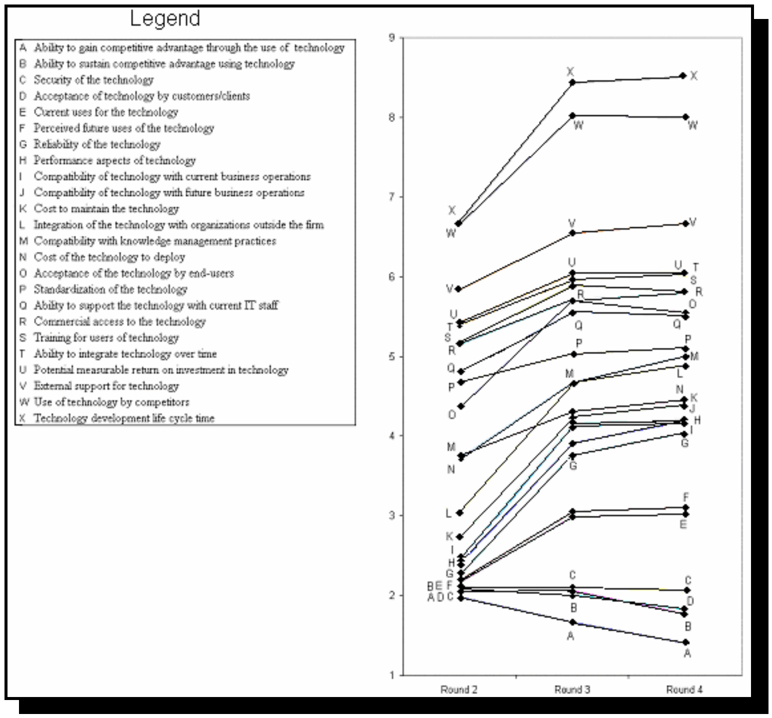
For the next round of the study, the same 33 executives again responded. The computation of Kendall's Coefficient of Concordance proved to be significant. Thus, the group achieved a consensus of the relative importance among the issues with respect to the integration of an emerging information technology into corporate IT strategy (Table 4). To improve the degree of consensus among the panel, each of the 75 registered participants received an email solicitation for a final ranking round (round 4). Thirty-one of the panelist responded to the final call for participation. All were participants in the previous three round of the study. Analyses of the fourth round data resulted in the desired outcome - a stronger degree of consensus among the panelists (Table 5). Figure 1 provides a graphical representation of the movement of the issues by round.

Table 4: Rank of Issues from Round Three

Issue	Round 2 Rank	Round 3 Rank	% of Participants who Ranked the Issue Equal to The Group Rank
Ability to gain competitive advantage through the use of technology	1	1	60.61
Ability to sustain competitive advantage using technology	2	2	48.48
Security of the technology	*3*	*4*	*51.52*
Acceptance of technology by customers/clients	*4*	*3*	*36.36*
Current uses for the technology	5	5	63.64
Perceived future uses of the technology	6	6	51.52
Reliability of the technology	7	7	57.58
Performance aspects of technology	8	8	63.64
Compatibility of technology with current business operations	9	9	45.45
Compatibility of technology with future business operations	10	10	63.64
Cost to maintain the technology	11	11	57.58
Integration of the technology with organizations outside the firm	*12*	*13*	*51.52*
Compatibility with knowledge management practices	*13*	*14*	*54.55*
Cost of the technology to deploy	*14*	*12*	*60.61*
Acceptance of the technology by end-users	*15*	*17*	*48.48*
Standardization of the technology	*16*	*15*	*66.67*
Ability to support the technology with current IT staff	*17*	*16*	*36.36*
Commercial access to the technology	18	18	51.52
Training for users of technology	19	19	48.48
Ability to integrate technology over time	20	20	69.70
Potential measurable return on investment in technology	21	21	75.76
External support for technology	22	22	75.76
Use of technology by competitors	23	23	87.88
Technology development life cycle time	24	24	90.91
Italic Denotes Change in Rank from Previous Round			

Table 5: Rank of Issues from Round Four				
Issue	Round 3 Rank	Round 4 Rank	% of Experts Ranking Issue Equal to Group Rank	% of Experts Ranking Issue in Top Ten
Ability to gain competitive advantage through the use of technology	1	1	77.42	100.00
Ability to sustain competitive advantage using technology	2	2	61.29	100.00
Security of the technology	*4*	*3*	*54.84*	*96.55*
Acceptance of technology by customers/clients	*3*	*4*	*45.16*	*93.10*
Current uses for the technology	5	5	70.97	93.10
Perceived future uses of the technology	6	6	51.61	86.21
Reliability of the technology	7	7	54.84	72.41
Performance aspects of technology	8	8	61.29	65.52
Compatibility of technology with current business operations	9	9	64.52	55.17
Compatibility of technology with future business operations	10	10	74.19	51.72
Cost to maintain the technology	11	11	64.52	44.83
Integration of the technology with organizations outside the firm	13	13	64.52	48.28
Compatibility with knowledge management practices	14	14	61.29	44.83
Cost of the technology to deploy	12	12	64.52	37.93
Acceptance of the technology by end-users	17	17	58.06	27.59
Standardization of the technology	15	15	67.74	27.59
Ability to support the technology with current IT staff	16	16	51.61	17.24
Commercial access to the technology	18	18	58.06	13.79
Training for users of technology	19	19	54.84	3.45
Ability to integrate technology over time	20	20	64.52	6.90
Potential measurable return on investment in technology	21	21	74.19	0.00
External support for technology	22	22	70.97	0.00
Use of technology by competitors	23	23	90.32	0.00
Technology development life cycle time	24	23	93.55	0.00
Italics Denotes Change in Rank from Previous Round				

Figure 1: The Movement of the Issues Through the Delphi Rounds (by Mean rank Score)



EVALUATION OF GROUP CONSENSUS

Following the completion the fourth round of the study, the computation of Kendall's Coefficient of Concordance (W) revealed a consensus existed among the participants with respect to the round 4 rankings of the importance of the issues. Kendall's W is a measure designed to determine the degree to which a set of ranked scores agree (Sigel, 1956). A significant W indicates that the participants applied essentially the same standard in judging the importance of the issues and they are in consensus. The formula to compute W is:

$$W = \frac{s}{\frac{1}{12}k^2(N^3 - N)}$$

In this expression, s is sum of squares of the observed deviations from the mean of R_j, k is number of sets of the rankings, N is number of issues ranked, and $\frac{1}{12}k^2(N^3 - N)$ is the maximum possible sum of squared deviations, i.e., the sum s that would occur with perfect agreement among k rankings. For the final round rankings of the Delphi study, W was ($W = 0.6103$, $p < .001$) statistically significant.

Two additional estimates of consensus, the percentage of respondents whose issue rank matched the group rank and the percentage of respondents who ranked a given issue with a rank of 10 or higher (Table 5) provided an additional support to the assertion that the group is in accordance. Based on the Kendall's W and both of the aforementioned rank percentages, it is clear that the group achieved a consensus. Consequently, no additional Delphi rounds were necessary.

VALIDATION OF DELPHI FINDINGS

One limitation of the Delphi technique is the generalizability of the results. That is, the ranking of the issues is valid only with respect to the panel sampled. An exploratory survey utilizing the Delphi results provided a mechanism through which to validate the aforementioned findings The use of exploratory survey techniques are common in IS research (Pinsonneault & Kraemer, 1993), and one of the primary purposes of exploratory survey research is to define the dimensions of a construct within a population of interest. Given the exploratory nature of the current study, the utilization of an exploratory survey instrument is an appropriate research design by which to assess the Delphi findings.

The instrument developed served the single purpose of corroborating the findings of the Delphi process. Thus, the instrument did not solicit from the respondents additional issues that may affect the integration of EITs into corporate strategy. The data collected using the exploratory instrument provided a means to comparative analyze the findings of the Delphi rounds.

The membership of two international professional IT organizations, Society for Information Management (SIM) and the Association for Systems Management (ASM) participated in the exploratory survey round. One hundred and thirty-one members of the SIM and ASM groups received a solicitation for participation via email. Each individual received the same definition of EIT and technology examples presented to the Delphi participants. Jointly, 75 SIM and ASM members responded to a 24-question survey instrument. The instrument required the participants to rate, on a 7-point Likert scale, the importance the previously identified issues with respect to integration into corporate IT strategy. A comparative analysis of the results of round 4 of the Delphi process and the exploratory survey reveal a considerable level of agreement among both groups with respect to the ranking of the issues (Table 6). Specifically, 7 of the top 10 issues from the final Delphi round also appeared as top10 ten issues in the exploratory survey rankings. Additionally, the first two issues in both rankings coincided. Given the concordance between the two sets of rankings, it is reasonable to assert that some level of generalizability exist regarding the findings in the study. However, additional testing is required to validate the assertion.

Table 6: Comparison of Round 4 Delphi and Exploratory Survey Rankings

Issues	Exploratory Survey Issue Rank	Round 4 Issue Rank
Ability to gain competitive advantage through the use of technology	*1*	*1*
Ability to sustain competitive advantage using technology	*2*	*2*
Security of the technology	14	3
Acceptance of technology by customers/clients	3	4
Current uses for the technology	4	5
Perceived future uses of the technology	5	6
Reliability of the technology	12	7
Performance aspects of technology	11	8
Compatibility of technology with current business operations	6	9
Compatibility of technology with future business operations	7	10
Cost to maintain the technology	13	11
Integration of the technology with organizations outside the firm	10	13
Compatibility with knowledge management practices	9	14
Cost of the technology to deploy	8	12
Acceptance of the technology by end-users	16	17
Standardization of the technology	*15*	*15*
Ability to support the technology with current IT staff	17	16
Commercial access to the technology	20	18
Training for users of technology	18	19
Ability to integrate technology over time	22	20
Potential measurable return on investment in technology	*21*	*21*
External support for technology	19	22
Use of technology by competitors	*23*	*23*
Technology development life cycle time	*24*	*24*
Italics denotes a matching Issue rank between both study groups		

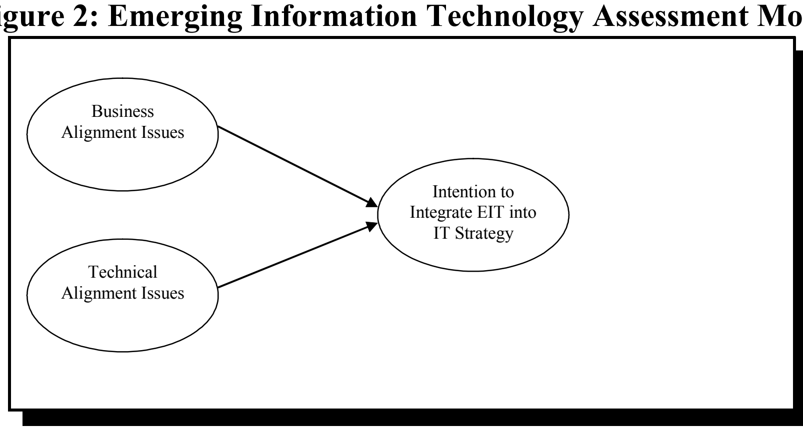
ANALYSIS

Qualitative feedback, obtained via an online chat session with the panel following the fourth Delphi round revealed that the overwhelming majority of the participating IT executives believe the EIT integration decision stratifies into two separate but interrelated assessment areas: *business alignment issues* and *technical alignment issues* (Table 7). Interestingly, *alignment*, in numerous facets, appears as a key issue in IT strategy in several previous research studies (Table 7). According to a CIO from a global information technology firm whose sentiments were widely supported by the group, the two areas differ in that, "business issues address the general ways and means that a particular technology will support an organization's objectives" while technical alignment issues focus on "the nuts and bolts of a particular technology like compatibility with existing systems." Generally, the panel agreed that business alignment issues reflect concerns that are universal to all organizations - competitive advantage, customer relationship management, and organizational fit. Interestingly, the study participants defined all of these issues in qualitative assessment measures. Conversely, the technical alignment issues are firm specific and, as the study group described, tend to focus on very quantifiable aspect of a technology. According to the panelist, the consensus rankings of the top 10 issues illustrates a clear distinction between these two areas. The feedback from the panelist provides the foundation for the Emerging Information Technology Assessment Model (Figure 2)

Table 7: Stratification and Definition of EIT Integration Issues

Business Alignment Issues	Technical Alignment Issues
Gain/Sustain Competitive Advantage	Current/Future Uses of Technology
Internal/External Usefulness of Technology	Performance of Technology
Compatibility of Technology with Operations	Implementation Impact on Systems

Figure 2: Emerging Information Technology Assessment Model



CONCLUSION

The results of the current study imply that the process through which EITs become part of corporate information technology strategy may center upon two distinct factors. The first, business alignment, represents the leveragability of an emerging information technology within the general context of the organization. The dimensions of business alignment include the competitive advantage offered by an EIT, the current and future compatibilities of an EIT, as well as the general usability of an EIT. Typically, all firms contemplating integrating an EIT into IT strategy must consider these aspects of the technology regardless of organizational scope or nature. The other factor, technical alignment, includes more firm-specific "nuts and bolts" concerns of an EIT. Reliability, security, and performance are some of the issues that comprise the technical alignment factor. Each firm must addressed, in specific IT context, the appropriateness of an EIT as a component of IT strategy. Finally, although two constructs emerged in the current study, additional research is necessary to frame the factors into a cohesive decision criteria.

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THE IMPACT OF PROCESS STANDARDIZATION AND TASK UNCERTAINTY ON CREATIVITY IN GSS ENVIRONMENTS

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ABSTRACT

This paper discusses the links between task complexity, group process structure and creativity in GSS environment. The type of standardization of the group process mediates the strength of the impact that groupware has on group creativity. Group creativity was found to increase when the group process is less restrictive. Greater levels of task uncertainty were found to lead to more creative solutions.

INTRODUCTION

Creativity has been considered a key factor to boost organizational effectiveness in post-industrial environments. As such environments pose new challenges; organizations are required to find novel ways to deal with more complexity and increased turbulence. In order to respond quickly to the constant and unexpected changes, organizations rely increasingly on teamwork. Group Support Systems (GSS) have been used to improve the generation of creative solutions by teams (Santanen, E.L., R.O. Briggs, G.J. de Vreede, 2000), consequently improving the effectiveness of the decision-making processes.

Creativity researchers have mainly focused on the qualities of the creative person or group, the creative product, or the contextual variables that affect creativity. Prior research has focused largely on creativity in the following dimensions: a) the idea generation phase of problem solving (Hender, J.M., T.L. Rodgers, D.L. Dean, & J.F. Nunamaker Jr., 2001; Massetti, B. 1996; Sosik, J.J., B.J. Avolio, B.J. & S.S. Kahai, S,S., 1998), b) the impact of technical aspects (Fjermestad, J., & S.R. Hiltz, 1999), and c) the cognitive, social and procedural structures behind creativity (Bostrom, R.P. & M. Nagasundaram, 1998). Very few studies have explored the process behind creativity. This research will look at creativity in GSS environments, from a process standpoint, and focusing on the output of the whole problem solving process. Understanding which types of processes yield increased levels of creativity is the main goal.

Group processes can be more or less restrictive, depending on the extent to which there is a pre-defined sequence of tasks they should go through when solving problems. Some researchers claim that "laissez-faire" group processes result in higher levels of group creativity, are more favorable to innovation, or provide freedom to try new ways of performing tasks. This research explores two group Process Structures in terms of their level of restrictiveness, and their impact on group creativity in electronic-mediated meetings. The two structures are: Standardization of Processes (SP) and Standardization of Outputs (SO). Additionally the research explores task complexity or uncertainty as an intervening variable affecting the relationship between structure and creativity.

PROCESS STRUCTURE, TASK COMPLEXITY AND CREATIVITY

Innovation and creativity mean to break away from highly formalized behaviors (Mintzberg, H., 1979). The literature on group innovation and creativity mentions five sets of antecedents to creative processes, namely (i) leadership, (ii) group cohesiveness, (iii) group longevity, (iv) group composition, and (v) group structure (King, N., & N. Anderson, 1990). High levels of innovation are facilitated by leadership styles that promote democratic collaboration. While low cohesiveness is necessary in the earlier stages of innovative processes, higher levels are required in subsequent phases (Nyström, H., 1979). In terms of group composition, minority influence theories argue that minority sources lead to more divergent thinking, which in turn establishes the ground for creative solutions (Nemeth, C.J., 1986). Finally, the level of restrictiveness of a group's structure and the group's degree of innovativeness are related (Meadows, I.S., 1980). This study focuses on the last set antecedent, that is, group structure and its impact on creativity.

A few authors assert that some level of structure is conducive to creative solutions, and that too much structure or the wrong structure may render the group process non-creative. "Laissez-faire" group structures are said to result in higher levels of group creativity (Glover, J.A., 1979). Low levels of restrictiveness are claimed to be favorable to innovation (Holbek, J., 1988). Finally, the provision of freedom to try new ways of performing tasks is claimed to be a necessary condition for creativity (Isaken, S.G., 1988). Nonetheless, the level of group structure did not have an impact on group's creativity in one case (Ocker, R., S.R. Hiltz, M. Turoff, & J. Fjermestad, 1995).

Groups' process structures are dependent on coordination needs. Coordination modes that yield effective performance are a function of groups' structural characteristics and the complexity of the group's task (Dailey, R.C., 1980). The nature of the group interactions becomes mostly determined by the level of task complexity (Hackman, J.R., 1968). Group size and cohesiveness mediate this causal relationship (Dailey, R.C., 1980).

Tasks are usually classified in terms of both level of goal agreement and beliefs about causation (Thompson, J.D., & A. Tuden, 1959). Complexity is defined as a function of the amount of relevant information that has to be processed to attain a solution. Decision-makers deal with both a broad span of goals, and a considerable number of pieces of information associated with each course of action. In one case, group members deal with information that enables the definition of the desired outcomes (i.e., goal agreement). In the other case, they deal with information that allows them to elucidate the associative links between actions and consequences. The lack of knowledge concerning these links has been referred to as task uncertainty.

When group members face an undetermined number of pieces of information associated with each course of action, standardization helps groups to reduce the task-related uncertainty (Mintzberg, 1979). In certain tasks, the options and their consequences can be fully determined in advance (Mintzberg, 1979). The contents of the task can be specified and programmed, by means of rules and procedures to secure acceptable outcomes (i.e., Standardization of Processes, SP) (Mintzberg, 1979). On the contrary, in uncertain tasks, options and consequences are not fully known, and the group is forced to turn to standardization of outputs (SO). While maintaining control, SO allows task-doers sufficient autonomy to manage their sub-tasks (Mintzberg, 1979).

If conflicting preferences about outcomes and internal conflicts over goals and values exist, a social process is needed to handle the level of goal disagreement. Group members engage in less structured interactions to generate a shared interpretation of the task at hand. This social process corresponds to a process of informal communication, that is, mutual adjustment (Mintzberg, 1979).

RESEARCH FRAMEWORK

Based on the discussion in the previous section the research framework presents two basic hypotheses. The first relate to the structure of the process and the second relate to task complexity or uncertainty.

SO provides structures that are less restrictive than those available under SP. Restrictive processes may exert pressure on the group to spend less time in the generation of alternative courses of action (11). On the contrary, less restrictive structures allow members to share ideas directly and increase the occurrence of novel associations, and hence of creative solutions (Van de Ven, A.H., & A.L. Delbecq, 1971). SO is hypothesized to (i) favor more divergent thinking, (ii) reduce conformity pressures, (iii) make possible for groups to spend more time in the generation phase, and (iv) increase the level of group creativity.

Hypothesis 1: Group processes based on SO will render the group more creative than those based on SP.

In highly uncertain tasks, group members spend a great deal of time gathering and sharing relevant information. As they engage in more information-exchanging activities, they consider more relevant pieces, and hence a broader set of alternative courses of action. When the pieces of new information are abundant, there is more need to share them directly. Direct sharing is related to the development of novel associations and, ultimately, to creativity (Van de Ven, A.H., & A.L. Delbecq, 1971).

Hypothesis 2:	Groups working on high-uncertainty tasks will generate more creative solutions than those groups working on low-uncertainty tasks.

RESEARCH DESIGN

The study used a 2x2 simple factorial design, fully counterbalanced for both variables: Uncertainty (i.e, the amount of informational exchange) and Standardization (i.e., amount of restrictiveness).

Two versions (i.e., low and high uncertainty) were developed for the selected task, a marketing case from HBP. Two experts rated the cases in terms of equivocality, uncertainty, and level of goal agreement (Cronbach's Alpha for the combined set of scores was 0.702). According to them, the levels of both equivocality and goal disagreement were low.

Two process structures were used, namely SP and SO. Under SP, groups were asked to follow a sequenced approach in their dealing with the task. The sequence imposed a tight process, with little room for improvisation. Under SO, groups were given more flexibility. They were asked to include three parts in the formal final report: issues, assumptions, and recommendations.

The GSS used provided an asynchronous electronic environment in which groups solved the case. Thirty-two groups (two four-person groups, and thirty three-person groups) that participated in the experiment were randomly assigned to one of the four conditions. There were not statistical differences between conditions for all the contextual factors. Facilitation of the group process was precluded by the design of the experiment.

Ninety eight undergraduate students, mostly in their junior and senior years, participated in the study. Extra credit was given for participation. The average age was 26 years, with an average of 4.4 years of experience. They reported to have moderate levels of experience in business environments, and low levels of experience working with groups.

Creativity was rated by a panel of experts (Cronbach's Alpha = 0.743). "A product or response is creative to the extent that appropriate observers independently agree it is creative…A product or response will be judged as creative if (a) it is both a novel and appropriate, useful, correct or valuable response to the task at hand, and (b) the task is heuristic rather than algorithmic." (Amabile, 1983: 31).

The hypotheses were tested using GLM ANOVA. According to values for the Shapiro-Wilk statistic, the observations were taken from populations normally distributed. Furthermore, the values for the Hartley statistic led to the acceptance of the null hypothesis that the variances for each set are equal

RESULTS

Tables 1 and 2 present the means and standard deviations by condition, and the ANOVA results for the set of hypotheses. According to these results, type of structure and level of uncertainty have an impact on creativity.

Based on the overall results, when the level of task uncertainty is higher, groups tend to be more creative (p=0.09). Interestingly, the results for the Type of Standardization are opposite to those hypothesized. When the coordination mechanism is more restrictive, that is, it explicitly defines the steps of the decision process, groups tend to be more creative (p=0.04)

Table 1: Creativity: Means, (Standard deviations)

Condition	Low Uncertainty	High Uncertainty	Totals
SP	61.67 (11.88)	77.90 (14.15)	69.24 (15.06)
SO	42.33 (15.30)	59.11 (23.71)	51.22 (21.40)
Totals	52.00 (16.58)	67.33 (21.74)	59.67 (20.55)

Table 2: ANOVA results

Hypothesis	F-Value	DF	p-value
Process Structure	4.67	1,28	0.04
Uncertainty	3.06	1,28	0.09

DISCUSSION

Overall, the study provided empirical evidence to support the claim that both the type of standardization of the group process and the level of task uncertainty have an impact on group creativity.

Although the type of process standardization affects the creativity of a group, the results were opposite to those hypothesized. When the group process is less restrictive, groups are less creative (p=0.04). This result may be due to the so-called "multi-headed animal syndrome" (Smith, J., & M.T. Vanececk, 1989). According to it, the lack of an orderly process may render the group process ineffective. Nobody seems to take the initiative and nothing seems to happen. Although asynchronous communication allows more time for reflective thinking, there is a tendency to procrastinate and become side-tracked. For some group members, frustration from the lack of a sense that something is happening contributes to a perceived lack of progress toward a goal. Although there are several techniques available to counter this asynchronous ineffectiveness and regulate GSS groups' behavior (e.g., facilitation), the empirical design precluded using them.

A "fading motivation" may have had a role in this result. The perceived process gains that were present in the earlier stages of the groups' decision processes wore out as groups moved to the later stages, due to the lack of participation. The initial motivation probably faded away and the final solution failed to include the richer set options originally considered. Participation, which was moderate to high in the early stages, declined for SO groups as the experiment progressed.

The nature of the groups used (i.e., ad-hoc) could also have impacted this result. Teamwork takes place in a variety of settings, which condition the life of a team and the nature of its processes. By their nature, ad-hoc groups lack a broader context. Had it existed, contextual norms may have pushed groups to move forward, not to become side-tracked.

The low-significant result for uncertainty may be associated with the low structural discriminability of the uncertainty manipulation, although its operational discriminability seemed acceptable. Structural discriminability refers to the capacity of the manipulation to express the degree of differentiation that was required in the levels of this independent variable. Operational discriminability refers to the extent to which the actual use of the manipulation succeeds in distinguishing perceptions of the variable levels (Kane, J.S., & E.E. Lawler III, 1979). Although both experts and subjects perceived different levels of uncertainty (i.e., good operational discriminability), the perceptions did not correspond to the uncertainty levels intended (i.e., poor structural discriminability).

SUMMARY

In summary, when groups work under orderly decision processes, they tend to have more dynamic conversations, that is, they tend to make shorter contributions and to have more conversation rounds. The presence of such dynamism seems to entail more creative outcomes. Moreover, in tasks with higher levels of uncertainty, as group members collect and share information, their participation increases and so does the level of creativity of the group solution. The most important conclusion of this research is that If GSS groups are to be more creative, their processes need some level of structure and restrictiveness. The lack of appropriate levels of structure seems to render the group ineffective. Furthermore, when the task is more uncertain, group processes are more dynamic and groups produce more creative solutions. However, the question of what level of process restrictiveness yield the highest level of creative outcome needs yet to be answered.

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CASE USE: MIXED SIGNALS FROM THE MARKETPLACE

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ABSTRACT

Continuing system development problems are causing organizations to seek methods and tools that will improve the efficiency and effectiveness of system development projects. One set of tools that have long promised to alleviate many system development problems has been computer-aided system engineering (CASE) tools. While these tools have been around for nearly two decades, previous research had indicated that organizations were being slow to jump on the CASE tools bandwagon. This study reports on a survey of IS professionals in the United States to compare CASE tool adopters to non-adopters today with CASE tool adopters and non-adopters of a decade ago. The results indicate that while the number of CASE tool adopters has remained relatively stable, the characteristics of those adopters has changed in some important aspects such as the size of the organization and the seniority of the CASE tool users.

INTRODUCTION

Information systems (IS) may be the real "field of dreams." IS professionals live at the intersection of "what-is" and "what could be." IS is an agent of change - a place where possibility meets reality. With the possible exception of the research and development function, no other unit within an organization spends so much of its time and resources working from a blank slate. This culture of "creativity" naturally yields both "hits" and "misses."

The curtain is drawing on the era of run-away IS budgets fueled primarily by market euphoria and competitive fear. As more technologically savvy functional area managers come to the planning table, the shine is dimming on the mystique of the "black box." The maturing of the IS function must include the means for effectively sorting through the promises without fatally puncturing the idealism inherent in its culture (Persse, 2001).

Is Computer-Aided Software Engineering (CASE) a "hit" or a "miss?" Is it just another in a long string of exaggerated broken promises or is it an evolving tool swimming upstream against unrealistic expectations? The verdict is not clear but the evidence suggests a split house, with long-term CASE users fairly entrenched despite a dim future for the prospect of new adoptions

(Finlay & Mitchell, 1994). A look at CASE use over time will shed insight on this controversial tool and, hopefully, help IS professionals develop skills in making the distinction between solutions and promises.

The underlying concept of CASE is too appealing to let die. The idea of systems that help produce systems is both sensational and sensible. Most companies struggle to bring information systems development projects to fruition on schedule and within budget while still providing all the requested functionality (Jalote, 2000).

Unfortunately, while CASE rolled out to great accolades, it has faced criticism early and often. Headlines such as "CASE Bandwagon Loses a Wheel" (Lauchlan, 1992) and "CASE Fights All Talk and No Action Image" (Margolis, 1988) announced its demise with dramatic fanfare almost before it got off the ground. For many, CASE has been just another unfulfilled promise (Glass, 1999).

In spite of being nearly stillborn and struggling both technically and financially through its adolescence, CASE is not dead. In fact, some reports suggest that new emphases like ERP and Object Oriented Programming have led to a resurgence of interest in CASE over the last few years (Hayes, 1997; Post & Kagan, 2001).

CASE promises to help organizations develop and maintain system solutions much faster and at far less cost than more traditional analysis and design methodologies (Nelson & Rottman, 1996). CASE tools assist IS professionals in the development of information systems by facilitating methodology activities and enforcing methodology rules and requirements. The potential benefits of CASE tool usage are apparent and have been documented (Post, Sambamurthy, & Zmud, 2000). However, adoption of CASE tools was originally slow and the use of CASE tools by IS professionals continues to be limited (Hughes & Clark, 1990; Hapgood, 2000). Slow adoption rates in the face of evidence of successful application of the technology suggest that CASE may need a closer look.

METHODOLOGY

A survey was mailed to 965 private sector IS professionals randomly selected from among the Association of Information Technology Professionals (AITP) membership roster. To protect the privacy of AITP members and honor the contractual commitments of the list access agreement, the researchers were not given the names or addresses of the subjects and no follow-up mailings or contact was allowed. The data collection process produced 83 usable surveys. The 8.6% response rate is considered good for a single cycle, mail project without follow-up reminders.

Hughes and Clark used the same survey instrument in 1990 to conduct a similar study. The earlier research by Hughes and Clark was also conducted with the assistance of the AITP (then, Data Processing Management Association). The nature of the data presented in Hughes and Clark (1990) limit the types of statistical comparisons that can be made across studies, however, the similarities in the instruments do allow for some comparisons to be made.

RESULTS

Where appropriate, the data were analyzed using a 2 test for homogeneity of proportions. Since the expected frequency for all cells in the contingency tables are at least 5, the 2 test for homogeneity of proportions is considered to be robust (Berenson & Levine, 1999). However, this statistical procedure is only appropriate when there are exactly two rows in the contingency tables. While it is not appropriate to draw statistical conclusions from some of the analysis of the results of the two surveys, the similarity of the instruments and the studies makes for interesting comparisons.

CASE Use by Organizations Remains Steady

Twelve years and incredible technological changes later, the number of responding organizations using CASE is virtually unchanged. In 1990, Hughes and Clark reported that 33% of the responding organizations were CASE users and, in 2002, the number of responding organizations using CASE was 36%.

Table 1: CASE Use by Organizations

	1990	2002	χ^2	p
% of Organizations Using CASE	33%	36%	0.239	NS

Given the often-heard arguments that CASE is a technology whose time has come (if at all) and gone, the 36% rate of use in 2002 is noteworthy. Perhaps, it suggests that rumors of its demise are greatly (or, at least somewhat) exaggerated.

CASE USE BY INDIVIDUALS - A MIXED BAG

In spite of the reported steady use of CASE by organizations, the survey results reflect a drop-off among responding individuals who use CASE from 31% in 1990 to 18% in 2002.

Table 2: CASE Use by Individuals

	1990	2002	χ^2	p
% of Individuals Using CASE	31%	18%	5.136	<.05

While no firm conclusion can be drawn from this drop-off, it is plausible to suggest that since 36% of the respondents are in organizations that use CASE, the difference in the rates of individual use of CASE is a function of the coincidence of who within the organization received the survey instrument. Since both the 1990 and the 2002 surveys were mailed to senior IS professionals, it is also reasonable to suggest that the use of CASE has become more specialized over the past twelve years. This specialization could tend to localize the responsibility for CASE use among a smaller subset of IS professionals.

STABLE LONG TERM COMMITMENT AND SOFT SHORT TERM ADOPTION

Responding organizations that use CASE tools tend to be long time users. Only 20% of the organizations using CASE tools indicated that they have been using the tools for less than four years. Eighty percent of the organizations using CASE have been using it for four or more years.

In the 1990 study, the length of service differed little within individual CASE users. The current study found that the gap in length of service has shifted. Among CASE users, most (65.5%) have been with the firm for four years or more, while only 34.5% have been with the firm less than four years, whereas in 1990 there was little difference (47.5% vs. 52.5%).

Table 3: Length of Service and CASE Use

	Three Years or Less	Over Four Years
1990	47.5%	52.5%
2002	34.5%	65.5%

The 1990 data seemed to suggest that senior IS professionals were reluctant to embrace the new CASE technologies. Today CASE is more likely to be the domain of experienced developers. It may be that the longer length of service among individual CASE users indicates the relatively early adoption and continuous use of the technology.

It is impossible to ascertain whether the primary catalyst for the association between longer service and CASE use is product satisfaction or professional inertia borne out of large investments in early commitments or even just resistance to change. Whatever the reason, the data suggests that the shift in experience among CASE users may be dramatic.

CASE USE AND FIRM SIZE: A MAJOR SHIFT

A substantial shift also appears to have occurred in the past twelve years in regard to the size of the firms using CASE tools. In 1990, CASE tool use appeared to be more prevalent in large firms (greater than $100 million). In 1990 only 25% of the responding smaller firms (less than $100 million revenue) reported CASE use, while 62.5% of the responding larger firms reported CASE use. In 2002, the results reverse dramatically with 53.3% of the smaller firms and only 30% of the larger firm reporting CASE use.

Table 4: CASE Use and Firm Revenue			
	Small ($100 million or less)	Large (Over $100 million)	N/A (Not Reported
1990	25.0%	62.5%	12.5%
2002	53.3%	30.0%	16.7%

This shift in emphasis to smaller organizations may be the result of the growth in power of microcomputers and the reduced cost of running these systems. In 1990, many CASE tools required powerful multi-user systems operating on mid-range or mainframe computers. Today, microcomputers have the processing capability necessary to power CASE tools thus making them more accessible to a wider range of organizations.

THE IMPEDIMENTS TO ADOPTION: KNOWLEDGE AND MONEY

Non-CASE user firms were asked to indicate their reasons for not adopting the tools. The reasons for non-adoption of CASE were grouped into two categories "Knowledge" and "Financial." "Knowledge" reasons included those items that deal with issues such as being unfamiliar with CASE tools and a perceived lack of benefits of using CASE tools. "Financial" reasons included the costs of the tools exceeding the potential benefits and a lack of financial resources to invest in CASE tools.

Table 5: Reasons for Non-Use of CASE by Firm Size				
	Knowledge		Financial	
	1990	2002	1990	2002
Small	40.9%	34.5%	50.0%	62.1%
Large	26.7%	50.0%	46.6%	44.4%
N/A	26.3%	33.3%	47.4%	55.6%

In spite of over a decade of market availability, large firms are more likely to reject CASE tools for "knowledge" reasons in 2002 than in 1990. The percentage of large firm rejecting CASE tools for "financial" reasons has remained relatively constant from 1990 to 2002. This could suggest that large firms have failed to realize the anticipated benefits of CASE tools and no longer see their benefit.

Even with widespread CASE availability on less expensive platforms, smaller firms "financial" concerns with CASE adoption have increased since 1990 from 50% to 62.1%. The "knowledge" concerns of smaller firms have been modestly reduced from 40.9% in 1990 to 34.5% in 2002.

AN UNCERTAIN FUTURE FOR CASE

The number of firms responding with "considering" is down dramatically. A "considering" response indicates that the firm is seriously looking at adopting a CASE tool. If this reduction is an indicator of intent to purchase, the future for CASE technology is, at best uncertain.

In 1990, over 60% of large firms used CASE and over 25% of the non-user firms were actively considering it. Therefore, in 1990 it was an unusual large firm that was not actively involved in either using or considering using CASE. Over 85% of all large firms responding to the 1990 survey were either using CASE or considering using CASE. In the 2002 survey only 35.6% of responding large firms are either using or considering using CASE. The percentage of larger firms considering the use of CASE dropped dramatically from 26.7% in 1990 to 5.6% in 2002. A large drop was also present in smaller firms, from 9.1% in 1990 to 3.4% in 2002.

Table 6: Considering CASE Use by Firm Size

Considering CASE Adoption in	1990	2002
Small	9.1%	3.4%
Large	26.7%	5.6%
N/A	26.3%	11.1%

If the percentage of responding firms presently considering using CASE is an accurate indicator, then the market has peaked and the future for CASE is uncertain.

CONCLUSION

The current study looks at CASE tool users and non-users to try and shed light on the lack of CASE tool adoption among IS professionals. Despite the potential benefits of using CASE tools to help IS organizations complete development projects on schedule, within budget, and with the necessary functions and features, CASE tool adoption, while somewhat stable, is still limited. The data also suggest that the trend is toward less rather than more adoption.

Is the promise of CASE largely unfulfilled? In many instances, the answer is yes. However, CASE is not dead, in fact, in a surprisingly large number of organizations of all sizes it appears to have taken root. The stability among existing CASE users and the reluctance among non-users adds another chapter to the paradox of information technology adoption. It appears that those who use CASE like it and those who do not use CASE are not likely to try it.

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EXPERIMENTS ON DESIGN MODELS SUPPLIED BY THEIR MANUFACTURER: AN EXAMPLE OF MANAGEMENT SCIENCE IN PRACTICE

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ABSTRACT

In-line poppet valves are used in fuel supply lines as on/off and metering valves. In certain instances, the fluid mechanic characteristics and dynamic behavior of such valves become extremely important. Such instances include the use of these valves in rocket engines' fuel lines, where it is critical that precise amounts of liquid oxygen and liquid hydrogen are introduced into the engine. To study the flow characteristics of these valves, various experiments were performed, and a summary of these tests and results are outlined in this paper.

INTRODUCTION

The experiments stated below are presented in the following sections throughout the paper.

(1) Determination of fluid flow pattern
(2) Tests on poppet valves
 A: Measurements of pressure drop across the base model design valve
 B: Measurements of force on the poppet cone of the base design valve
 C: Tests on modified design valves

GENERAL FLUID FLOW PATTERN

In many fluid flow problems, a physical insight of an overall flow behavior is essential to the analysis of flow field. Flow visualization techniques are used to obtain a qualitative understanding and knowledge about a desired flow field. This allows for observation of the behavior of the flow at different regions of interest in a flow field. Once the overall flow pattern is known, theoretical or experimental means are used to obtain more detailed information about the flow field.

The valve-housing cylinder and valve housing contours are made from clear plexiglass to allow visual observation of the flow field in the valve test section. There are three relatively large separation regions and two smaller separation regions. Flow separation causes significant losses in the kinetic energy of the moving fluid stream that translates into larger pressure loss in the flow field. To reduce the pressure losses associated with flow separations, some modifications were made to the valve poppet cone and upstream housing. The rationale for new designs and the effects of various modifications on the flow field over the poppet valve are presented. In the next section, tests designed to evaluate the performance characteristics of the poppet valve under investigation are presented.

TESTS ON POPPET VALVES

Various experiments were conducted to study the fluid flow properties over the poppet valve. To present the results obtained from these experiments, it is necessary to establish a systematic procedure of referring to different tests performed on different poppet valve configurations. Therefore, prior to presentation of the experimental results, it is appropriate to discuss the poppet valve assembly configuration along with the method of referencing the assembly to different valve configurations.

MEASUREMENTS OF PRESSURE DROP ACROSS THE VALVE (BASE MODEL DESIGN)

When a fluid flows through a valve, it passes through a number of constrictions. Since certain irreversibilities associated with each expansion or contraction exist, the total useful energy of the moving fluid is reduced. This reduction of useful energy translates into loss of pressure across the valve. The pressure losses are minimal when the valve is in the fully open position. However, these losses become significantly higher when the valve is operating in a partially open or nearly closed position, and at the same time the internal flow fields become more complex. These conditions add considerably to the complexity of the theoretical modeling of such flow cases. Therefore, experiments are necessary to predict the performance characteristics and pressure loss coefficient of the flow over a valve.

The pressure loss coefficient, ζ, is related to the pressure drop across the valve, ΔP, average velocity of the fluid in the approach piping to the valve, $\overline{V}$, and the density of the flowing medium, *p*, by:

$$\zeta = \frac{\Delta P}{\frac{1}{2}\rho \overline{V}^2}$$

To calculate ζ, the pressure drop across the valve and the average upstream velocity of the approaching flow are required. These quantities were measured experimentally for different poppet valve configurations. The tests on poppet cone #1, H1 (the base model poppet valve design configuration) are considered first. This model was tested at the fully open position and at partially open/closed positions.

MEASUREMENTS OF FORCE ON THE POPPET CONE AT VARIOUS OPENING POSITIONS

In the above discussion, it was shown that as the poppet cone was moved downstream from its fully open position, the pressure drop across the valve section increased significantly. Since larger pressure differences across the valve produce larger forces on the poppet cone of the valve, it was necessary to study the forces exerted on the valve during opening/closing positions. Therefore, the poppet cone was moved downstream from its fully open position to a nearly closed position at intervals of 5 mm. For each position of the poppet cone, the drag force, the dynamic pressure upstream, and the temperature of the water were measured at different flow rates. The drag force was then plotted vs. average velocity for the different valve opening/closing positions. All the curves have parabolic shapes indicating that if the average velocity is increased by a factor of two, then the drag force is increased by a factor of four.

TESTS ON MODIFIED DESIGN VALVES

Minimizing pressure losses improves the performance of the valve. To achieve this goal, in addition to the components of the base model design valve, four other upstream housing contours and two other poppet valve cones were designed. The downstream housing contour design was not changed for sealing purposes. The static pressure loss across the test section and the dynamic pressure upstream of the test section were measured for different poppet valve cones with combinations of various upstream housing contours at different upstream velocities. The average velocity was calculated by using an equation that is valid for fully developed turbulent pipe flow (Fox & McDonald, 1985).

CONCLUSION

Table 1, on the following page, provides a summary matrix of the test results.

TABLE 1: SUMMARY MATRIX OF TEST RESULTS

	Poppet Cone and Position	Upstream Valve Housing Contour	$\zeta = \frac{\Delta P}{\frac{1}{2}\rho \overline{V}^2}$ $C_D = \frac{F_D}{\frac{1}{2}\rho \overline{V}^2 A_{popp.}}$	Velocity (m/s) Reynolds No.
A	Poppet Cone #1 Fully Open	Contour #1	$\zeta=0.82$ $C_D=0.89$	$\overline{V}=2.98$ $Re=2.63\cdot10^5$
B	Poppet Cone #1 -5 mm	Contour #1	$\zeta=0.93$ $C_D=1.34$	$\overline{V}=2.66$ $Re=2.35\cdot10^5$
C	Poppet Cone #1 -10 mm	Contour #1	$\zeta=1.26$ $C_D=2.42$	$\overline{V}=2.66$ $Re=2.35\cdot10^5$
D	Poppet Cone #1 -15 mm	Contour #1	$\zeta=3.08$ $C_D=4.09$	$\overline{V}=2.65$ $Re=2.34\cdot10^5$
E	Poppet Cone #1 -20 mm	Contour #1	$\zeta=7.68$ $C_D=10.75$	$\overline{V}=1.49$ $Re=1.32\cdot10^5$
F	Poppet Cone #1 -25 mm	Contour #1	$\zeta=29.39$ $C_D=26.42$	$\overline{V}=1.14$ $Re=1.00\cdot10^5$
G	Poppet Cone #1 -30 mm	Contour #1	$\zeta=60.53$ $C_D=55.04$	$\overline{V}=0.78$ $Re=6.89\cdot10^4$
H	Poppet Cone #1 Fully Open	Contour #1 with Flow Deflectors A, B, C	$\zeta=1.36$	$\overline{V}=2.94$ $Re=2.56\cdot10^5$
I	Poppet Cone #1 Fully Open	Contour #1 with Flow Deflectors A & C	$\zeta=1.11$	$\overline{V}=2.80$ $Re=2.44\cdot10^5$
J	Poppet Cone #1 Fully Open	Contour #1 with Flow Deflectors B & C	$\zeta=1.14$	$\overline{V}=2.83$ $Re=2.46\cdot10^5$
K	Poppet Cone #1 Fully Open	Contour #2	$\zeta=0.69$	$\overline{V}=2.66$ $Re=2.43\cdot10^5$
L	Poppet Cone #1 Fully Open	Contour #3	$\zeta=0.77$	$\overline{V}=2.49$ $Re=2.28\cdot10^5$
M	Poppet Cone #1 Fully Open	Contour #4	$\zeta=0.81$	$\overline{V}=2.86$ $Re=2.53\cdot10^5$
N	Poppet Cone #3 Fully Open	Contour #1	$\zeta=0.71$ $C_D=0.37$	$\overline{V}=3.01$ $Re=2.45\cdot10^5$
O	Poppet Cone #3 -10 mm	Contour #1	$\zeta=0.99$ $C_D=0.98$	$\overline{V}=2.81$ $Re=2.28\cdot10^5$
P	Poppet Cone #3 -20 mm	Contour #1	$\zeta=5.58$ $C_D=3.36$	$\overline{V}=2.30$ $Re=1.87\cdot10^5$
Q	Poppet Cone #3 -30 mm	Contour #1	$\zeta=92.68$ $C_D=58.15$	$\overline{V}=0.63$ $Re=5.12\cdot10^4$
R	Poppet Cone #3 Fully Open	Contour #3	$\zeta=0.80$	$\overline{V}=3.27$ $Re=2.54\cdot10^5$
S	Poppet Cone #3 +8.4 mm	Contour #3	$\zeta=0.56$	$\overline{V}=3.20$ $Re=2.66\cdot10^5$
T	Poppet Cone #3 +16.5 mm	Contour #3	$\zeta=0.58$	$\overline{V}=3.20$ $Re=2.66\cdot10^5$
U	Poppet Cone #3 Fully Open	Contour #4	$\zeta=0.83$	$\overline{V}=3.18$ $Re=2.24\cdot10^5$
V	Poppet Cone #3 +8.4 mm	Contour #4	$\zeta=0.79$	$\overline{V}=3.16$ $Re=2.29\cdot10^5$
W	Poppet Cone #3 +16.5 mm	Contour #4	$\zeta=0.80$	$\overline{V}=3.14$ $Re=2.28\cdot10^5$
X	Poppet Cone #3 Fully Open	Contour #5	$\zeta=0.75$	$\overline{V}=3.26$ $Re=2.60\cdot10^5$
Y	Poppet Cone #3 +5 mm	Contour #5	$\zeta=0.49$	$\overline{V}=3.26$ $Re=2.53\cdot10^5$
Z	Poppet Cone #3 +8.4 mm	Contour #5	$\zeta=0.47$	$\overline{V}=3.25$ $Re=2.36\cdot10^5$
AA	Poppet Cone #3 +10.5 mm	Contour #5	$\zeta=0.47$	$\overline{V}=3.26$ $Re=2.53\cdot10^5$
AB	Poppet Cone #3 +12 mm	Contour #5	$\zeta=0.48$	$\overline{V}=3.24$ $Re=2.51\cdot10^5$
AC	Poppet Cone #3 +14.2 mm	Contour #5	$\zeta=0.48$	$\overline{V}=3.25$ $Re=2.36\cdot10^5$
AD	Poppet Cone #3 +10.5 mm	Contour #5 moved +10 mm	$\zeta=0.42$	$\overline{V}=3.24$ $Re=2.35\cdot10^5$
AE	Poppet Cone #3 +10.5 mm	Contour #5 moved +10 mm**	$\zeta=0.37$	$\overline{V}=3.30$ $Re=2.65\cdot10^5$

** A single leg support is used to hold the valve in the test section

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DUDE, WHERE'S MY COW?: THE UNITED STATES AUTOMATIC IDENTIFICATION PLAN AND THE FUTURE OF ANIMAL MARKETING

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ABSTRACT

This article examines how two trends – the fear of Mad Cow and other animal borne diseases and alarm over the possibility of "agroterrorism" – are converging to force agribusinesses and governments around the world to take proactive steps to protect the food supply. Today, the United States is on the verge of implementing a plan, developed jointly by government, industry, and health experts, that will enable the nation to have the necessary "traceback" capability to locate and isolate animals in the food supply that have active foreign animal disease (FAD) or been exposed to disease, whether the source be from natural causes or by terrorist intervention.

The article details the fundamentals of the United States Animal Identification Plan (USAIP) and the timeline for its implementation over the next two years. It then goes on to explore the implications of the USAIP, including the funding, privacy and liability issues that need to be resolved in order for the promises of automatic identification of animals in the food supply system to become reality.

INTRODUCTION

Until recently, Americans generally didn't think much about where their hamburgers and steaks came from. That all changed last December with the discovery of a Holstein cow in Washington State that was infected with Mad Cow disease. The popular name applied to what is scientifically labeled as bovine spongiform encephalopathy (BSE) inspires fear in the heart of meat eaters everywhere. After all, it has not been that long since the outbreak of mad cow disease in England, where 143 people died of the human form of mad cow, the always lethal variant Creutzfeldt-Jakob disease (Gantenbein, 2004). We were treated to unforgettable images on the news of whole herds of cattle being slaughtered and piles of their carcasses being burned. Certainly, these are not the kind of images that make the consumer think that beef is "what's for dinner."

HOW NOW MAD COW?

There is cold-comfort that the risk of human contraction of Mad Cow disease is slight. However, with the almost across the board bans on importation of American beef that countries enacted almost overnight after the discovery of the diseased cow and the recall of tons of beef products in the Western United States, the incident highlighted the potential human and economic toll that naturally-occurring maladies in feed animals could have on a nation.

Michael Jacobson (2004), Executive Director of the Center for Science in the Public Interest correctly characterized the Mad Cow situation as a "crisis that probably didn't have to occur," but one that did because the United States had not instituted the types of control measures that were in place in many other industrialized, beef-producing countries (p. 2). In fact, the incident brought to light the fact that the U.S. had not instituted the type of testing for BSE found in other countries. Where countries in the European Union test one in four cows and Japan tests every head of cattle, the United States Department of Agriculture presently tests only one in every 10,000 cows. In fact, the Mad Cow-afflicted animal in the United States had in fact been tested, but was slaughtered and her meat entered the food supply, simply because the test on this visibly sick "downer cow" were not read and relayed on a timely basis (Gantenbeim, 2004).

In the United States alone, naturally-occurring food-borne illnesses of all types annually cause 5,000 deaths. While the U.S. has not seen a human case of Mad Cow, Americans have seen periodic and localized E. coli outbreaks. The most consequential was an E. coli outbreak that hit primarily Jack-in-the-Box fast-food outlets in the U.S. a decade ago, killing several children and sickening hundreds more from tainted beef in the chain's hamburgers (Gantenbein, 2004). Likewise, last year, a hepatitis outbreak affected several hundred patrons of a single Chi-Chi's Mexican Restaurant in Pennsylvania, traced to tainted onions. It took Jack-in-the-Box several years to recover from the stigma associated with the E. coli incident, a problem that Chi-Chi's is currently dealing with chain-wide.

AGROTERROR?

Now, in a post-September 11th world, there is a newfound fear of "agroterrorism" where potentially, human evil-doers could use the food supply chain – and specifically beef cattle – as a way of spreading disease and economic turmoil.

C*ould* a cow be used as a weapon of mass destruction? Historians point to unconfirmed allegations of bioterror, including alleged German attacks in World War I and II. Likewise, Cuba has on twenty-one separate occasions accused the United States of aggression in the form of poisoned animals and crops – an allegation that has never been proven. However, epidemiologists *can* point to one confirmed case of bioterror in fairly recent American history. Twenty years ago, 751 people in Oregon were ill with salmonella. This outbreak was no accident, as the leader of the

Ranneeshee cult confessed that the spate of cases had been caused when his followers intentionally disbursed salmonella onto salad bars in Oregon (Shactman, 2003).

How real is the threat of this form of terror today? Experts disagree, with many falling in the camp of Phil Anderson, a homeland security analyst with the Center for Strategic & International Studies, who recently observed: "I'm not sure how attractive this is to the bad guy. He likes body bags, explosions, things that look good on CNN" (quoted in Shachtman, 2003, n.p.). Nonetheless, the U.S. Department of Homeland Security has recently announced that later in 2004, two American universities will ultimately split $33 million in funding to establish "centers of excellence" for the study of how to safeguard the U.S. animal food supply chain (Shachtman, 2003).

One factor that does lend credence to the threat of agroterror or natural disease to the American food supply is the concentration of the "hubs" for cattle in the United States. In fact, at present, over ninety percent of American cattle pass through only five feed lots. Thus, if a major disease outbreak occurred – whether through natural causes or terrorist action – the potential impact could be devastating due to the sheer number of cows centralized in these locations (Shachtman, 2003).

THE NEED FOR "TRACKABILITY"

With concerns over Mad Cow disease, E. coli, foot and mouth disease, listeria, salmonella and agroterror, it has become increasingly necessary to have the ability to track cattle – and other livestock – as they move through the animal food supply chain. According to Leon Thacker, a veterinary pathologist at Purdue University, the current U.S. system makes it very difficult – if not impossible, to track a particular cow to a particular farm (cited in Associated Press, 2003). This was evident in the American Mad Cow scare of December 2003, when it was finally found that the "downer cow" with the disease had actually come from a herd in Alberta, Canada, prompting many to simply "blame Canada" (Gantenbein, 2004).

After the "wake-up call" that was the British Mad Cow outbreak, countries around the globe both instituted new cattle testing programs and began taking a hard look at how to track animals - even beyond cattle - that were destined for the food supply chain. As John Meyer, Chief Executive Officer of the Holstein Association USA, put it bluntly "national animal identification has gone beyond being a good idea" (cited in (Natzke and Johnson, 2003, n.p). Now, it has become an amalgamation of issues, as national security, public health, and economic realities come together to make this a necessity for countries to assure the safety of the food chain, both for their domestic consumers and for export markets.

Countries around the globe, especially those who have been hard hit by cattle-borne diseases, such as the United Kingdom, Canada, and Japan, now have a variety of systems in place to ensure traceability of their livestock supply. These efforts are mostly focused on cattle, with a variety of technologies being employed (ranging literally from branding in Argentina to bar codes and RFID (radio frequency identification chips). The programs have a range of compulsion (from voluntary to mandatory) and an array of administrative and funding models (government administered, public-private partnerships, and industry-run programs).

Table 1: National Programs for Animal Identification

Country	Name of Program/Administrator	Website
Australia	National Livestock Identification Scheme (NLIS)	http://www.mla.com.au/
Brazil	National Program of Meat Certification (SISBOV)	http://www.certificadora.com.br/
Canada	Canadian Cattle Identification Agency (CCIA)	http://www.canadaid.com/
Mexico	Confederación Nacional Ganadera (CNG)	http://www.gob.mx/wb2/egobierno/ gob_Confederacion_Nacional_Ganadera
European Union	Livestock Passport Program	http://europa.eu.int/comm/food/animal/index_en.htm
New Zealand	Animal Health Board of New Zealand	http://www.ahb.org.nz
Northern Ireland	Northern Ireland (DANI)	http://www.afsni.ac.uk
United Kingdom	British Cattle Movement Service (BCMS)	http://www.defra.gov.uk/animalh /tracing/bcms/bcms_index.htm
United States	United States Animal Identification Plan (USAIP)	http://www.usaip.info/

RFID technologies have found increasing use in animal identification over the past decade. They have been utilized for some time in identifying pets and a wide variety of valuable animals, whether they be used for breeding stock or research projects. Literally millions of RFID devices have used in pet location services, whereby owners can have a chip implanted in their dog or cat to ensure their traceability should they become lost or stolen. An animal's RFID tag can contain reams of data about that individual animal's pedigree, age, movements, and medical history. After having a permanent tag either injected under its skin/hide or permanently affixed to it (most commonly in the outer ear in animals larger than a dog or cat), the animal then has an identifier that can be scanned by a RFID reading device (Destron Fearing Corporation, 2004).

THE UNITED STATES ANIMAL IDENTIFICATION PLAN

While Canada and Australia are now moving to RFID-based systems, the U.S. is breaking new ground with the United States Animal Identification Plan (USAIP). On December 30, 2003, the Secretary of Agriculture, Ann Veneman, officially threw her backing behind the USAIP (cited in Associated Press, 2003). The USAIP is ambitious in that it will be the first national animal identification system to be based on automatic identification technologies from the start. It will also be far broader in scope of covered species than any other national program, including that of the European Union (please see Table 2). Dale Blasi, an industry expert at Kansas State University, says RFID will eventually be used to track *every* domesticated animal in the United States (Anonymous, 2004, n.p.).

Table 2: Categories of Species to be Included under the U.S. Animal Identification Plan

Category	Species
Bovine	Bison, Cattle
Camelid	Alpaca, Llama
Equine	Horses
Porcine	Swine
Ovine	Sheep
Caprine	Goats
Cervids	Deer, Elk
Ratites	Ostriches, Emus
Poultry	Chickens, Turkeys, Geese, Ducks, Pheasants, Guineas, Quail, Pigeons, Game Birds
Aquaculture	Trout, Salmon, Catfish, Tilapia, Striped Bass, Shrimp, Crawfish, Oysters, Clams, Scallops, Mussels
Source: U.S. Animal Identification Plan (2003) (http://www.usaip.info)	

The push for a national automatic identification system for cattle and other livestock in the United States began in 2002, with the forming of the National Institute for Animal Agriculture (NIAA). The NIAA represents a combined effort of industry, government (both state and federal), and animal health professionals. In fact, the plan was formulated through a combined effort of more than a hundred professionals, representing more than seventy industry associations and regulatory bodies. What became known as the United States Animal Identification Plan (USAIP) was released at the annual conference of the United States Animal Health Association (USAHA) in October 2003 (National Institute for Animal Agriculture, National Identification Development Team, 2003).

The overarching goal of the USAIP is to provide the United States with a traceback system that will enable the identification of all animals with whom an animal with a Foreign Animal Disease (FAD) and the locations that need attention due to the presence of the infected/exposed animals. The objective is to have the system able to provide full intelligence on such a FAD outbreak, whether it would be caused by natural means or by human intervention (i.e. terrorists), within 48 hours of the initial case report. The 48-hour concept is especially important, due to the simple fact that animals and animal-based products move so rapidly in the American economy (National Institute for Animal Agriculture, National Identification Development Team, 2003).

For instance, in the American beef industry, there is widespread shipment of cattle throughout the United States. John Meyer, Chief Executive Officer of the Holstein Association USA, cited the fact that in a single year, cattle from forty states entered California. Thus, a serious livestock epidemic could literally spread from coast-to-coast quite quickly without greater means of identification and isolation than are present today (Natzke and Johnson, 2003). Likewise, Wal-Mart is today the world's largest beef retailer (Anonymous, 2004). If meat product from a BSE-infected cow were to be shipped by a processor to one of its regional distribution centers, it could literally be in the hands of consumers within that 48-hour time frame.

ANIMAL AND PREMISES IDENTIFICATION UNDER THE USAIP

There are two core components of the USAIP schema. These are the creation of: (1.) an individual and group/lot identification classification system, and (2.) a nationwide premises identification system.

The individual and group/lot identifier is the foundational element of the USAIP. This is a numbering system that will assign a unique tracking code to each animal (or group of animals) covered under the USAIP. Which categories of animals will require an individual identifier and which only group codes? This will be dependent upon the species involved and the practices of how these animals are managed.

For instance, only a group identifier will be required in those categories of agribusiness where production practices involve management of large groups of animals who typically are not commingled with other sources of the same species-type. This would include business types such as aquaculture and poultry, where ponds of catfish or chickens raised together typically progress through life as a unit. With such species, there is no traceback advantage to using individual identification, which indeed would be seemingly impossible with some animal types. Individual identifiers will be standard for animals, such as cattle, swine and horses, which are typically commingled with animals of various species and at various stages in their lifecycles (National Institute for Animal Agriculture, National Identification Development Team, 2003).

While the USAIP has provisions for the proper display of visible tags on the left ear of the animal, the heart of the system is its requirements for RFID tagging. Its automatic identification schema is based on the ISO 11784 standard for Radio Frequency Identification of Animals, representing a 64-bit international code structure that is anticipated to become the global coding structure standard for electronic animal identification. The USAIP's technical standards are also based on another ISO technical standard, 11785, for the tracking of animals. As such, RFID readers must be capable of decoding both half duplex (HDX) and full duplex (FDX-B) ISO 11784 compliant transponders, as well as having the capability of having the user enter the data from the tag manually, if need be, into the data collection system. While RFID is focused upon, the U.S. Animal Identification Plan holds open the door for what perhaps could be successor automatic identification technologies, including two-dimensional symbology and biometrics (National Institute for Animal Agriculture, National Identification Development Team, 2003).

The second integral part of the USAIP is the premises identification standard. The concept of the premises identifier is to assign a unique code to each and every location where animal stock is housed, grazed, transported, fed, slaughtered, processed, and/or given medical attention. In keeping with the American tradition of states' rights, each state will have flexibility in their actual administration of their premises identification system, being able to create their own system for assigning and managing premises identifiers. However, they must demonstrate the capacity to track animal entries/exits from the system (i.e. tagging after birth and removal after death) and each time an animal (or group of animals) moves between premises (i.e. sold, transferred for care, relocated to a new grazing location, or slaughtered). With this capability, veterinary and public health officials can trace each animal back to its source quickly and identify other animals that may have been exposed to the same disease (National Institute for Animal Agriculture, National Identification Development Team, 2003).

It is important to bear in mind that the USAIP will expand to encompass both individual and group/lot identification. The timeline to bring this all about is also ambitious. By July 2004, the states are to have a premises ID system in place. They must then have the ability to issue the individual or group/lot ID numbers by February 2005. By July 2005, all cattle, swine, and small ruminants (goats and sheep) that are moved between state lines must possess the required individual or group/lot ID's. Then, by July 2006, all the remaining species covered by the USAIP must likewise be in compliance with the requirement for individual or group identifiers. All animals in the species listed in the USAIP will required to have identifiers, regardless of whether they are even used for commercial purposes (National Institute for Animal Agriculture, National Identification Development Team, 2003).

ANALYSIS

The U.S. appears to be on the right track to leveraging automatic identification technology to add intelligence and visibility to what has formerly been an overlooked and hidden part of America's food supply. At the nexus of fears of "Mad Cow" and agroterrorism, along with the push of Wal-Mart and other retailers for RFID compliance, the U.S. Animal Identification Plan appears to be on the road to implementation. Certainly, there are issues that need to be addressed, including who will bear the costs of compliance and how the traceability of animal food products will impact the liability of retailers, distributors, processors and farmers and ranchers throughout the country. While animal tracking does not raise the specter of "Minority Report" traceability of human tracking, there are still very real privacy concerns to be addressed. In fact, some in the American farming and ranching community are fearful that the prospect of a centralized cattle database could yield too much actionable information, both to government regulators and competitive interests (Anonymous, 2004).

Yet, the benefits of a national automatic identification system cannot be minimized, as all involved in livestock farming of all forms, food processors, and food marketers will all gain a great deal from a previously unattainable level of real-time business intelligence on their animal operations. There are a number of vendors already offering software and hardware solutions specifically geared for agribusiness. Great opportunities will exist over the next decade for innovative firms that can bring IT to the range, field, processing site and warehouse and create solutions that will make management of animal-based operations more effective and efficient. Many such firms are beginning to market such solutions in an agribusiness market that is both mandated to use the basic technology and interested in how such technologies can produce solid improvements in their business operations and demonstrable ROI (return on investment) (Please See Table 3).

Table 3: Leading U.S. Vendors of RFID Animal-based Applications

Company	Website
AgInfoLink USA	http://www.aginfolink.com/default.htm
Allflex USA	http://www.allflexusa.com
APEIS (Animal Permanent Electronic Identification System, Inc.)	http://www.apeis.com/home.htm)
Cow/Tek, Inc.	http://www.cowtek.com
Digi-star	http://www.digi-star.com/default.asp
Digital Angel Corporation	http://www.digitalangel.net

Table 3: Leading U.S. Vendors of RFID Animal-based Applications	
Company	Website
eMerge Interactive	http://www.cattleinfonet.com
EZ-ID, LLC Animal Identification	http://www.ezidavid.com
Farnam Companies, Inc.	http://www.farnam.com
Gallagher Power Fence, Inc.	http://www.gallagherusa.com
Global Animal Management, Inc.	http://gamappdev.mygamonline.com/pls/portal30
I.D. ology	http://www.id-ology.com
Idlogic	http://www.idlogic.cc
IMI Inc.	http://www.imiglobal.com
Kaniwi Korrals Ltd	http://www.kaniwi.ab.ca
Micro Beef Technologies, Ltd.	http://www.microbeef.com
Midwest Micro Systems LLC	http://www.midwestmicro.com
PetFinder	http://www.petfinder.com
Red Wing Software	http://www.redwingsoftware.com
Reliable Scale Corp.	http://www.reliablescale.com
SFK Technology, Inc.	http://www.sfktech.com
ScoringSystem, Inc.	http://www.scoringsystem.info
Temple Tag, Ltd.	http://www.templetag.com
Texas Instruments	http://www.ti.com
VeriLogik, Inc.	http://www.verilogik.com
Y-TEX Corporation	http://www.y-tex.com
Zeitlow Distributing Company	http://www.zeitlow.com/home.asp

In the beef industry alone, the possibilities for how to best use this business intelligence are limited only by imagination and yes, resources. For instance, with total visibility of their herd, cattle ranchers can track the history, health and disease characteristics, yield and profitability of various bloodlines of cattle. In fact, by tracking the characteristics of each cow, patterns can be detected in terms of birth defects and other anomalies. Likewise, beef processors can better track their internal quality and yield statistics and match to external source information. Beef wholesalers, distributors, and retailers will gain valuable information on their source product.

This information can even be turned into a marketing weapon. For instance, one Japanese firm marketing Wagyu beef now offers customers literally “farm-to-fork” traceability, providing Japanese consumers with a level of transparency on the source of their beef products unimagined at this point in other countries. The Wagyu beef products print the ID number of the source cow on a package of beef product, and the consumer is given instructions on how to enter the locator code on the company's website to learn the source cow's birth date, breed, point of origin, BSE test results (required for every cow processed in Japan), and other relevant information (Peck, 2003). One might question if American consumers would desire such detail on their evening meal, but if fears of beef-borne illness arise, such as with a Mad Cow outbreak or agroterror incident, the data may in fact be the only way to make the product both saleable and palatable for consumers.

First and foremost however, there is the cost issue - and who will bear it. Researchers at Kansas State University have estimated the cost of RFID tags and the associated readers and software to be anywhere between $25 per head of cattle for small herds and as low as $3-4 per head for large herds. However, with the average size of a herd being only forty in number, many ranchers will face high per head costs (cited in Anonymous, 2004). Further, these small cattle farms may have little use for the data supplied through automatic identification technologies in the day-to-day management of their operations. Thus, the only times their animals may have their tags “read” may be initially at birth and at transaction and transportation points. Indeed, the Canadian government backed-off implementing an RFID-based tracking system a few years ago, simply because it was deemed too costly for ranchers to implement at the time. However, as Canada moves to replace its bar code-based current system with automatic identification technologies next year, The Administrator of the Canadian Cattle Identification Agency, Julie Stitt, estimates that the per-head cost of the alternate technologies will be roughly equivalent – likely below $2 per head (cited in Associated Press (2003).

As with much of the rest of RFID-implementation in other sectors of the economy, the cost issues may solve themselves over time, as the cost of the technology decreases with more widespread applications. Still, the upfront costs to establish the identification scheme in the United States will be significant. In fact, according to the NIAA, the implementation costs of the U.S. Animal Identification Plan will total over half a billion dollars over five years (National Institute for Animal Agriculture, National Identification Development Team, 2003).

While businesses small and large in the cattle, swine, chicken and other animal resource industries do stand to benefit from the national automatic identification program, government is likely to pay the lion's share of the costs for the basic infrastructure of the American program. Certainly, the threat of agroterror will likely mean that funding from the federal government will come not only from the Department of Agriculture, but from the Department of Homeland Security as well. Also, with U.S. food exports being dependent on assuring the safety of the product and having trackability to conform to foreign standards for importation, federal funding can also be drawn from the Department of Commerce. With states having to develop and administer their own premises identification system as part of the larger, national program, their information technology, staffing, and administrative costs will be significant.

One can argue that all businesses and consumers will benefit from the safety assurances that come from animal identification, and thus, as a social good, government is the most logical funding mechanism. Still, the American taxpayer will end up footing the bill, whether through increased general taxation or a specific tax on livestock products (i.e. a "beef" tax, "chicken" tax, etc.). With political realities being what they are, the former is far and away the most likely option for the basic mechanics of the USAIP program. However, many actors in all phases of American agribusiness may find that investments in hardware and software products that augment the basic program will provide significant business intelligence and ROI (return on investment). Washington may also need to consider specific, targeted tax credits for small agribusinesses and farmers/ranchers to purchase automatic identification technologies beyond the basic level of equipment to comply with the USAIP to foster the competitiveness of American livestock-based economy.

The liability issue will also squarely have to be addressed, as this newfound transparency could create a wave of litigation. From a public policy standpoint, legislation may be necessary at the federal and state levels to legally shield actors in the livestock supply chain. This will be particularly crucial for small family farmers and small businesses in the food supply system, who may find themselves in a particularly precarious position with the traceability of animal-based products back to them. In fact, such a trade-off for liability protections may entice the livestock, processing, marketing and retail members of the animal-based food supply system to bear more of the cost of implementing and administering the national identification plan.

CONCLUSION

For critics that argue that costly food system security measures are unnecessary and cost ineffective, consider the recent case of China's Asian Bird Flu epidemic. Within the last year, 18 deaths have been reportedly linked to the disease in several Chinese provinces. What initially appeared to be a problem limited to one province, quickly spread to other farms throughout the country. The quick spread of this disease is due mainly to poor records noting the shipping of animals and a potential cover-up of the number of human infections. As a result, China has experienced it's own version of England's Mad Cow epidemic. A nation's entire economy has been affected, people have become ill and even died, tens of thousands of animals have been destroyed, and a worldwide ban imposed on the shipping of animals. To date, cases of avian flu have been reported in ten other Asian nations, and the fear is that it will spread wider throughout 2004 (Feng, 2004).

In the United States, we have recently begun to feel the effects of an avian flu could have on our domestic production of poultry. In Delaware, 12,000 chickens were destroyed after chickens were tested positive for a different strain (H7) from the one that has killed poultry in China (H5N1).

Now, cases have been reported in Pennsylvania, New Jersey, and Texas, prompting concern that the outbreak could be more widespread in the United States than previously thought. Already, other countries have reacted quickly by imposing a ban on all American poultry exports, making the economic impact of the disease a serious issue for U.S. poultry farmers (Jackson, 2004).

In sum, fears of Mad Cow, bird flu, and agroterror may indeed accelerate the adoption of the national animal identification plan in the United States and the integration of RFID-based technologies in not only the cattle supply, but throughout the American live food chain. In the end, as *Slate Magazine* writer Douglas Gantenbein (2004) observed: "Mad cow disease in the United States may be the best thing to happen to the U.S. food industry and consumers since the invention of refrigeration" (n.p.).

NOTE

The full USAIP can be found at www.usaip.info.

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2+2 TIER BANDED FRAMEWORKS OF INTERCONNECTEDNESS: INDUSTRY STRUCTURE DETERMINANTS

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ABSTRACT

The Internet industry is generally considered to be vertically structured with the Internet Backbone Provider (IBP- long distance service carrier) in the upstream and Internet Service Providers (ISP) in the downstream. Although there are many ISPs and IBPs in each stream, both markets are considered independent oligopolies in that there are a few dominant providers for both ISPs and IBPs. The market leaders in each market create their own hierarchical tier and it is generally accepted that the Internet industry structure has evolved into a four-tier hierarchical structure. To understand the Internet industry, it is necessary to understand interconnection between ISPs and IBPs. The key element as an industry structural determinant is peering interconnection and the relationship created by that interconnectedness. Peering interconnection occurs within the same tier and the transit interconnection between the different tiers. This paper examines the internet industry structure using market share and interconnection strategies.

INTRODUCTION

The Internet industry is dynamic. It consists of millions of computers and switching devices. The number of Internet Service Providers (ISPs) increased rapidly from the mid 90' and the structure of the industry continues to change. It is widely accepted that today's Internet industry has vertical structure: over 40 Internet Backbone Providers (IBPs) including 5 top-tier backbones constitute the upstream industry (Kende, 2000) and over 10,000 ISPs for accessing the Internet make up the downstream industry (Weinberg, 2000). A backbone provider service is critical for any ISPs desiring to connect to the Internet. There are manifold interconnections between ISPs and IBPs. Moving data from one interconnection (tier-to-tier (IBP-to-ISP), or IBP-to-IBP, ISP-to-ISP) to another is the catalyst changing the Internet market structure. Compounding this is when users change mode of access from narrowband (dial-up) to broaderband (DSL or Cable Modem). Narrowband dial-up access has been a major way to connect the internet, but in the summer of 2004, the number of broadband internet users surpassed the number of narrowband dial-up users. In this paper, we analyze the dynamic internet industry (both IBP and ISP) using market share and Internet interconnection strategies and dissect its complicated industry structure.

VERTICAL INDUSTRY STRUCTURE

Overview of Internet Industry

The Internet industry integrates the equipment, software, and organizational infrastructure required for Internet communications. As a rough approximation it can be said it is divided into two components: IBPs that transfer communications in bulk among network exchange points, and ISPs that (1) receive communications from individuals or institutions and transfer them to an IBP's network, and (2) receive communications from a IBP and transfer them to their destination. ISPs are used to refer to any company who can offer Internet connectivity. Some people use ISPs as a general term including IBPs. Some people argue that ISPs can be differentiated from other types of online information services, such as CompuServe or American On Line, because ISPs do not provide content but they focus only on providing Internet connectivity.

Generally speaking, the Internet industry has a vertical structure: Upstream IBPs provide an intermediate good and downstream ISPs using this input sell connectivity to their customers. Simplified, we suggest the analogy that the relationship between IBPs and ISPs is very much like that of "wholesalers and retailers."

In reality the internet is much more complex. The ISPs themselves are networks of users that may directly exchange information among each other. In addition, the IBPs may provide services directly to users and also may interconnect with other IBPs. A gestalt perspective gives the understanding that the internet is a network of networks that is accessible in many parts of the world. Since the telephone industry is tightly intertwined with the Internet industry, we begin by with its examination.

Telephone Industry and its Relationship with Internet Industry

Public Switched Telephone Network (PSTN) was designed and optimized for the transmission of the human voice. In the United States, telephone service is divided into two industries: (1) local telephone service provided by Local Exchange Carriers (LECs) and (2) long distance telephone service provided by Interexchange Carriers (IXCs). This structure creates a vertical hierarchy: Upstream IXCs provide the connection between LECs, and the downstream LECs have direct access to telephone users. The hierarchical structure of telephone industry has a strong impact on the Internet industry. This is due to the fact that many of these companies provide some type of service to either or both the ISP and IBP and/or the end user. End users in this case can be either public, private, or governmental users.

Traditionally, a LEC was a monopoly that served a specific geographic region without competition. Even after deregulation, LECs are still considered by many to be a local monopoly, especially for residential customers. In the U.S., the local telephone services provided flat-rate billing, that is, a telephone user can originate local calls as many times and as long as he wishes with only monthly flat rate. This type of billing system has been a great influence on the growth of Internet access market. This is not true for foreign countries where consumers often pay for time and distance for each call, whether it is local or long distance. Although not the topic of this paper, it is a good example why the internet is so expensive in countries where time and distance charges are levied against each call as compared to local telephone rates in the U.S.

The long distance market is now generally considered to be a very competitive market, though it too was a monopoly less than thirty years ago. Users can make a long distance call with pre-selected IXC through their LEC. Any IXC that wishes to handle calls originating in a local service area can build a switching office, called a Point of Presence (POP). The function of the POP is to interconnect networks so that any site where networks interconnect may be referred to as a POP.

Dial-up access using PSTN is the most universal form of Internet access. In the U.S., a modem call is typically a local call without a per-minute charge. ISP's lines are treated as a business telephone user not as a carrier, so they are not required to pay the measured Common Carrier Line Charge (CCLC) for originating and terminating calls, which recovers part of the cost of the local loop. The switching system in LEC's POP connects calls between Internet users and ISP's modem pool so the LECs' facilities support dial-up Internet communications. In addition, IBPs and large ISPs often construct their backbone networks by leasing lines from IXCs and LECs. As a result, we can say that telephone industry provides the basic infrastructure for the Internet industry.

INTERNET INTERCONNECTION STRATEGY

Background of Internet Interconnection

There are two types of Internet interconnection among ISPs and IBPs: peering and transit. The only difference among theses types is in the financial rights and obligation that they generate to their customers (Weiss & Shin, 2004). To understand the relationship between peering and transit, it is necessary to recall the non-commercial origin of the Internet. During the Internet's early development, there was only one backbone and only one customer, the military, so interconnection was not an issue. In the 1980s, as the Internet was opened to academic and research institutions, the National Science Foundation (NSF) funded the NSFNET as an Internet backbone. Around that time, the Federal Internet Exchange (FIX) served as a first point of interconnection between federal and academic networks. At the time that commercial networks began appearing, general commercial activity on the Internet was restricted by Acceptable Use Policy (AUP), which prevented the commercial networks from exchanging traffic with one another using the NSFNET as the backbone

(Kende, 2000). In the early 1990s, a number of commercial backbone operators including PSINet, UUNET, and CerfNET established the Commercial Internet Exchange (CIX) for the purpose of interconnecting theses backbones and exchanging their end users' traffic. The NSF decided to stop operating the NSF backbone which was replaced by four Network Access Points (NAPs) (Minoli and Schmidt, 1998). NAPs are public interconnection points where major providers interconnect their network and these connections consist of high-speed switchs or a network of switches to which a number of routers can be connected for the purpose of traffic exchange. The function of NAPs is similar to major airport hubs; all ISPs and IBPs are gathered at the NAPs to connect each other. The NSF required that any ISP receiving government contracts or receiving money from public universities must connect to all of the NAPs. After the advent of CIX and NAPs, commercial backbones developed and a system of interconnection known as peering quickly evolved.

Peering Interconnection Strategy

The term "peering" is sometimes used generically to refer to Internet interconnection with no financial settlement, known as a "Sender Keeps All (SKA)" or "Bill and Keep," which can be thought of as payments or financial transfers between ISPs in return for interconnection and interoperability (Cawley, 1997). Peering can be divided into several categories: (1) according to its openness, it can be private peering or public peering, (2) according to the numbers of peering partners it can be Bilateral Peering Arrangement (BLPA) or Multilateral Peering Arrangement (MLPA), and (3) according to the market in which it occurs, it can be primary peering in the backbone market or secondary peering in the downstream market (Weiss and Shin, 2004). A peering arrangement is based on equality, that is, ISPs of equal size would peer. The measures of size could be (i) geographic coverage, (ii) network capacity, (iii) traffic volume, (iv) size of customer base, or (v) a position in the market. The ISPs would peer when they perceive equal benefit from peering based on their own subjective terms (Kende, 2000).

The original four NAPs were points for public peering. As the Internet traffic grew, the NAPs suffered from congestion. Therefore, direct circuit interconnection between two large IBPs was introduced (called bilateral private peering) which takes place at a mutually agreed place of interconnection. This private peering is opposed to public peering that takes place at the NAPs. It is estimated that 80 percent of Internet traffic is exchanged via private peering (Kende, 2000).
Before the Internet privatization, the NSF was responsible for the operation of the Internet. There are probably around 50 major NAPs world-wide in the internet, most of which are located in the U.S. (Moulton, 2001). As the Internet continues to grow, NAPs suffer congestion because of the enormous traffic loads. Because of the resulting poor performance, private direct interconnections between big IBPs were introduced, called peering points.

From the interconnection perspective, NAPs are the place for public peering. Anyone who is a member of NAP can exchange traffic based on the equal cost sharing. Members pay for their own router to connect to the NAP plus the connectivity fee charged by the NAP. Historically, in public peering, there was no discrimination for interconnection among the service providers (no priority given or taken based on usage). On the other hand, the direct interconnection between two equal sized IBPs is bilateral private peering, which takes place at the mutually agreed place of interconnection.

According to Block (Cukier, 1999), there are two conditions necessary for the SKA peering, that is, peering with no settlement, to be viable: (1) The traffic flows should be roughly balanced between interconnecting networks; and (2) the cost of terminating traffic should be low in relation to the cost of measuring and billing for traffic. The conclusion drawn from the above observations is that peering is sustainable under the assumption of mutual benefits and avoidance of costly, unnecessary traffic measuring. Nevertheless, peering partners would make a peering arrangement if they each perceive that they have more benefits than costs from the peering arrangement. Most ISPs in the U.S. historically have not metered traffic flows and accordingly have not erected a pricing mechanism based on usage. Unlimited access with a flat rate is a general form of pricing structure in the Internet industry. Finally, peering makes billing simple: no metering and no financial settlement.

Peering benefits come mainly from the network externality. Network externalities arise when the value or utility that a customer derives from a product or service increases as a function of other customers of the same or compatible products or services; that is, the more users there are, the more valuable the network is (Kende, 2000). There are two kinds of network externalities in the internet. One is direct network externality: the more E-mail users, the more valuable the internet. The other is indirect network externality: the more internet users there are, more web content will be developed which makes the internet even more valuable for its users. The ability to provide direct and indirect network externalities to customers provides an almost overpowering incentive for ISPs to cooperate with one another by interconnecting their networks (Kende, 2000). Contributing to the motivation for peering is lower latency because cooperation makes it necessary for only one hop to exchange traffic between peering partners.

Transit Interconnection Strategy

Transit is an alternative arrangement between ISPs, in which one pays another to deliver traffic between its customers and the customers of other provider. The relationship of transit arrangement is hierarchical: a provider-customer relationship. Unlike a peering relationship, a transit provider will route traffic from the transit customer to its peering partners. With transit agreements, usually small IBPs are able to receive and send communications using the facilities of large IBPs, and must pay a fee for these services. A concern related to transit is that while small IBPs do not have to pay in the case of peering through NAPs, they must pay a transit fee if they directly connect to one of the large IBPs. Before the commercialization of the Internet, carriers interconnected without a settlement fee, regardless of their size. However, after the Internet's commercialization, the large IBPs announced their requirements for a peering arrangement, and any carrier who could not meet those terms would be required to pay a transit fee in addition to the interconnection costs. An IBP with many transit customers has a better position when negotiating a peering arrangement with other IBPs. Another difference between peering and transit is existence of a Service Level Agreement (SLA), which describes outage and service objectives, and the financial repercussion for failure to perform. In a peering arrangement, there is no SLA to guarantee rapid resolution of problems. In case of an outage, both peering partners may try to resolve the problem, but it is not mandatory. This is one of the reasons peering agreements with a company short on competent technical staff are broken. In a transit arrangement it is a contract and customers could ask the transit provider to meet the SLA. Many e-commerce companies prefer transit to peering for this reason. A one minute outage cause the IBP, ISP, and the customer losses, hence, rapid recovery is critical to their business. Furthermore, in the case of transit, there is no threat to quit the relationship while in the case of peering a non-renewal of the peering agreement is a threat. ISPs are not permitted to form transit relationship over public NAPs because these are designed as a neutral meeting place for peering. When purchasing transit service, ISPs will consider other factors beside low cost: performance of the transit provider's backbone, location of access nodes, number of directly connected customers, and a market position.

ANALYSIS OF BACKBONE AND ACCESS MARKETS

Internet Backbone Market

With some simplification, it can be said that the IBPs receive communications in bulk from POPs or NAPs and distribute them to other POPs or NAPs close to the destination. To make the Internet a seamless network, the IBPs have multiple POPs distributed over the whole world. Most frequently they are located in large urban centers. These POPs are connected to each other with owned or leased optical carrier lines. Typically, these lines are 622 Mbps (OC-12) or 2.488 Gbps (OC-48) circuits or more, as defined by the SONET hierarchy, a standard for connecting fiber-optic transmission systems. These POPs and optical carrier lines make up the IBP backbone network. The IBP's POPs, are also connected with the POPs of many ISPs. The relationship between an ISP's POP and IBP's is the same as that of ISPs and IBPs.

According to Erickson (2001), the North American backbone market had around 36 IBPs in the first quarter of 2001. However, these numbers misinterpret the Internet backbone market structure because this market is highly concentrated. There were 11,888 transit interconnections between backbone and access markets in April 2000 (McCarthy, 2000). Counting by the number of connections to downstream market, MCI/Worldcom is a dominant player in the backbone market with 3,145 connections and Sprint is the second largest backbone provider with 1,690 connections and AT&T (934 connections) and C&W (851 connections) are the third and the fourth.

Several of the large IBPs are subsidiaries of large telephone companies such as AT&T, MCI/WorldCom, Sprint, etc. Since these companies own the infrastructure needed for telephone services, they are very favorably positioned to provide the facilities and equipment required by the IBPs. In addition, due to their economies scale, they are able to offer large volume discount rates or bundling agreements of both telephone and Internet lines for the services they provide. This is possible because the Internet industry is lightly, if at all, regulated. In particular, there are no regulations with respect to the tariffs that can be charged for the services provided. From these observations it follows that the large IBPs, supported by the large telephone companies, are in a position to capture large shares of the upstream market.

According to the Carlton and Perloff (1999), the most common measure of concentration in an industry is the share of sales by the four largest firms, called the 'C4' ratio. Generally speaking, if the C4 ratio is over 60, the market is considered a tight oligopoly. For the upstream backbone market this ratio based on the 1999 U.S. backbone revenue (Worldcom 38%, Genuity 15%, AT&T 11%, Sprint 9%) is 73, which shows high concentration in the market. The entry barrier is also high because there is a large sunk cost for nationwide backbone lines and switching equipment. The number of IBPs for the past three years shows just how high the entry barrier in the backbone market is: 43 (1999), 41(2000), and 36 (2001) (Erickson, 2001). The slight reduction for last three years is caused by mergers and acquisitions and reclassification. According to the number of players, we conclude that the overall backbone market is stable although oligarchic. In addition there are significant economies of scale and the rapid pace of technological change generates a large amount of uncertainty about the future return on investments. It is not easy to enter this market without large investments and advanced technology.

The interconnection price is usually determined by the provider's relative strength and level of investment in a particular area (Halabi, 2000). It is certain T-1 transit price has been decreasing continuously. In 1996, the internet connectivity for T-1 was $3,000 per month with $1000 setup fee (Halabi, 1997). According to Martin (2001), the average price of T-1 connection in 1999 was $1,729. In 2000, it was $1,348. In 2001, it was $1,228. One of reasons for decreasing T-1 interconnection price is advent of substitute services for T-1 line, such as wireless Internet access technology (LMDS, Satellite), digital subscriber line (DSL) technology, and cable-modem technology, which exerts a downward pressure on T-1 prices. As technology continues to improve and data transmission rates increase, pressure will continue to maintain a cap on service.

Internet Access Market

An ISP's product is public access to the Internet, which includes login authorization, e-mail services, some storage space, and possibly personal web pages. The ISP's coverage area is usually determined by the existence of an ISP's POP within the local telephone area. ISPs are classified as local, regional, and national according to the scope of their service coverage. The distribution of ISPs is presented in the Table 2.

Among 307 telephone area codes in U.S., the largest ISP covers 282 area codes and the smallest covers only 1 area code. The ISPs with 1 to 10 area codes constitute 79.81% of the total number of ISPs. This explains that most of ISPs in the downstream market are small, local companies. Some of these small ISPs are subsidiaries or affiliates of CLECs (Competitive Local Exchange Carriers), which are small telephone companies established in the 1990s as a result of telephone industry deregulation.

Table 1: Distribution of ISPs by their coverage (Erickson, 2001)

Telephone area codes covered by ISP	Percentage	Type
1	35.14%	Local
2-10	44.67%	Local / Regional
11-24	4.11%	Regional
25-282	16.08%	National

AOL-Time Warner is a dominant player in the dial-up access market. According to Goldman (2004), AOL-Time Warner had 22.8 million subscribers in the 3rd Quarter of 2004. AOL-Time Warner's subscribers are 22.8 million (24%) out of 81.1 million U.S. subscribers (Goldman, 2004). The Table 2 shows top 10 dial-up ISPs ranked by the number of subscribers.

Table 2: Top 10 U.S. ISPs (Q3 2004) (Goldman, 2004)

Rank & ISP	Subscribers	Market Share	Rank & ISP	Subscribers	Market Share
(1) AOL	22.8M	24.0%	(6) Road Runner	3.9M	4.1%
(2) United Online	6.6M	6.9%	(7) Verizon	3.3M	3.5%
(3) Comcast	6.5M	6.8%	(8) Coax	2.4M	2.5%
(4) EarthLink	5.2M	5.7%	(9) BellSouth	1.9M	2.0%
(5) SBC	4.7M	4.9%	(10) Charter	1.8M	1.9%

In the downstream access market the C4 ratio is 43 and would be defined as relatively concentrated. However, the entry barrier in the downstream market is much lower than in the backbone market. Since subscribers can utilize the PSTN line to connect ISPs' modems and ISPs purchase business telephone lines from a LEC, ISPs for dial-up service do not have to invest in access lines to individual subscribers. They can build POPs to link to the PSTN and other ISPs. Since a T-1 lines prices and telecom equipment prices are currently dropping quickly, a large number of small ISPs are possible, especially in the less densely populated areas. The number of North American ISPs for the past several years is an evidence of low entry barrier in the downstream market: 1447 (February 1996), 3640 (February 1997), 4470 (February 1998), 5078 (March 1999), 7463 (April 2000), and 7288 (March 2001) (Erickson, 2001).

Most ISPs provide unlimited Internet access with a monthly flat rate. For major national ISPs, the price ranges generally from $0 to $25 per month dependent on the level of service. Some ISPs provide Internet access service with zero monthly subscription fees to their customers; their revenues depend completely on Internet advertising income. Some base their service on speed, while others on memory usage as an upgrade to their standard service.

ISPs are free to make local peering arrangements with other ISPs. Cremer and Tirole (2000, p445) call this local secondary peering. The Pittsburgh Internet Exchange (PITX) is an example of local peering arrangement. Without this local peering, all network traffic passing from one Pittsburgh network to another had to be sent through Washington, D.C., Chicago, or New York City. The sending and receiving networks pay an unnecessary cost for this inefficient handling of data that should have remained local. Participants in this local exchange point reduce their costs and improve performance and reliability for their local Internet traffic with the equal basis of cost recovery. However, this kind of peering is confined to local internet traffic. Outbound traffic (connected to other networks through an IBP) to other areas still has to depend on the IBP's transit service.

Broadband Internet Market

The Internet access technologies are roughly divided into two categories: narrow band access using dial-up modem technology and broadband access such as Cable-Modem, DSL, and wireless broadband access technology. Among the above broadband access technologies, DSL and Cable-Modem are the two dominant broadband access methods. According to Vara (2004), in July of 2004, more than half of U.S. internet users connected to the internet using a broadband service. It was the first time high-speed broadband internet connection had more market share than dial-up connection. The broadband service providers usually confine their business to high density regions because broadband service requires large investments in "advanced" (read expensive) technologies. Internet users in the rural area rarely have a chance to enjoy the benefit of the higher speed access that broadband services offer.

According to Leichtman Research Group, the twenty largest cable and DSL providers in the US account for about 95% of the market in high speed internet access. The top broadband providers now account for over 30.9 million high-speed Internet subscribers, with cable having nearly 18.8 million broadband subscribers, and DSL trailing behind at 12.2 million subscribers. If we confine the access market into the broadband technology, the C4 ratio in this market is 55% which is considered oligarchic. Table 3 shows the top 10 broadband access providers in the U.S.

DE-PEERING AND FOUR-TIER HIERARCHICAL STRUCTURE

In 1996, AGIS was the first IBP to unilaterally terminate peering arrangements. After that, a series of IBPs announced that they were ending peering with many of their previous peering partners and were no longer accepting peering arrangements from other networks whose infrastructure would not allow the exchange of similar levels of traffic access. Instead of peering, they would charge those smaller ISPs for transit. Finally, the large IBPs moved away from public NAPs to private peering or maintained relatively small capacities like T3 in the NAPs and then placed themselves in a new hierarchy, so called top-tier IBPs (Jew and Nicolls, 1999). Most top-tier IBPs are subsidiaries or affiliates of the major facilities-based telecommunication carriers. They are UUNET (Worldcom), C&W, Genuity, AT&T WorldNet, and Sprint, the 'so called' Big 5. They don't need transit service from others and they make peering arrangement with each other. Over 80% of the U.S. backbone traffic is estimated to pass through their systems and switches (Weinberg, 2000). Other non Big 5 IBPs make peering arrangements among themselves and simultaneously purchase transit services from the Big 5.

Table 3: Top 10 U.S. Broadband ISPs (Q3 2004)
(Lehichman Research Group, http://www.itfacts.biz)

Rank & ISP	Subscriber	Market Share	Rank & ISP	Subscriber	Market Share
(1) Comcast (Cable)	6.5M	20%	(6) Bell South (DSL)	1.9M	6%
(2) SBC (DSL)	4.7M	14%	(7) Charter (Cable)	1.8M	6%
(3) Time Warner (Cable)	3.7M	11%	(8) Adelphia (Cable)	1.3M	4%
(4) Verizon (DSL)	3.3M	10%	(9) Cablevision (Cable)	1.3M	4%
(5) Cox (Cable)	2.4M	7%	(10) Qwest (DSL)	1.0M	3%

There are two cases for which peering is generally refused: (1) Regional IBPs which do not have a national backbone network and (2) content providers or web hosting companies, so called web farms. The main reason for this refusal is a free-rider issue. Peering partners generally meet in a number of geographically dispersed locations. In order to decide where to pass traffic to another, they have adopted what is known as "hot-potato routing," where an ISP will pass traffic to another backbone at the earliest point of exchange. Under the hot-potato routing rule, someone who does not have a national backbone network must transport its traffic on the others' backbone networks. In addition to that, asymmetric traffic patterns, which occur in file transfer or web surfing, result in increased capacity costs without commensurate revenues.

Some of the Big 5 recently disclosed their policy for peering but some of them still do not. There is an unwritten rule shared by the Big 5 about their peering standard: (i) A coast to coast national backbone with a certain level of bandwidth requirement, (ii) a number of presences in the major exchange points, (iii) 7 days by 24 hours Network Operation Center (NOC) and highly experienced technical staffs, and (iv) a certain level of traffic ratio between inbound and outbound, usually 1:4. It is indeterminate what the exact requirements for the private peering are since peering agreements are under non-disclosure. Without a doubt, these requirements could be a significant entry barrier for any new entrant.

PSINet, which was one of the large IBPs, used a peering standard called "open peering policy", that was different from the Big 5. It would peer with any ISP including local, regional, and national except for companies whose primary business was web hosting or content collection. Some of the Big 5 did not want to peer with PSINet, because some of PSINet's private peering partners are transit customers of the Big 5. Whenever the Big 5 upgrade their networks, they upgrade their peering policy. From the tier-2 IBP's point of view, peering requirements are getting tougher and tougher. Nobody can enter into the top tier group without their approval. This cartel-like behavior has been an important issue in the Internet industry for several years and will eventually be a sticking point with the Federal Trade Commission in the future.

After being refused peering in the backbone market, ISPs in the downstream access market, usually operating in a limited geographic region, tried to peer among themselves. Cremer and Tirole (2000) in their paper call this kind of peering "local secondary peering." This is a major factor in proliferation of local and regional Internet exchange points. These smaller exchange points (compared to NAPs) referred to as Metropolitan Exchange Points (MXPs) (OECD, 1998).

Most of Internet exchange points, or POPs of major IBPs are located near the metropolitan areas, which are far from the rural areas. The local ISPs in a rural area have to lease long expensive lines to reach an interconnection point. The long distance from private or public peering points is an additional obstacle to overcome for the rural ISPs. The Pittsburgh Internet Exchange (PITX) is an example of local peering arrangement. Without this local peering, all network traffic passing from one Pittsburgh network to another has to be sent through Washington, D.C., Chicago, or New York City. The sending and receiving networks are burdened with this inefficient handling of data that should remain local. Participants in this local exchange point reduce their costs and improve performance and reliability for their local Internet traffic with the equal basis of cost recovery. However, the local peering is confined only to local traffic. Outbound traffic to other areas still has to depend on the IBP's transit service.

Through de-peering in one tier and peering in lower tier in both markets, the four-tier hierarchical structure has emerged; in the backbone market, tier-1 IBPs with their nationwide backbones interconnect each other and make a core network in the Internet and tier-2 IBPs with their regional backbones interconnect each other and pay tier-1 IBPs for connectivity to rest of internet, which mean they are customers of tier-1 providers. A few of nationwide big ISPs are also a member of tier-2 group. In the access market, tier-3 regional ISPs are customers of tier-1 or tier-2 connecting them to the rest of internet. Local, small ISPs are tier-4 providers and they are customers of higher tier providers. However, the demarcation between the tiers is not clear. In the following section we explain how peering decisions are made.

PEERING DECISION-MAKING PROCESS

An interconnection strategy may be different according to its priority. If expense of interconnection is the number one issue, ISPs will try to find as many peering partners as they can and try to choose minimum combination costs among them. Or if performance is the top priority, they may prefer private peering or transit to public peering. All interconnection decisions start from the analysis of their own traffic. An ISP should try to find the available options and negotiate with their interconnection partners for interconnection methodology, interconnection line capacity, interconnection settlement, etc. This process will be explained below in detail. (Norton, 1999)

Phase I: Identification of ISP's Traffic

The costs of peering and transit vary according to the distance of the ISPs' POP and interconnection point. Generally, the cost of transit is more expensive than that of peering. Before deciding on a transit or peering arrangement, the ISP may systematically sample inbound and outbound traffic flows and then map these flows to the originating Autonomous System (AS), which is defined as a collection of networks that are under the administrative control of a single organization and that share a common routing strategy. Calculations are made to determine where to reduce the load on the expensive transit paths.

Phase II: Finding Potential Interconnection Partners

Based on the traffic map and the aforementioned analysis, ISPs try to find interconnection partners. Because peering policies are often exposed only under Non-Disclosure Agreements (NDA), it is not easy to know them in advance of negotiations. It is reasonable for an ISP to find its peering partners in its own level of Internet industry hierarchy. If a top-tier IBPs makes a peering arrangement with a second tier IBP, then the latter could be the formers' competitor. Therefore, a higher tier ISP would prefer selling transit service to lower tier ISPs and have an incentive to reduce the number of their own competitors. Many ISPs, except for top tier IBPs, have adopted a hybrid approach to interconnection, peering with a number of ISPs and paying for transit from one or more IBPs in order to have access to the transit provider as well as the peering partners of the transit provider.

Phase III: Implementing Interconnection Methodology

Since peering is seen as being of mutual benefit, both parties explore the interconnection methods that will most effectively exchange traffic. Both parties decide (1) how many interconnection points they have, (2) where to locate the interconnection points, (3) how they interconnect, private peering or public peering, (4) what line capacity they will use, (5) settlement free or settlement involved, etc.

Table 4 illustrates comparison of per Mega-bit cost of transit, private peering, and public peering. If we compare cost per Mbps shipped (CPMS) per month of OC3 capacity, the order from the cheapest is public peering ($30), private peering ($64~$129), and transit ($464).

Table 4: Per M-bit Cost Comparison (AT&T (Transit), Norton (2000, Private Peering), and Chicago NAP (Public Peering))			
Interconnection Type	Capacity	Cost / Capacity	Per M bit Cost
Transit	DS3	$26,000/45M	$578/M
	OC3	$72,000/155M	$464/M
Private Peering	OC3	($10,000~$20,000) /155M/2	$64/M ~ $129/M
	OC12	($20,000~$30,000) /622M/2	$32/M ~$48/M
Public Peering	DS3	$3,900/45M	$87/M
	OC3	$4,700/155M	$30/M

CONCLUSION

The Internet has become an important social and business tool. Furthermore, the market has become even more dynamic since it was privatized. Peering has emerged as a phenomenon that can at one time be beneficial to both parties while simultaneously discriminate against one of the peering partners. Professor Frieden calls it a "balkanization" in the Internet. If a new technology was introduced in this market, the internet providers with this technology would have a tendency from past practices to create their own peer groups to make money against the provider without this technology. On the other hand, ISPs are competitors and cooperators simultaneously: competitors for market share and cooperators for global connectivity. One ISP's decision has an influence on other ISP's decisions. Thus, they have a strong dependence on each other beyond just competitive factors.

In our paper, we believe that the two-tier, two layer market structure of both backbone and access is oligopolistic. This means, if a new technology is developed lowering costs, or increasing speed, or if some of them reach an agreement they could exercise their market power, maybe for the better for the consumer, maybe not. A policy maker's goal for the Internet industry is continuing growth and innovation. To achieve this goal, regulators need to continue to encourage competition and to give incentives for ongoing investment and in the development and deploying of new technologies, which will benefit consumers in the internet market. Therefore, it is a role of internet policy makers to make socially desirable competitive environments between higher tier ISBs and lower tier ISPs in the Internet industry.

ENDNOTES

Dr. Correa, an international scholar and professor in the Graduate School of Public and International Affairs at the University of Pittsburgh passed away in the summer of 2004. We deeply appreciate his effort in this paper.

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