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Most Popular Package Design

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Abstract

Given a set of elements, and a set of user preferences (where each preference is a conjunction of positive or negative preferences for individual elements), this research investigates the problem of designing the most "popular package", i.e., a subset of the elements that maximizes the number of satisfied users. Numerous instances of this problem occur in practice. For example, a vacation package consisting of a subset of all possible activities may need to be assembled, that satisfies as many potential customers as possible, where each potential customer may have expressed his preferences (positive or negative) for certain activities. Likewise, the problem of designing new products, i.e., deciding which features to add to a new product that satisfies as many potential customers as possible, also falls under this framework. The research presents innovative optimal and approximate algorithms, and studies their performance. The experimental evaluation on real and synthetic datasets shows that the proposed optimal and approximate algorithms are efficient for moderate and large datasets respectively.

Keywords: package design, popular package, maximize visibility, customer satisfaction, algorithms.

1. INTRODUCTION

Problem Motivation

Consider a travel agency that wishes to design one (or more) vacation packages, given the travel preferences of its clients. For example, a vacation package to Costa Rica can include some of the following elements: beaches such as *Puerto Vijeo*, *Jaco*, *Flamingo*, etc.; mountains and national parks such as *Arenal area*, *Monteverde*, *Tortuguero*, etc. The clients of the agency provide their preferences by specifying "yes", "no", or "don't care" for each element. The purpose of trip/vacation package design is to select a subset of these elements to satisfy as many customers as possible.

As another example, consider the problem of creating a social network and selecting the main topics of the network based on users' interests, with the goal of representing the collective group interests as optimally as possible. For example, assume one wants to create a new group focused on sports interests. One can leverage the users' profiles to select the main topic preferences of the network– *e.g., Basketball*, *Soccer*, *Baseball*–of the users.

The above examples can be generalized to an abstract problem, which we call the *Package Design (PD) Problem*. Assume that a package needs to be designed by selecting a subset of Boolean features (or elements, or attributes) from a large set of possible features. In particular, we focus on a specific and novel problem formulation, where we are given a set of user preferences in the form of a query log (or workload) of user queries, where each query is a conjunction of positive or negative preferences for some of the features, and we are asked to design the most *popular* package, i.e., the package that satisfies the maximum number of queries in the query log. We refer to this problem as the *Package Design* (*PD*) problem. Because of the vast use of the Internet nowadays, it is very easy to collect online such query logs of user preferences for many such package design applications, and the new package can be designed based on real users' perception on desirable features.

Overview of Solutions

We propose an optimal algorithm, based on the *Binary Tree* data structure. We also provide an approximate algorithm for the problem. The algorithm does not have provable bounds, but is scalable and is shown to work very well in practice.

Summary of Contributions

1. We define the problem of designing an optimal package given user preferences, expressed as positive and negative preferences on the elements.

2. We present a feasible optimal (exact) algorithm based on the Binary Tree data structure.

3. We present fast approximate algorithm that work well in practice for large problem instances.

4. We perform detailed performance evaluations on real and synthetic data to demonstrate the effectiveness of our developed algorithms.

The rest of the paper is organized as follows. Related work discussed in Section 2. Section 3 provides formal problem definitions. Section 4 and Section 5 present the optimal and scalable approximate algorithms respectively. In Section 6 we present the result of extensive experiments. We conclude in Section 7. Section 8 provides the references.

2. RELATED WORK

Optimal product design or positioning is a well studied problem in Operations Research and Marketing. Shocker and Srinivasan (1974) first represented products and consumer preferences as points in a joint attribute space. After that, several approaches and algorithms ([Albers & Brockhoff, 1977], [Albers & Brockhoff, 1980], [Albritton & McMullen, 2007], [Gavish, Horsky, & Srikanth, 1983], [Gruca & Klemz, 2003], [Kohli, & Krishnamurti, 1989]) have been developed to design/position a new product. Works in this domain require direct involvement (one or two step) of consumers and users are usually shown a set of existing alternative products (predesigned) to choose or set preferences. Like our work, users in this domain in fact do not get to select the attributes or features they like and don't like. Instead of involving users directly in the process of designing new package, we use previous user search queries for the same package and it is easy to collect the preferences (search queries) for large number of Internet users nowadays. We also consider large query logs to design the new package and allow users to express their interests in attribute or feature level in terms of positive, negative and "don't care".

Recent works on dominant relationship (Li, Ooi, Tung, & Wang, 2006) and dominating neighborhood (Li, Tung, Jin, & Ester, 2007) uses skyline query semantics assuming that attributes are min/max, that is, all users have the same preference for an attribute (e.g., 2 doors is always better than 4 doors). Further, they assume there is a profitability plane which simplifies the algorithm given that the optimal solution is a point on the profitability plane. In contrast, in our work users may have opposite preferences for the same attribute, and our algorithms can be used with or without a profitability plane. Li et al. (2007) also considers spatial, non-preference attributes. Our algorithms can be modified to support skyline semantics; however, more efficient algorithms may be possible for this problem variant given its restrictive nature.

Works in (Miah, Das, Hristidis, & Mannila, 2008) tackled a related problem of maximizing the visibility of an existing object by selecting a subset of its attributes to be advertised. The main problem was: given a query log with conjunctive query semantics and a new tuple, select a subset of attributes to retain for the new tuple so that it will be retrieved by the maximum number of queries. The work did not consider negated conditions as in our work in this paper. In this paper, we consider designing an object (a new tuple), that is, assign values for all attributes instead of selecting subset of attributes.

3. PROBLEM FRAMEWORK

To define our problem more formally, we need to develop a few abstractions.

Attributes: Let $A = \{a_1 \ldots a_M\}$ be the set of Boolean attributes (or elements, or features).

Query (with negation): We view each user query as a subset of attributes and/or negation of attributes. The semantics is *conjunctive*, e.g., query $\{a_1, a_3\}$ is equivalent to "$a_1 = 1$ and $a_3 = 1$". We also consider queries *with negations*, e.g., $\{a_1, \sim a_2\}$ is equivalent to "$a_1 = 1$ and $a_2 = 0$". The remaining attributes for which values are not mentioned in the query are assumed to be "don't care", i.e., the value can be either 0 or 1.

Query Log or Workload: Let $Q = \{q_1 \ldots q_S\}$ be a collection of queries.

The problem definition is as follows:

Package Design (PD) Problem: *Given a query log Q with conjunctive semantics where a query can have negations, design a new tuple t (assign value [0, 1] for each attribute for the new tuple) such that the number of queries that retrieve t is maximized.*

Thus, we wish to ensure that the new package (or tuple) satisfies as many customers as possible.

Query ID	Beach	Boating	Casino	Fishing	Historical Site	Museum
q_1	1	0	1	?	?	?
q_2	1	?	0	?	1	?
q_3	0	?	1	?	1	?
q_4	?	0	0	1	1	?
q_5	?	1	?	0	?	1
q_6	1	0	0	?	?	0

Figure 1. Query Log Q for Running Example

Example 1. *Consider Figure 1 which shows a query log for a vacation package application, containing S=6 queries and M=6 attributes where each tuple (query) represents the preferences of a user. A query has values 1, 0, or ?, where 1 means the attribute must be present, 0 means the attribute must not be present, and "?" means "don't care". For this specific example, it is not hard to see that if we design a new package with Beach = 1, Boating = 0, Casino = 0, Fishing = 1, Historical Site = 1, Museum = 0 (i.e., new tuple t = [1, 0, 0, 1, 1, 0]), we can satisfy a maximum of 3 queries (q_2, q_4 and q_6). No other selection of attribute values for the new tuple will satisfy more queries.* □

4. A FEASIBLE OPTIMAL ALGORITHM

A naïve brute-force optimal approach seems to be a solution to design a new tuple (package) where we can generate all possible combination of attribute values and pick the combination (assignment of values) that is satisfied by the highest number of queries in the query log.

While the naïve algorithm is polynomial in the size of the query log, it is unfortunately exponential in number of attributes. Thus it is not feasible when the number of attributes is large since the algorithm has to generate an exponential number of possible combinations of attribute values.

We propose a novel optimal algorithm based on adaptations of the Binary Tree data structure which is much more efficient than the Naïve algorithm. Our algorithm works well for moderate problem instances. A binary tree is a tree data structure in which each node has at most two child nodes, usually distinguished as "left" and "right". Nodes with children are parent nodes, and child nodes may contain references to their parents. Outside the tree, there is often a reference to the "root" node (the ancestor of all nodes), if it exists. Any node in the data structure can be reached by starting at root node and repeatedly following references to either the left or right child. Figure 2 shows a simple binary tree of size 9 and height 3, with a root node whose value is 2. The tree is unbalanced and not sorted.

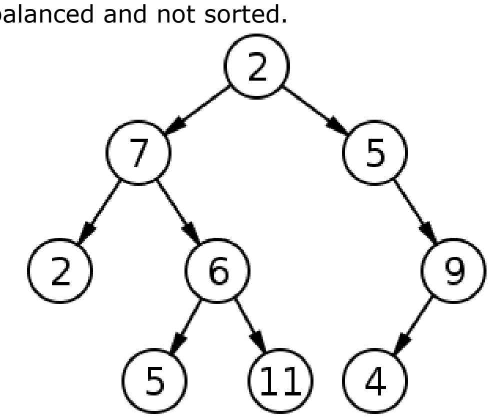

Figure 2. A Simple Binary Tree

Optimal Algorithm Based on Binary Tree Data Structure (*TreePD*)

We build a Binary tree structure like tree for our algorithm using the query log where each child (left and right) is created based on the attribute values. As described earlier in our running example (Figure 1), each attribute can have a value either 1 (attribute present in the query), 0 (attribute not present in the query), or "?" (don't care). We build the tree such that the query log is split into two groups based on an attribute value (which becomes a node in the tree) – the left child contains the queries with value 0 and "?"; and the right child contains the queries with values 1 and "?" for that specific attribute. The queries with attribute value "?" (don't care) go with both the left and right children of a node because in a newly designed package the value of that attribute could be either 1 or 0.

Once the tree is created, then we search the tree starting from the root of the tree and keep track how many queries can be satisfied the by assignment of the attribute values from root to the leaf. We pick the path (assignment of attribute values) with the highest count (number of satisfied queries) as the new package (tuple).

The *TreePD* optimal algorithm is much faster than the naïve optimal approach as we don't have to generate all possible combinations of attributes, but still the algorithm can be slow in case of very large number queries and attributes. So we propose approximate algorithm that work well for large dataset which is discussed next.

5. APPROXIMATE ALGORITHM BASED ON *MINSAT* HEURISTIC (*HeuristicPD*)

Package Design (PD) problem is the complement of the *MINSAT* problem (Kohli et al., 1994), which is an NP-complete problem. Given a set *U* of Boolean variables and a collection of disjunctive clauses over *U*, the goal of *MINSAT* problem is to find a truth assignment that minimizes the number of satisfied clauses. *PD*, which has conjunctive clauses (queries), can be converted to *MINSAT* as follows:

a) Complement the value of each attribute for each query in the query log, i.e., if an attribute has value 0 then convert it to 1 and vice versa.

b) Complement the conjunctive semantics to disjunctive semantics. Let *~Q* denote the converted query log *Q*. Solving *MINSAT* on *~Q*, we get an assignment that satisfies the minimum number of queries in *~Q*; which corresponds to satisfying the maximum number of queries in the original query log *Q*.

Our algorithm adopting a greedy *MINSAT* heuristic (Kohli et al., 1994) operates as follows. Given any ordering of the variables, the greedy heuristic sequentially selects an assignment for each variable to satisfy the smallest number of additional clauses (clauses in *~Q* in *PD*). Figure 3 displays the pseudocode of the algorithm.

```
Approx Algorithm: HeuristicPD
Let Q be the query log, A (a1…aM) be the attributes in Q
Complement the query log (~Q)   // convert 1 to 0 and 0 to 1,
also convert conjunctive form to disjunctive form
For (int i = 1 to M)
    If ~Q not empty
        Count # of queries satisfied both for ai = 1 and ai = 0.
        Assign the value of ai that gives the minimum count
        Remove queries from ~Q satisfied by the value of ai
Return the attributes assignment
```

Figure 3. Pseudocode of Approximate Algorithm Based on *MINSAT* Heuristic, *HeuristicPD*

The above heuristic has an approximation ratio equal to the maximum number of attributes (literals) in any query (clause). Note that this ratio does not hold for *PD* since in *PD* the solution is complemented, that is the number of satisfied queries is *S* minus the number of satisfied queries in *MINSAT*. Nevertheless, our experimental results in Section 6 show that the algorithm has a very small approximation error in practice.

6. EXPERIMENTS

Our main performance indicators are (a) the time cost of optimal and approximate algorithms, and (b) the approximation quality of approximate algorithm.

System Configuration: We used Microsoft SQL Server 2000 RDBMS on a P4 3.2-GHZ PC with 1 GB of RAM and 100 GB HDD for our experiments. Algorithms are implemented in C#.

Datasets: We used datasets of products and product queries. Note that products are just one of the possible instantiations of the more general packages of this paper. We used real and synthetic datasets (query logs). In specific, we use two datasets: (i) *REAL*: real query log, and (ii) *REAL+*: synthetic query log generated from the real query log.

Real query log (REAL): We collected 240 queries for cell phones from university users of and friends through an online survey. The survey was designed with 30 Boolean features such as *Bluetooth*, *Wi-Fi*, *Camera*, *Speakerphone* and so on. Users were asked to select the features they prefer to have (positive) and most likely not to have (negative) in their cell phones. Users selected 3-6 positive and 1-2 negative features on average. Hard disk was a popular negative feature.

Synthetic query log generated from real query log (REAL+): As the real query log is very small, it is inappropriate for scalability experiments. So we generated larger datasets from the real query log. A total of 200,000 queries were generated as follows: at each step we randomly select a query from the *REAL* query log, randomly select two of its attributes and swap their values. We also generate datasets for a fixed size of query log for varying number of attributes (10, 15, 20, 25, and 30).

Table 1 summarizes the query logs or datasets.

Query log	# of attributes	Query log size
REAL	30	237
REAL+_30	30	25K, 50K, …, 200K
REAL+_1000	10, 15, …, 30	1000

Table 1. Summary of Query Logs (Datasets)

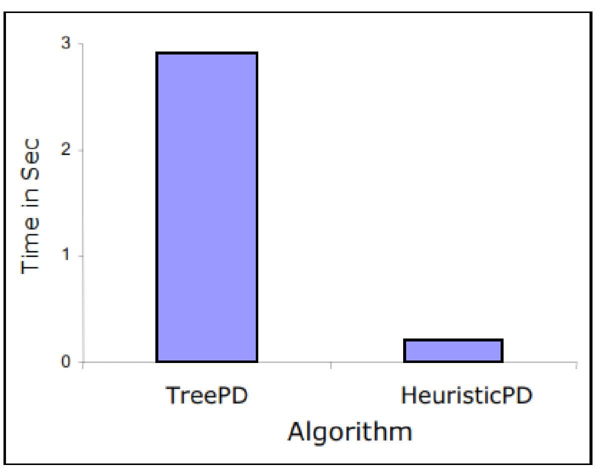

Figure 4. Time cost for *REAL* dataset

Figures 4 and 5 show the performance and quality of the algorithms for the real query log (*REAL*). Here, by quality we mean how many queries are satisfied by a newly designed package. Note that *HeuristicPD* has almost optimal quality.

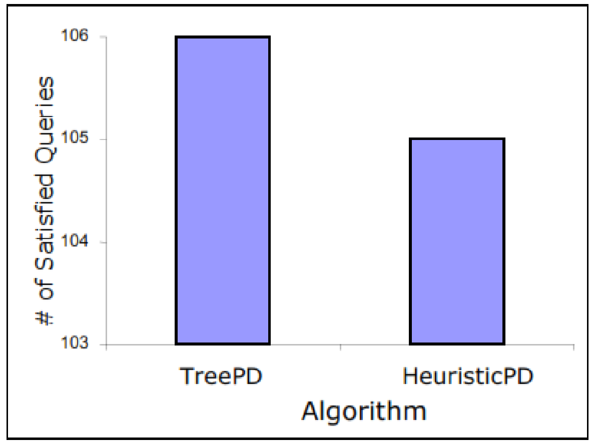

Figure 5. Quality for *REAL* dataset

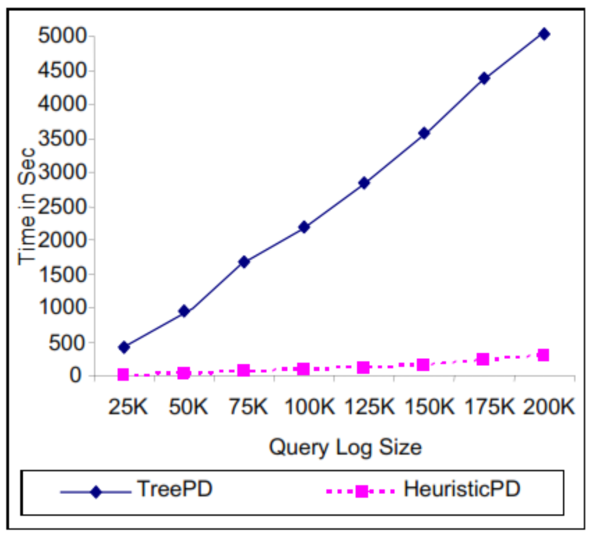

Figure 6. Time cost for varying query log size for *REAL+_30*

Figures 6 and 7 show the performance of the algorithms for varying query log size and number of attributes respectively, for *REAL+* dataset. For varying query log size, we want to see how our algorithms perform when query log sizes (datasets) increase. For varying number of attributes, we again want to see how the algorithms perform when number of attributes increases for a fixed number of queries. We randomly select a subset (of size 10, 15, ..., 30) of the attributes of the dataset. As we can see from the graphs, the approximate algorithm is much more efficient than optimal algorithm.

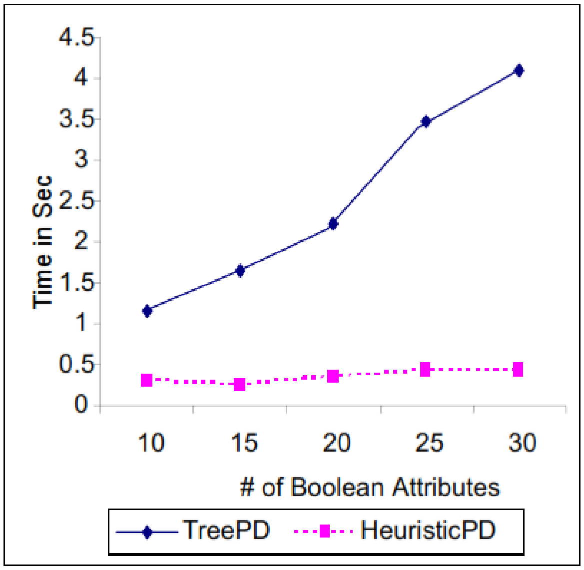

Figure 7. Time cost for varying # of attributes for *REAL+_1000*

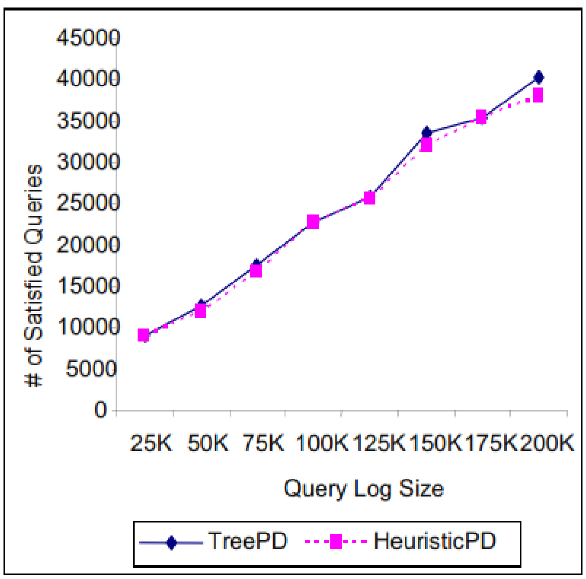

Figure 8. Quality for varying query log size for *REAL+_30*

Figures 8 and 9 show the quality (number of queries satisfied in the query log) of the approximate algorithm for varying query log size and number of attributes respectively for *REAL+* dataset. As we can see from the graphs, the approximate algorithm performs well. As we see in Figure 9, the number of satisfied queries decreases as the total number of attributes increases. The number decreases because as more attributes are added, the queries become more selective and harder to be satisfied. The approximate algorithm has quality close to the optimal algorithm.

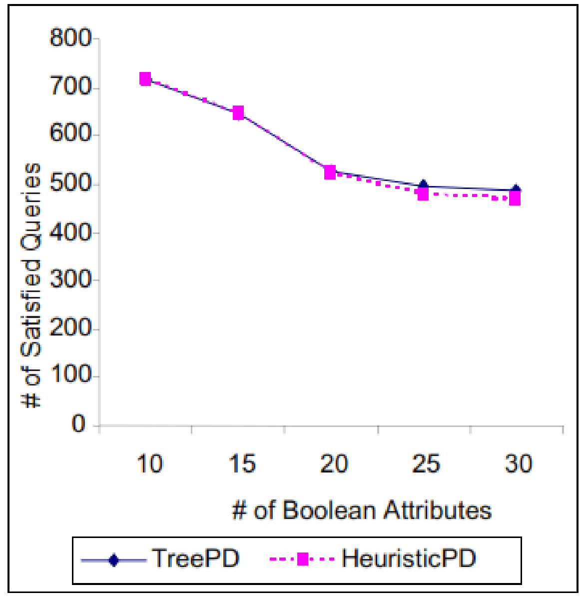

Figure 9. Quality for varying # of attributes for *REAL+_1000*

7. CONCLUSIONS AND FUTURE WORK

In this work we investigated the problem of designing a package, such that, given a query log, this package will be returned by the maximum number of queries in the query log where a query can have negations. We proposed an innovative optimal algorithm and showed the algorithm is feasible for moderate inputs. Furthermore, we present approximate algorithm, which are experimentally shown to produce good approximation ratios for large databases. A future direction is to extend the problem to other data types, such as categorical, text and numeric and different query semantics like top-*k* and skyline retrieval.

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Editor's Note:

This paper was selected for inclusion in the journal as a CONISAR 2011 Distinguished Paper. The acceptance rate is typically 7% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2011.

The Effects of Interruptions on Remembering Task Information

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Abstract

Interruptions can cause us to take longer to complete our tasks and lower the quality of the results. Yet, we are interrupted frequently in our daily lives by other people, by ourselves, and by our computers. We may not be able to control some of these interruptions, but it should be possible to create computer interfaces that control the interruptions. Two methods are examined in this paper. The first method is to allow the user to postpone the secondary task (the interruption). The second method is to allow the user to take a note about the current task before moving on to the interruption. In the first experiment, subjects had the choice to postpone or not and in the high cognitive workload task, 83% chose to postpone. In the second experiment, memory for details of the task was examined when the user postponed the secondary task and when they did not. There were no significant differences between the two conditions. In the final experiment, some subjects could take a note about the primary task. Counter intuitively, the subjects who could not take a note performed better on the task, but not significantly.

Keywords: interruptions

1. INTRODUCTION

Interruptions are a fact of everyday life. While trying to complete a task, we can be interrupted multiple times by external people or events or by ourselves. For example, a typical information worker is interrupted every 12 minutes, with most of these self-interruptions (Jin & Dabbish, 2009). The main effects of an interruption appear to be negative; the time to complete the primary task increases and the quality of the results may decrease.

When an interruption occurs, a person is working on a *primary task*. The user must deal with the interruption and complete the *secondary task*. To work on the secondary task, a *problem state* for the primary task is kept in memory. This problem state essentially "saves your place" by remembering some temporary task-relevant information. Interruptions vary in their duration and the interrupted and secondary tasks vary in cognitive workload required to complete them. Lag time is the amount of time it takes an individual to continue work after an interruption.

Many of the modifications to existing user interfaces attempt to assist users in dealing more effectively with interruptions. One way determines the most effective time for an interrupt to occur (McFarlane & Latorella, 2002). Another way tries to limit resumption lag. *Resumption lag* is the time needed to resume the primary task after an interruption.

These two methods of handling interruptions are discussed in this paper. The first two experiments examined the capability to defer an interruption when it occurs. When an alert appears telling the user there is a secondary task, the user decides whether or not to complete the secondary task then or to defer it until a later time. The third experiment examined whether or not taking notes about the problem state of the primary task helped subjects return to it after an interruption, effectively reducing the resumption lag.

2. LITERATURE REVIEW

Much research has been done on the potential impact of interruptions and their effects on people, and in the past 15 years the focus has turned to people using computers. Mark, Gonzalez, and Harris (2005) found that work is highly fragmented as seen by shorter amounts of time on a task and an increase in the number of interruptions. Information workers switch work events frequently; averaging every three minutes (Gonzalez & Mark, 2004). Differences were found due to the type of work (central or peripheral) (Mark et al, 2005), cognitive workload of task (Dismukes, Loukopoulos & Jobe, 1998), or timing of the interruption (McFarlane & Latorella, 2002).

During an interruption, work becomes fragmented and the cognitive representations supporting the primary task performance will decay. These representations may be replaced by cognitive representations needed to perform the second task (Altmann & Trafton, 2002).

Studies have shown that there is a negative impact on primary task completion when the primary task is complex, such as flying an airplane (Dismukes, Loukopoulos, & Jobe, 1998). Other studies have shown that interruptions can actually be beneficial with regard to simpler tasks. In an early study performed by Zeigarnik (1929), interrupted simple tasks actually demonstrated better results in terms of recalled detail than those tasks that were not interrupted. This higher success rate can be explained by the brain's need to keep the problem state. It is easier to make a quick mental reminder (problem state) with a simple task than it is with a more complex task. By causing the reminders to occur, the interruption actually leads to better recall and an improved performance.

Altmann and Trafton (2004) studied the effect of informing a user that an interruption is coming. Their study showed that simply informing the user that he or she *is going to be* interrupted had a positive impact on completion rate and decreased resumption lag. Therefore, giving the user the ability to "prepare to resume" the primary task after the secondary task has been completed has a positive effect on task completion (Altmann & Trafton, 2005).

The timing of an interruption has been studied and results have shown that the negative effects of interrupting users can be somewhat mitigated by deferring interruptions until a better time in the task sequence (Adamczyk, Iqbal, & Bailey, 2005). Salvucci and Bogunovich (2010) found that users are capable of handling the incoming alerts and the process of deferring a task. Users tend to choose to defer an interruption if they are at a point of high cognitive workload while working on the primary tasks (Salvucci & Bogunovich, 2010). While there has been some research in the area of deferred interruptions, specific measurements have not been made to actually examine if deferring an interruption actually benefited the user. These benefits could be shown by decreasing the time to complete a task or the number of errors in task completion.

Figure 1 (Appendix A) demonstrates the decision process that the user underwent during the experiments. The user is initially working on the primary task and an alert about the secondary task appears. This alert tells the user that an interruption is coming and prompts the user to decide whether to postpone that interrupting secondary task or not. If the user accepts the interruption, then the secondary task will be completed. Following the secondary task, the primary task will be resumed and completed. If the user defers the interruption, the primary task is finished and then the secondary task is completed. If users were interrupted during a time of high cognitive workload, they would defer an interruption until they reached a point of lower mental workload (Salvucci & Bogunovich, 2010). The study showed that 94% of users opted to postpone an interruption during a time of high cognitive workload compared to 6% during a time of lower cognitive workload. When users have the ability to defer an interruption, they will concentrate on one task until mental workload decreases.

In addition to deferring an interruption, the effect of note taking on interruption and resumption lag has been studied. Parnin and DeLine (2010) examined 371 Microsoft programmers while they made changes to specific programs and were interrupted by another program. The programmers had to make changes to the second program before going back and finishing the first program. When the person was interrupted, they were given the chance to take down one note using the program or method of their choice. After both programs were changed, the programmers were asked about what they normally would do. Fifty-eight percent would take mental notes on where they were in the first program when interrupted (Parnin, & DeLine, 2010). Also, when resuming the first task 58% would normally read over the program and navigate to related code to jog their memory of where they were in the process (Parnin, & DeLine, 2010). Both of these methods are considered to increase lag time and, in turn, lessen the amount of work that can be done in a day.

To study how deferring interruptions or taking notes affected task performance, the following three experiments were conducted:

1. Experiment 1 replicates the Salvucci & Bognunovich 2010 study by looking at how many subjects switched from the primary task to the secondary task and at which cognitive load.
2. Experiment 2 investigates whether or not postponing the secondary task had a positive or negative impact on the completion of both the primary and secondary tasks and examined measures such as recall of detail, quality of task performance, total time (primary task and secondary task), interruption lag, resumption lag, and user satisfaction.
3. Experiment 3 examines whether being able to take a note about the primary task before being interrupted helped subjects perform the primary task better and reduced resumption lag.

3. METHODOLOGY

Experiment 1: **Replicating Salvucci & Bogunovich**

The first experiment was designed to verify the results of the 2010 Salvucci and Bogunovich study where each user was given the option to choose whether or not to postpone an interruption. The subjects were 33 college students divided into two separate groups. The first group was presented with a high-cognitive primary task: a list of 4 digit numbers (Figure 2) that they were asked to memorize in 20 seconds.

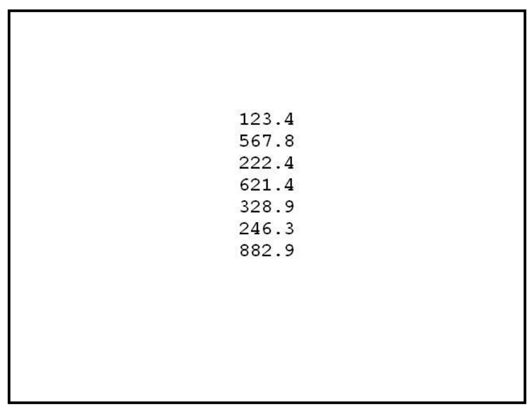

Figure 2: Experiment 1 Primary Task – High Cognitive

In the study by Salvucci and Bogunovich (2010), the high cognitive task was the memorization of the model number of a piece of hardware. For our study, the second group required a primary task involving a low cognitive workload to compare under what conditions a user will decide to defer the interruption. For their low-cognitive workload primary task, the users were presented with a number of different shapes of varying size and they were asked to click on the shapes from smallest to largest (Figure 3).

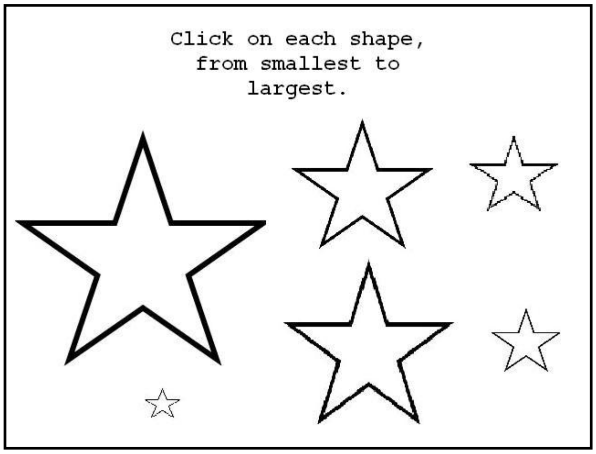

Figure 3: Experiment 1 Primary Task – Low Cognitive

In the middle of each subject's primary task, they were presented with an alert indicating that there was a secondary task that needed to be completed. The user then had the opportunity to choose whether or not to defer (Figure 4).

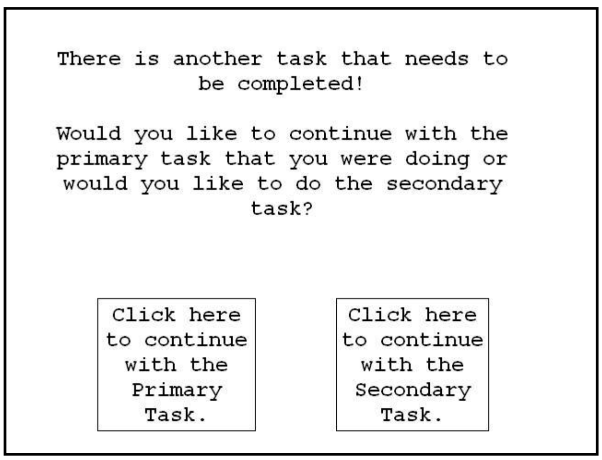

Figure 4: Decision Slide

The secondary task was a low cognitive task where users were presented with a random order of three colored boxes and they were asked to reproduce that sequence on the response slide (Figures 5 and 6).

After the subject made a decision at the decision slide, she would see one of two courses: 1) If the subject chose to continue with the Primary Task, she would be directed to the respective response screen (Figures 7 and 8). After completing this screen, the subject would then complete the colored boxes task; or 2) If the subject chose to take the Secondary Task, she would be directed to the colored boxes task first, and then she would receive their respective response screen after the colored boxes task was finished. After the first experiment was conducted, each subject was asked to take a user satisfaction survey (Appendix B).

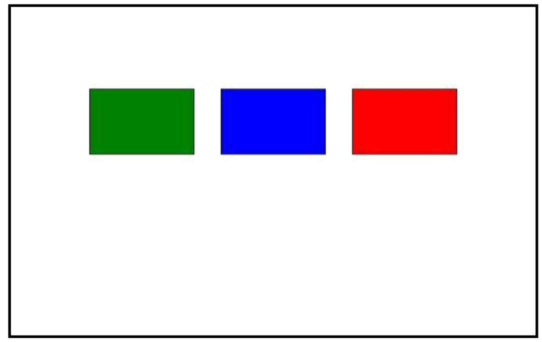

Figure 5: Experiment 1 Secondary Task Stimulus

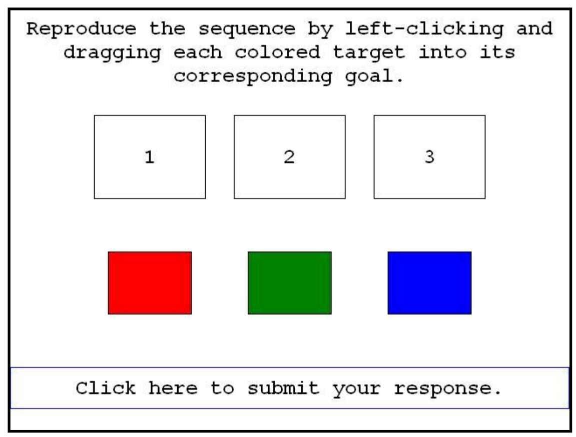

Figure 6: Experiment 1 Secondary Task Response Screen

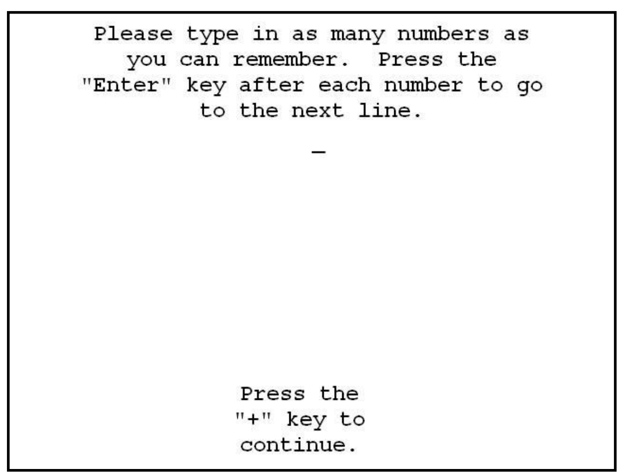

Figure 7: Memorizing Numbers Response Screen

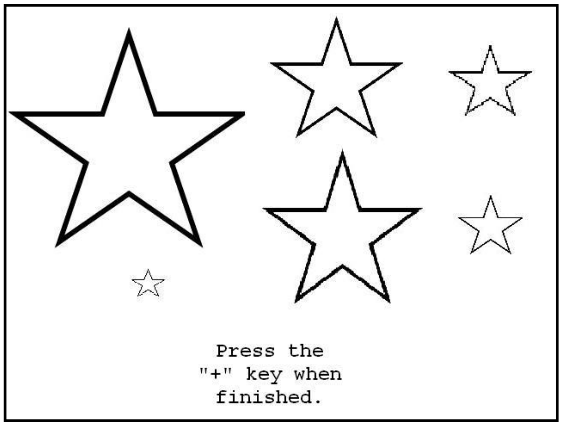

Figure 8: Clicking Stars Response Screen.

Experiment 2: Effects of Deferring an Interruption

Subjects were randomly assigned to one of three groups. The first group consisted of 11 subjects who were given the high cognitive task of memorizing numbers. While they were performing the primary task they were alerted about the secondary task, but were forced to complete the primary task. This group was known as the *Forced Primary Group*. The second group started the same high cognitive task and was also alerted about the secondary task, but this group was forced to complete the secondary task first before returning to the primary task. This group was known as the *Forced Secondary Group.* The third group was 11 subjects who started the same high cognitive task, finished it, and then moved on to complete the low cognitive task with no alert in between. This group was known as the *Control Group*.

In the second experiment, the same 33 college students were utilized as in the first experiment. The primary task for all users was the same in this experiment and the primary task involved a high cognitive workload. The users were presented with a different list of four digit numbers and again asked to memorize as many as possible in 20 seconds, as seen in Figure 9.

The low cognitive secondary task was the same colored boxes task described in Experiment 1. These three groups provided variation to investigate whether or not actually postponing the secondary task benefited the user. In the background during each experiment, E-Prime software was recording the total time to complete the tasks and measuring the resumption lag time. After the first experiment was conducted, each subject was asked to take a user satisfaction survey (Appendix B).

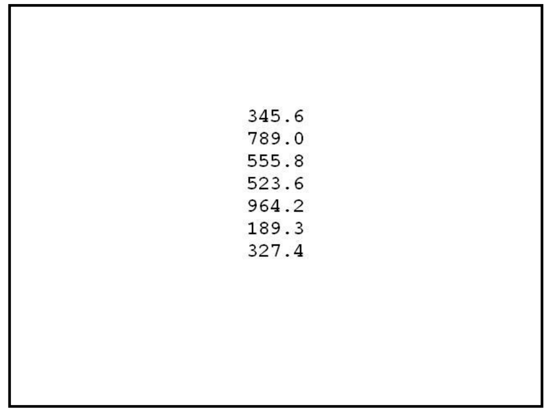

Figure 9: Experiment 2 Primary Task – High Cognitive

Several different resources were needed for the running and analysis of the experiments. The 33 subjects were recruited from the student population on campus for both experiments 1 and 2. These subjects were randomly assigned to one of the two conditions in experiment 1 and one of the three conditions in experiment 2. In addition, accurate mouse tracking software was utilized to accurately measure what the user does throughout the experiment and when it happens. E-Prime software was the chosen software for mouse tracking since it is a technology that is capable of tracking the cursor with millisecond accuracy. Millisecond measurements are necessary because the user made very quick decisions and this software helped to eliminate measurement errors in data collection during the experiments.

Experiment 3: Effects of Taking a Note

Forty students were tested to see how well they could retain memory of a primary task after being interrupted by a secondary task and if the process of taking a note would help their performance. To examine if it is the process of taking a note or if the note itself is useful, some subjects were able to keep the note to use later while others were not.

The game of Simon was used for the primary task. The game starts by showing four lights in a pattern and requires the player to repeat the pattern. After each level of Simon the game gets harder by adding one light and gaining speed. The secondary task used the game of Concentration, which starts with a group of cards lying face down. Two cards are flipped at a time. When the two cards match, they are left face up. Subjects were randomly assigned into four groups: 1) Control group who went through the testing without interruption; 2) Group 2 who was interrupted, but not allowed to take a note; Group 3 who was interrupted and allowed to take one note down on a piece of paper when interrupted (The note could contain whatever they thought could help them when they returned to the task); and 4) Group 4 who was interrupted and allowed to take a note down when interrupted, but would not be able to use that note upon returning to the first task.

Subjects in groups 2-4 were told to stop after seeing the next color in the eighth level of Simon so that they could be interrupted with the secondary task (Concentration). At the end of each experiment subjects completed a survey.

4. RESULTS

Experiment 1: Replicating Salvucci & Bogunovich

The complete statistics from Experiment 1 can be seen in Appendix 3. A summary of the results is shown in Figure 10. These results show that of the 33 subjects that were run through the experiment, a total of six decided to switch tasks (move from working on the Primary Task to working on the Secondary Task). Of the six that decided to switch, five of the six switched when the Primary Task was the low cognitive Stars task versus only one subject who switched when the Primary Task was the high cognitive Numbers Task. The percentage of subjects that switched tasks when having a low cognitive task was 83% for this experiment, compared to 94% in the Salvucci and Bogunovich (2010) study. In addition, it can be seen that the Average Resumption Lag for the high cognitive Numbers Task was, on average, almost 1.5 seconds higher than those subjects who did the low cognitive Stars Task.

For experiment 1, 95% confidence intervals were calculated to determine whether any of these measurements between groups were statistically different from each other. For Experiment 1 resumption lag, the high cognitive group had a confidence interval of (3.678, 5.286) seconds and the low cognitive group had a confidence interval of (1.950, 4.230) seconds. The confidence intervals for the other metrics, such as how many numbers were remembered correctly can be seen in the complete statistics in the appendices. Overall in all cases and all measurements, there appeared to be no statistical significance between the groups in for this experiment.

	# Users who switched tasks	Salvucci	Average Resump-tion Lag
Numbers Task (high-cognitive)	1/6 17%	6%	4.482 secs
Stars Task (low-cognitive)	5/6 83%	94%	3.090 secs

Figure 10: Experiment 1 – Notable Results

Experiment 2: Effects of Deferring an Interruption

The complete statistics from Experiment 2 can be seen in Appendix 4. A summary of the results is shown in Figure 11. Overall, it can be seen that the Forced Primary group took more time to complete both tasks, taking 106.99 seconds as opposed to 97 and 98 seconds for the other two groups. The Forced Primary group also had less resumption lag (3.14 seconds), compared to the other two groups (which had values over 4 seconds). Also, the Forced Secondary group, on average, remembered less of the numbers (1.78 numbers) than the Forced Primary or Control groups (2.00 numbers or higher).

	Total Time	**Resumption Lag**	**Accuracy**
Forced Primary	106.990 secs	3.141 secs	2.18 numbers
Forced Secondary	97.967 secs	4.194 secs	1.78 numbers
Control	97.246 secs	4.172 secs	2.00 numbers

Figure 11: Experiment 2 – Notable Results

In conducting the user satisfaction surveys after each experiment, the following can be seen. Most subjects in both experiments found the memorizing numbers task difficult or very difficult; 16/17 subjects in Experiment 1, and 26/32 subjects in Experiment 2. Most subjects also found the colored boxes task and the stars task to be easy or very easy (29/32 and 14/16 respectively). Most subjects indicated that they were either not very stressed (stars – 12/16) or moderately stressed (numbers – 8/17 subjects). In the open comments section of the surveys, some of the subjects indicated that they were more comfortable in the second experiment after having completed the first (5/33 subjects).

For experiment 2, 95% confidence intervals were calculated to determine whether any of these measurements between groups were statistically different from each other. For Experiment 2 resumption lag, the Forced Primary group had a confidence interval of (2.048, 4.234) seconds, the Forced Secondary group had a confidence interval of (2.928, 5.460) seconds, and the Control group had a confidence interval of (2.497, 5.847) seconds. The confidence intervals for the other metrics, such as how many numbers were remembered correctly can be seen in the complete statistics in the appendices. Overall in all cases and all measurements, there appeared to be no statistical significance between the groups for this experiment.

Experiment 3: Effects of Taking a Note

Each experimental group had 10 subjects randomly assigned to it. The Control Group was not interrupted, Group 2 was interrupted, Group 3 was interrupted, wrote a note and got to keep it and Group 4 was interrupted, wrote a note, but the note was taken away. The average level finished for each of the groups is shown in Figure 12.

	Average level finished
Control	9.40
Group 2	11.40
Group 3	10.50
Group 4	9.50

Figure 12: Average level of Simon finished in Experiment 3

The group that performed the best was Group 2 who was interrupted but could not take or use a note.

5. DISCUSSION

Overall, Experiment 1: Replicating Salvucci & Bogunovich ended up being close to the Salvucci and Bogunovich study comparing the 94% of their study to the 83% of this study. This difference can be attributed to individual user differences and also the number of subjects tested. All three studies had a small number of subjects. An experiment on a larger scale would be more indicative of the actual results. Also, the ability to postpone a task appeared to increase accuracy and lessen resumption lag, but the statistical analysis makes this look less definitive. Also, the results were less definitive on the overall time metric because it took users slightly more time when given the decision slide, about 107 seconds vs. the 97 seconds of the other groups.

The user satisfaction survey results indicate that the cognitive level of the tasks desired matched the actual cognitive level that the subjects experienced. Also, because the same subjects were used, many subjects may have been influenced in Experiment 2 after having completed Experiment 1.

The results in Experiment 3 were totally opposite of that predicted by the prior research. In Parnin, & DeLine 's (2010) study of Microsoft programmers, the programmers were being interrupted by the same type of task (programming with programming), where in Experiment 3, a visual/auditory task (Simon) was interrupted by a visual task (Concentration). Individual differences and experimental flaws may also to be responsible due to cognitive or physical differences of the subjects. It would be worth examining these differences further.

6. CONCLUSIONS

Overall, computer users have shown a great interest in having the ability to postpone interrupting tasks. Giving control to the user has a strong potential to limit any negative impact of the interruptions. Also, interrupting at more appropriate cognitive levels appears to be a key indicator of how willing a user is to accept an interrupting task. Ultimately, utilizing these postpone options could save significant time and money.

To get more definitive results with regard to interruptions, a study with more subjects would be ideal. Also, investigating the Experiment 2 metrics more carefully would be very important to see if it is worth implementing these postpone options to software. It would also be interesting to look at self-interruptions because they are a different brand of interruptions that were not even considered in this study. In addition, it took the users only a few minutes to complete the tasks described above, so running a study with a longer-term task would definitely be an important and interesting consideration in conducting future research.

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Appendix A

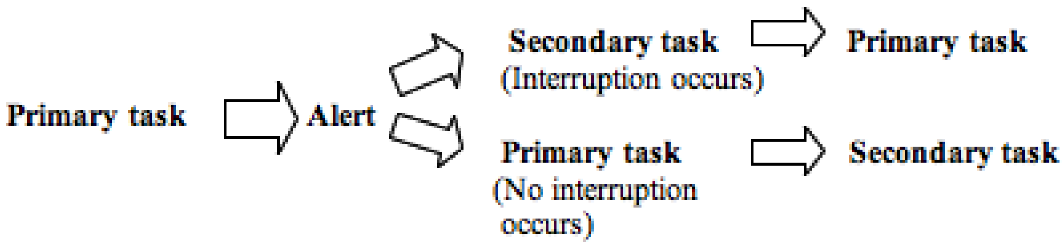

Figure 1: Sequence of events

Appendix B : Interruptions and the Effects of Postponement of a Secondary Task: Experiment 1

Subject #: _________

Please rate the following on their level of difficulty:

Task	Very Difficult	Difficult	Neither Difficult nor Easy	Easy	Very Easy
Experiment 1: The Primary Task Please circle one: (memorizing numbers) (clicking stars)					
Experiment 1: The Secondary Task (ordering the boxes)					

In the first experiment, why did you choose to postpone the primary task? (or why didn't you choose to postpone the primary task?)

During the first experiment primary task, how many digits did each number have? Or how many stars were there on the screen?

Please rate the following on your experience during the experiment using the scale from 1 to 5:

	Not Very				Very
I felt stressed.	1	2	3	4	5
	Not enough				Plenty of time
The amount of time to do the primary task.	1	2	3	4	5
	Difficult				Easy
It was easy to remember the numbers	1	2	3	4	5

Additional Comments:

Appendix C Interruptions and the Effects of Postponement of a Secondary Task Experiment 2

Subject #: _________

Please rate the following on their level of difficulty:

Task	Very Difficult	Difficult	Neither Difficult nor Easy	Easy	Very Easy
Experiment 2: The Primary Task (memorizing numbers)					
Experiment 2: The Secondary Task (ordering the boxes)					

How well do you think you correctly memorized the numbers? How many do you think you remembered?

During the second experiment primary task, how many digits did each number have?

Please rate the following on your experience during the experiment using the scale from 1 to 5:

Not Very

	Not Very				Very
I felt stressed.	1	2	3	4	5
	Not enough				Plenty of time
The amount of time to do the primary task.	1	2	3	4	5
	Difficult				Easy
It was easy to remember the numbers	1	2	3	4	5
	Not Very				Very
I was frustrated that I was forced to postpone or not postpone	1	2	3	4	5

Additional Comments

Appendix D

Subject #	1st Experiment Total Time	Decision	Resumption Lag	Numbers Accuracy (out of 7)	Stars Accuracy (of 6)	Boxes Accuracy (of 2)
NumbersBoxes Tasks						
1	124326	Primary	4220	4		1
3	123790	Primary	4004	3		1
5	110341	Primary	6404	2		1
7	200015	Primary	5341	1		1
9	121633	Primary	4229	4		2
11	107115	Primary	2809	3		0
13	165277	Primary	5154	3		0
15	131839	Primary	2681	2		1
17	129133	Primary	3841	4		2
19	142866	Primary	3815	3		1
21	140525	Primary	5855	5		2
23	112859	Primary	2999	3		0
25	113195	Primary	3167	3		1
27	113355	Secondary	2583	2		1
29	152743	Primary	4091	3		2
31	119161	Primary	5787	2		0
33	122484	Primary	9219	3		2
Average	**131215.12**	**94.12%**	**4482.29**	**2.94**		**1.06**
Standard Deviation	**23713.617**		**1692.962**	**0.966**		
Confidence	11272.53		804.77			
Interval	(119942.59, 142487.65)		(3678, 5286)			
StarsBoxes Tasks						
2	77673	Secondary	1640		6	2
4	120454	Primary	4889		6	1
6	84743	Secondary	8968		6	0
8	100523	Primary	7744		6	0
10	73416	Primary	1128		6	1
12	72097	Secondary	1384		6	2
14	85570	Primary	1600		6	1
16	97892	Primary	2488		6	1
18	87194	Primary	2392		6	2
20	51896	Secondary	2312		6	2
22	99879	Primary	2169		6	0
24	75276	Secondary	1376		6	1
26	83475	Primary	1417		6	0
28	86221	Primary	4192		6	0
30	103521	Primary	2040		6	0
32	99653	Primary	3712		6	1
Average	**87467.69**	**68.75%**	**3090.69**		**6.00**	**0.88**
Standard Deviation	**16123.808**		**2327.704**			
Confidence	7900.520505		1140.554218			
Interval	(79567, 95367)		(1950, 4230)			

Appendix E

Subject #	2nd Experiment Total Time	Decision	Resumption Lag	Numbers Accuracy (out of 7)	Boxes Accuracy (of 2)
ForcedPrimary Tasks					
1	116017	ForcedPrimary	1948	4	2
4	121242	ForcedPrimary	6516	1	1
7	114149	ForcedPrimary	3309	1	1
10	135443	ForcedPrimary	6794	1	2
13	123329	ForcedPrimary	2081	4	2
16	105529	ForcedPrimary	2273	2	2
19	93776	ForcedPrimary	1111	2	2
22	101009	ForcedPrimary	2750	4	2
28	100066	ForcedPrimary	3147	1	2
29	81618	ForcedPrimary	1795	3	2
31	84722	ForcedPrimary	2827	1	2
Average	**106990.91**		**3141.00**	**2.18**	**1.82**
Standard Deviation	**16770.374**		**1850.612**	**1.328**	
Confidence	9910.475343		1093.621904	0.784795078	
Interval	(97080, 116900)		(2048, 4234)	(1.40, 2.96)	
ForcedSecondary Tasks					
2	88554	ForcedSecondary	3133	2	1
5	88622	ForcedSecondary	6228	1	2
8	141674	ForcedSecondary	3199	2	2
14	106624	ForcedSecondary	3074	3	2
17	80678	ForcedSecondary	2250	2	2
20	115405	ForcedSecondary	7958	2	2
25	90591	ForcedSecondary	2287	3	2
26	90368	ForcedSecondary	4495	0	1
32	79194	ForcedSecondary	5123	1	2
Average	**97967.78**		**4194.11**	**1.78**	**1.78**
Standard Deviation	**20089.637**		**1937.925**	**0.972**	
Confidence	13124.98841		1266.087702	0.634914206	
Interval	(84843, 111091)		(2928, 5460)	(1.15, 2.41)	
Control					
3	87250	None	2484	3	1
6	97865	None	1838	2	2
9	121011	None	4679	2	2
12	71063	None	3205	2	2
15	88038	None	5485	3	2
18	87067	None	2991	1	2
21	139622	None	11525	3	1
24	93178	None	2719	1	2
27	99020	None	6336	1	1
30	92467	None	2527	1	1
33	93132	None	2112	3	2
Average	**97246.64**		**4172.82**	**2.00**	**1.64**
Standard Deviation	**18423.388**		**2835.809**	**0.894**	
Confidence	10887.32626		1675.824948	0.52856298	
Interval	(86359, 108133)		(2497, 5847)	(1.47, 2.53)	

Does Size Matter in IT? An Exploratory Analysis of Critical Issues Facing Organizations Based on Company Size

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Abstract

Information technology (IT) continues to play a vital role in business organizations. The critical IT issues that are important to organizations, however, are varied, and range from strategic fit to replacement of legacy systems. Our study reviews fourteen commonly expressed IT issues and measures their importance based on the size of an organization. Company size has been determined to be a significant variable affecting what is important to an organization. This study finds that this company size, as measured by sales volume, does affect what IT issues are critical to an organization, and that there are statistically significant differences based on the size of an organization.

Key words: critical issues, company size, information technology issues

1. INTRODUCTION

Information technology (IT) continues to play a vital role in business organizations. It is estimated that nearly 9% of our gross national product is spent on information technology (Trading Economics, 2011), and that tremendous productivity gains have been accomplished via information technology. But despite the prevalence and importance of IT, success has not been universal. It is estimated that 68% of IT projects fail (Krigsman, 2008). It has also been posited that not all information technology expenditures are adding to US productivity. There are many areas that have been explored to improve IT performance and return. One of the areas that is often reviewed is key information technology issues. The AICPA annually surveys members on their views on the top information technology issues. They publish an annual report of the top ten technology initiatives, which suggests areas that need attention (see Table 1). The Financial Executives International organization also surveys their members and asks what the critical issues are among their members. Our study re-explores their data to determine whether size of an organization plays a role in the identification of what issues are critical, important, or not important and performs chi-square analysis to determine whether the issues differ by size of an organization.

2. SIZE

The use of size as a variable affecting organization performance and issues is well established in the literature. Van Biesebroeck (2005) studied manufacturing firms from in sub-Saharan African countries He found that large firms achieve higher productivity levels and are more likely to survive. "The labor market relocates workers toward the most productive firms, and this reinforces the importance of large firms for aggregate productivity growth. Formal credit institutions award most financing to large firms, and access to credit is positively correlated with productivity, even conditional on firm size." According to Biesebroeck (2005) size matters in the success of the manufacturing firms he studied. Larger firms perform better. González-Benito and González-Benito (2010) found company size to be a determinant factor in stakeholder environmental pressure. Our study will review key issues in information technology and determine whether company size influences the criticality of these issues among the firms.

Table 1: 2011 Top Ten Technology Initiatives

1.	Control and Use of Mobile Devices
2.	Information Security
3.	Data Retention Policies and Structure
4.	Remote Access
5.	Staff and Management Training
6.	Process Documentation and improvements
7.	Saving and Making Money w/Technology
8.	Technology Cost Controls
9.	Budget Processes
10.	Project Management & deployment of new

3. SURVEY SOURCE AND METHODOLOGY

In order to explore critical issues, specific corporate data were required. We found a rich data set that was available from Financial Executives International. Financial Executives International is "the preeminent association for CFOs and other senior finance executives." It has … CFOs, VPs of Finance, Treasurers, Controllers, Tax Executives, Academics, Audit Committee members [in] companies large and small, public and private, cross-industry. (FEI, 2006, b) The FEI, each year, commissions a large scale study of "technology issues for Financial Executives". The survey instructions follow.

"FEI's Committee on Finance and information Technology (CFIT) and Financial Executives Research Foundation (FERF), in partnership with Computer Sciences Corporation (CSC), are conducting the eighth annual survey of Technology Issues for Financial Executives. This initiative explores and reports on information technology from the perspective of the financial executive. Last year we set another record for survey participation with nearly 800 responses, continuing our unbroken streak of year-over-year increases since the survey's inception. As part of this year's effort, we are targeting another significant increase in response volume so that we can expand the resulting publication to include more analyses by industry and company size. ." (FEI, 2006)

As a part of this study, specific information was obtained from top financial executives on systems project management. These questions and responses were sufficiently detailed and pertinent to our hypotheses to serve as the bases for testing this study's hypotheses. The main advantage is the large data set and the independent collection from a private membership trade group. All data has been collected and furnished by the Financial Executives International and remains their property. Use for academic and research purposes was obtained by the author. The author wishes to sincerely thank the organizations for their cooperation.

The overall questionnaire included 44 questions in the noted categories but sub-questions and ranked responses raised the overall individual data points to more than 220. From this overall report a small subsection was used to analyze the relevant hypotheses. Selected responses from the Demographics section were included as well. The specific questions used to test the hypotheses are listed below:

What overall return is your organization obtaining on its technology investments? (Mark only one.)
_ High
_ Medium
_ Low
_ Negative
_ Unknown

What is your overall return?
What is the size of your organization in annual revenues, stated in U.S. dollars?
_ Less than $100 Million
_ $100 Million - $499 Million
_ $500 Million - $999 Million
_ $1 Billion - $5 Billion
_ Greater than $5 Billion
Please indicate how important you believe each of these technology issues is to your organization.
(1 = critical; 2 = important; 3 = not a concern.)
_ _ _ Identifying the appropriate level of technology investment
_ _ _ Upgrading or replacing legacy systems

_ _ _ Evaluating or measuring the return on technology investments
_ _ _ Prioritizing technology investments
_ _ _ Educating senior management on the value of technology
_ _ _ Establishing and maintaining effective dialogue between IT and users
_ _ _ Identifying the appropriate level of security for information and electronic applications
_ _ _ Identifying how IT can improve or influence business processes
_ _ _ Using technology to drive business change
_ _ _ Training staff in new technologies and upgrades
_ _ _ Developing disaster recovery capabilities
_ _ _ Deploying wireless technologies
_ _ _ Evaluating the adoption/use of XBRL
_ _ _ Using technology to improve the system of internal controls
_ _ _ Aligning business and IT strategy

From the preceding list, which is your most critical concern? Enter the letter representing your selection _____

4. CRITICAL ISSUE TOPICS BACKGROUND, RESULTS, AND DISCUSSION

The following are the critical issues that were extracted and tested from the survey. There is literature support for each area followed by the analysis of the actual question used in the survey. Statistical analyses were used to study each of these potential key issues facing information technology organizations today.

Identifying the appropriate level of technology investment

The first issue studied in the FEI survey was the exploration of the appropriate level of technology investment. In other words, how much money should we be spending for IT. Too much suggests wasted costs and too little could affect marketing efforts or productivity improvements. The concept of determining business value has been recognized by researchers. Melville, Kraemer, and Gurbaxani (2004) suggest that information technology is value but depends on many other issues and factors in an organization; therefore it is extremely important to determine the business value of your IT expenses.

Overall, it was found that 44% of all companies see identifying the appropriate level of technology investment as a critical issue for information technology management. Another 51% see it as important. Our chi-square analysis furthermore reveals that there is a significant variation based on company size at $p < .01$. Large companies generally see level of investment as more critical than smaller companies. In addition, nearly all the companies surveyed with over $1 billion in sales saw this as either important or critical. It is interesting to speculate on the cause of this disparity. It may be due to lesser understanding of the importance of IT or due to the lower complexity of IT among smaller companies. It may also reflect more of a perceived inability to change IT costs among smaller firms. Further study is necessary to determine the reasons behind this difference.

Table 2 Identifying the appropriate level of technology investment

[See Appendix]

Upgrading or replacing legacy systems

Old, legacy systems linger in many organizations. According to Chowdhury and Iqbal (2004), "Most Companies have an environment of disparate legacy systems, applications, processes and data sources. Maintaining legacy systems is one of the difficult challenges that modern enterprises are facing today." They discuss the challenges and approaches that can be implemented to deal with modernization of these legacy systems.

Overall, nearly 80% of firms surveyed find legacy systems critical or important. Our study finds that generally, once again, larger firms see that legacy systems as more important. For the smallest firms, 27% see legacy work as not a concern, whereas only 11% of the largest firms express this view. A probable cause is the complexity of businesses and systems as they grow in size, leading to more difficult legacy issues. Significant differences were found based on company size at $p < .05$.

Table 3 Upgrading or replacing legacy systems * SIZE Crosstabulation

[See Appendix]

Table 4 Upgrading Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.949[a]	8	.031
Likelihood Ratio	17.026	8	.030
Linear-by-Linear Association	8.140	1	.004
N of Valid Cases	696		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.19.

Table 5 IT Return Report

SIZE	Mean	N	Std. Deviation
< 100 M	1.72	286	.450
100-499M	1.66	196	.476
500-999M	1.55	65	.501
1-5B	1.45	107	.500
>5B	1.37	35	.490
Total	1.63	689	.484

Evaluating or measuring the return on technology investments

For many years there has been a debate on the return that information technology is providing. Mahmood and Mann (1993) write, "Organizations are investing ever-increasing amounts in information technology (IT). However, the existing literature provides little evidence of a relationship between IT investment and organizational strategic and economic performance. The exploratory research reported here appears to be the first to relate comprehensive sets of IT investment measures to organizational strategic and economic performance measures." This work supports this study. According to this FEI survey, the average return for each size group ranged between High (1) and Medium (2), see table 5. It was also found thought that larger firms reported higher returns on information technology investments, significant at $p < .001$. Once again, size does matter, in this case for IT return.

This work also supports the importance of measurement of these returns. 43% of Firms over $5 billion see IT return measurement as critical, while only 16% of firms under $100 million feel this way. Chi-square differences are significant at $p < .001$.

Table 6 Evaluating or measuring the return on technology investments * SIZE Crosstabulation

[See Appendix]

Prioritizing technology investments

Bardhan, Sougstad, and Sougstad (2004) have suggested that prioritizing a portfolio of information technology projects could provide significant benefits for an organization. Our participants seem to agree with this proposition, with 92% of all organizations seeing this as either important or critical. Higher criticality is noted by larger firms at $p < .001$.

Table 7 Prioritizing technology investments * SIZE Crosstabulation

[See Appendix]

Educating senior management on the value of technology

Beath (1991) found that project champions and support are vital to information technology support. This is one area where there is only a weak significant difference based on company size, however (significant at $p < .10$). Approximately 20% see this as a critical issue, 50% as important, and 30% as not a concern (perhaps suggesting that the support already exists).

Table 8 Educating senior management on the value of technology * SIZE Crosstabulation

[See Appendix]

Establishing and maintaining effective dialogue between IT and users

Boynton et al. (1994) report that the effective application of IT is dependent on the interactions between IT and line managers.

Table 9 Establishing and maintaining effective dialogue between IT and users * SIZE Crosstabulation

[See Appendix]

Dialogue also appears to be an area that is understood and addressed by all sizes of organizations. There is no significant difference among the company sizes on the issue of Establishing and maintaining effective dialogue between IT and users based on company size at $p < .05$. About 40% see this as critical, 50% as important, and 10% not a concern, across all company sizes.

Identifying the appropriate level of security for information and electronic applications

According to Baker and Wallace (2007) , "organizations are consequently more aware of information security risks and the need to take appropriate action. Previous studies of organizations' use of information security controls have focused on the presence or absence of controls, rather than their quality."

Table 10 Identifying the appropriate level of security for information and electronic applications * SIZE Crosstabulation

[See Appendix]

All company sizes recognize the importance of determining the adequate level of security necessary. Security increases costs and decreases flexibility, therefore it is important to get this right. 50% of respondents see this as critical and another 46% as important. There is no significant difference based on company size.

Identifying how IT can improve or influence business processes

One of the most important initiatives in business in the past several decades has been overall process and productivity improvement. Broadbent, Weill, & St Clair (1999) found that those who emphasized IT in conjunction with BPR had higher levels of success.

Table 11 Identifying how IT can improve or influence business processes * SIZE Crosstabulation

[See Appendix]

Since much BPR has already been accomplished, this issue had a reduced importance across the board. 40% still see it as a critical issue, though, and 52% as important. This issue may be already well understood among all sizes of companies. There is no significant difference based on company size.

Using technology to drive business change

Davenport (1993) suggests that using technology to drive business change is "best hope we have for getting value out of our vast IT expenditures."

Table 12 Using technology to drive business change * SIZE Crosstabulation

[See Appendix]

Though important (52%), only 34% of organizations see this as a critical issue. There is no significant difference in this view based on company size.

Training staff in new technologies and Upgrades

According to Cynthia and Peter (2000)," 308 small business executives were interviewed and asked to identify the single most important thing they had learned about managing the use of information technology (IT) in their firms. The most common response was staying current/keeping up with changing IT." This view does not seem to be shared by our respondents. Only 20% saw this skills maintenance as a critical item, though 66% did see it as important. There was no significant difference in this view based on company size.

Table 13 Training staff in new technologies and upgrades * SIZE Crosstabulation

[See Appendix]

Developing disaster recovery capabilities

In Disaster recovery planning: a strategy for data security, Hawkins, Yen, and Chou (2000) express a strong concern and plan for disaster recovery, noting its damaging and costly results if such a plan is not in place. This is a view not necessarily shared across our participants. 29% see DRP as critical and 60% see as important. There was no significant difference across company size.

Table 14 Developing disaster recovery capabilities * SIZE Crosstabulation

[See Appendix]

Note the importance of information technology disaster recovery planning. There are advantages and costs of having a DRP. Some of the advantages are the reduction in data loss, minimizing the need of decision-making process during a disaster, and the protection of company employees. It also causes extra expenses and requires manpower. Despite the questions that arise when considering a DRP, companies should focus on the most important commodity: company data. Depending on the importance of the data, developing a DRP can be more economical than replacing the lost data.

Deploying wireless technologies

According to Islam, Khan, Ramayah, and Hossain (2011) wireless technologies are extremely important for mobile commerce suggesting " the real value of M-commerce lies in its ability to realize the tremendous business opportunity and address lifestyle issues prevalent in an aware, hyper-efficient, "on always" world."

Table 15 Deploying wireless technologies * SIZE Crosstabulation

[See Appendix]

Since this data is from 2006, this issue may not be as important as it is today. In this survey only 8% saw this issue as critical. In addition, much traditional wireless infrastructure is already in place. Nearly 50% saw this issue as not a concern. There were no significant differences across company sizes.

Evaluating the adoption/use of XBRL

According to Doolin and Troshani (2007), "XBRL is an emerging innovation that has the potential to play an important role in the electronic production and consumption of financial information." This issue was here check since it was a survey of financial executives. Even still, only 3% see as critical and 27% as important. There were no significant differences across company sizes.

Table 16 Evaluating the adoption/use of XBRL * SIZE Crosstabulation

[See Appendix]

Using technology to improve the system of internal controls

Wallace and Cefaratti (2011) see "Information technology (IT) is a vital component of information security. IT refers to any technology that helps to manage, process, or disseminate information, such as some combination of computer hardware, software, and associated communications systems." It is especially important for internal controls and Sarbanes-Oxley compliance.

Table 17 Using technology to improve the system of internal controls * SIZE Crosstabulation

[See Appendix]

Our financial officers placed a relatively high degree of importance on this issue with 23% viewing as critical and 62% as important. There was a weak relationship with size, with the largest companies expressing the highest importance. This was significant at $p < .10$.

Aligning business and IT strategy

There is much research focusing on the importance of aligning business and IT strategy, such as Estrada (2010) and Reich and Benbasat (2000).

Table 18 Aligning business and IT strategy * SIZE Crosstabulation

[See Appendix]

Our practitioners echo this importance with a full 45% seeing this issue as critical, and another 46% as important. The recognition of this increased directly with company size, and was significant at $p < .001$.

Table 19 Most important issue * SIZE Crosstabulation

[See Appendix]

The final question asked was, what was the most important issue across all the noted issues. As expected, there were a variety of answers, and each size group had a different importance ranking. These differences were significant at $p < .05$.

The smallest firms had the widest variety of most critical issues. Surprisingly, the greatest issue was replacing legacy systems. This issue was at or near the top of all size categories. The largest firms had prioritization of technology investments as their top priority. This issue was not on the top five for firms in the lowest two size categories. This suggests that IT project portfolio management does not have high implementation until firms reach about $500 million in sales. Aligning business and IT strategy was in the top 5 issues for all size firms, confirming its understanding and importance. Finally, identifying how IT can improve business process was on the top list for all but companies over $5 billion. This suggests that this issue may have been addressed by the largest companies already.

5. CONCLUSION

The overall objective of the manuscript was to determine if and whether size mattered in the recognition and prioritization of critical and important IT issues. Over the 14 issues, our analysis has determined that seven of the fourteen did have significant differences at $p < .10$ based on company size. For information technology issues, size does indeed matter, just not for all issues. As a general rule, the more strategic issues, including level of investment, evaluating return, and aligning business strategy tended to vary based on company size. More general skills such as effective dialogue, training, and wireless technologies did not vary with size. One could suggest that this reflects an overall management maturity, and does represent an opportunity for small and medium sized businesses to improve their information technology management.

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Appendices

Table 2 Identifying the appropriate level of technology investment

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	120	83	23	55	24	305
		% within SIZE	41.7%	41.9%	34.8%	51.4%	64.9%	43.8%
	Important	Count	147	101	40	51	13	352
		% within SIZE	51.0%	51.0%	60.6%	47.7%	35.1%	50.6%
	Not a Concern	Count	21	14	3	1	0	39
		% within SIZE	7.3%	7.1%	4.5%	.9%	.0%	5.6%
Total		Count	288	198	66	107	37	696
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 3 Upgrading or replacing legacy systems * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	91	61	33	39	16	240
		% within SIZE	31.6%	30.8%	50.0%	36.4%	43.2%	34.5%
	Important	Count	119	95	24	47	17	302
		% within SIZE	41.3%	48.0%	36.4%	43.9%	45.9%	43.4%
	Not a Concern	Count	78	42	9	21	4	154
		% within SIZE	27.1%	21.2%	13.6%	19.6%	10.8%	22.1%
Total		Count	288	198	66	107	37	696

Table 3 Upgrading or replacing legacy systems * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	91	61	33	39	16	240
		% within SIZE	31.6%	30.8%	50.0%	36.4%	43.2%	34.5%
	Important	Count	119	95	24	47	17	302
		% within SIZE	41.3%	48.0%	36.4%	43.9%	45.9%	43.4%
	Not a Concern	Count	78	42	9	21	4	154
		% within SIZE	27.1%	21.2%	13.6%	19.6%	10.8%	22.1%
Total		Count	288	198	66	107	37	696
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6 Evaluating or measuring the return on technology investments * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	46	35	8	18	16	123
		% within SIZE	16.0%	17.7%	12.1%	17.0%	43.2%	17.7%
	Important	Count	173	122	46	77	19	437
		% within SIZE	60.1%	61.6%	69.7%	72.6%	51.4%	62.9%
	Not a Concern	Count	69	41	12	11	2	135
		% within SIZE	24.0%	20.7%	18.2%	10.4%	5.4%	19.4%
Total		Count	288	198	66	106	37	695

Table 6 Evaluating or measuring the return on technology investments * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	46	35	8	18	16	123
		% within SIZE	16.0%	17.7%	12.1%	17.0%	43.2%	17.7%
	Important	Count	173	122	46	77	19	437
		% within SIZE	60.1%	61.6%	69.7%	72.6%	51.4%	62.9%
	Not a Concern	Count	69	41	12	11	2	135
		% within SIZE	24.0%	20.7%	18.2%	10.4%	5.4%	19.4%
Total		Count	288	198	66	106	37	695
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 7 Prioritizing technology investments * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	117	88	28	59	27	319
		% within SIZE	40.6%	44.4%	42.4%	55.7%	75.0%	46.0%
	Important	Count	143	93	30	45	9	320
		% within SIZE	49.7%	47.0%	45.5%	42.5%	25.0%	46.1%
	Not a Concern	Count	28	17	8	2	0	55
		% within SIZE	9.7%	8.6%	12.1%	1.9%	.0%	7.9%
Total		Count	288	198	66	106	36	694

Table 7 Prioritizing technology investments * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	117	88	28	59	27	319
		% within SIZE	40.6%	44.4%	42.4%	55.7%	75.0%	46.0%
	Important	Count	143	93	30	45	9	320
		% within SIZE	49.7%	47.0%	45.5%	42.5%	25.0%	46.1%
	Not a Concern	Count	28	17	8	2	0	55
		% within SIZE	9.7%	8.6%	12.1%	1.9%	.0%	7.9%
Total		Count	288	198	66	106	36	694
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 8 Educating senior management on the value of technology * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	56	34	15	22	8	135
		% within SIZE	19.5%	17.3%	22.7%	20.6%	21.6%	19.5%
	Important	Count	131	102	27	56	16	332
		% within SIZE	45.6%	52.0%	40.9%	52.3%	43.2%	47.9%
	Not a Concern	Count	100	60	24	29	13	226
		% within SIZE	34.8%	30.6%	36.4%	27.1%	35.1%	32.6%
Total		Count	287	196	66	107	37	693

Table 8 Educating senior management on the value of technology * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	56	34	15	22	8	135
		% within SIZE	19.5%	17.3%	22.7%	20.6%	21.6%	19.5%
	Important	Count	131	102	27	56	16	332
		% within SIZE	45.6%	52.0%	40.9%	52.3%	43.2%	47.9%
	Not a Concern	Count	100	60	24	29	13	226
		% within SIZE	34.8%	30.6%	36.4%	27.1%	35.1%	32.6%
Total		Count	287	196	66	107	37	693
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9 Establishing and maintaining effective dialogue between IT and users * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	98	94	24	49	17	282
		% within SIZE	34.0%	47.5%	36.4%	45.8%	45.9%	40.5%
	Important	Count	153	82	32	49	18	334
		% within SIZE	53.1%	41.4%	48.5%	45.8%	48.6%	48.0%
	Not a Concern	Count	37	22	10	9	2	80
		% within SIZE	12.8%	11.1%	15.2%	8.4%	5.4%	11.5%
Total		Count	288	198	66	107	37	696
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 10 Identifying the appropriate level of security for information and electronic applications * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	150	94	31	50	22	347
		% within SIZE	52.4%	47.7%	47.0%	46.7%	59.5%	50.1%
	Important	Count	123	98	31	51	14	317
		% within SIZE	43.0%	49.7%	47.0%	47.7%	37.8%	45.7%
	Not a Concern	Count	13	5	4	6	1	29
		% within SIZE	4.5%	2.5%	6.1%	5.6%	2.7%	4.2%
Total		Count	286	197	66	107	37	693
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 11 Identifying how IT can improve or influence business processes * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	119	77	25	44	15	280
		% within SIZE	41.5%	38.9%	37.9%	41.1%	40.5%	40.3%
	Important	Count	152	103	36	52	21	364
		% within SIZE	53.0%	52.0%	54.5%	48.6%	56.8%	52.4%
	Not a Concern	Count	16	18	5	11	1	51
		% within SIZE	5.6%	9.1%	7.6%	10.3%	2.7%	7.3%
Total		Count	287	198	66	107	37	695

Table 11 Identifying how IT can improve or influence business processes * SIZE Crosstabulation

		SIZE					Total
		< 100 M	100-499M	500-999M	1-5B	>5B	
Critical	Count	119	77	25	44	15	280
	% within SIZE	41.5%	38.9%	37.9%	41.1%	40.5%	40.3%
Important	Count	152	103	36	52	21	364
	% within SIZE	53.0%	52.0%	54.5%	48.6%	56.8%	52.4%
Not a Concern	Count	16	18	5	11	1	51
	% within SIZE	5.6%	9.1%	7.6%	10.3%	2.7%	7.3%
Total	Count	287	198	66	107	37	695
	% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 12 Using technology to drive business change * SIZE Crosstabulation

		SIZE					Total
		< 100 M	100-499M	500-999M	1-5B	>5B	
Critical	Count	95	65	21	37	18	236
	% within SIZE	33.1%	32.8%	31.8%	34.6%	48.6%	34.0%
Important	Count	156	99	34	58	15	362
	% within SIZE	54.4%	50.0%	51.5%	54.2%	40.5%	52.1%
Not a Concern	Count	36	34	11	12	4	97
	% within SIZE	12.5%	17.2%	16.7%	11.2%	10.8%	14.0%
Total	Count	287	198	66	107	37	695
	% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 13 Training staff in new technologies and upgrades * SIZE Crosstabulation

		SIZE					Total
		< 100 M	100-499M	500-999M	1-5B	>5B	
Critical	Count	62	46	10	16	5	139
	% within SIZE	21.6%	23.2%	15.2%	15.0%	13.5%	20.0%
Important	Count	187	126	40	79	27	459
	% within SIZE	65.2%	63.6%	60.6%	73.8%	73.0%	66.0%
Not a Concern	Count	38	26	16	12	5	97
	% within SIZE	13.2%	13.1%	24.2%	11.2%	13.5%	14.0%
Total	Count	287	198	66	107	37	695
	% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 14 Developing disaster recovery capabilities * SIZE Crosstabulation

		SIZE					Total
		< 100 M	100-499M	500-999M	1-5B	>5B	
Critical	Count	90	45	21	29	13	198
	% within SIZE	31.4%	22.8%	31.8%	27.1%	35.1%	28.5%
Important	Count	161	130	38	66	19	414
	% within SIZE	56.1%	66.0%	57.6%	61.7%	51.4%	59.7%
Not a Concern	Count	36	22	7	12	5	82
	% within SIZE	12.5%	11.2%	10.6%	11.2%	13.5%	11.8%
Total	Count	287	197	66	107	37	694
	% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 15 Deploying wireless technologies * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	25	14	6	5	3	53
		% within SIZE	8.7%	7.1%	9.2%	4.7%	8.1%	7.6%
	Important	Count	126	95	27	49	19	316
		% within SIZE	43.9%	48.2%	41.5%	45.8%	51.4%	45.6%
	Not a Concern	Count	136	88	32	53	15	324
		% within SIZE	47.4%	44.7%	49.2%	49.5%	40.5%	46.8%
Total		Count	287	197	65	107	37	693
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 16 Evaluating the adoption/use of XBRL * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	5	4	3	3	3	18
		% within SIZE	1.8%	2.1%	4.6%	2.9%	8.1%	2.6%
	Important	Count	71	54	16	31	14	186
		% within SIZE	25.1%	28.0%	24.6%	29.5%	37.8%	27.2%
	Not a Concern	Count	207	135	46	71	20	479
		% within SIZE	73.1%	69.9%	70.8%	67.6%	54.1%	70.1%
Total		Count	283	193	65	105	37	683

Table 16 Evaluating the adoption/use of XBRL * SIZE Crosstabulation

		SIZE					Total
		< 100 M	100-499M	500-999M	1-5B	>5B	
Critical	Count	5	4	3	3	3	18
	% within SIZE	1.8%	2.1%	4.6%	2.9%	8.1%	2.6%
Important	Count	71	54	16	31	14	186
	% within SIZE	25.1%	28.0%	24.6%	29.5%	37.8%	27.2%
Not a Concern	Count	207	135	46	71	20	479
	% within SIZE	73.1%	69.9%	70.8%	67.6%	54.1%	70.1%
Total	Count	283	193	65	105	37	683
	% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 17 Using technology to improve the system of internal controls * SIZE Crosstabulation

		SIZE					Total
		< 100 M	100-499M	500-999M	1-5B	>5B	
Critical	Count	61	42	11	35	13	162
	% within SIZE	21.3%	21.3%	16.7%	32.7%	35.1%	23.3%
Important	Count	177	123	43	62	22	427
	% within SIZE	61.7%	62.4%	65.2%	57.9%	59.5%	61.5%
Not a Concern	Count	49	32	12	10	2	105
	% within SIZE	17.1%	16.2%	18.2%	9.3%	5.4%	15.1%
Total	Count	287	197	66	107	37	694
	% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 18 Aligning business and IT strategy * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
	Critical	Count	107	77	35	66	25	310
		% within SIZE	37.3%	39.1%	53.0%	62.9%	67.6%	44.8%
	Important	Count	145	105	23	35	12	320
		% within SIZE	50.5%	53.3%	34.8%	33.3%	32.4%	46.2%
	Not a Concern	Count	35	15	8	4	0	62
		% within SIZE	12.2%	7.6%	12.1%	3.8%	.0%	9.0%
Total		Count	287	197	66	105	37	692
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 19 Most important issue * SIZE Crosstabulation

			SIZE					
			< 100 M	100-499M	500-999M	1-5B	>5B	Total
		Count	4	1	0	2	0	7
		% within SIZE	1.4%	.5%	.0%	1.9%	.0%	1.0%
	a	Count	33	20	4	7	6	70
		% within SIZE	11.4%	10.1%	6.1%	6.5%	16.2%	10.0%
	b	Count	47	33	15	18	6	119
		% within SIZE	16.3%	16.6%	22.7%	16.8%	16.2%	17.0%
	c	Count	7	6	1	4	4	22
		% within SIZE	2.4%	3.0%	1.5%	3.7%	10.8%	3.2%

	d	Count	25	25	6	15	9	80
		% within SIZE	8.7%	12.6%	9.1%	14.0%	24.3%	11.5%
	e	Count	11	3	2	1	1	18
		% within SIZE	3.8%	1.5%	3.0%	.9%	2.7%	2.6%
	f	Count	13	11	2	4	0	30
		% within SIZE	4.5%	5.5%	3.0%	3.7%	.0%	4.3%
	g	Count	32	10	4	4	0	50
		% within SIZE	11.1%	5.0%	6.1%	3.7%	.0%	7.2%
	h	Count	35	30	8	11	0	84
		% within SIZE	12.1%	15.1%	12.1%	10.3%	.0%	12.0%
	i	Count	21	15	2	10	3	51
		% within SIZE	7.3%	7.5%	3.0%	9.3%	8.1%	7.3%
	j	Count	2	8	2	2	0	14
		% within SIZE	.7%	4.0%	3.0%	1.9%	.0%	2.0%
	k	Count	9	3	0	2	0	14
		% within SIZE	3.1%	1.5%	.0%	1.9%	.0%	2.0%
	l	Count	3	2	0	0	0	5
		% within SIZE	1.0%	1.0%	.0%	.0%	.0%	.7%
	m	Count	1	1	0	0	0	2
		% within SIZE	.3%	.5%	.0%	.0%	.0%	.3%
	n	Count	11	7	3	2	2	25

		% within SIZE	3.8%	3.5%	4.5%	1.9%	5.4%	3.6%
	o	Count	35	24	17	25	6	107
		% within SIZE	12.1%	12.1%	25.8%	23.4%	16.2%	15.3%
Total		Count	289	199	66	107	37	698
		% within SIZE	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The New Tech Effect: Analyzing Juror Credibility In Cases Involving Digital Evidence

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Abstract

In recent studies, the "Tech-Effect" theory has replaced the "CSI-Effect" theory as a means to explain the potential impact of technology on jurors. In past studies, proponents of the CSI-Effect (Crime Scene Investigation Effect) proposed that jurors tend to acquit suspects when forensic evidence is not as prevalent as it is in television crime dramas. The newer "Tech-Effect" (Technology Effect) proponents argue that crime dramas do not influence jurors; rather, jurors have heightened expectations for technical and scientific evidence simply because technology is so widespread in society. This study surveyed 131 students in a medium-sized, private university to determine if a Tech-Effect truly exists, and if so, could it influence juror credibility. The survey attempted to answer two questions: 1) Will students in IS/IT degree programs demonstrate greater knowledge of forensic technology in cases involving digital evidence?, and 2) Will students in IS/IT programs demonstrate lower acquittal rates in cases involving digital evidence? The study found that students in IS/IT programs do demonstrate greater knowledge of forensic technology. However, the study failed to reveal a relationship between higher levels of digital forensic knowledge and higher rates of acquittal.

Keywords: Tech-Effect, CSI-Effect, Computer Forensics, Network Forensics, Digital Forensics, Digital Evidence, Information Security

1. INTRODUCTION

The "CSI-Effect" is a term that has been coined by the media to describe the potential impact that CSI (Crime Scene Investigation) –type television shows (i.e., those that depict forensic science as a major part of the fictional investigations) have on jurors in the U.S. criminal justice system. Some authors have argued that jurors who watch television crime shows tend not to convict suspects because procedures and forensic technology observed from the shows were not applied to the case (Heinrick, 2006). However, the actual impact (if any) of the CSI-Effect on the outcome of court trials continues to be a topic of dispute. Many researchers have attributed any noted influence on jurors to a much broader "Tech-Effect." Both the "CSI-Effect" and the more general, "Tech-Effect" are explored in the current research; the CSI-Effect is discussed first.

Many researchers have conducted studies on the CSI-Effect with mixed results. For example, A.P. Thomas surveyed 102 prosecutors and concluded that the prosecutors perceive the CSI-Effect to exist (Thomas, 2006). Of the prosecutors who were surveyed in the study, 38% believed that they had a trial that resulted in an acquittal or "hung" jury (i.e., a jury that is "deadlocked" and cannot reach a verdict) because forensic evidence was not available. The study recognized that is it common (after a verdict has been delivered) for attorneys to survey jurors on how the jurors came to their decision.

In 2008, G. Thomas conducted a study on the CSI-Effect that included 455 law enforcement agencies in North Carolina (Thomas, 2010). Out of the 264 (58% response rate) agencies that responded to the survey, a large majority (74.6%) agreed that CSI-type television shows are changing the way law enforcement collects evidence and conducts investigations. The results of this recent study show that " . . . the law enforcement respondents overwhelmingly claim that their agency has changed their law enforcement practices to overcome a perceived CSI effect" (Thomas, 2010).

While the above studies provide evidence for a CSI-Effect, other studies have found little to no evidence of the CSI-Effect. Schweitzer and Saks, for example, surveyed 48 university students to determine if watching television crime shows had a marked impact on how a potential juror might decide in a case (Schweitzer & Saks, 2007). In this study, the researchers presented the 48 participants with a courtroom transcript from a hypothetical criminal trial. The simulated trial involved a hair sample that was left at the crime scene by the suspect. The transcript also contained simulated "testimony" typical of a hair identification expert. After reading the transcript, participants were asked how they would decide if they were serving on a jury for the case. The results of the study revealed that there were no statistically significant difference in conviction rates between participants who reported watching television crime shows and participants who did not watch such shows. The study revealed, however, that viewers of such shows did expect more forensic science to be available in court cases: " . . . people who watch such television programs regularly expect better science than what they are often presented with in courts" (Schweitzer & Saks, 2007).

In 2007, Kim, Barak, and Shelton surveyed 1,027 people who had been called for jury duty. Jurors' television viewing habits was compared to expectations that forensic evidence would be introduced during the course of the trial (Kim, Barak & Shelton, 2009). Similar to the Schweitzer and Saks study, this study also found that jurors had increased expectations regarding forensic evidence. Unlike the Scheitzer and Saks study, however, the Kim, et al. study did not find a link between the viewing of television crime shows and heightened expectations regarding forensic evidence.

Recently, the forensic expert, Max Houck, noted that the verdict is still out on the CSI Effect and suggested the need for more conclusive studies on the phenomenon. Houck wondered if there is, in fact, a *quantifiable* influence: "Whether the CSI-Effect truly exists as a quantifiable influence on courtroom behavior is still a subject of debate" (Houck, 2006).

In order to conduct a more conclusive study, the authors of the current research explored the CSI-Effect in a 2010 study (Davis, Paullet, Swan, & Houck, 2010). Like many others in this field, however, the researchers in the 2010 study found indications of a CSI-Effect on the beliefs of participants, but failed to find a correlation between these beliefs and actual courtroom behavior. The lack of conclusive findings led the authors to explore what some have called the "Tech-Effect." The Tech-Effect dismisses the notion that television crime dramas alone can alter juror expectations. Rather, this newer, more general theory surmises that any potential juror influence arises from the much broader impact of modern scientific and technological advances (Kim, Barak & Shelton, 2009).

The possible effect of modern technology on jurors has prompted the current, follow-up study, which aims to determine if a Tech-Effect truly exists, and if so, whether or not this phenomenon impacts juror credibility in the U.S. Criminal Justice System.

Since the Tech-Effect has numerous definitions and applications in current research, the authors of the current study chose to isolate a previously unexamined aspect of the Tech-Effect, namely, the influence of technology education resulting from instruction in an Information Systems/Information Technology (IS/IT) degree program. Research participants (discussed in Methods and Procedures) included college students enrolled in IS/IT degree programs and in non-IS/IT programs. Statistical tests were performed to identify any significant difference between the experimental group (i.e., IS/IT students) and the control group (i.e., non-IS/IT students).

2. RESEARCH QUESTIONS

The current study attempted to gather and analyze data concerning a specific aspect of the Tech-Effect by asking the following research questions:

1. Do students in IS/IT degree programs demonstrate greater knowledge of forensic technology (than students in non-IS/IT degree programs) in cases regarding digital evidence?

2. Do students in IS/IT programs demonstrate lower acquittal rates (than students in non-IS/IT degree programs) in cases involving digital evidence?

3. RELATED RESEARCH

The Tech-Effect (i.e., Technology Effect) is a generic term with countless definitions and applications. In its broadest sense, the Tech-Effect is the impact which advances in science and technology have on various aspects of culture. In this sense, the "Tech-Effect" has been used to describe the impact of technological innovations on everything from motion pictures to men's disposable razors (Bittar, 1999).

In terms of academic research, the Tech-Effect has typically been studied to determine its impact on education and student learning. For example, numerous studies have been conducted to determine whether or not investments in classroom technology have a positive impact on traditional K through 12 learning. In a 2000 study, researchers from Morehead University and Iowa State University studied the impact of computerized dissection on middle-school biology classes. The researchers found that students who used computerized dissection software in addition to physical dissection learned significantly more about a frog's anatomy than students who only preformed the physical dissection (Akpan & Andre, 2000). A similar, 2001 study compared grade school students who had read CD-ROM storybooks to students who had read traditional hard-bound books. As in the previous study, the 2001 study revealed that the students who had used the technology-enabled CD-ROM books scored significantly higher on examinations regarding reading comprehension (Doty, Popplewell & Byers, 2001).

Studies analyzing the Tech-Effect on the legal system, however, are not as common. The literature regarding the Tech-Effect and the criminal justice system has focused on jurors texting and tweeting during trials. The "Twitter-Effect" or "Google-Mistrials," which involves the use of hand-held computing devices during legal proceedings, has become a serious problem through all levels of the court system (Schwartz, 2009). In a 2010 study, law professor Thaddeus Hoffmeister analyzed juror behavior with portable computing devices and discussed several possible remedies. In an attempt to minimize the use of electronic devices during trials, Hoffmeister's study proposed a draft model of jury instruction (Hoffmeister, 2010). Douglas Keene, president of the American Society of Trial Consultants, identified various categories of jurors who use portable devices during trials. Like Hoffmeister, Keene also made suggestions for instructing jurors and for imposing penalties on defiant jurors (Keene, 2010).

Although they did not set out initially to analyze the Tech-Effect, Baskin and Sommers discussed the Tech-Effect in their follow-up study on the CSI-Effect. When they failed to find statistically-significant evidence of the CSI-Effect in their 2010 study, the authors presented the following explanation:

> . . . the general public has had, over the past thirty years, increasing exposure to and experience with such a wide range of scientific and technological advances that they "naturally" expect the trial venue to be similarly affected and, therefore, rely on scientific evidence wherever appropriate (Baskin & Sommers, 2010).

To date, there are no comprehensive or conclusive studies on the Tech-Effect--its existence and whether or not it affects juror credibility. Clearly, more research is warranted to determine whether or not it exists, and, more importantly, whether or not such an effect influences the decisions of jurors in the U.S. criminal justice system.

Judge Donald E. Shelton, along with Gregg Barak and Young Kim (2007) surveyed 1027 people who had been called for jury duty in the Washington Circuit Court in 2006. The survey was administered to potential jurors prior to jury selection. Participants were asked about their television viewing habits of crime related shows and whether or not they believed the programs accurately portrayed the criminal justice system. The study showed that jurors who watch CSI also watched other law related programs. The more frequently the juror viewed a particular crime-related program, the more accurately they perceived the program to be. Forty-six percent (46.3%) of those surveyed expected the prosecution to present more scientific evidence. CSI watchers as a group have higher expectations about scientific evidence than non CSI watchers. The study did not find that watching crime related television shows had a significant impact on whether jurors were likely to acquit a defendant without scientific evidence (Shelton, Kim & Barak, 2007). The researchers concluded that the CSI effect is not to blame; rather, a broader phenomenon, which they called the "Tech Effect," was to blame.

In 2008, Shelton, et al. conducted a comparison study in Wayne County, Michigan which was similar to the 2006 study. This revised study used the above questions with slight modifications. Questions were modified to reflect changes in television programming and to test whether or not participants believed in the existence of a tech-effect. Additional questions were added to determine the jurors' level of computer usage, cell phones, GPS devices, etc. The results of the new study were merged for a total of 2,246 jurors taking the survey from both counties. Jurors' expectations that the prosecution would present scientific evidence were higher than anticipated. Over 58% of jurors expect to see some type of scientific evidence; 42% expect to see DNA and 56% expect to see fingerprint evidence in every case (Shelton, 2009). In spite of these expectations, both studies found no evidence of the existence of a CSI-Effect.

The data collected from the Wayne County study showed that 87% of jurors had a computer in their home, 92% had cell phones, and over 40% could access the Internet through their phones. The study indicated that the more sophisticated jurors were with their use of technological innovations, the more they expected the prosecution to use scientific evidence to present its case (Shelton, 2009). The researchers concluded from the combined study (Washtenaw County, 2006 and Wayne County, 2009) that jurors generally expect the use of scientific evidence in criminal trials. These expectations result, largely, from what the researchers called the tech-effect, a general awareness of and regular use of technological innovations, with a resulting expectation to see these and other innovations used in the criminal justice system. Shelton et al. believe that the increased juror expectations for scientific/technological evidence are grounded in a mass-mediated tech-effect, which is now ingrained in the criminal justice culture (Shelton, 2009).

4. METHODS AND PROCEDURES

Approach and Sample

This study involved the administration of a survey to 131 undergraduate, graduate, and post-graduate students enrolled in IS/IT–related degree programs and students in non-IS/IT programs. The non-IS/IT programs included Biology, Business, Communications, Journalism, Nursing, Psychology, et al. Students completed an online survey on their own time and submitted anonymous results directly into an electronic database for analysis. The students who participated in the study were attending a private, Mid-Atlantic University and were eighteen years of age or older. The survey was administered using Vovici Feedback, an online survey tool. The survey link was active from March 26, 2011 through June 30, 2011. The participants included residential and non-residential students.

The survey instrument replicated a similar research survey developed by Campbell (Campbell, 2006) and features of an earlier study by the authors. Anecdotal accounts of the CSI-Effect were represented in the survey by creating additional data collection variables. In addition, Deputy District Attorney Tom Swan, Allegheny County District Attorney's Office and Blase Kraeer, City of Pittsburgh Mobile Crime Unit, assisted in creating crime scenarios based on actual cases from the criminal justice system. Survey questions were then developed from the crime scenarios.

The survey results were analyzed using SPSS (Statistical Package for the Social Sciences) statistical software. A Pearson Chi-Square and Independent Samples T-Test were run to determine whether or not a technology education received in an IS/IT degree program might affect a potential juror's decision in a criminal case. Statistical frequencies were used to determine the difference between participants enrolled in IS/IT-related programs and those not enrolled in IS/IT-related programs.

Survey Instrument

The survey instrument was designed to measure two things: 1) the participants' knowledge regarding forensic evidence, and 2) the participants' tendency to acquit a suspect (i.e., find "not-guilty"). The survey also asked participants to report their area of study in school. The area of study (i.e., degree program) was used to divide the participants into groups for comparison. The two groups consisted of students who were IS/IT majors and those who were Non-IS/IT majors.

The survey instrument consisted of forty-two closed-ended questions in which five of the questions allowed students to type their own response. The first question asked participants if they had ever served as a juror in a criminal court. Questions two through five addressed the participants' television viewing habits, including whether or not the participants had watched fictional television crime shows or non-fictional (i.e., documentary) television crime shows. Participants were also asked how many hours per week they watched such shows. Questions six through twelve solicited demographic information from the participants, such as age-range, gender, and enrolled degree program. Questions thirteen and fourteen asked whether or not participants owned a mobile computing device (e.g., smart phone, laptop, or tablet PC) and if so, which mobile device. Questions fifteen through twenty-three queried the participants' knowledge of the criminal justice system. In order to answer questions twenty-four through forty-one, participants were instructed to respond as if they had been selected to serve on a jury in a criminal court. Finally, participants were asked to read each crime scenario and respond as if they were sitting on a jury that was assigned to the case. Participants were to use their current knowledge of U.S. law and the U.S. criminal justice system. The final question addressed participants' knowledge of the criminal justice system (i.e., experience, fictional television crime shows, non-fictional documentaries, serving as a juror, giving testimony, or from formal education).

5. RESULTS

Knowledge of Forensic Technology

In order to address the first research question (i.e., will students in IS/IT degree programs demonstrate greater knowledge of forensic technology than students in non-IS/IT degree programs in cases regarding digital evidence?), the survey questions were designed to gauge the participants' knowledge of forensic evidence. In particular, the survey asked the following questions concerning forensic knowledge: 1) If a person is fingerprinted for the military, a job, or security will that person's fingerprint be found in a criminal fingerprint database?, 2) Can a picture or video that is "pixilated" become a perfect photograph or perfect video image?, and 3) Is digital evidence subject to the same evidence laws as blood spatters, shell casings, and fingerprints? The results from the responses to these questions are summarized in APPENDIX A – Tables 1 through 3.

The Pearson Chi-Square was used to determine whether or not statistically significant differences in responses existed between participants enrolled in IS/IT programs and those students not enrolled in IS/IT degree programs. As explained in the METHODS AND PROCEDURES section, non-IS/IT programs represented included Biology, Business, Communications, Journalism, Nursing, Psychology, et al. Participants completed the online survey on their own time and submitted their anonymous results directly into an electronic database for analysis.

A higher percentage of participants in IS/IT programs answered the finger-printing question correctly, 45%, (i.e., "No" being the correct response) as compared to 29% of non-IS/IT students (Appendix A, Table 1). (If a person is fingerprinted for the military, a job, or security will that person's fingerprint be found in a criminal fingerprint database?) Although a statistically significant difference did not exist, the value approached statistical significance (x^2 = 3.344, p = .067).

The results from the second knowledge question (i.e., Can a picture or video that is "pixilated" become a perfect photograph or perfect video image?), are striking. (Appendix A, Table 2). Among students enrolled in IS/IT programs, 74%, answered the question correctly, compared to Non-IT/IS students, of which 33% answered the question correctly. This difference revealed a strong statistical correlation (x^2 = .20.832, p = .000).

The final knowledge question in the survey concerned whether or not digital evidence is subject to the same evidence laws as blood spatters, shell casings, and fingerprints? Seventy-seven percent of participants enrolled in IS/IT programs answered this question correctly. Seventy-six percent of Non IS/IT participants answered this question correctly. Based on these results the difference between IS/IT and Non-IS/IT was not statistically significant at the .05 threshold (x^2 = 0.23, p = .879). (Appendix A, Table 3)

Impact on Potential Jurors' Decisions

In order to address the second research question (i.e., Will students in IS/IT programs demonstrate lower acquittal rates than students in non IS/IT degree programs in cases involving digital evidence?), the survey asked participants to read and then respond to various crime scenarios. Participants were asked to respond as if they were jurors assigned to the case in question. The survey asked participants to respond to the following two crime scenarios: 1) a drive-by shooting case that hinged on modern surveillance technology, and 2) a murder case that hinged on digital evidence recovered from a computer and from the Internet. (Tables 4 and 5)

The Independent Samples T-Test was used to determine whether statistically significant differences existed in the responses from the two groups: 1) those enrolled in IS/IT programs and 2) those not enrolled in IS/IT programs. A Likert-like scale was used to solicit participants' responses concerning the guilt or innocence of the suspects in the crime scenarios. The response scale for each crime scenario ranged from a value of 1 ("I am VERY CONFIDENT that the suspect is guilty") to a value of 6 ("I am VERY CONFIDENT that the suspect is Not Guilty").

For the drive-by shooting scenario, participants enrolled in IS/IT programs reported a higher number of "Not Guilty" judgments) than those enrolled in Non IT/IS programs. The mean rate of acquittal among participants who were enrolled in IS/IT programs was 3.19. Alternatively, the mean rate of participants enrolled in Non IS/IT programs was 3.00. No statistically significant differences were identified (t = -1.027, p = .306). (APPENDIX B, Table 4)

The final crime scenario involved a murder, which was planned using computers and the Internet. As in the previous scenario, participants were asked to weigh the evidence involved and decide whether the suspect is guilty or innocent. As with the drive-by shooting scenario, there was little difference in the rates of acquittal between IS/IT (x = 3.05) and Non-IS/IT students (x = 3.13). Consistent with the results from the other crime scenarios, the difference in participant groups regarding the murder scenario were not statistically significant (t = .455, p = .650). (APPENDIX B, Table 5.)

6. CONCLUSIONS

The present research surveyed undergraduate, graduate and post-graduate students various college degree programs to examine the following questions: 1) Will students in IS/IT degree programs demonstrate greater knowledge of forensic technology (than students in non-IS/IT degree programs) in cases regarding digital evidence? and 2) Will students in IS/IT programs demonstrate lower acquittal rates (than students in non-IS/IT degree programs) in cases involving digital evidence?

For this study, three survey questions were analyzed to gauge the participants' knowledge of forensic evidence. All three of the questions showed that participants in IS/IT degree programs did have greater knowledge of digital forensic evidence. However, only one of the three questions showed a difference between the two participant groups, which was statistically significant. A second question concerning the participants' digital forensic knowledge approached statistical significance. It is not surprising that students in IS/IT programs performed better (than students in non-IS/IT programs) on the knowledge questions, since digital topics would in all likelihood be discussed in their programs of study. The almost negligible difference observed in question #38 (i.e., is digital evidence subject to the same evidence laws as blood spatters, shell casings, and fingerprints?) is also not surprising, since most IS/IT programs only cover a limited amount of digital evidence and other legal topics.

Analysis of the data did reveal some interesting findings regarding digital fingerprint databases. Students were asked "if fingerprints from the associated scenarios were run through a national fingerprint database system, what is the name of the system that would be used?" The correct answer to the question is the "Automated Fingerprint Identification System (AFIS)." Sixty-seven percent of IS/IT students answered the question correctly compared to 56% of Non-IS/IT students who answered the question correctly. Although difference in percentages between the two groups was slight, the result of the follow-up question was surprising. After answering the above question, students were asked what the acronym of the database (from their prior answer) stood for? Fifty-two percent of IS/IT students were able to correctly define the acronym compared to sixteen percent of Non-IS/IT students. This finding further suggests that students in IS/IT programs do indeed demonstrate greater knowledge of forensic technology.

As with past studies, the current study revealed that a "tech effect" may exist and does affect knowledge of digital evidence for a potential juror. Shelton, Barak, and Kim (2007) conducted a study to determine which factors increased jurors' knowledge of and expectations for forensic evidence. The study suggested that the changes in juror knowledge and expectations were indeed the result of a tech-effect. However, as with the current study, the Shelton et al. study could not establish a relationship between increased juror knowledge (and expectations) and higher rates of acquittal. Clearly, additional research is needed to further explore the CSI-Effect and its potential (if any) effects on the American Criminal Justice System.

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APPENDIX A – CHI-SQUARE TEST RESULTS

Table 1: Chi-Square Test Results

Cross tabulation of Area of Study and "Military/Security in Fingerprint database?"

			X^2	Sig.
	Area of Study			
In Fingerprint Database	IS/IT	Non-IS/IT		
Yes	47 (-1.8)	32 (1.8)	3.344**	.067
No	39 (1.8)	13 (-1.8)		

*Note: ** = p ≤ .05. Adjusted standardized residuals appear in parentheses below group frequencies.*

Table 2: Chi-Square Test Results

Cross tabulation of Areas of Study and "Pixilated Image Made Perfect?"

			X^2	Sig.
	Areas of Study			
Pixilated Image Made Perfect?	IS/IT	Non IS/IT		
Yes	22 (-4.6)	30 (4.6)	20.832**	.000
No	64 (4.6)	15 (-4.6)		

*Note: ** = p ≤ .05. Adjusted standardized residuals appear in parentheses below group frequencies.*

Table 3: Chi-Square Test Results

Cross tabulation of Area of Study and "Digital Evidence and the Law?"

			X^2	Sig.
	Area of Study			
Digital Evidence and the Law?	IS/IT	Non IS/IT		
True	66 (.2)	34 (-.2)	.023**	.879
False	20 (-.2)	11 (.2)		

*Note: ** = p ≤ .05. Adjusted standardized residuals appear in parentheses below group frequencies.*

APPENDIX B – T-TEST RESULTS

Table 4: Independent Samples T-Test Results

Independent Samples T-Test Results of Drive by Shooting Scenario

	Mean	Std. Dev.	t-test	df	Sig.
Drive by suspect innocent (1 = no confidence; 6 = very confident) – Area of Study = IS/IT	3.19	.964	-1.027**	129	.306
Drive by suspect innocent (1 = no confidence; 6 = very confident) – Area of Study = Non IS/IT	3.00	1.022			

*Note: ** = p ≤ .05.*

Table 5: Independent Samples T-Test Results

Independent Samples T-Test Results of the AOL Murder Case

	Mean	Std. Dev.	t-test	df	Sig.
Murderer suspects innocent (1 = no confidence; 6 = very confident) – Area of Study = IS/IT	3.05	1.126	.455**	129	.650
Murderer suspects innocent (1 = no confidence; 6 = very confident) – Area of Study = Non IS/IT	3.13	.842			

*Note: ** = p ≤ .05.*

CMobile: A Mobile Photo Capture Application for Construction Imaging

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Abstract

In recent years the mobile application space has exploded in popularity, a fact which is reflected in the increasing availability of both free and paid applications on a variety of mobile platforms. In order to take advantage of this ever-growing market, the authors developed a mobile photo capture application, called CMobile, to supplement data gathering for a project/content management system. This paper describes the original design requirements and features of the application, the methodology by which design choices were tracked and implemented, reviews the issues and problems encountered, discusses the resolutions employed and lessons learned, and concludes with a discussion of potential future developments.

Keywords: mobile application development, web services, agile development methodology

1. INTRODUCTION

Construction Imaging (CI), a leader in industry specific content management solutions, has been looking for opportunities to extend its suite of desktop product solutions into the exploding arena of mobile applications and devices (Construction Imaging, 2011).

CI has received numerous requests to enhance its content management model to include photograph management. The types of photographs project managers on site tend to take include images of completed or in-progress construction, safety violations or various impediments to job progress.

Currently, these photos must be extracted from the camera and then uploaded to a computer where they can be manually indexed into CI's content management system either via a desktop or web application. At times the project manager (user) might be out in the field and unable to immediately access a workstation to index the photographs. If the user is using a camera and needs to upload the photos immediately, he/she would have to find a suitable location to index the photos. If the user has a web enabled camera-phone there's an easier solution, but still far from ideal, namely e-mail. Finally, another option is to simply send the images to a third-party to index them.

An optimal solution would be for the user to take photos using their smart phone and automatically upload them to the system with a set of index values populated with data such as the phone's GPS coordinates, a related job number, vendor number and other values. Thus, CI partnered with the authors to develop a solution in the mobile application space, specifically an application designed to take advantage of the features provided by Apple's iPhone 4 (Apple Inc, 2011).

This paper discusses the software development methodology, systems analysis and design, and implementation details of a system called CMobile that allows users to interface with and add photographic content automatically to CI's content management system via his or her iPhone.

The paper describes the specific requirements for the one firm, however the implementation of the analysis and design plus the tool set employed and discussed may be used in other similar photo applications for mobile devices.

2. REQUIREMENTS

Currently, there is only one mobile application on the market that performs the desired customer requirements related to photo management for content management services. Vela Systems provides a product called Vela Mobile that includes an application for the iPad, but the application only interfaces with the proprietary Vela Field Management Suite (Vela Systems, 2011). In discussions with CI's management, it was decided to develop a proprietary product that interfaces only with CI's Content Manager, thereby giving the company complete control over branding and the ability to fully optimize the graphical user interface through seamless integration with their existing product. Management also desired to enhance CI's market position by being able to provide current and potential customers with a mobile application that would assist with data collection in the field.

The following is the original list of requirements for CMobile as identified by CI management and the application's developers (paper authors):

a) Required features:
   - CMobile needs to integrate with the phone's camera, allowing the user to take a photograph directly from the application.
   - The photograph must be processed (compressed if necessary) with index values associated with it from various static and configurable criteria including but not limited to the phone's number, GPS coordinates and an associated job number, and other configurable values predefined for the content type or selectable from a list of keywords.
   - An option to upload a photograph and its accompanying index values via a configurable web service interface to CI's content management system must be provided.
   - An option must be provided to allow a photograph and its index values to be emailed directly from the application.
   - The application must have the ability to upload photographs that exist on the phone but were not taken from within the mobile application.
   - Application access must be restricted by login credentials validated against the web service, however, the username and password may be saved locally for quick login.

b) Optional features:
   - The ability to upload/email a batch of photographs with a single set of index values.
   - The ability to attach a voice note or other recording.

3. DEVELOPMENT METHODOLOGY

In order to produce a mobile photo management application that achieved the objectives set forth for this project, the system was implemented using the following methodologies and technologies:

- Scrum Agile Development Methodology (Scrum Alliance, 2011).
- An Apple Macintosh computer using the iOS development platform provided by the Xcode Integrated Development Environment (Apple Developer, 2011).
- Objective-C using Interface Builder for the user interface development (Apple Developer, 2011).
- Communication with CI's Content Manager (the backend) with a web service API created using Windows Communication Foundation (WCF) with a JSON (Java Script Object Notation) enabled endpoint (Microsoft WCF, 2011).
- All source code was versioned and managed using Microsoft Team Foundation Server (TFS) via the Team Explorer Everywhere command line tool for OSX (Microsoft, TFS, 2011).
- Development progress was recorded and tracked via Tasks in Microsoft Team Foundation Server's (TFS) development management tools.
- Functionality was tested by Microsoft Test Manager, which fully integrates with TFS (Microsoft, Testing, 2011).

The Scrum development methodology was chosen over other potential methods due to the fact that it is the primary methodology currently employed by the developers and CI. The need to quickly adapt to changing requirements that tend to shift the direction of a development project mid-stream requires an agile approach, as opposed to the sequential approach of the waterfall model or other iterative models of development. The Scrum methodology suited our needs best.

The decision to use Xcode with Objective-C and Interface Builder was reached as these technologies are the standard development tools for Apple's iOS environment. The decision to develop for the iPhone itself instead of other mobile platforms, such as Android, Blackberry, etc., was based on the overall marketability of Apple's product at this time, with potential to expand CMobile to other platforms in the future.

4. IMPLEMENTATION

When CMobile launches for the first time it prompts the user to configure application settings (Figure 1). The user must specify a URL that points to an exposed Content Manager Web service (this web service URL will be preloaded into the application upon download from the 'appstore'). Once the address is verified and the connection is established, the user is directed to a Login screen (Figure 2). Login credentials can be saved locally in the settings menu in order to bypass the login screen on subsequent use of the application.

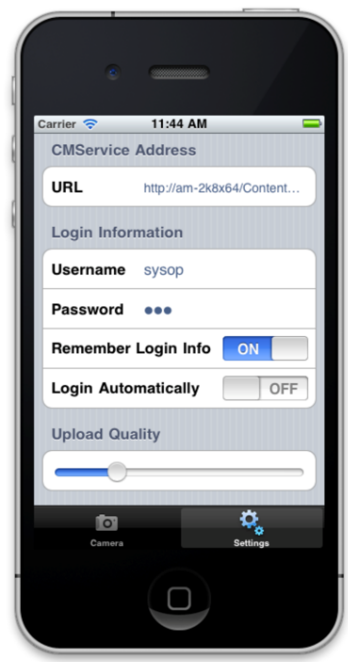

Figure 1: The CMobile Settings Screen

After successful authentication, the user is presented with the home screen (Figure 3). This screen allows the user to take a photo, index or email a photo or image stored on the phone, or edit the application's settings.

If the user chooses to take a photo they will be presented with the iPhone's camera, otherwise they can browse for a photo or image. Once the user has specified the image they wish to use they are returned to the home screen where they can choose to index or email the image. If the user opts to index the image they are presented with the index screen (Figure 4).

Figure 2: The CMobile Login Screen

Figure 3: CMobile's main navigation screen

The index screen allows a user to index values associated with an image. Fields configured for GPS coordinates or heading are pre-populated from the phone if that data is available. Once the user has completed the input, the image can be uploaded. When the upload has completed the user is informed of its success and redirected to the home screen.

Figure 4: Indexing an image

The process is similar if a user decides to index a photo already stored on the phone, except that the user is presented with the iPhone's camera roll where he/she can choose the images to index (Figure 5).

If the user decides to email an image instead of uploading it to the web service, they can follow the same steps, but this time they will be presented with the email screen (Figure 6). Here they can specify recipients, a subject and a message to send along with the attached image.

One thing to note is that once an image is indexed and uploaded to CI Content Manager via the WCF (Windows Communication Foundation) service it is no longer CMobile's concern. It may be saved, placed in a workflow, routed, trigger notifications, etc. CMobile's primary purpose is to create and present the data, not perform any other actions on it.

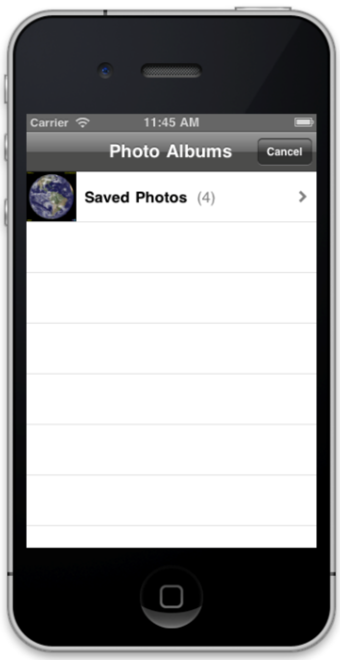

Figure 5: Browsing for an image

For version 1.0 of CMobile we have decided not to incorporate the ability to upload video or voice recordings. We also do not allow the user to upload batches of images under one set of index values.

Figure 6: Indexing a photo

Service Method Calls

We have implemented a web service API using WCF technology that performs some basic tasks for our web products, such as retrieving data source information, authenticating and authorizing user credentials, and importing and saving documents. We use this service to communicate with CI Content Manager.

The following is a list of preexisting service methods that were required for the application:

- **GetDataSources() -** A JSON enabled WebGet method that returns a list of available data sources to the user (JSON, 2011).

- **Login(string uname, string pass) -** A JSON enabled WebGet method that authenticates the user based on supplied username and password and begins the user session.

- **GetLayouts() -** A JSON enabled WebGet method that returns the layout of the content type. Includes configuration information about user settings and preferences and available fields and their configurations (name, data type, default value, etc.).

- **Logout() -** A JSON enabled WebGet method that ends the current user session.

- **IsLoggedIn() -** A JSON enabled WebGet method that determines if the user is still logged in and that the session has not expired. Required for instances where the user leaves the application running for an extended period of time. This method is typically called before making any other service calls that require the user session to be active.

The following is a list of new service methods that were implemented for the application:

- **GetNewDocument() -** A JSON enabled WebGet method that returns a stub of a Document object. In CMobile's case this object contains all the information required to import a photo: its data and index values. This particular method was added so that the JSON representation of the Document object would not have to be constructed programmatically from scratch in the application.

- **GetNewDocumentWithCount(int fieldCount, int fileCount) -** A JSON enabled WebGet method that returns a stub of a Document object. It is similar to the GetNewDocument() method but also returns the supplied count of stubs of Fields and Files properties on the Document object.

- **ImportDocumentWithImageStreamAsInvoke(Document document) -** A JSON enabled WebInvoke method that returns a document object that describes the photo to be imported into the content management system. This document contains the index field values and the image's data stream.

Figure 7 (in Appendix A) is a representation of the process by which CMobile communicates with the WCF Service API in order to submit content to the CI content management system. The seven service methods that CMobile calls are depicted under the category in which they operate, with the service methods listed in italics. Note that only the service methods required for the mobile application are listed. Figures 8 and 9 (in Appendix A) show a graphical view of the classes and their relationship to one another. Finally, Figures 10 and 11 (in Appendix A) show screen shots of the CMobile web and desktop interfaces.

5. DEVELOPMENT CHALLENGES

Fully implementing memory management was a major programming challenge encountered during implementation. Issues included understanding when an object needed to be retained as not to lose a reference to it later, when an object needed to be released in order to prevent memory leaks, and when an object should be ignored because another object currently required access to it.

Fortunately, Xcode provides both a code analyzer and a real-time leak detection tool. The analyzer can be run on the source code and offers information on locations where memory leaks are bound to occur, areas where leaks may occur, and sections where it was unnecessary to release objects. While the analyzer provides a lot of useful suggestions for handling memory, it can't always account for the flow of the application, so employing a leak detection tool assists with debugging in the Xcode simulator. It supplies real-time information about current memory allocations, including all introduced leaks.

One of the simplest tasks in CMobile's development was the incorporation of the iPhone's camera and email interface. Apple has made accessing these features simple and the integration seamless.

The most time consuming part of the development process was implementing the necessary service calls to the CI WCF service. After a few unsuccessful attempts at using various toolkits designed to communicate with non-RESTful services, the best approach was to enable certain service methods to return JSON formatted dictionaries and use the iOS JSON Framework to consume and convert these objects. Doing so made accessing data from the service as simple as constructing a RESTful URL and waiting for a response.

Even using the JSON Framework, we ran into a few problems trying to pass image data to the service. The first issue was that the service did not accept very large query strings. We updated the size the service would accept and were then able to successfully upload images. The second issue occurred when we realized that images over a certain size (about 1.3 megabytes) would exceed even the maximum allowable query string size. As a result we had to find another method to import the images. The solution was to enable the service methods to accept JSON web invoke calls. This allowed us to configure an HTTP POST message with the image data in the body of the message, bypassing the query string size limits. We were then able to import images of a much larger resolution and quality.

The implementation of the settings menu was completed by using InAppSettingsKit, an open source solution by Edovia (2010). This toolkit allows for the easy inclusion of in-app settings or a duplication of the iPhone's application settings in your application.

All software development was focused on creating the application to run on the iPhone, however some of the decisions made along the way, such as the one to use the JSON format for communication, make the project more easily adaptable to other platforms. As discussed, the application communicates with Content Manager via an exposed WCF web service which acts as an API to all the functionality of the content management system itself. Once CMobile has passed its photo and index information to the web service, the content management system is free to perform any number of functions with the photo based on the data associated with it.

In order to verify that the requirements for the completion of this project were met we created test suites in Microsoft Test Manager. Each test suite is associated with a given story or task and has associated test cases that test the entire range of functionality implemented by the story's tasks.

Figure 12 (in Appendix A) displays a test designed to assess CMobile's ability to index a photo taken from the iPhone's camera, from login to success. Each test is comprised of multiple steps, each with their own expected outcome. As the test progresses, each step can be marked as having passed or failed. The test itself only passes if all of its steps have passed and then the code was considered complete, having met its requirements.

6. SUMMARY AND LESSONS LEARNED

CMobile was conceived and commissioned, after reviewing requests for enhancement from both current and potential customers, in order to establish CI as an enterprise content management provider in the mobile space. This allowed CI to expand its suite of products to what most consider the platform of the future in both enterprise content management and computing as a whole.

To further this goal we were charged with creating a simple yet powerful mobile photo capture application for the iPhone. To complete the task we leveraged the power of newer platforms and technologies and integrated them with more recognizable tools and systems in a completely seamless and unified fashion while maintaining both extensibility and adaptability on both sides.

The simplicity of the JSON protocol, when compared to standard XML formatted protocols, makes it ideal for use in situations that require the consumption of data passed over protocols like HTTP. Unlike XML, JSON does not require knowledge of a document type definition that the recipient understands, making its payload smaller and easier to parse, quicker to transmit (due to its smaller size), and generally easier to construct. JSON requires only simple evaluation of the text of the serialized string using a corresponding method in the given language.

The ease of taking non-RESTful, .NET-based WCF service methods and adapting them to send and receive JSON messages is an extremely useful and powerful lesson learned from this project. By doing little more than adding a service attribute, one can transform a service designed to work with specific .NET client architecture, such as C# applications, services and assemblies, or browser-embedded Silverlight applications, into a near universally accessible API.

Another important lesson learned was the need to understand the quirks and intricacies of Objective-C. Having to learn the uniqueness of the language's syntax and the methods by which memory is managed and the tools available to avoid or correct these issues allows developers to more effectively construct and deploy Objective-C applications on an iPhone.

The final key takeaway for all developers is the ease of integrating GPS with photos, the simplicity with which the iPhone allows said integrations, and the ease of using those features to expedite and simplify the process of transferring that information via a web service to a content management system.

While we are confident that we accomplished what we set out to do in CMobile Version 1.0, the product is far from finished as Version 1.1 is already underway. Ideas for additional features are abundant including, but not limited, to the following:

a) Reintroduction of batch image processing.
b) The ability to view images and documents in the user's work list and take action on them (approve, reject, review, annotate, attach notes, etc).
c) The ability to view a mapping of all images containing GPS and heading index data in a given area.

This is just a small list of many possible opportunities to expand this project in the future. This first iteration of CMobile will provide a solid platform from which to move forward and realize the full potential of Construction Imaging solutions in the mobile space.

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Appendix A (Figures)

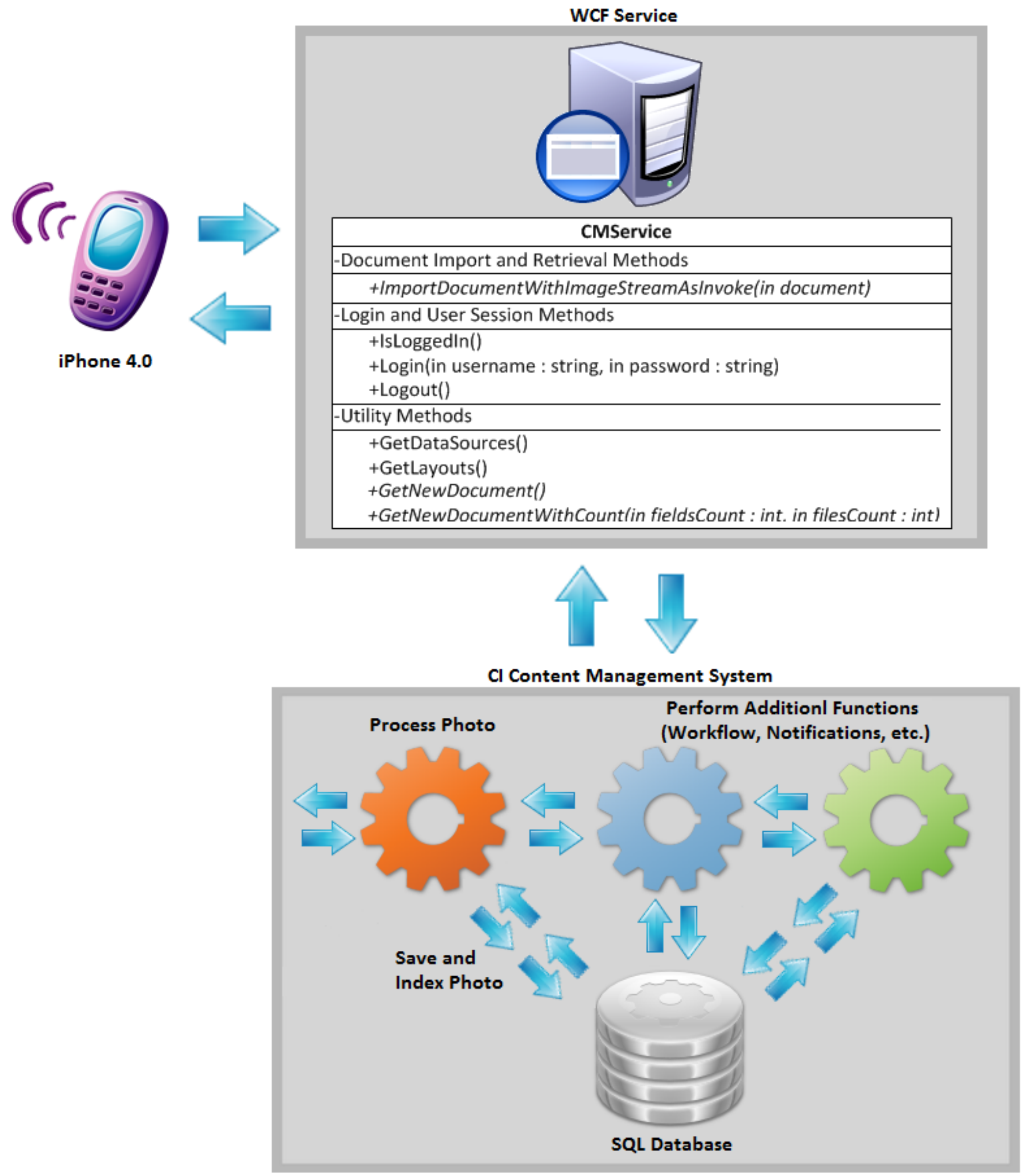

Figure 7: A graphical representation of CMobile and its integration with CI Content Manager

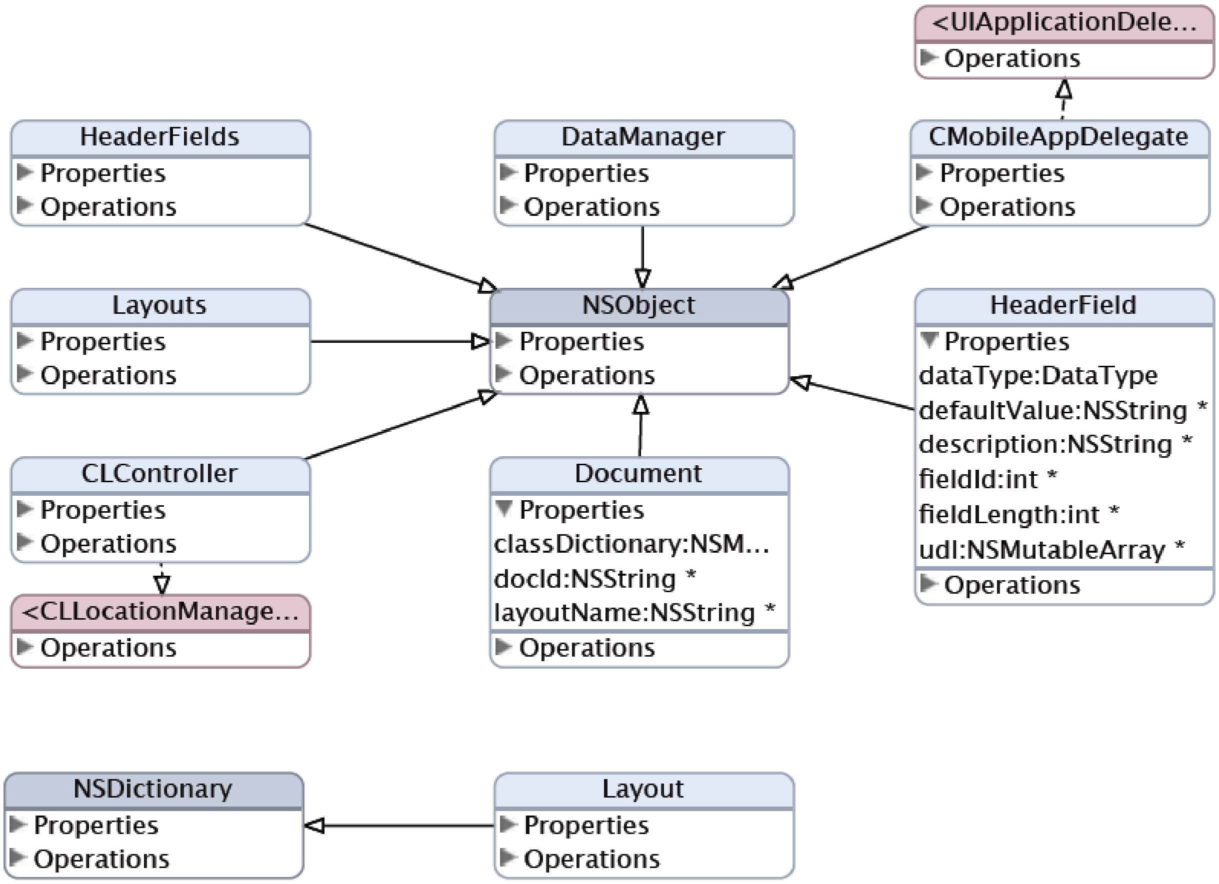

Figure 8: Class Model from Xcode

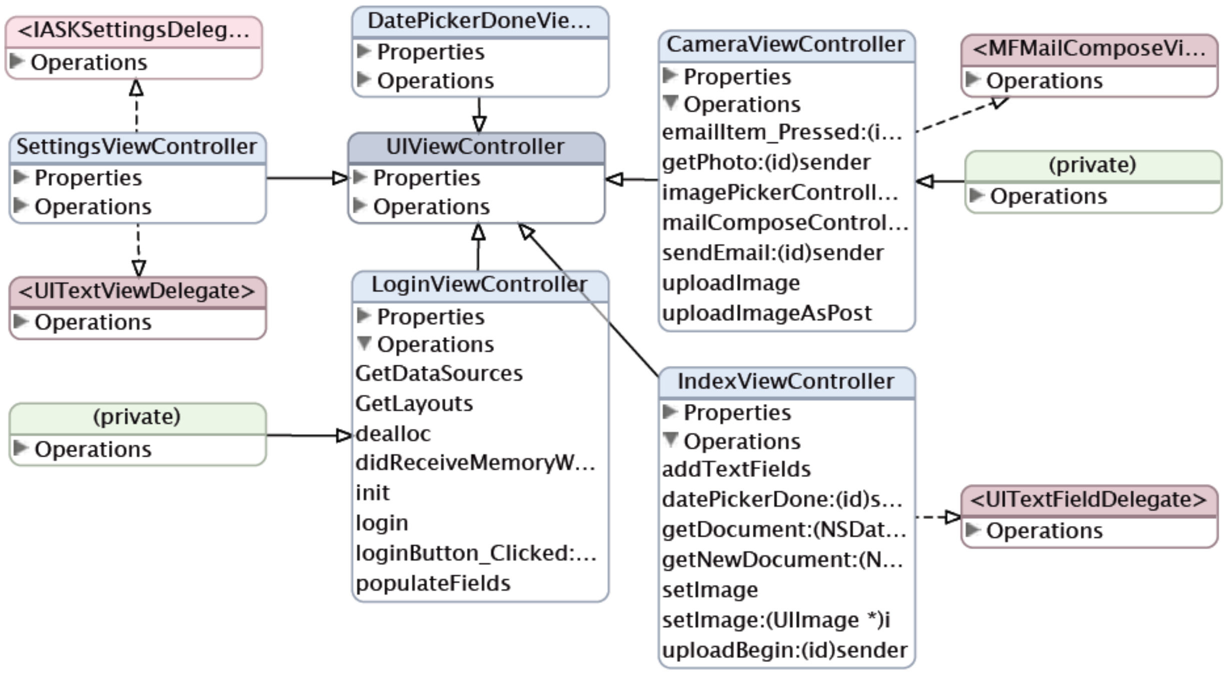

Figure 9: Class Model from Xcode

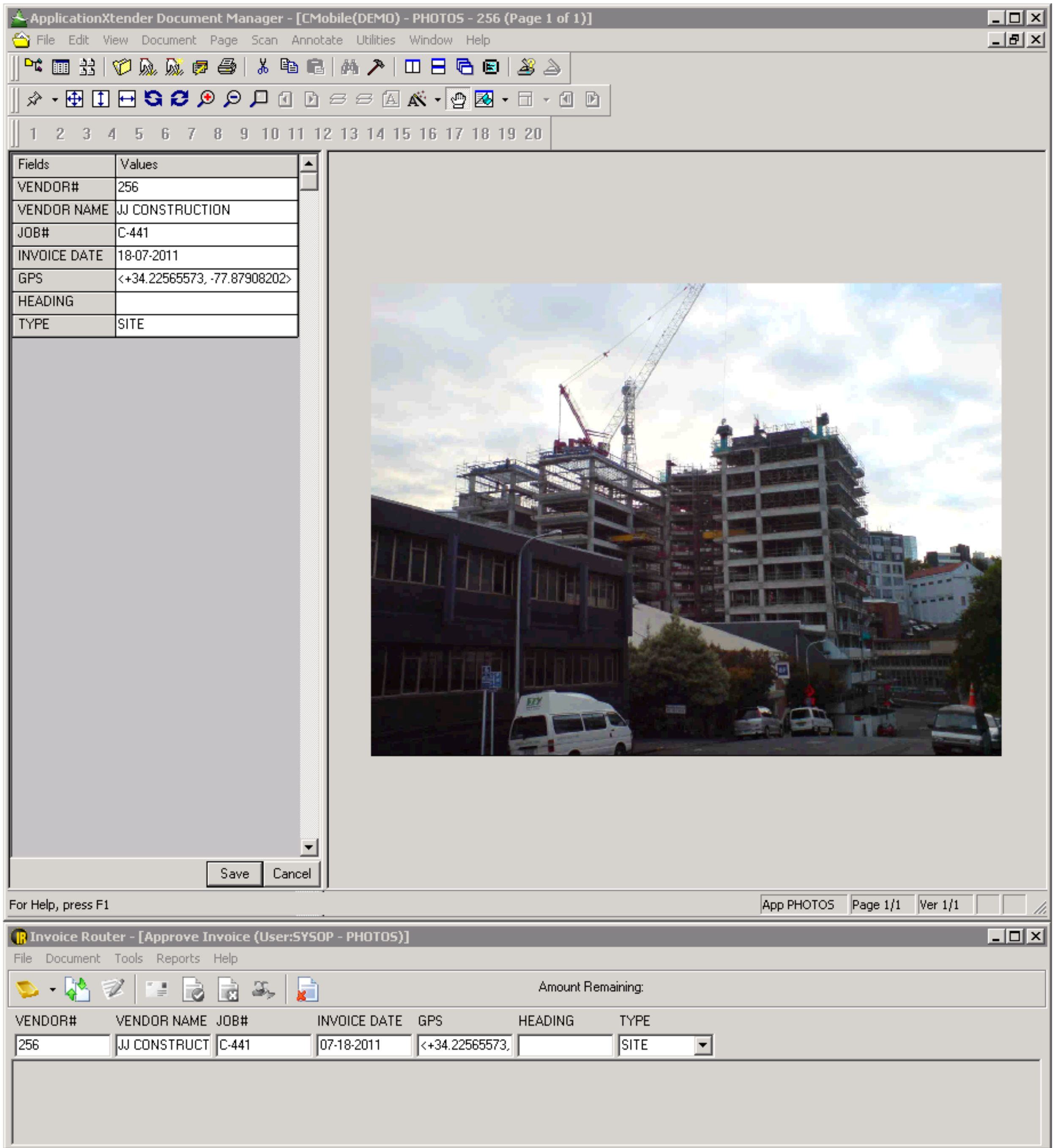

Figure 10: CI Content Manager Desktop Interface

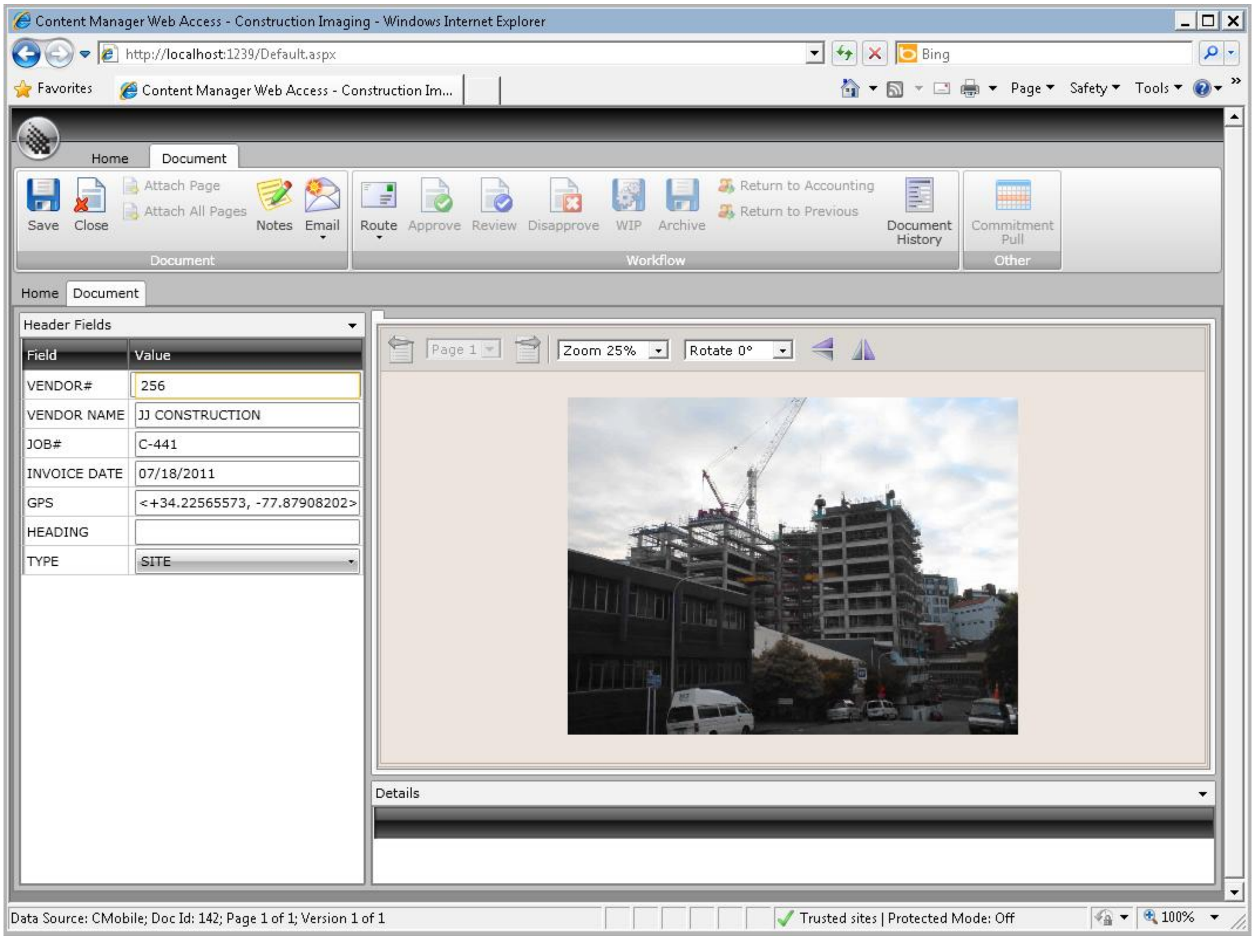

Figure 11: CI Content Manager Web Browser Interface

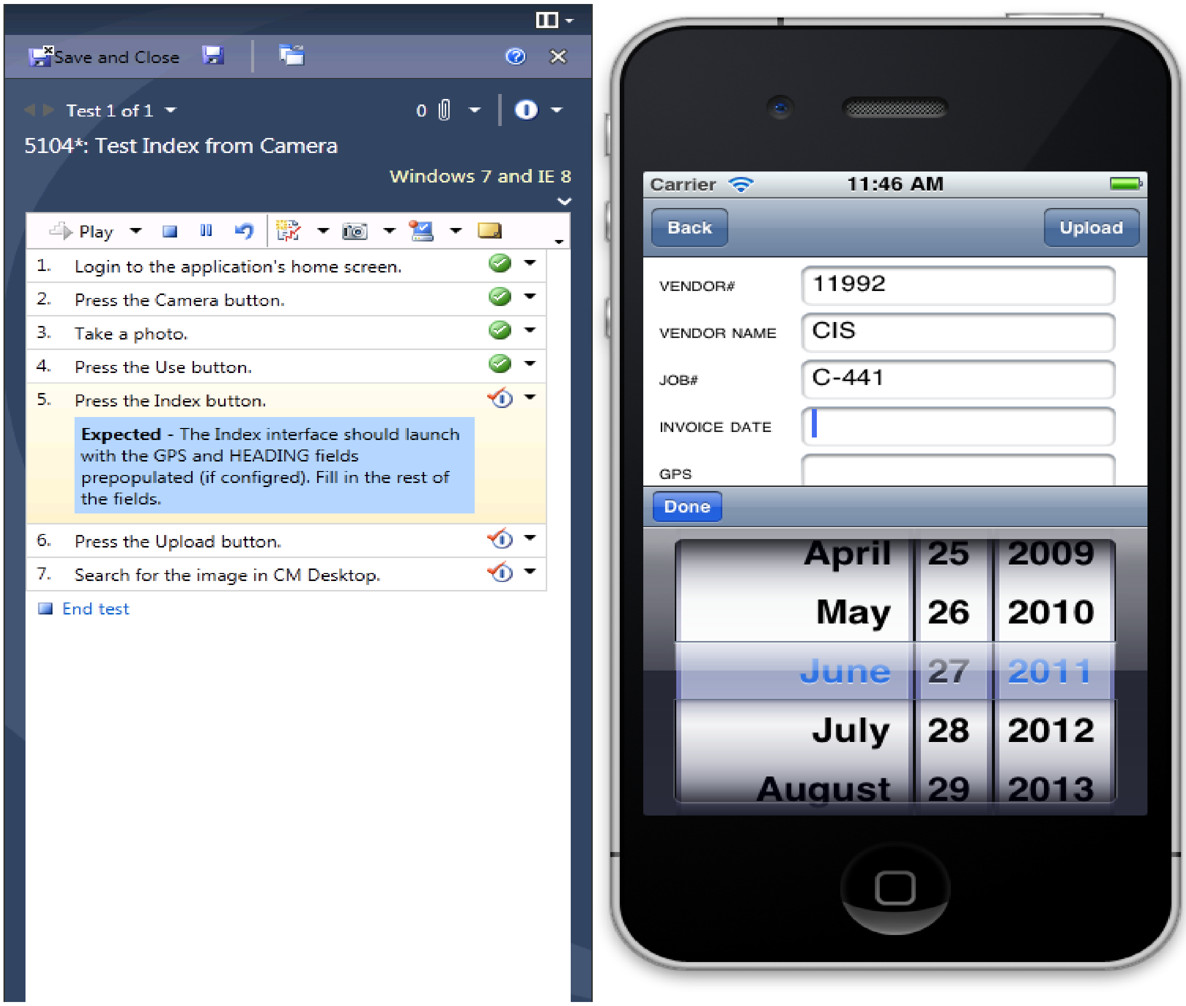

Figure 12: An execution of Test Case 5104