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JOURNAL OF INFORMATION SYSTEMS APPLIED RESEARCH

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Building a Competitive Edge through Social Media

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Abstract

Social media has become a necessity in today's information marketplace, so business executives can no longer ignore it. Many executives today are now more interested in how to get in on the social media craze, what kind of social media to utilize, and how social media will enhance their brand. Unlike traditional marketing where firms talk to consumers, social media has now created a new form of marketing where consumers now talk to both firms and other consumers. Consumers now have the power to define brands and leave firms powerless about social media. It is imperative that firms utilize social media tools to facilitate conversations about their brands in order to create competitive advantage. Social media can be used not only to acquire and retain customers, but also to build brand loyalty through social media conversations between firms and consumers. This paper presents four strategies to help researchers and firms to recognize the use of social media in building competitive advantage. The four strategies for using social media to achieve competitive advantage are (a) inviting customers on social media outlets, (b) marketing products good for social media, (c) having beneficial conversations on social media, and (d) developing the best attitude for social media success.

Keywords: Web 2.0, social media, competitive advantage, customer interaction, online strategy

1. INTRODUCTION

Social media provide an avenue for firms to create a competitive advantage by facilitating consumers' conversations about their brand and even offering tips about their products and services. This paper discusses and explains how firms can build competitive advantage through the use of social media. Social media are Web-based and mobile technologies used to interact and dialogue with organizations, communities, and individuals. Social media are platforms and applications through which information is exchanged in order to keep consumers actively engaged and affect each other's behavior and decisions in any way (Thurau, Malthouse, Friege, Gensler, Lobschat, Rangaswamy, & Skiera, 2010). Social media have a lot of influence on consumer behavior and have empowered consumers in the areas of technology, business strategy, and marketing (Constantinides & Fountain, 2008). While the fears of many top executives about social media are understood because they do not know how to use them, they have to see social media as an opportunity to converse with their customers in order to build a following for their brand. So it has become necessary for executives to make social media a top priority in their business strategy.

Firms can no longer dictate to consumers what they want their consumers to know about their brand. Consumers are now educating each other about firms and their brands before purchasing decisions are made. Firms need to be more proactive in deciding what social media their customers respond to best and how to present themselves on it competitively. Social media is a priority for many executives in the information and knowledge-based economy and companies are trying to identify the best ways to build a competitive edge on social media platforms such

as Wikipedia, Facebook, Twitter, YouTube, Internet blogs, and Second Life (Kaplan & Haenlein, 2010).

Before firms can be successful with social media and apply effective strategies, firms should understand customer behavior on social media and how these behaviors affect consumption (Durukan, Bozaci, & Hamsioglu, 2012). For social media to be profitable as an IT and business strategy, firms have to study what customers want, how they act, and what they want to know on social media sites. Change management has become crucial to firms in redefining and transforming their mission, based on customer demands and technological capabilities (Rockart, Earl, & Ross, 1996). In the flexible, dynamic, and adaptive business world of today, business executives need IT and business process strategies that conform to the competitive marketplace and meet the demands of the customers.

Social media is as flexible, dynamic, and adaptive as any business process strategy for any competitive firm in the 21st century that is interested in reaching its potential customers and retaining its current customers. For a social media outlet to be successful, it must possess an infrastructure provider and a content provider. These providers determine the success of any social network. The infrastructure is the platform on which users interact; while the content is the wealth of conversation the users create (Chai, Potdar, & Chang, 2007).

Social media should be used to know what customers are thinking and feeling during conversations, and also to find out what their competitors are doing for them in terms of customer satisfaction. Firms already understand the usefulness of customer feedback, but do not know how to take advantage of it on social media sites, a venue where customers are empowered. Customers' praise means excellence, and their dislike leaves an unwanted scare on the internet (Gallaugher & Ransbotham, 2010). Web 2.0 and social media have empowered customers to define brands and influence the reputation of organizations (Mathur, Black, Cao, Berger, & Weinberg, 2012) and social media venue are great interactive places created by customers (Dwyer, 2007). Successful firms use social media to change the way they interact with their customers in order to meet customer demand in the new and competitive marketplace. For instance, through dialogue on social media, firms may find out what customers want from their brand and their desired prices.

Unlike paid advertisements on mass media, social media provides a free outlet to reach millions of dedicated users to affect their buying behavior, shopping habits, and purchasing decision in favor of firms. Social media are changing how firms and their customers interact (Gallaugher & Ransbotham, 2010). Social media constitute a modern outlet that can be used to affect the interest of goods and services in any way, as well as impact purchase decisions (Mathur et al., 2012).

Social media directly impact product ratings and sales. By the same token, negative product reviews do reduce the value of a brand (Durukan, Bozaci, & Hamsioglu, 2012). Social media is a strategy that firms must take seriously and take advantage of in order to have some input on how customers see their brand and products, as well as play an active role in helping customers make purchasing decisions to favor their brand. Firms should take social media seriously because the majority of their customers are on social media, spend a lot of time in this realm, and do impact purchasing decisions online.

Firms can never go wrong with social media, as long as their strategy is planned appropriately to improve customer satisfaction because dedicated social media users are increasing in number. In 2007, 56% of internet users were on social media through social networks, blogs, as well as contributing to online shopping reviews, and that number increased to 75% by 2008 (Kaplan & Haenlein, 2010). Customers now gather consumer information through interactive communication on social media, which now constitutes about 25% users' online time, compared to gaming time of 10% and email time of 8% (Gallaugher & Ransbotham, 2010). Twitter as of 2009 had 41 million users worldwide and its trending topics are ranked according to headline news and active period of user's account, while the retweets (responses to original tweet) are ranked by number of followers and popularity of account (Kwak, Lee, Park, & Moon, 2010). Numbers do not lie, and these numbers show that millions of customers are online sharing information and exchanging ideas. Some social media users are now so popular that they have huge followings in the thousands and millions listening to them online.

Firms need their own social media presence so they can defend themselves and express themselves through profitable conversations against what others may say. A firm's social media outlets should be a place where customers can come to verify information and offer suggestions while interacting actively as well as exchanging information freely with the firm and other customers.

Social media has now become the ultimate truth and purpose behind the creation of the internet, which was to freely facilitate the exchange of ideas and enhance communication. Social media is basically helping us realize the original intent of the internet, which was to create a platform through which users could share and exchange information freely (Kaplan & Haenlein, 2010). Social media, unlike traditional media, allow both firms and customers to interact in both synchronous and asynchronous media, as well as to view the opinions of other customers towards firms (Gallaugher & Ransbotham, 2010). Any competitive firm in today's competitive information marketplace has no excuse not to be on social media. The firm should be representing themselves and interacting with customers in spaces where customers spend most of their time while making purchasing decisions.

The first section provides a literature review that point to the organizational need for social media. The second section discusses the relationship between social media and competitive edge, presents the model of the relationship, and discusses the implications of the study for researchers and managers. The third section shows how firms can invite customers to participate in their social media, and products and services best suited to social media will be addressed in the fourth section. The fifth section discusses the type of conversations needed to make social media strategy a success. Lastly, the right attitude for social media will be presented before the conclusion and limitations of the paper.

2. LITERATURE REVIEW

Today's companies have little to no control over what customers say about their brand to each other on social media and the firm merely acts as observer to customer communication and consumer behaviors (Kaplan & Haenlein, 2010). Firms can now use social media to interact with and engage customers in real time, solicit innovative ideas from customers, correct error reports, emphasize positive and factual messages, fix damages, and disperse viral information like a giant word-of–mouth machine (Gallaugher & Ransbotham, 2010). Social media functions like a giant word-of-mouth machine that accelerates distribution of information (Dellarocas, 2003; Godes & Mayzlin, 2004). Despite the fact that firms cannot control what people may say about their brand, their presence on social media will give them the opportunity to address any misconceptions or errors through dialogue with any customer that stops by to verify or inquire.

Social media include Wikipedia, Facebook, Twitter, Linked-In, Virtual games, and YouTube. Social media, such as Wikipedia (Online Encyclopedia), can be used for collaborative projects, where customers can create a source of information that they can depend on for making their purchasing and spending decisions (Kaplan & Haenlein, 2010). This means that anyone can put negative information on Wikipedia about a firm and visitors might see it as credible information that may influence their purchase decisions later. Blogs are social media that are equivalent to personal Websites that allow others to participate through comments, links, texts, pictures, and videos (Kaplan & Haenlein, 2010). Customers create information, dialogue, knowledge, and opinions about goods and services via social media. It is, therefore, in the best interest of firms to get on board to have direct access to their customers. A firm getting on social media is one thing, yet knowing what social media to get on is another.

Firms should be careful on how they implement their social media strategy and on what platform they choose to do so. This is because different social media attract different kinds of customers and appeal to different kinds of purposes as well as messages (Kaplan & Haenlein, 2010). Firms should align their social media strategy with their corporate culture and strategy. While Wikipedia may be for customers who want detailed information about firms, Facebook is for people who like to know what their friends think, YouTube is for those that want to see and hear about a brand or products, and Twitter is usually for trendy people who like headlines and trending news. Firms must understand what kind of audience they cater to and how the audience likes to learn about things. Unattended issues left on social media by customers may become an embarrassment, and

firms should respond without emphasizing negative behaviors (Gallaugher & Ransbotham, 2010).

Firms that choose to use multiple social media must ensure that their activities are aligned. Social media activities should be integrated with other forms of traditional advertising (TV, radio, print, email blast), and should provide access to all, including employees (Kaplan & Haenlein, 2010). Social media can be content communities, such as YouTube, through which users share large amounts of content by the minute through videos, text, slides, as well as pictures, and YouTube shares 100 million videos a day (Kaplan & Haenlein, 2010). Social networking sites like Facebook and Twitter, allow users to create profiles, invite and accept friends, exchange emails and instant texts, share videos, pictures, and links. Facebook has over 250 million users (Kaplan & Haenlein, 2010). There are a lot of users and markets on social media for firms to capitalize on, but they should align and integrate their conversations with traditional advertising in order to reach those that still respond to non-online interactions.

Firms can also reach customers through virtual games, which is also a form of social media. According to the Huffington Post (2008) and the New York Times (2008), President Obama utilized Xbox 360 games to reach out to male youth voters and players (ages 16-30) in 10 states during his Presidential campaign race in 2008. President Obama got 66% of voters below the age of 30 to win the 2008 Presidential election as his strongest voting age group (USA Today, 2011). Virtual game world, like Microsoft's X-Box, are social media that allows users to appear as three-dimensional avatars and interact with other users' avatar as if they were their real selves in the gaming world restricted by rules (Kaplan & Haenlein, 2010). Virtual social worlds, like Second Life, are just like the virtual gaming world, but are free to behave in any manner and live as they like without the restriction of rules, as well as create content that can be exchanged or sold for money (Kaplan & Haenlein, 2010). Multiple users in virtual games can be present at the same time, within the same screen, and viewing the same setting or scene. Any advertisement or conversation placed at that setting can be viewed by thousands or millions of users simultaneously. If President Obama could use social media towards winning his Presidential election, then firms in need of maintaining or creating a competitive edge regularly need social media to target particular audiences with the right message at the right time.

3. RELATIONSHIP AND MODEL

The model below is based on the mix of literature outlined below, as well as author's experience in social media (Facebook) usage.

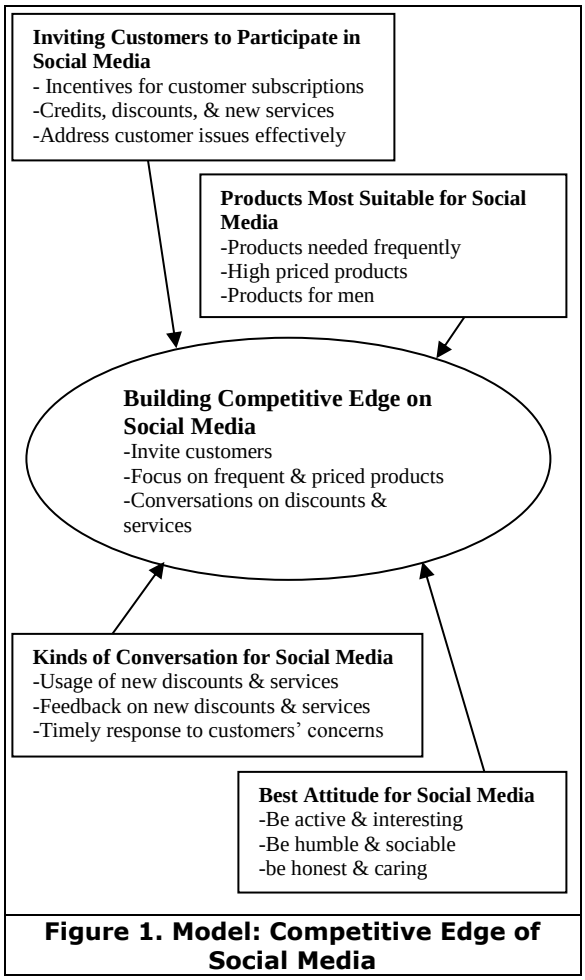

Figure 1. Model: Competitive Edge of Social Media

For a social media tool to be effective for a firm, it must have visitors and customers to engage with, products and content, conversation and feedback, as well as the right attitude to enhance its effectiveness. A firm must be able to acquire customers through its social media to even have a chance of interacting with them in order to have any impact on their purchasing decisions. While the customers are interacting on the firm's social media site(s), the firm must

offer some special products, services, or tips to make their brand appealing to the customers.

Through interaction and comments on social media sites, potential customers get to see what the current customers are saying about the firm's brand. Even if firms pretend to be satisfied customers, others customers have the option to disagree freely. This may even make the potential consumer now join the firm's social media or make the firm's brand favorable to others outside the social media outlets.

4. INVITING CUSTOMERS TO PARTICIPATE IN SOCIAL MEDIA

Social media offer a platform for traditional marketing where firms talk directly to customers, and modern marketing, where customers can talk to each other and to the firms (Mangold & Faulds, 2009). According to Ellison, Steinfield, & Lampe (2007), social capital is having people stay connected and sharing ideas within a community that is already inhabited. There is a need for firms to have social capital (i.e., retained customers on social media) in an attempt to promote their goods and services within a comfortable and trusted environment, such as social media provides.
Ellison, Steinfield, & Lampe (2007) state that Facebook provided some psychological well-being for users with low self-esteem and low life satisfaction that creates social capital. In so doing, ideas and involvement are shared without physical contact or individuals actually knowing each other. Many people who are shy in real life find comfort in social media to express themselves freely. In order to attract these kinds of customers and many more, incentives and discounts should be offered to customers in order to attract them first for interaction and dialogue.

Provide Incentives for Customer Subscription

Today, Wikipedia is one of the top five results whenever you search for many companies and products, and customers can read all the remarks that other customers have about that brand without any company's ability to defend themselves (Kaplan & Haenlein, 2010). Instead of firms expecting customers to utilize search engines to find all kinds of information about their brand, the firm can create their own social media, which can also be referenced by other social media and be found on the top search engine results as well.

Mass e-mail campaigns as well as a message on their monthly bills can be used to invite customers to join their social media for a little discount or coupon for a product or service. If they are already social media fanatics, they will easily join—often for free. These customers may not only verbally tell their physical friends about their new social media friend (the firm), but whenever the firm accepts their friendship, the social media friends of the user are notified (Facebook). On Twitter, users can search for the firm and request to follow their tweets or can view who their friends are following and decide to join the firm. On YouTube, users are allowed to search for firms and subscribe to their videos so that they get notified when new videos are posted. Users can also connect their videos to the firm's video(s) on similar issues and whoever finds the video on the list of "related videos" can also watch it. It is advisable for firms to use social media to converse about their coupons and new services.

Offering Credits, Discounts, and New Services

Customers are utilizing social media as a resource center and tool to research their purchasing options before they make their purchasing decisions (Mangold & Faulds, 2009). As long as firms are frequently offering credits, discounts, and new services, this will always keep the firm's conversation on social media very interesting. Customers love to feel like they are getting more for their money. They will always visit the firm's social media to read their notifications or post on their own account to see what they can benefit from the following month or later. The more customers comment and share their opinion (like or dislike), the more their friends get to see firm's messages or postings.

Addressing Customers' Issues Effectively

Customers are now relying more on social media as a more reliable source of information than firms' commercials or traditional marketing when making purchasing decisions (Mangold & Faulds, 2009). Social media can be utilized to solve customer-related problems for free, thereby increasing customer service and quality while reducing service cost (Thurau et al., 2010). Customers are making purchasing decisions in real time, so the earlier firms respond to customer concerns and issues, the better for them. This is because for each comment a user posts, their friends get to see the firm's response too, like in Facebook. This means that

negative issues left unattended to can be very disastrous for the firm. On Twitter, a user's friends get notified and they can also see all the comments when they go on their friend's social media sites. On YouTube videos, anybody can leave a comment about each video and you do not have to be a customer or subscriber, and everyone can see each comment in real time, as in posted-article and blog commentaries. Firms should strategically use their postings to promote their products. For instance, McDonalds and Wal-Mart have a presence on Facebook, while TV stations have a presence on Twitter.

5. TYPES OF PRODUCTS FOR SOCIAL MEDIA

Products and services should be designed with talking points to emphasize their uniqueness, value, visibility, and use in order to promote emotional stimulation on social media (Mangold & Faulds, 2009). Firms need to have products and services that are unique and interesting, which will make customers converse in order to generate emotional sensation as well as meet the needs of the customers on a regular basis.

Provide Products Needed Frequently

The higher the frequency of advertising on social media, the more it influences purchasing behavior (Mathur et al., 2012). Social media and E-marketplace should provide products and services that are needed frequently (Reibstein, 2002), such as snacks, coffee, and software. ReadwriteWeb.com (2008) reports that Skittles (snacks), Starbucks (coffee), H&R Block (tax), Oracle (software), Comcast (Cable TV), and Wal-Mart (shopping) are doing great on social media. According to Vatanasombut, Stylianou, and Igbaria (2004), the best online businesses are those that have products (and services) that need reordering due to frequent usage. Frequent usage equates to what customers need (i.e., high demand). There is need for product differentiation and affordable prices to generate continuous dialogue for the best products and price.

Provide High Priced Products

While low priced products and services had no influence in social media, high priced products and services above $300 were highly discussed on social media before customers made purchase decisions (Mathur et al., 2012). A look at Facebook on April 23, 2012, which is automatically set for Baltimore, Maryland with a global positioning system, shows cars, refrigerators, guitars, and houses as the new postings above $300. This makes sense because people want other people's opinions on issues that cost a lot of money, which will lead to lots of discussions.

Provide Products for Men

On social media, men utilized social media more than women as a tool for communicating, opinion leadership, and negative word-of-mouth, as well as the higher the daily usage, the greater the consumption of interaction and behavior (Durukan, Bozaci, & Hamsioglu, 2012). It is unwise not to have products for women, but it is a strategic advantage to have products for men. This is because research shows that men seem to have a stronger impact on consumer behavior and decision in their usage of social media. Men's comments and experiences may bring a firm more buyers and visitors to their sites. The number of visitors to a site is related to the number of visitors that are converted into buyers (Hoffman and Novak, 2000). If high-priced products lead to more interaction and men utilize social media more for buying the higher priced products, then it will be wise for firms to target more men with higher priced goods in order to influence their purchasing decisions through adequate conversations. Since social media get millions of users daily, then they are ideal venues to convert millions of customers into buyers by conversing with them.

6. KINDS OF CONVERSATIONS FOR SOCIAL MEDIA

Social media content is intentionally crafted by customers in an attempt to educate and advise others about products, services, brands, and issues (Xiang & Gretzel, 2012). Customers are more bonded to firms (and their products) that openly accept their feedback (Mangold & Faulds, 2009). Since customers are determined to use their interaction and conversations to influence each other's shopping habits, it will be business savvy for firms to openly invite customers to their social media sites in order to bond with them through excellent customer service.

Encourage Usage of New Discounts and Services

Social media content is updated frequently and indexed favorably by search engines in a more frequent manner (Xiang & Gretzel, 2012). So it is important for firms to update their social media with the latest coupons or sales. Brands that can persuade customers to fall in love with

their conversations in Web 2.0 will be successful (Meadows-Klue, 2008). Wikipedia and YouTube are usually the top-five favorites in search engine results on any topic they are affiliated with. So firms that have their social media results in search engines displaying interesting messages will spark active conversations from any visitor, such as videos on new services or frequent promotions listed by the firm. The aim of social media is also to convert these conversations into healthy feedback that encourages positive conversations between firms and customers as well as customer-customer interactions.

Encourage Feedback for New Discounts and Services

Firms must compete for consumer-related content on social media that has significant and persuasive effect on brands (Xiang & Gretzel, 2012). The ability to get customers by interacting with other Websites is a form of marketing and strategic partnership (Hoffman and Novak, 2000). Firms that have a presence in a cross or related Websites in an attempt to diversify and increase their customer base are more successful in term of marketing and strategic partnerships. Social media constitute a form of cross-related Website that can help to diversify, retain, and increase a firm's customer base through marketing and strategic partnership. Social media are used to have a positive effect on brands, products, and services through timely responses to customers' issues and requests. For instance, when visitors on a firm's social media realize that customers' issues have not been addressed for months and the comments are negative, this implies that the firm is avoiding the situation, or the firm does not care about their customers. Also, firms can request feedback on discounts to encourage used and conversation.

Provide Timely Response to Customers' Concerns

Search engine results are very favorable to social media information searches and play a great role in trip planning (Xiang & Gretzel, 2012) as well as other products and services decisions. Social media, such as YouTube and Wikipedia, are easily found and accessed through search engines. Any comments or statements made on these social media can easily affect customer's decisions. Since firms are not allowed to modify what is written on Wikipedia about them (Kaplan & Haenlein, 2010), they can at least respond to comments on YouTube strategically. A firm having a huge following on Facebook or Twitter will be a great way to counter other negative remarks on blogs or Wikipedia because a good percentage of visitors on those other social media are also on Facebook and Twitter interacting with the firm. A company's reflexes is measured by how fast it can respond to emergencies and bad news, while listen to customers' feedback in order to learn from mistakes and improve products is the foundation for competitive advantage (Gates, 1999). It is in the best interest of the firm to have a great social media attitude while interacting with customers.

7. BEST ATTITUDE FOR SOCIAL MEDIA

Social media can be used to make customers feel special by giving tips and information about upcoming promotions, a new product or service, as well as supporting causes that may appeal to their audience, such as promoting education and fighting diseases (Mangold & Faulds, 2009). Firms can use social media to stand for something socially, aside from profit-making. Firms promoting a cause on social media that customers feel strongly about, or giving them more for their money breeds a sense of loyalty from the customers. This shows that the firm has character and a good attitude.

Be Active and Interesting

Firms on social media must be active in real time in order to respond to all customer concerns and be interesting as well as innovative in the way they communicate with customers (Kaplan & Haenlein, 2010). Firms should be very active on social media regardless of who it belongs to as long as it concerns their brand. They need to respond on time to have some influence on customers' decision making. Firms also need to be innovative in their interactions with customers. They can use links to games, surveys, trick questions, or even word-puzzles about their products and services.

Be Humble and Sociable

Firms must realize that they need their customers' candid feedback in order to have a competitive edge in their industry, and they have to be friendly to their customers in order to get the necessary information about their brand (Kaplan & Haenlein, 2010). Firms must remember that they are only in business to serve their customers through adequate customer service. It is the customer that keeps

them in business and nothing else, so they need to be friendly and treat customers with maximum respect in their communication and reception of customers' feedback.

Be Honest and Caring
Firms should use social media to inform their customers about what they can truly do and provide with their brand and products, as well as show that the firm is determined to meet their needs on a timely basis (Kaplan & Haenlein, 2010). Firms should never promise what they know they cannot deliver or give information on coupon and new services that they cannot fulfill. Firms should not leave customers' comments unanswered or focus too much on the money than the service. Firms dialogue on social media must make customers feel that the firm means what it says and the firm has their best interests at heart.

8. IMPLICATIONS OF STUDY

The implication of the study for researchers and managers is to see the benefit of social media as a tool for adapting to the flexible and dynamic marketplace of today through the interaction with customers in order to meet customers at their point of need. Since one of the uses of IT is to free workers from doing work and instead focus their time and energy on customer service as well as quality (Gates, 1999), social media can be the exact tool to enhance customer service and quality.

By interacting with customers on social media, offering new products and discounts, having interesting and innovative conversations, and by possessing a good attitude in response to customers' feedback, firms appear caring and credible. Also, offering the right timely response on social media and providing the exact products as well as services that the customers are demanding (on social media) is also a form of improved quality. This paper is essentially about the utility of social media in enhancing competitive advantage through interactive customer service aimed to improve quality. For social media strategy to be effective, firms must first invite customers to their social media.

For managers, social media is a tool for customer acquisition and retention. Through dialogues on social media, managers get to know how customers are feeling about their brand, the improvements that customers want to see in their products, and what needs to be done to encourage customers to return for more dialogue. Social media can enhance the relationship between firms and customers if they are utilized effectively by firms. Firms may want to use social media to explain the benefits of their new products, new services, and the impact of new government regulations on their business or industry. Customers may utilize social media to inform other customers about how great a brand is, inform the firm on how to improve on their services, or even ask other customers about the benefits of other brands. Firms should utilize these opportunities to retain their customers and acquire their friends on social media. This can be done through their conversations; differentiation of their brand based on price and product desires of customers, and improves upon their customer service, as well as quality.

Researchers may be interested in what social media influences competitive edge more for various types of customers, what kind of conversation and products are various customers interested in on social media, and what types of attitudes brings out the most profits from various customers on social media. Researchers may also want to know if the loyalty of customers on social media lasts longer than that of other advertising methods, or if customers just stop by to talk with little loyalty to the brand. Also, researchers may want to know if social media marketplaces that allow users to sell their goods and services that may soon become more profitable that Amazon.com or Craigslist.com. Studies can be done to investigate if advertisements placed on social media are more profitable than conversing on social media to retain and acquire customers.

9. CONCLUSION

Social media is a necessity for today's competitive information marketplace where customers are empowered and are determined to educate as well as inform each other about brands and products. Many customers now rely on social media to get information as a credible source before they make their purchasing decisions, especially men and for highly priced goods. It is in the best interest of firms to engage with their customers already on social media in order to influence their purchasing decisions.

Customers should be invited to subscribe to or join a firm's social network in exchange for incentives. It is through interactions with these customers that other customers will be attracted to join in the interesting conversation of new services and new discounts that will give customers more value for their money. The aim of social media is to keep customers conversing while providing adequate customer service as well as quality products and services that meet customers' needs (determined through their feedback).

It is imperative for firms to provide products and conversations that are used frequent and very interesting to the customers. Products such as coffee, taxes, diapers, drinks, shopping items, snacks, cable TV, games, and latest software are great for social media. This is because they are needed frequently, people want the best offer for their money, customers are prepared to switch brands for better deals, and social media will keep customers conversing as well as giving productive feedback. Also, high priced goods such as houses, guitars, refrigerators, and cars are also good for social media because many people want to discuss with other customers about highly priced products before they let go of their cash.

Social media is not just a good way to get involved in customers conversations online, but it is also a good way to take charge of the conversation. By giving customers something interesting to talk about frequently, it keep them focused on firm's new deals, promotions, products, and services instead of letting them dwell on past issues. Regardless of what customers want to talk about, either the new deals or old complaints; firms must be ready and equipped to address all issues efficiently without focusing too much on the negatives.
Social media sites are also a place for firms to sell their customer service expertise by showing that they truly care about their customers and have a positive attitude. Firms must use the opportunity provided by social media to be social, humble, active, honest, and interesting. With humility, firms are to allow customers to always be right and use social as well as cordial languages to resolve issues. Firms should be active, present, and frequent on their social media sites in order to respond to customer requests in a timely manner. It is also wise to keep the conversation interesting and honest in order to increase credibility and give customers a reason to come back for more interesting conversations.

10. LIMITATIONS

Social media do not guarantee profitability or competitive advantage for a firm. Just because incentives are offered does not guarantee that customers will willingly join a firm's social media or just because they are conversing on the social media outlets does not guarantee that a firm can affect the customers' purchasing decisions. Even with the right products, conversations, and attitude, social media do not guarantee competitive edge in the industry, especially with the competitors doing some of the exact same things to get the same kinds of customers.

More research needs to be done on the most effective way to attract customers to join a firm's social media, what exact products and services do well on various types of social media, and what type of demographics respond positively in relation to competitive advantage on social media. Also, the type of conversation needed and in what manner the conversation should be facilitated to maximize competitive advantage for the firm needs to be researched further.

Another interesting area of research on social media is a study of companies that are successfully using social media, like Wal-Mart, H&R Block, Starbucks, Comcast, and Oracle to see what makes them successful. We need to know what conversations their customers are creating about them, how they invite customers to their social media sites, how they respond to customers' feedback, and how their products affect their conversations and attitudes on social media.

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Information Security Blueprint For Nationwide Health Information Network

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Abstract

With the increasing costs and the decreasing quality of care in the US healthcare industry, there are substantial incentives by the US government to move towards an integrated national health network. The sensitive nature of the healthcare data to be exchanged requires the integrated network to address the privacy and information security concerns. This study describes the design and implementation considerations to provide an information security blueprint for the Nationwide Health Information Network (NHIN). The objective of this research is twofold. First, it aims to provide background information about technology implementations in healthcare organizations, current Healthcare Information Technology (HIT) services, electronic healthcare records (EHRs) and design considerations for healthcare networks. In addition, it explores current wide area network (WAN) technologies and various security methods for assuring the secure healthcare information exchange between medical providers. The positive preliminary feedback from several HIT professionals validates the proposed blueprint.

Keywords: Healthcare information technology, information security, nationwide health information network, wide area network technologies, electronic health records

1. INTRODUCTION

Healthcare represents a significant segment of the U.S. economy and workforce. In 2010, total health expenditures reached $2.6 trillion, which translates to $8,402 per person or 17.9% of the nation's GDP (Thompson & Brailer, 2004). Healthcare is the single largest industry in the United States, providing 14 million jobs through approximately 580,000 establishments (Bureau

of Labor Statistics, 2010). Healthcare spending per person has grown faster than the nation's economic output per person, on average by nearly 2 percentages per year, for the past several decades. In 2009, the Office of the Actuary at the Centers for Medicare and Medicaid Services (CMS) projected that by 2030, given current trends, national health expenditures will exceed 30% of the GDP (HIMMS, 2012).

Use of healthcare information technology (HIT) in healthcare organizations can help to decrease costs while increasing overall quality of patient care. HIT services involve the use of technology to provide healthcare as well as to enable the comprehensively exchange the digital health information (The Office of National Coordinator for Health Information Technology, 2012b). Currently, one of HIT services is Electronic Healthcare Record (EHR) system, which is an electronic record of patient health information generated by one or more encounters in any care delivery setting (Caldis, 2009). With EHR doctors can have a complete picture of the patient's health without redundant tests and examinations. EHR implementations can increase the quality of healthcare delivery and reduce the associated costs (National Institutes of Health National Center for Research Resources, 2006). To encourage organizations to adopt EHRs, the federal government has set aside funding as part of the American Recovery and Reinvestment Act of 2009 (ARRA) (Blumenthal, 2011). One of the primary goals behind the government's initiative for encouraging the adoption of EHRs is to increase Health Information Exchanges (HIEs) and eventually maintain a Nationwide Health Information Network (NHIN), which aims to provide a secure and interoperable health information infrastructure that allows stakeholders, such as physicians, hospitals, payors, state and regional HIEs, federal agencies, and other networks, to exchange health information electronically (Cline, 2012). NHIN will help significantly to reduce healthcare spending in the US while improving the patient care quality.

Besides the advantages they offer; EHRs and HIEs pose several challenges to entities participating in the delivery of healthcare. One of these challenges is the security of the patient data exchanged between the healthcare organizations. Healthcare practices increasingly rely on networks for their core operations; thus, become more vulnerable to information security threats. A major section of the Health Insurance Portability and Accountability Act (HIPAA) of 1996 aims to standardize the steps that needs to be taken to protect patient privacy. More specifically, HIPAA mandates healthcare institutions take actions for ensuring the security of personal health information (HIPAA, 2012).

The US government intends to enhance HIEs and establish the NHIN in near future, which makes securing healthcare systems, networks and information exchange important and time-sensitive tasks for medical providers. To support these efforts, the Office of the National Coordinator (ONC) for Health Information Technology, which sponsors the creation of the NHIN, has established some goals for maintaining the secure information exchange (US Department of Health and Human Services, 2012c). However, the specific security methods, tools, their implementations and related standards for healthcare organizations have not yet been stated clearly. There are a few guidelines and research studies addressing this loophole. The Connected Health Framework Architecture and Design Blueprint, a Microsoft published guideline (2006), proposes a solution for transforming healthcare through technology options that are cost-effective, productive, and connected by design. Even though information security is discussed as one of the architectural challenges, the guideline does not explore the security concerns of interconnected network design extensively. The security architecture for interconnecting health information systems proposed by Gritzalis and Lambrinoudakisbby (2006) is mainly designed for providing authentication and authorization services in web-based distributed systems and fails to cover the information security considerations in a broader perspective.

This study focuses on the information security best practices and proposes an information security blueprint for the NHIN with security and privacy concerns in mind. The findings of this research can be utilized as a guide for understanding current wide area network (WAN) technologies, and various security measures that can be implemented for HIE networks.

2. HEALTHCARE INDUSTRY IN THE US

In 2000, the World Health Organization (WHO) ranked US health care systems, among 191 member nations, as the highest in cost, first in

responsiveness, 37th in overall performance and 72nd by overall level of health (The World Health Organization, 2000). It was indicated in this ranking; the US spends more than $2.6 trillion annually on healthcare (Thompson & Brailer, 2004). The poor quality of healthcare delivery in the US compared to the most developed nations in the world indicates that this amount is not spent efficiently (Bower, 2005; Peterson & Burton, 2007).

Healthcare in the US faces multiple problems, including high and rising expenditures, inconsistent quality, and gaps in care and access (Bower, 2005; Varshney, 2009). According to Commonwealth Fund, a private foundation working toward a high performing health system, healthcare delivery in the US is a "cottage industry" (Shih, Davis, Schoenbaum, Gauthier, Nuzum, & McCarthy, 2008), i.e. providers have no relationship or accountability to one another. This comparison mainly indicates the fragmentation at the national, state, community, and practice levels; which is a result of not having a single national entity or set of policies guiding the US healthcare system. Today, states divide their responsibilities among multiple agencies, while providers practicing in the same community and caring for the same patients often work independently from one another (Shih et al., 2008). The fragmentation of healthcare delivery system is a fundamental contributor to increased spending and poor overall performance of the healthcare system. In this fragmented system, patients navigate unassisted across different providers and care settings; while poor communication and lack of clear accountability for the patient among multiple providers' leads to medical errors, waste, and duplication.

Technology Integration in the Healthcare and Healthcare IT

Brailer & Thompson (2004) define healthcare IT as the application of information processing involving both computer hardware and software dealing with the storage, retrieval, sharing, and use of health care information, data, and knowledge for communication and decision making. Particularly, HIT provides a framework to describe the comprehensive management of health information across computerized systems and its secure exchange between consumers, providers, government, and insurers (Thompson & Brailer, 2004). HIT is increasingly viewed as the most promising solution for improving the overall quality and efficiency of the healthcare delivery system in the US (The Office of National Coordinator for Health Information Technology, 2012b; Bower, 2005; Medpac, 2004). According to a study by RAND Health, if HIT were properly implemented and widely adopted in the healthcare organizations, the US healthcare system could save $77 billion annually, increase safety, and improve the quality of patient care (RAND, 2005).

For understanding the potential uses and benefits, many researchers and government agencies studied HIT so far (Bower, 2005; US Department of Health and Human Services, 2012a; RAND, 2005; Medpac, 2004; Mitchell & Yaylacicegi, 2010). According to their findings, the major advantage of utilizing HIT is having easy access to complete and accurate medical and patient information (The Office of National Coordinator for Health Information Technology, 2012b). This functionality helps doctors to diagnose health problems faster and reduce medical errors, provides safer and quality care to the patients, and lowers healthcare costs. HIT also strengthens the coordination of care as it enables enhanced peer-to-peer and professional-patient communication (Fineberg, 2012). Furthermore, HIT strengthens the patient privacy and data protection since its applications offer a way to securely store and share patient information between different entities (The Office of National Coordinator for Health Information Technology, 2012b). HIT applications also increase the administrative efficiency significantly as they store information digitally. This helps to reduce paperwork in the healthcare organizations and enables clinicians to spend more time on the patient care, rather than their administrative responsibilities (The Office of National Coordinator for Health Information Technology, 2012b; Thompson & Brailer, 2004). Moreover, as tracking health information digitally provides easier access to patient histories, test results, and can provide automatic alerts; HIT offers an increased early detection of medical conditions. It also prevents the duplication of the tests, control the costs and reduces the diagnose time (Cisco HIN Curriculum, 2012). In addition, utilizing HIT services improve disease prevention and response, as digital tracking of health information makes it easier to observe trends in the general population as well as track successful treatment methods. This functionality promotes public health and preparedness (Fineberg, 2012). As a result, widespread use of

HIT expands access to the affordable, quality and cost-effective patient care while improving the delivery of healthcare in US (The Office of National Coordinator for Health Information Technology, 2012b). One of the most commonly employed HIT applications in the healthcare environment is electronic health records (EHR) software (The Office of National Coordinator for Health Information Technology, 2012b), otherwise known as electronic patient records or computerized patient records.

Electronic Healthcare Records (EHRs)

According to the definition provided by the Health Information Management Systems Society (HIMSS), electronic health record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports (HIMMS, 2012). An EHR system improves patient care by allowing physicians, radiologists, nurses, and laboratory technicians to gather the complete picture of the individual and work in parallel with accurate and current information. Also, EHRs improve health information accessibility by making possible for the patient record to be used by multiple providers at once. Therefore, EHR implementation encourages coordination of care between doctors (US Department of Health and Human Services, 2012a). By implementing EHRs and meeting interoperability standards, healthcare organizations can join Health Information Exchanges (HIEs). This allows medical practices to share information, have access to already performed tests and lab results and ensure that the complete picture of a patient's health is documented (US Department of Health and Human Services, 2012b). By making it easier to use and share patient information, EHRs can help health care providers to reduce medical errors, save money and time (US Department of Health and Human Services, 2012a).

Despite the many benefits that EHR systems offer, physicians in the US have been slow to adopt HIT. According to an EHR adoption study, which is done in 2010, only % 4 of physicians have fully functional electronic medical systems (Elhauge, 2010). Healthcare organizations explain these low implementation rates with the insufficient resources or a negative return on investment associated with purchase, implementation, and operation of EHRs (Thompson & Brailer, 2004). The federal government, as part of ARRA of 2009, set aside funding to use for incentives, grants, and loans for encouraging medical providers to implement EHR systems. ARRA, also known as the Stimulus Bill, was signed into law to help stimulate the U.S. economy (The Office of National Coordinator for Health Information Technology, 2012a). The funding for the transition to EHRs, which is called the Health Information Technology for Economic and Clinical Health (HITECH) Act, is approximately $19 billion (Blumenthal, 2011). Under HITECH, eligible health care professionals and hospitals can qualify for Medicare and Medicaid incentive payments when they adopt HIT and use qualified EHR technology (Leslie, 2012).

Healthcare IT Interoperability and Health Information Exchange (HIE)

Interoperability describes the extent to which systems and devices can exchange data, and interpret the shared data. For enabling interoperability between systems and devices, some standards should be in place to provide a common language and a set of expectations (HIPAA, 2012). Health Information Exchange (HIE) is defined as the standards and systems used to allow for the transmittal of healthcare information electronically across multiple healthcare organizations within a region, community, or hospital system (Cisco HIN Curriculum, 2012). In order to join HIE, a medical provider should adopt an EHR system. Joining HIE improves care coordination, reduces healthcare disparities, empowers patients, and improves population health while ensuring adequate privacy and security (Leslie, 2012). More specifically, fully implemented HIE allows medical providers to have comprehensive, high-quality patient information to make the right decision as they have access to the prior patient tests and medical history (Leslie, 2012).

Technology is a critical tool in achieving the benefits of HIE (AHIMA, 2012). Adoption of HIE practices requires an adequate technical infrastructure, which is the design and implementation of the architecture, including the hardware, software, applications, network configurations, and other technological aspects that enable data exchange in a secure manner (Cisco HIN Curriculum, 2012). The main roadblocks the health providers are encountering

in the implementation of HIEs are data sharing, patient consent, standards, complexity costs and competition (Government Health IT, 2011).

Nationwide Health Information Network (NHIN)

One of the primary goals behind the government's initiatives for encouraging the adoption of EHRs and HIEs is to eventually establish a NHIN (Medpac, 2004). The core goals of the NHIN include having the ability to find, retrieve and deliver healthcare information within and between HIEs; having ability to support consumer preferences regarding the exchange of health information; supporting secure information exchange; establishing of a common trust agreement that states the obligations and assurances to which all NHIN participants agree; and supporting of harmonized standards, which have been developed by voluntary consensus standards bodies (US Department of Health and Human Services, 2012c). The conceptual representation of NHIN is shown on Figure 1.

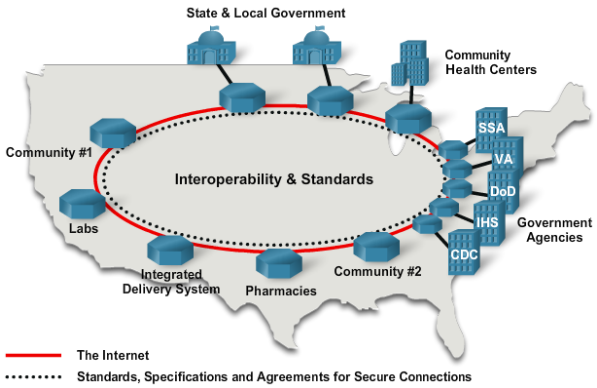

Figure 1. Nationwide Health Information Network

The sharing of patient information through a nationwide network brings some security concerns (Medpac, 2004). Especially, specific requirements regarding access to medical records and breach of such data are the primary concerns; since privacy, disclosure, and breach laws usually differ from state to state. Therefore, exchange of clinical health information across states requires national regulatory guidance, and harmonization of privacy and security regulations. Another issue for interstate exchange of health information is the need to develop national standards for locating and matching patient information across HIE entities and networks as well as across healthcare facilities and organizations in the different states (AHIMA/HIMMS, 2011). In the US, Health Insurance Portability and Accountability Act (HIPAA) was the first initiative for ensuring the patient privacy (Medpac, 2004). Then, the HITECH portion of the ARRA expanded the privacy protections in the healthcare delivery. For secure NHINs, these existing regulations must be translated into consistent policies and practices across healthcare entities involved in HIEs, within and across state borders (AHIMA/HIMMS, 2011).

Protecting Patient Information: Health Insurance Portability and Accountability (HIPAA) Act

In 1996, The U.S. Congress passed HIPAA to uniform the steps that had to be taken to protect patient privacy. Before HIPAA, rules and regulations varied from state to state, and even from one healthcare organization to another. HIPAA require HHS to adopt national standards for electronic health care transactions and national identifiers for providers, health plans, and employers. To date, the implementation of HIPAA standards has increased the use of electronic data interchange (HIPAA, 2012).

HIPAA is made up of two parts. Title I of HIPAA protects health insurance coverage for workers and their families when they change or lose their jobs. Title II, also known as the Administrative Simplification provisions, enacted federal regulations to protect patient information and has provisions including the following goals:

- Protecting the confidentiality of an individual's health information,
- Ensuring that health information is properly protected, while allowing the flow of information needed to provide and promote quality healthcare,
- Allowing healthcare providers to become more interconnected, while maintaining the integrity and security of patient information (Cisco HIN Curriculum, 2012).

Under HIPAA, the information that must be secured is called protected health information (PHI). PHI is any information that is individually identifiable, can be related to the individual's past, present, or future physical or mental health; the provision of healthcare to the individual and the past, present, or future

payment for healthcare (US Department of Health and Human Services, 2012d).

HIPAA ensures the privacy and security of PHI through two separate rules: the privacy rule and the security rule. Privacy rule mandates the protection and privacy of all health information and defines the authorized uses and disclosures of PHI. According to the privacy rule, safeguards must be put in place to protect health information. Privacy rule applies to written, oral, and electronic types of information (US Department of Health and Human Services, 2012d). On the other hand, the security rule defines the standards of basic security safeguards to protect electronic protected health information (ePHI), which refers to health information that is created, stored, transmitted, or received electronically. The security rule provides broader protection guidelines, focusing on the confidentiality, integrity, and availability of all electronic information (US Department of Health and Human Services, 2012d).

3. DESIGNING HIT NETWORKS

Having access to the right information at the right time is critical to deliver quality and cost effective patient care. Therefore, healthcare organizations need an integrated network and advanced technology that provide secure access to the information (Cisco HIN Curriculum, 2012). This will be the first step for successful implementation of the HIEs, which will eventually lead to the establishment of the NHIN.

When designing and deploying the network architecture, healthcare practices must start by considering the types of applications the network will support initially versus long-term goal. For example, implementing a full scale EHR software that must interface with systems outside of the organization for data sharing will require a more complicated infrastructure. Therefore, when installing EHR system, it is important to perform application characterization, which encompasses the understanding of technical requirements and interactions of an application in the network (Lewis, 2009). The EHR implementation model might result in greater internal traffic if the EHR server devices are local, or it might produce greater external traffic if the services are housed remotely (Harris, 2008). It is important to understand the traffic flow to determine the connection and bandwidth requirements to prevent network congestion and degraded performance (Cisco HIN Curriculum, 2012; Jackson, 2012).

Medical providers are quite concerned about access to patient information; thus, every effort must be made to prevent downtime and loss of data. For ensuring this, there is a need to plan for redundancy for any possible link and/or device failures (Lewis, 2009).

Diagramming helps a network designer to evaluate traffic flows and addressing structures as well as identify where topology or equipment changes needed. These diagrams also provide a visual representation of the network and help to understand security picture by identifying information such as the placements of VLANs, access control lists, and other security applications and protocols (Lewis, 2009).

After the internal LAN is characterized and diagrammed, the network designer should focus on the traffic expectations of remote sites and virtual private networks (VPN). It is also important to diagram the outgoing traffic flows destined for the Internet and the incoming traffic flows from the Internet to locally provided services. In addition, a diagram for external traffic or WAN should include the information about the central location (healthcare facility), connectivity to EHR vendor sites (for EHR vendor support), connectivity to remote sites and connectivity to business partners (Cisco HIN Curriculum, 2012; Oppenheimer, 2004).

Healthcare practices should ensure that the network foundation incorporates with security services, such as port security and quality of service (QoS), to prioritize the most important network services and guarantee consistent performance. In addition, healthcare organizations should use both firewalls and intrusion prevention systems (IPS) to protect their network perimeter. Organizations should also implement daily backup systems and all backup storage assets must be protected (Harris, 2008). All protocols, including routing protocols such as Enhanced Interior Gateway Routing Protocol (EIGRP), and switching protocols such as Spanning Tree Protocol (STP), should be properly configured and managed to ensure continuous uptime. Also, healthcare organizations must ensure that WLANs provide the same level of security as wired LANs (Lewis, 2009).

4. DEVELOPMENT AND IMPLEMENTATION CONSIDERATIONS FOR NHIN

Today, many healthcare organizations use WAN connections to other clinics, hospitals, or suppliers in order to exchange data. WANs use facilities provided by a service provider, such as a telephone or cable company, to connect specific, geographically dispersed organizations or to connect to external services and remote users (Cisco HIN Curriculum, 2012). For ensuring the secure HIE, and the establishing the NHIN; it is crucial to have security implementations in the HIT networks. Therefore, when medical providers are implementing WAN services, they should consider information security measures that each technology offers. The healthcare organizations currently use the leased lines, frame relay, asynchronous transfer mode (ATM), metro Ethernet and Internet with the use of virtual private networks (VPNs) as WAN technologies for interconnectivity. Characteristics of each of these technologies are detailed in Table 1a-1e of Appendix A. In an attempt to create a blueprint and recommend best practices for NHIN security, Table 2 in Appendix B compares the WAN technologies using eight criteria capturing the most essential measures for securing the interconnected health networks (Vachon & Graziani, 2009; Minoli, 2008; Circadence, 2010). The criteria used for comparison are general information, connection types, security, performance, flexibility, cost, complexity and HIPAA compliance.

Under these main categories, more specific features are examined. For connection type, typical bit rate; remote access capability; site-to-site connection functionality; persistence, which examines if the technology requires a constant connection; use of virtual circuits and physical carrier types are discussed. For security criteria, the availability of the SSL, encapsulation (tunneling) protocols, data integrity mechanisms, the use of private or public infrastructure, authentication protocols and encryption methods are examined. For the performance, data segmentation, overhead considerations, error and flow control mechanisms, Quality of Service (QoS) and fixed bandwidth availability are studied. From the flexibility perspective, the availability of the reproducibility, scalability and location dependency is explored. In this part, reproducibility refers to the ability of re-implementation of the technology in the case a healthcare provider moves to another location. In addition, location dependency refers to the remote access by questioning if the medical providers have an access to their networks from another locations, such as their homes. Under the cost criteria, general costs and operational costs are discussed. For the complexity, minimum hardware requirements and required protocols for data transfer are compared. Lastly, HIPAA compliances of these technologies are examined. As this compliance can be achieved by the use of technical safeguards, such as encryption, mechanism to authenticate ePHI and integrity controls; the decisions are based on the existence of these functionalities. Furthermore, in this section, the major advantages and disadvantages of these WAN technologies are listed. Review of these WAN connection options enables the adoption of the best WAN technology that meets the requirements of a specific HIT network design in the healthcare context.

According to the findings presented in the blueprint above, the major advantage of the lease line technology is security. They are considered most secure technology among all the option. However, since they are the most expensive option, they don't offer the cost efficiency. Frame relay, on the other hand, provides highly efficient on the use of bandwidth and offers more affordable WAN technology. In spite of this advantage, frame relay share media across the link, which causes some security concerns. ATM networks can be utilized for simultaneous use of voice, video and data effectively. It creates fixed-cells during the segmentation, and these cells can provide an advantage during the transmissions. However, in ATM, overhead can be considerable disadvantage. As an alternative to ATM technology, metro Ethernet services are provided over a standard, widely available and well-understood Ethernet interface. Therefore, this option can be utilized by the healthcare organizations in a convenient way. Although, metro Ethernet does not have QoS and other traffic-prioritization capabilities, which can create some security and performance concerns. On the other hand, Internet with the use of VPN technology is the least expensive, globally available WAN technology. However, it offers least secure way of data transmission over the wide area networks. Thus, VPN security protocols should be implemented. Multiprotocol Label Switching (MPLS) based Ethernet is a preferred method used to provide high performance telecommunications networks.

In an attempt to validate the recommended best practices, a preliminary survey was conducted with regional HIT professionals. The feedback received showed that VPN and metro Ethernet were the most flexible; and VPN, leased lines and metro Ethernet were the most secure WAN technologies. Also, ATM and metro Ethernet had the best network performance, while VPN was rated as the least expensive choice. Lastly, leased lines were indicated as the least complex WAN option. In overall, metro Ethernet was rated as the best technology choice while VPN was closely following it. These results are well matched with the information provided in the WAN technologies blueprint.

5. CONCLUSIONS

This study provides a comprehensive review of the background information necessary selecting the most viable WAN solution for the integrated health networks. According to the findings of this research and feedback have been gathered from the industry professionals, the metro Ethernet technology is the best alternative for interconnecting the HIT networks. Since it offers site-to-site connections over Ethernet and remote access services through Ethernet VPNs, organizations can extend their LAN to the metropolitan area, which enables them to have reliable connections between remote offices and headquarters where they can securely access their applications and data.

According to one of the local health organization's information security expert, most healthcare providers are converting to MPLS based metro Ethernet for Internet connections and connections between sites due to high transmission, high bandwidth and cost savings characteristics of metro Ethernet. The major advantage of this WAN option is having a standard, widely available and well-understood Ethernet, as a core technology. Also, with the use of Ethernet VPN service, Metro Ethernet provides the services that VPN technology offers. With this functionality, healthcare professionals are given the flexibility to connect their networks remotely, from anywhere and anytime.

Implications

Implementing HIT services in the medical providers and utilizing them in daily operations improves disease prevention and response. Digital tracking of health information makes it easier to observe trends in the general population as well as track successful treatment methods. This functionality promotes public health and preparedness. As a result, widespread use of HIT can help to expand access to the affordable, quality and cost-effective patient care while improving the delivery of healthcare in US.

This research provided comprehensive background information on specific technologies for interoperable HIT networks and best practice approaches for fulfilling security requirements, in order to secure communications between organizations. Also, information security requirements in the healthcare industry, related regulations and how these regulations effect healthcare organizations are discussed in detail. The findings of this study can be utilized as a technology guide by the healthcare entities. They can use this research to understand and compare the current information security practices that can be applied to their HIT networks; and WAN technologies for interconnecting their networks. In combination, this research can help to offer the information security blueprint for interconnecting HIT networks, where the information exchange will be achieved.

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Appendix A: Characteristics of the five widely used WAN technologies.

Table 1a. Leased Line

LEASED LINE (Dedicated Link or Point-to-Point Link)		
Definition	It is one single link that is pre-established for the purposes of WAN communications between two destinations. It is dedicated, meaning only the destination points can communicate with each other. This link is not shared by any other entities any time.	
Advantages	♦ These lines are truly dedicated and connect two locations ♦ They are considered very secure as only two locations will be using the same media ♦ Establishing a dedicated link is ideal for two locations that will communicate often will require fast transmission and specific bandwidth	
Disadvantages	♦ A dedicated line is expensive because organizations have to pay for a dedicated connection for every site they connect and a standard bandwidth, even they do not use. ♦ It is not flexible since when healthcare organizations grow or move to another location, they must purchase a separate circuit for every connection that the organization want to make	
Carrier Technology	♦ T-carriers are dedicated lines that can carry voice and data information over trunk lines. ♦ The most commonly used T-carriers are T1 lines that provide up to 1.544 Mbps and T3 lines that provide up to 45 Mbps.	
Layer 2 (Data Link) Encapsulation Protocols	High-Level Data Link Control (HDLC)	Point-to-Point Link Protocol (PPP)
	♦ standard bit-oriented encapsulation ♦ uses synchronous serial transmission, which provides error-free communication between two points ♦ provides flow control and error control through the use of acknowledgments ♦ only supports one protocol at a time (IP) ♦ vendors have developed their own parameters within their versions of HDLC, which has resulted interoperability issues	♦ uses a layered architecture to encapsulate and carry multi-protocol datagrams ♦ enables communication between equipment of different vendors ♦ provides link quality management ♦ supports multiple protocols at a time ♦ features supported include: authentication, PPP callback, compression and multilink ♦ two authentication methods are supported: PAP and CHAP ♦ has two sub-protocols
PPP Sub-Protocols	Link Control Protocol: ♦ establishes, maintains, and terminates the point-to-point link. ♦ supports authentication, compression, and error detection	Network Control Protocol: ♦ encapsulates multiple network layer protocols, so that they operate on the same communications link

Table 1b. Frame Relay

<table>
<tr><th colspan="3">FRAME RELAY</th></tr>
<tr><td>Definition</td><td colspan="2">It is a high performance WAN solution that uses packet switching technology, which works over the public networks. Frame Relay let multiple companies and networks share the same WAN media.</td></tr>
<tr><td>Advantages</td><td colspan="2">♦ Whereas point-to-point links have a cost based on the distance between the endpoints, the frame relay cost is based on the amount of bandwidth used.
♦ Since the infrastructure is shared, if one subscriber is not using the bandwidth, it is available for others to use.
♦ Because several organizations use the same media and devices (routers and switches), costs can be greatly reduced per healthcare provider compared to dedicated links.
♦ It gives companies much more flexibility than leased lines as it offers an easier implementation.
♦ It also provides greater reliability and resiliency than single dedicated lines because one physical interface can support multiple VCs, which provides multiple dedicated lines.
♦ The simplified handling of frames leads to reduced latency.</td></tr>
<tr><td>Disadvantages</td><td colspan="2">♦ Frame relay does not implement error or flow control.
♦ When traffic levels increase, the available bandwidth in the frame relay cloud decreases. Therefore, if subscribers want to ensure a certain bandwidth, they need to pay a higher committed rate.
♦ Sharing a single interface can cause problems for distance vector routing protocol updates.</td></tr>
<tr><td>Carrier Technology</td><td colspan="2">♦ Frame relay offers data rates up to 4 Mbps.
♦ In a dedicated-line model, customers use dedicated lines provided in increments of 64 kb/s, but frame relay customers can define their virtual circuit needs in far greater granularity, often in increments as small as 4 kb/s.
♦ Since frame relay shares bandwidth across a larger base of customers, a network provider can service 40 or more 56 kb/s customers over a T1 circuit.</td></tr>
<tr><td rowspan="2">Connection Types for Data Transfer (Virtual Circuits)</td><td>Switched Virtual Circuit (SVC)</td><td>Permanent Virtual Circuits (PVC)</td></tr>
<tr><td>♦ A temporary connection that is created for each data transfer, and then terminated when the data transfer is complete.</td><td>♦ Permanent connection preconfigured by the carrier.</td></tr>
<tr><td>Frame Relay Characteristics</td><td colspan="2">♦ A VC is identified by a Layer 2 data-link connection identifier (DLCI), which is assigned by the Frame Relay service provider. A DLCI identifies a VC to the equipment at an endpoint.
♦ After establishing DLCI, Inverse Address Resolution Protocol (Inverse ARP) provides a mechanism to create dynamic DLCI-to-Layer 3 address maps.
♦ Frame relay providers offer services with guaranteed average data-transfer rates and committed information rate (CIR), which specifies the maximum average data rate that the network delivers under normal conditions.
♦ A CIR is assigned to each DLCI that is carried on the local loop. If the location attempts to send data at a faster rate than the CIR, the provider network flags some frames with a discard eligible (DE). If there is congestion, it discards any frames marked with the DE.
♦ Many inexpensive Frame Relay services are based on a CIR of zero. A zero CIR means that every frame is a DE frame, and the network can throw any frame away when there is congestion. Since there is no guarantee of service with a CIR set to zero, mission-critical data, such as EHR system data should not be relay on so these services.
♦ Frame Relay implements two mechanisms to help manage traffic flows in the network: Forward-explicit congestion notification (FECN) and Backward-explicit congestion notification (BECN).</td></tr>
</table>

Table 1c. Asynchronous Transfer Mode

ASYNCHRONOUS TRANSFER MODE (ATM)	
Definition	ATM technology can transfer voice, video and data through private and public networks. It is built on a cell-switching method rather than being packet-switch method. ATM is a high speed networking technology used for LAN, MAN, WAN and service provider connections.
Advantages	♦ ATM is a high-bandwidth technology that usually has low overhead and low delay. ♦ Data is segmented into fixed-size cells of 53 bytes, instead of variable-size packets ♦ Small, fixed-length cells are well suited for carrying voice and video traffic, because this traffic is intolerant of delay. Video and voice traffic do not have to wait for a larger data packet to be transmitted. ♦ ATM allows multiple VCs on a single leased-line connection to the network edge. ♦ In combination with SVC/PVC capabilities of ATM, the same packet size segmentation provides more efficient and faster use of communication paths. Because with the use of VCs, the path is established before the data transfer, all the packets are routed to the same path and as a result, reassembly overhead of the packets is reduced significantly. ♦ It supports various interfaces to provide flexibility and use of different QoS practices.
Disadvantages	♦ The 53-byte is less efficient than the bigger frames and packets of frame relay. ♦ The ATM cell has at least 5 bytes of overhead for each 48-byte payload. When the cell is carrying segmented network layer packets, the overhead is higher, because the ATM switch must be able to reassemble the packets at the destination. ♦ A typical ATM line needs almost 20 percent more bandwidth than frame relay to carry the same volume of network layer data.
Carrier Technology	♦ ATM was designed to be extremely scalable. It can support link speeds of T1/E1 to OC-12 (622 Mbps) and higher.
Connection Types for Data Transfer (Virtual Circuits)	♦ ATM offers both PVCs and SVCs, although PVCs are more common with WANs. ♦ These VCs can guarantee bandwidth and QoS. Therefore, ATM is a good carrier for voice and video transmission.
ATM Characteristics	♦ ATM is used by carriers and service providers and makes up part of the core technology of the Internet. It can also be used for a company's private use in backbones and connections to the service provider's networks. ♦ Like frame relay, it is a connection-oriented switching technology and uses a fixed channel. ♦ ATM cells are always fixed length of 53 bytes. The ATM cell contains a 5-byte ATM header, followed by 48 bytes of ATM payload. ♦ ATM sets up a fixed channel for all data to transfer through during a transmission. The fixed channels are preprogrammed into the switches along that particular communication path. ♦ ATM was the first protocol to provide true QoS, but later, QoS integrated into other technologies.

Table 1d. Metro Ethernet

METRO ETHERNET NETWORK (MEN)	
Definition	Metro Ethernet Networks broaden Ethernet to the public networks run by telecommunications companies. IP-aware Ethernet switches enable service providers to offer enterprises converged network services. This technology enables organizations to inexpensively connect LANs and individual end users to a WAN or to the Internet.
Advantages	♦ Due to its broad usage in networking products, the Ethernet interface itself is inexpensive. Ethernet services also offer lower equipment, service and operational costs, compared to competing services. ♦ Metro Ethernet provides a switched, high bandwidth Layer 2 network that can manage data, voice, and video all on the same infrastructure. This increases bandwidth and eliminates expensive conversions to ATM and Frame Relay. ♦ Since Ethernet services are provided over a standard, widely available and well-understood Ethernet interface, the network operations, administration and management is simplified in MENs. ♦ Metro Ethernet connects easily to existing Ethernet LANs, reducing installation cost and time. ♦ It enables businesses to take advantage of productivity-enhancing IP applications that are difficult to implement on Frame Relay networks, such as IP communications, VoIP, streaming video. ♦ Eth. services allow subscribers add bandwidth in small increments (1Mbps). ♦ It offers reliability, scalability, performance guarantees and greater bandwidth management.
Disadvantages	♦ Metro Ethernet does not have QoS and other traffic-prioritization capabilities.
Carrier Technology	♦ Standard Ethernet speeds of 10 Mbps, 100 Mbps, 1 Gbps and 10 Gbps are supported in Metro Ethernet. ♦ Physical Media includes 10BaseT, 100BaseT and 1000BaseSX.
Connection for Data Transfer (Ethernet Virtual Connection)	♦ An EVC is defined as the association of two or more User Network Interfaces (UNIs), where the UNI is a standard Ethernet interface that is the point of demarcation between the Customer Equipment and service provider's MEN. ♦ It connects two or more UNIs enabling the transfer of Ethernet service frames between them. ♦ It also prevents data transfer between subscriber sites that are not part of the same EVC. This capability enables an EVC to provide data privacy and security similar to a Frame Relay or ATM PVC. ♦ Based on these characteristics, an EVC can be used to construct Layer 2 Private Line or Virtual Private Network (VPN). ♦ There are two types of EVCs: point-to-point and multipoint-to-multipoint.
Metro Ethernet Characteristics	♦ There are two Ethernet service types: Ethernet Line (E-Line) Service and Ethernet LAN (E-LAN) Service. ♦ E-Line Service provides a point-to-point EVC between two UNIs, which is analogous to Frame Relay PVCs or private leased lines to interconnect sites. Such services have some characteristics such as minimal Frame Delay, Frame Jitter and Frame Loss and no Service Multiplexing. ♦ Even though E-Line Service can be used to construct services similar to Frame Relay or private lines, the Ethernet bandwidth range and connectivity options is much greater in E-Line Services. ♦ E-LAN Service provides multipoint connectivity by connecting two or more UNIs. Each UNI is connected to a multipoint EVC. As new UNIs are added, they get connected to the same multipoint EVC, which simplifies provisioning and service activation. ♦ An E-LAN service can be used to create a broad range of services such as Private LAN and Virtual Private LAN services. ♦ An E-LAN service allows UNI to communicate with all other UNIs, whereas an E-Line Service requires separate EVCs to all UNIs. Therefore, an E-LAN Service can interconnect large number of sites with less complexity than point-to-point network technologies, such as Frame Relay or ATM. ♦ E-Line Service and E-LAN Services can provide symmetrical bandwidth for data sent in either direction, with no performance assurances. ♦ They also may provide a Committed Information Rate (CIR) and associated Committed Burst Size (CBS), Excess Information Rate (EIR) and associated Excess Burst Size (EBS) and delay, jitter, and loss performance assurances between two different speed UNIs.

Table 1e. Internet with the use of Virtual Private Network

VIRTUAL PRIVATE NETWORK (VPN)	
Definition	A VPN is a secure, private connection through a public network or otherwise unsecure environment. It is a private connection, because the encryption and tunneling protocols are used to ensure confidentiality and integrity of the data in transit. Today, the Internet has become an attractive way to interconnect remote sites as VPN technology enables organizations to create private networks over the public Internet infrastructure.
Advantages	♦ Healthcare organizations can use cost-effective, third party Internet transport to connect remote clinics and users to the main healthcare organization site. This eliminates expensive dedicated WAN links and modem banks. ♦ Data on a VPN is encrypted and undecipherable to anyone not entitled to it. ♦ Advance authentication protocols protect data from unauthorized access. ♦ Instead of using a dedicated Layer 2 connection, such as a leased line, a VPN uses virtual connections that bundle data and safely route it across the Internet. ♦ Healthcare organizations using VPNs benefit from increased flexibility and productivity since remote sites and clinicians can connect securely to the healthcare organization's network. ♦ VPNs use the Internet infrastructure within ISPs and carriers, making it easy for organizations to add new users. Organizations are able to add large amounts of capacity without adding significant infrastructure.
Disadvantages	♦ VPN tunnels are created using a number of different encapsulation protocols and not all protocols offer the same level of security. ♦ IPSec cannot transmit multicast/broadcast traffic; therefore, some routing protocols (EIGRP or OSPF) could not be transmitted in an IPSec tunnel making scalability of multiple site-to-site VPNs unmanageable. (Solution: Dynamic Multipoint VPNs)
Tunneling (Encapsulation) Protocols	♦ Generic Routing Encapsulation (GRE): provides a specific pathway across the shared WAN. Tunnels do not provide true confidentiality (like encryption does) but can carry encrypted traffic. ♦ IP Security (IPsec): acts at the Network Layer, protecting and authenticating IP packets between participating IPsec devices. IPsec is not bound to any specific encryption, authentication, security algorithms, or keying technology, it is a framework of open standards. ♦ Layer 2 Forwarding (L2F) Protocol: developed by Cisco that supports the creation of secure virtual private dialup networks over the Internet by tunneling Layer 2 frames. ♦ Point-to-Point Tunneling Protocol (PPTP): was developed by Microsoft, widely deployed in Windows client software to create VPNs across TCP/IP networks. ♦ Layer 2 Tunneling Protocol (L2TP): is an IETF standard that incorporates the best attributes of PPTP and L2F. L2TP is used to tunnel Point-Point Protocol (PPP) through a public network, such as the Internet, using IP.
Encryption Protocols	♦ Data Encryption Standard (DES): developed by IBM, DES uses a 56-bit key, ensuring high-performance encryption. DES is a symmetric key cryptosystem. ♦ Triple DES (3DES): a variant of DES that encrypts with one key, decrypts with a different key, and then encrypts one final time with another key. 3DES provides significantly more strength to the encryption process. ♦ Advanced Encryption Standard (AES): The National Institute of Standards and Technology (NIST) adopted AES to replace the existing DES encryption in cryptographic devices. AES provides stronger security than DES and is computationally more efficient than 3DES. ♦ Rivest, Shamir, and Adleman (RSA): an asymmetrical key cryptosystem.
Data Integrity and Authentication Algorithms/Methods	♦ Hashed Message Authentication Codes (HMAC): a data integrity algorithm that guarantees the integrity of the message using a hash value. There are two common HMAC algorithms: ▪ HMAC-Message Digest 5 (MD5): Uses a 128-bit shared secret key. ▪ HMAC-Secure Hash Algorithm 1 (SHA-1) - Uses a 160-bit secret key. HMAC-SHA-1 is considered cryptographically stronger than HMAC-MD5. It is recommended when slightly superior security is important. ♦ There are two peer authentication methods. ▪ Pre-shared key (PSK): The pre-shared key (PSK) authentication method uses a secret key that is shared between the two parties using a secure channel before it needs to be used. PSKs use symmetric key cryptographic algorithms. ▪ RSA signature: The RSA signature authentication method uses the exchange of digital certificates to authenticate the peers.
VPN Characteristics	♦ VPNs secure data by encapsulating or encrypting the data. Most VPNs can do both. Encapsulation is also referred to as tunneling. ♦ The sending and receiving ends must have the necessary hardware and software to set up an encrypted tunnel, which provides the private link. ♦ Tunneling encapsulates an entire packet within another packet and sends the new, composite packet over a network. Tunneling uses three classes of protocols: the passenger protocol, the encapsulating protocol, and the carrier protocol.

Appendix B: Comparison of the widely used WAN technologies.

Table 2. Comparison of WAN Technologies

WAN Type	Leased Line	Frame Relay	ATM	Metro Ethernet	Internet with VPN
General Information					
	point-to-point connection between two computers' LAN	connection-oriented, packet-switch method	connection-oriented, cell-switching method	LAN technology, commonly known as the CSMA/CD protocol	connectionless packet switching
Connection Types					
Typical Bit Rate	up to 45 Mbps (E3/T3)	offers data rates up to 4 Mbps	can support 622 Mbps and higher	Standard Ethernet speeds of supported, up to 500 Mbps	depends on service provider offerings
Remote Access	no	no	no	no	yes
Site-to-Site	yes	yes	yes	yes	yes
Persistence	yes	yes (PVC), no (SVC)	yes (PVC), no (SVC)	yes	yes (site-to-site VPN), no (remote-access VPN)
Virtual Circuits?	no	PVC, SVC	PVC, SVC	EVC	no
Carriers	T-carriers, especially T1 and T3	T1, fractional T1, or 56-Kb circuits	T1/E1 to OC-12	10BaseT, 100BaseT and 1000BaseSX.	depends on service provider offerings
Security					
SSL	no	no	no	no	yes
Encapsulation (Tunneling) protocols	HDLC, PPP	no	PVC provides PVP tunneling	Ethernet MAC Sub layer, through PPP	GRE, IPsec, L2F, PPTP, L2TP, DMVPN
Data Integrity	not checked	FCS in the frame	not checked	not checked	HMAC
Public/Private Infrastructure	private	both	both	both	both
Authentication protocols	PPP provides authentication through PAP and CHAP	no	no	EVC and UNI provides port authentication through Layer 2 Control Protocol	PSK, RSA signature
Encryption methods	no	no	no	no	DES, 3DES, AES, RSA
Performance					
Data Segmentation	variable-length LCP packets	variable-length packets	fixed cells of 53 bytes	An Ethernet frame's size depends on the MTU of the underlying network, max frame size is 1526 bytes	An IP datagram's size depends on the MTU of the underlying network
Overhead/Delay	5-9 bytes of header and variable-length data can increase overhead	the simplified handling of frames leads to reduced latency	low (5 bytes of overhead for each 48-byte payload)	Ethernet frame preamble sequences (8 bytes), frame headers (14 bytes) and acknowledge packets constitute the overhead.	TCP and IP headers each take up to 20 byes, which can increase overhead
Error Control	HDLC provides error control	cyclic redundancy check (CRC)	yes (in physical layer)	cyclic redundancy check (CRC)	checksum
Flow Control	HDLC provides flow control	FECN, BECN	yes (in the header)	through the use of a pause frame, generated by the receiving MAC	yes, sliding window method
Quality of Service (QoS)	yes	yes	yes	no	no
Fixed Bandwidth Availability	yes	no, the infrastructure is shared	yes	yes	no, the infrastructure is shared

Table 2. Comparison of WAN Technologies Continued

WAN Type	Leased Line	Frame Relay	ATM	Metro Ethernet	Internet with VPN
Performance	Performance	Performance			
Major advantage	most secure	highly efficient on the use of bandwidth	best for simultaneous use of video, voice and data	the service is provided over a standard, widely available and well-understood Ethernet interface	least expensive, globally available
Major disadvantage	most expensive	shared media across the link	overhead can be considerable (When the cell is carrying segmented packets)	limited to geographic scope	least secure, use of VPN security protocols can help
Flexibility	Flexibility	Flexibility			
Reproducible	no	yes	yes	yes	yes
Scalable	no	yes	yes	yes	yes
Location Dependant	no	no	no	no	yes
Cost	Cost	Cost			
Cost based on	distance, capacity	capacity	capacity	monthly subscription	monthly subscription
General Costs	most expensive (priced based on bandwidth required and distance between the two connected points)	based on the bandwidth usage	pay for use, bandwidth on demand	based on the bandwidth usage	least expensive
Complexity	Complexity	Complexity			
Min Hardware Requirements	CSU/DSU, DTE	DTE (customer-owned terminals, personal computers, routers, and bridges), DCE (service providers' switches), DCU/CSU	DSU, ATM switch, DTE for ATM interfaces	Ethernet switch, CE (all networking equipment connect to network using Ethernet)	VPN gateways (routers, firewalls, VPN concentrators and ASAs)
Protocols Required	PPP or HDLC	Frame Relay	ATM	Layer 2 Control Protocols (MAC Control Protocol, LACP, GARP, STP..)	TCP/IP
Compliance	Compliance	Compliance			
HIPAA	yes	no	no	no	yes

Early Stage Probabilistic Software Project Schedule Estimation

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Abstract

This paper proposes a framework for the objective and accurate estimation of software project schedules in the proposal preparation stage, while taking into account project uncertainty. The project size, resource effort, and the Project Delivery Rate (PDR) value are fundamental to the software project schedule estimation process, and such factors are calculated and determined by function point analysis and the equations and data repository of the International Software Benchmarking Standards Group (ISBSG). Project uncertainty is accounted for so that numerous possibilities may be explored. The framework provides a probabilistic approach by using the @RISK tool which is based on Program Evaluation Review Technique (PERT) analysis. This approach generates a schedule estimation *range*; this range is then narrowed by applying the Central Limit Theorem (CLT) to the Work Breakdown Structure (WBS) which reduces the overall uncertainty and increases the schedule accuracy. WBS Chart Pro is used to create the project Work Breakdown Structure, and Microsoft Project 2010 is used to determine the project critical path.

Keywords: Software Project Schedule Estimation, Function Point, Effort Estimation, Central Limit Theorem

1. INTRODUCTION

According to the Project Management body of Knowledge (PMBOK) (Project Management Institute, 2008), project management is driven by 9 knowledge areas and 42 processes, and it consists of the following 5 process groups: initiating, planning, executing, monitoring and controlling, and closing. Among these groups, planning accounts for 20 out of 42 total processes (approximately 48%) so that its role is very significant; that is, regardless of project type, a good project plan in vital since poor project planning can lead directly to project failure. The research (Project Management Solutions, Inc., 2012) shows that only 47% of information technology (IT) projects are completed successfully and 37% of IT projects are repaired or cancelled. One of the reasons that IT projects are cancelled is that they frequently go over schedule (Emam & Koru, 2008), so schedule estimation is critical within the planning process group.

While poor planning and estimation as well as unrealistic schedules and budgets can be associated with projects of any kind, these issues have been specifically mentioned as challenges for software projects (Hughes & Cotterell, 2009). Other issues discussed as

unique to software development projects include inadequate quality controls, a lack of understanding between clients and developers, the volatility of software requirements, and problems associated with using ontologies in the requirement elicitation stage (Hughes & Cotterell, 2009, Ogwueleka, 2012). The work in this paper focuses on the issues associated with respect to schedule estimation.

It is important to note that schedule estimation is necessary prior to the actual initiation of a project (Gido & Clements, 2009); in other words, contractors must estimate the project schedule to prove that they are able to complete a project within the given time frame required in the Request for Proposal (RFP). However, it is difficult to estimate the project schedule due to the fact that uncertainty is inherent is all types of projects (Xiao Liu et. al., 2009). Furthermore, such uncertainty results from the fact that contractors depend on high level Statement of Work (SOW), requirements and deliverables in the proposal preparation stage. It is especially difficult for software project managers to estimate accurate project schedules because they should consider a variety of factors such as project size, resource effort, and so on, and it is very hard to figure out such factors without the agreed design documentation. This lack of information injects uncertainty into the planning process, causing timetable deviations (a major cause of overall project schedule overruns), and a chance for project failure or cancellation (Emam & Koru, 2008, Tesch et. al., 2007).

Another important fact is that project risks originate from uncertainty, and managing such risks is critical (Project Management Institute, 2008). There are two kinds of risks: known and unknown and they are presented using the quadrant form in Figure 1 (Douglas & Ra, 2010, Dobson & Leemann, 2010).

The major objective of the "knowns unknowns" quadrant is to transform *unknown unknowns* into *known knowns*, *known unknowns*, or *unknown knowns*. For the framework proposed herein, the risk type is *known unknowns* because the process used to estimate activity durations is known, but the outcome is unknown. Although the outcome is unknown, a project manager can create outcomes with probability using risk management tools and techniques.

The probabilistic approach keeps all possibilities in mind so that emphasis is placed on generating a schedule range as opposed to producing a point estimation. This is done based on inferential statistics, which is the fundamental concept of the Central Limit Theorem (CLT) (Smith & Wells, 2006).

Therefore, the thrust of this paper is aimed at probabilistic software schedule estimation in the proposal preparation stage of the project life cycle rather than in the planning stage. We propose methodologies such as the CLT, PERT analysis, International Software Benchmarking Standards Group (ISBSG) equations, and function point calculation based on International Function Point User Group (IFPUG) as well as tools such as WBS chart pro, @RISK, and Microsoft Project 2010. The rest of the paper is organized as follows: Section 2 provides a brief literature review. Section 3 defines the schedule estimation methodology, and Section 4 demonstrates how to estimate a software project schedule within the proposed framework. Lastly, Section 5 provides conclusions and future work.

2. LITERATURE RESEARCH

In this section, we briefly discuss aspects of software project scheduling from the literature that are related to our research objectives.

Initially, it was necessary to find out which factors and processes are crucial to estimate software project schedules, and the literature defined the following software project estimation processes sequentially: 1) requirements collections, 2) product size estimation, 3) effort estimation, 4) schedule creation, 5) cost estimation, 6) estimation approval, 7) and product development (Nasir, 2006). Since our work is concerned only through step 4 (schedule creation), the main factors about which we will be concerned are size and effort.

Based on the above results, it is clear that methodologies used to estimate size needed to be examined. The research (Malik, 2010) introduced six major size estimation categories: 1) expert judgment, 2) analogy-based estimation, 3) group consensus estimation, 4) decomposition, 5) probabilistic methods which refer to PERT sizing, and 6) hybrids of the previous categories. The research also mentioned how to measure size in terms of two categories: Function Point Analysis (FPA) and

physical size measurement, the latter being related to Source Lines of Code (SLOC) (Malik, 2010).

Due to the fact that project uncertainty in the early stage is very high, we believe that probabilistic methods have great potential for solving the size estimation problem with respect to project scheduling. Additionally, as it is mentioned in Figure 1, a project manager is aware of estimating the project schedule which is known as a process, but the outcome of schedule estimation is unknown. For this reason, we focused on the probabilistic method which refers to PERT sizing based on FPA. Also, FPA was selected over SLOC because function points can be more readily and accurately measured in the requirements phase (Nassif et. al., 2010, Lind & Heldal, 2010). This point has an important meaning because we focus on schedule estimation in the proposal preparation stage with high level requirements.

The other factor that clearly needed to be examined within the literature was how to estimate effort. There are a variety of models to estimate effort: analogy-based effort estimation (Chiu & Huang, 2007, Kocaguneli et. al., 2012, Cherjee et. al., 2009, Basha & Dhavachevan, 2010), regression equations, COCOMO, and so on. (Basha & P., 2010, ISBSG, 2010). Among them, we selected to use the regression equations which were generated by data analysis of the ISBSG repository based on IFPUG FPs (ISBSG, 2010). This is due to the fact that they are the most suitable in the early estimation stage (ISBSG, 2010). Moreover, COCOMO models such as COCOMO 81 and COCOMO II mostly use Line of Code (LOC) instead of FP for effort estimation; although COCOMO II uses FP, it possibly causes error in effort estimation (Basha & Dhavachevan, 2010).

According to the literature research above, we determined that software size and resource effort are fundamental factors for schedule estimation, and FPA and the ISBSG regression equations are necessary methodologies to measure and calculate project size and resource effort. Yet, those factors and methodologies should be performed in the pre-bid stage because accurate pre-bid estimation leads to successful project completion and better project progress (Nasir, 2006). This point corresponds with our study objective to produce better project schedule estimates in the proposal stage.

3. SCHEDULE ESTIMATION METHODOLOGY

The proposed model for software project schedule estimation is depicted in Figure 2 (See Figure B1 in Appendix 2 for the enlarged version). This section will provide a step-by-step explanation of the methodology.

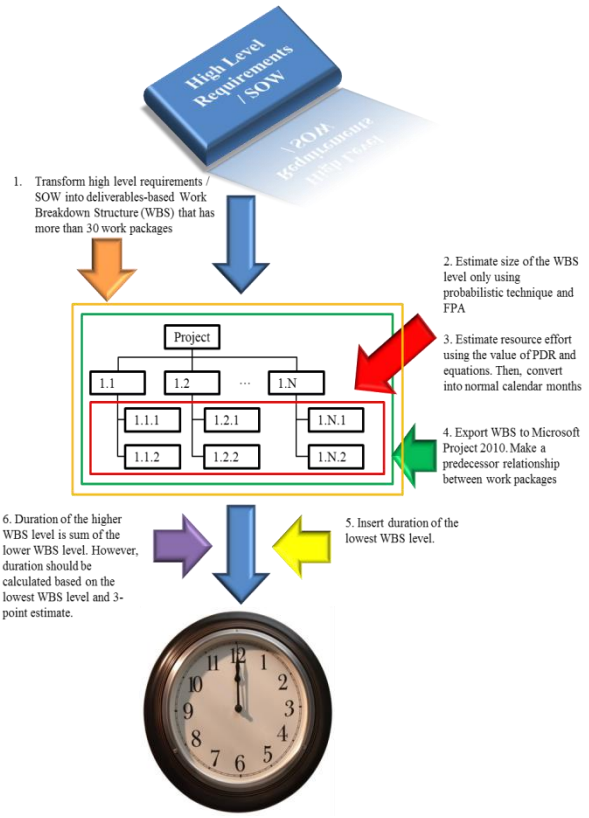

Figure 2 - Overall research model.

Size Estimation

Once the RFP is released, the first step towards schedule estimation is to identify and understand the stakeholder's requirements and to create a project Work Breakdown Structure (WBS) to represent the project scope. There are two kinds of WBS creation: phase-based and deliverables-based (Project Management Institute, 2008). For our purposes, deliverables-based WBS is more effective than phase-based because the major functionalities of the target system or application can be placed in the WBS level 2 and those functionalities have specific modules as work packages which can be placed in the WBS level 3. The research (Bottenfield, 2005) also defined that there are 2 types of WBS: product WBS and activity WBS. However, these basically map to deliverables-based WBS

and phase-based WBS, respectively. Since we follow the software functional size method of IFPUG, the deliverables-based WBS is needed so that we may apply function point analysis.

The functional size method uses five functional component types: External Inputs (EI), External Output (EO), External Inquiry (EQ), Internal Logical Files (ILF), and External Interface Files (EIF) (Cuadrado-Gallego et. al., 2010). Figure 3 depicts a deliverables-based WBS.

The second step is to count the function points of each WBS level. Our assumption is that each deliverable and work package follows the architecture as shown in Figure 4 so that a software project manager is able to count how many EIs, EOs, and EQs ILFs, EIFs are in each work package.

One thing to keep in mind is that since this estimation phase is performed in the proposal stage without design documentation to which all stakeholders agree, it is very difficult to figure out the exact number of EIs, EOs, EQs, ILFs, and EIFs (we assume a lack of historical records and experience for similar projects). For example, assume that a primary stakeholder wants to develop an online tire market and one of the functionalities is to search for tires. The number of EIs can be one if a tire is searched for by brand, but if a tire is searched for using brand, size, and vehicle model, the number of EIs is three. For this reason, the number of each EI, EO, EQ, ILF, and EIF should be measured in terms of a probabilistic technique (optimistic, most likely, and pessimistic), and then a software project manager is able to calculate Unadjusted Function Point (UFP) by the equations in the UFP calculation (Singhal & Srikrishna, 2008, Pressman, 2009).

However, there are two issues that complicate the size estimation. The first issue is size measurement at WBS level 2. The simplest way to calculate UFPs at WBS level 2 is for a software project manager to count the UFPs of the WBS level 3. However, we realized that this methodology may not make sense in some cases. For instance, assume that there is an employee management functionality that consists of 2 modules such as employee registration and employee deletion. The number of ILF relates to the number of database tables. Now, assume that both modules are performed using a single database table; thus, since both modules require only the same database table,

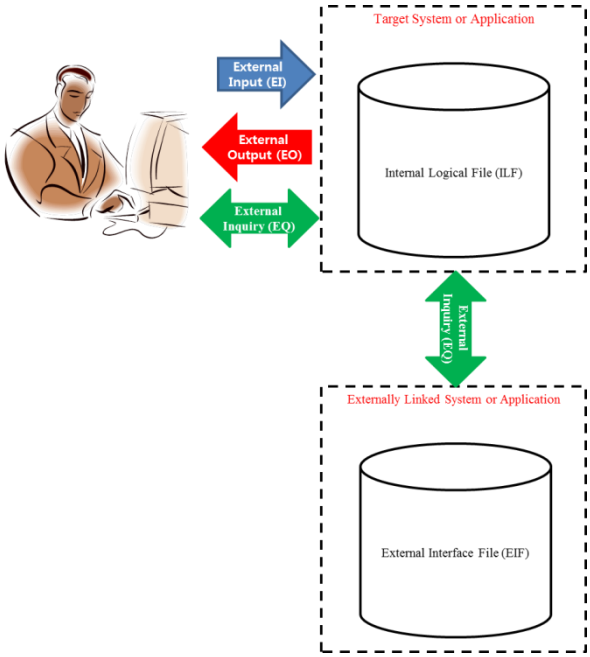

Figure 4 - Architecture of function point counting

the number of ILFs in the employee management functionality is 1, not 2. For more details, consider an example in terms of database Structured Query Language (SQL). If an employee table consists of 3 fields such as Social Security Number (SSN), first name, and last name, the SQL command of employee registration and deletion is as follows based on SQL command syntax.

1. Syntax of insert command
   A. INSERT INTO table_name (table column1, column2, …) VALUES (data, data);
2. SQL command for employee registration
   A. INSERT INTO Employee (SSN, first_name, last_name) VALUES (123456789, 'Sam', 'Smith');
3. Syntax of delete command
   A. DELETE FROM table_name WHERE condition
4. SQL command for employee deletion
   A. DELETE FROM Employee WHERE SSN=123456789;

From the above, it is easy to figure out that the same database table is used for both modules. As a result, it clearly points out that the sum of counted UFPs from WBS level 3 does not always work properly for WBS level 2.

The second issue is that while, theoretically, the equations in the UFP calculation are valid, the Expected Count value is a weighted average of a 3-point estimation, so it is considered as the mean value. The meaning of the mean value is a population mean that indicates only 50% of a probability distribution result, so it does not correspond to our final research objective that generates the range of schedule estimation with consideration of all possibilities based on inferential statistics. For example, suppose that the number of EIs, EOs, EQs, ILFs, and EIFs is as shown in Table 1.

Table 1 - Example number of functional component types

Category	3-Point Estimation		
	Op	ML	Pess
EI	8	10	13
EO	6	12	16
EQ	4	7	10
ILF	3	5	7
EIF	9	12	15

According to Table 1, each functional components type indicates a triangular distribution which is shown in Figure 5.

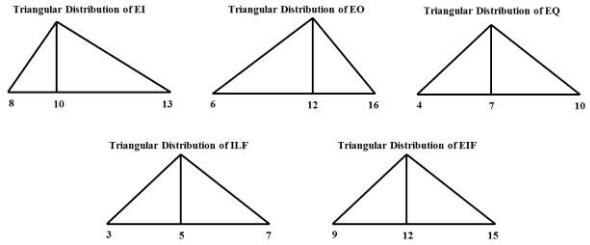

Figure 5 - Triangular distribution

There are many possibilities to pick any random numbers between the optimistic and pessimistic values of each functional component type; this relates to the Monte Carlo technique based on iterative simulations.

The key idea of using the Monte Carlo technique is that randomly chosen input values are used to transform the triangular distributions into normal probability distributions which will be calculated from the iterations (Project Management Institute, 2008). Therefore, it is required to simulate all cases hundreds or thousands times to calculate UFP for software size measurement.

In summary, the second step provides how to estimate project size using UFPs and requires the Monte Carlo technique for 3-point estimation which is based on triangular distribution.

Resource Effort Estimation

The third step of Figure 2 is to estimate the resource effort for each work package using the value of Project Delivery Rate (PDR). As it is mentioned in Sections 1 and 2, the ISBSG equations are used for effort estimation. The equations actually used in this paper are shown in ISBSG regression equations (See Table A1 in Appendix 1, ISBSG, 2010). However, there are two cases that could cause potentially cause a different PDR value.

The first case is that if all work packages are performed by one project team, the value of PDR is possibly the same because each of the work packages is able to have the same productivity rate. The second case is that if each work package is performed by different project teams, the PDR value could be different because a software project manager cannot expect same productivity from each different project team.

For this reason, we propose two solutions for determining the PDR value. The first solution is to find the appropriate fixed PDR value in the ISBSG data repository based on programming language and platform if a software project expects same productivity (ISBSG, 2010). The second solution (ISBSG, 2010) is to use the equation, $C*Size^{E1}*Maximum\ Team\ Size^{E2}$. The value of C, E1, and E2 should be found from the ISBSG data repository according to development type, platform, and programming language. The value of size is the calculated UFPs, and the maximum team size is the number of programmers who participate in a project. The selection of which method to use is up to the project manager based on the circumstances of the project.

Once the resource effort calculation is done, it must be converted into normal calendar months.

Export WBS to Microsoft Project 2010

The fourth, fifth, and sixth steps of Figure 2 involve exporting the created WBS to Microsoft Project 2010 and calculating the duration of the WBS level 2 by inserting durations of the WBS level 3 into the duration column. These steps are necessary due to the fact that since the sum of

counted UFPs from the WBS level 3 may not work properly for the size measurement of the WBS level 2 as mentioned earlier, it is not possible to directly calculate duration of the WBS level 2. That is, the duration of WBS level 2 definitely depends on the predecessor relationship between its work packages, so making the predecessor relationship of each work package should be conducted first through Microsoft Project 2010. Suppose that there are two modules as work packages in WBS level 3, and the duration of the first module and the second module is 1.5 months and 1 month, respectively. The duration of WBS level 2 can be 2.5 months or 1.5 months depending on the predecessor relationship of both modules; in other words, if both modules are on the critical path activities, the duration of WBS level 2 is 2.5 months. But if they are performed in parallel at the same time, the duration of WBS level 2 is 1.5 months because the first module has longer duration than the second module.

One final process is required before the duration estimate is finalized. Just as was done in the second step for *size*, a 3-point estimate should be used here for *duration*. To get the optimistic, most likely, and pessimistic duration for each work package, the UFP values from the second step that are associated with 25%, mean, and 75% probabilities, respectively, should be used. The Monte Carlo technique is also required to produce a normal probability distribution for the durations.

Comments on Applying the Concepts of the Sampling Distribution of the Mean and the Central Limit Theorem

It is important to note that the estimate of the final schedule uses two fundamental concepts: sampling distribution of the mean and the Central Limit Theorem (CLT). First of all, the key idea of the sampling distribution of the mean is that it has a mean μ and a standard deviation б/ $\sqrt{N}$ (N = sample size) if a population is given with mean μ and standard deviation б (Lane, 2007). Accordingly, the spread of the sampling distribution of the mean becomes narrower as long as the sample size increases (Lane, 2007). The main idea of the CLT comes from the concept of the sampling distribution of the mean. If the random samples are X1, X2, ⋯, Xn (n=sample size) with mean μ and variance $б^2$, the sample mean is:

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

(Thomas & Luk, 2008, Kim & Ra, 2011)

This means that as long as the sample size increases, the sampling distribution of the sample mean from random samples forms an approximate normal distribution no matter what the shape of the original distribution (Smith & Wells, 2006, Lane, 2007, Kim & Ra, 2011). Figures 6 and 7 graphically portray the idea of these two concepts.

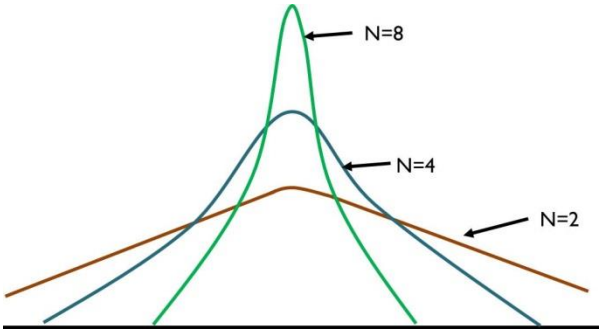

Figure 6 - The concept of the sampling distribution of the mean

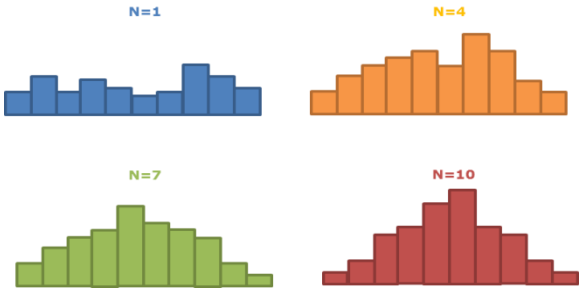

Figure 7 - The concept of the CLT

One important fact is that a sample size of more than 30 is required to generate the normal sampling distribution (Smith & Wells, 2006, Kim & Ra, 2011); based on this, we relate the number of work packages to the sample size. For this reason, the number of work packages should be more than 30 if a software project manager wants to apply the CLT to the project WBS.

To summarize this section, the idea is to have the WBS represent a detailed enough decomposition so that the number of work packages is greater than 30. This in turn generates a narrower normal distribution due to

the concepts of the sampling distribution of the mean and the CLT. Thus the estimation accuracy will be improved.

4. SIMULATION

In this section, we will use an inventory management software development project as an example to demonstrate the methodology; the demonstration will be explained step by step. This software is intended for large business, and it addresses the issue of management and tracking inventory. There are seven assumptions in this scenario. The first assumption is that all weight factors in the Unadjusted Function Point Calculation are "simple" (versus "average" or "complex"; See Table A1 in Appendix 1). The second assumption is that 3 programmers participate as a single team in the project and they perform the project with same project delivery rate (PDR). The third assumption is that project team members do not have historical records and experience of inventory system development so that they could compare an already developed inventory system which is currently available in the market to find out the number of EIs, EOs, EQs, ILFs, and EIFs. The fourth assumption is that the given timeframe is 30 months. The fifth assumption is that this project is based on multiplatform and uses the Java programming language. The sixth assumption is that all work packages are critical path activities, and the last assumption is to use 75% UFP value for calculating effort and duration.

The first step in this example is to transform the high level requirements into a deliverables-based WBS; the WBS of this project is presented in Figure 8 (See Figure B2 in Appendix 2 for the enlarged version). Note that since 30 work packages are placed in WBS level 3 it enables us to use the concept of the CLT, and further decomposition is not required.

The second step is to estimate the size of the lowest WBS level (WBS level 3) using FPA and the probabilistic technique. For each work package, the number of EIs, EOs, EQs, ILFs, and EIFs is counted in terms of a 3-point estimation, and then the *expected count* is calculated (see Table A1 in Appendix 1) (Pressman, 2009). Next, using the "simple" weighting factor (as per the first assumption above), the *sub total* for each function point is determined; then all the subtotals are summed to arrive at the *grand total* for each work package – this gives the

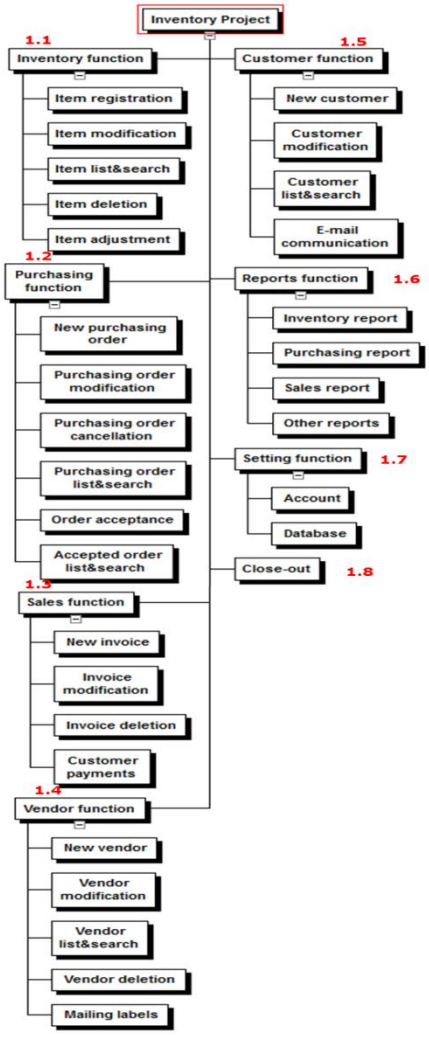

Figure 8 – Inventory Project WBS

expected size for each work package. The @RISK tool is then used to invoke the Monte Carlo technique by picking 1000 random numbers from the triangular distribution range (that is, between the pessimistic and optimistic values of the range), which produces a normal distribution. The value determined at the 75% probability range (see the "75% UFP" column in Table A4, Appendix 1) is used for the work package UFP.

The third step is to calculate the resource effort based on the ISBSG regression equations (see Table A2 in Appendix 1). Per Table A3 in Appendix 1, the fixed value of 8.1 is used as the PDR (based on a Java platform and the 75% column). Then, for each work package, PDR is

multiplied by the 75% UFP value calculated for the work package in step 2 – this produces effort in terms of hours. This value is converted into months per the "if team size is known" equation in Table A2 of Appendix 1 (the team size is 3 per the second assumption). The resulting durations for each work package are shown in the "Duration" column of Table A4 in Appendix 1. Note that these are the expected durations based on the pessimistic (75% value) UFP.
The fourth and fifth steps are to export the WBS to Project 2010 and to form the predecessor relationships between each work package. The calculated durations based on the three programmers are simply put in the WBS level 3 duration column.

As shown in Figure B3 in Appendix 2, the duration of WBS level 2 and the entire project (the sixth step) is calculated automatically based on the duration and the predecessor relationship of WBS level 3. The calculated duration of the entire project is 28 months.

However, as implied by the comment at the end of step 3, this total project duration is based on a single-point duration estimate for each work package using the pessimistic UFP value. To complete the sixth step, a 3-point estimate in conjunction with the Monte Carlo technique should be used to generate a normal probability distribution for the duration estimate (as was done with the *size* calculations in step 2).

To accomplish this, the 25%, mean, and 75% values for UFP from Table A4 in Appendix 1 are used to calculate optimistic, most likely, and pessimistic duration values, respectively, for each work package. The @RISK tool is then used again to provide a Monte Carlo simulation by picking 1000 random numbers in the optimistic to pessimistic range; this produces normal distributions for the work package durations, which can then be summed to produce a probabilistic estimate of the overall project duration. The final schedule estimate using WBS level 2 (a sample size of 7 work packages) is shown in Table 2; the final estimate at WBS level 3 (using all 30 work packages) is shown in Table 3. Note that the expected total duration reflected in both tables is less than the 28 months that was calculated based on the single-point estimate.

As an example of how to use the information in Tables 2 and 3, suppose a customer wants to know the chance of completing this project within 26.13 months. The project manager can see that the answer is either 40% (Table 3) or 45% (Table 2). Our claim is that the estimate information in Table 3 (based on more work packages) is more accurate. Indeed, the values in Table 2 may be suspect since the sample size is less than 30, thereby not ensuring a normal distribution due to the requirements of the CLT.

It is important to observe that the range of schedule estimation becomes narrower by applying the CLT in terms of inferential statistics. This is shown graphically in Figure 9. The taller, narrower schedule estimation range is produced when the 30 work packages (samples) from WBS level 3 are used, whereas the shorter, wider range is based on using only the 7 work packages reflected at WBS level 2.

Table 2 - Final schedule estimate of WBS level 2

Simulation Results		**Probability Range**	
Min Dur.	25.33	10%	25.81
Mean Dur.	26.16	15%	25.87
Max Dur.	26.94	20%	25.93
N/A		25%	25.99
		30%	26.02
		35%	26.06
		40%	26.10
		45%	26.13
		50%	26.17
		55%	26.20
		60%	26.24
		65%	26.27
		70%	26.30
		75%	26.33
		80%	26.40
		85%	26.43
		90%	26.50
		95%	26.61
		100%	26.94

Table 3 - Final schedule estimate of WBS level 3

The effectiveness of this framework can also be viewed as a method to assist with monitoring and controlling overall project performance. For instance, projects are usually seen as being constrained by the three main factors of scope, schedule, and cost (Gido & Clements, 2009); it is obvious that a change in one of these will impact the other two. Since our approach focuses on developing a more accurate schedule, the chance for budget or scope changes caused by schedule problems is significantly reduced.

Table 2 - Final schedule estimate of WBS level 2

Simulation Results		Probability Range	
Min Dur.	25.33	10%	25.81
Mean Dur.	26.16	15%	25.87
Max Dur.	26.94	20%	25.93
N/A		25%	25.99
		30%	26.02
		35%	26.06
		40%	26.10
		45%	26.13
		50%	26.17
		55%	26.20
		60%	26.24
		65%	26.27
		70%	26.30
		75%	26.33
		80%	26.40
		85%	26.43
		90%	26.50
		95%	26.61
		100%	26.94

Table 3 - Final schedule estimate of WBS level 3

Simulation Results		Probability Range	
Min Dur.	25.74	10%	25.98
Mean Dur.	26.16	15%	26.01
Max Dur.	26.6	20%	26.04
N/A		25%	26.06
		30%	26.09
		35%	26.11
		40%	26.13
		45%	26.14
		50%	26.16
		55%	26.18
		60%	26.20
		65%	26.22
		70%	26.24
		75%	26.27
		80%	26.28
		85%	26.31
		90%	26.34
		95%	26.38
		100%	26.60

5. CONCLUSION AND FUTURE WORK

The goal of this research was to develop a methodology to provide more accurate software project schedule estimates early in the project life cycle (perhaps in the proposal preparation stage).

This is a difficult task due to the uncertainty that exists in the early stages. A major contribution of this paper is the development of a framework for such estimates, and the demonstration that it is possible to generate greater probability accuracy by making the range of schedule

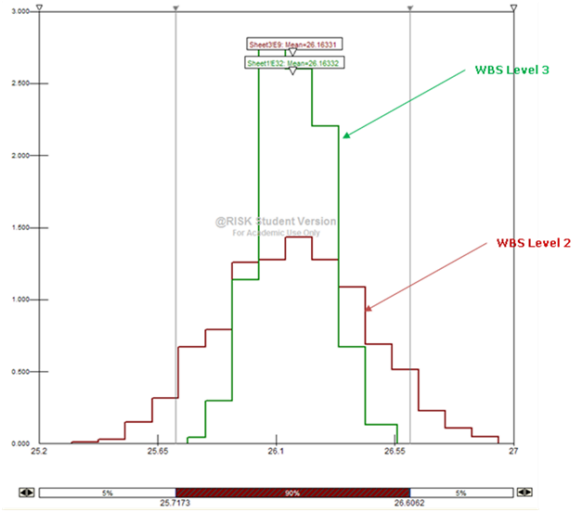

Figure 9 - Comparison analysis of the range of schedule estimation between WBS level 2 and level 3

estimation narrower using the CLT concept. We believe that probabilistic schedule estimation based on inferential statistics is able to assist in reducing project risks by taking into account the uncertainty associated with project schedules, especially in the early project stages.

Another contribution of this paper is that our framework is applicable to not only IT projects, but also projects of other types. While the methods used to estimate size and effort may vary with non-software development projects, the overall methodology can still be utilized. Further, the proposed method is not only useful for the initial schedule generation, but is equally applicable in any required re-estimation efforts to adjust the schedule in later stages of the project life cycle.

The use of the proposed estimation methodology was demonstrated on an example project. However, to more accurately examine the efficacy of the framework and to verify that it can be used to produce more accurate estimations, the methodology must be applied to real-world case studies. This will be an important next step.

Additionally, there are certainly improvements that should be considered for future work. First, redundancy in the work packages or modules must be taken into account while creating the project WBS. Further, schedule estimation should be conducted in the planning stage using actual design documentation when possible;

even further, size and resource requirements of previously performed similar efforts should be able to be used when available. Calculating Adjusted Function Points (AFPs) with the Value Adjustment Factor (VAF) should be also paired with schedule estimation in the planning stage.

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Appendix A

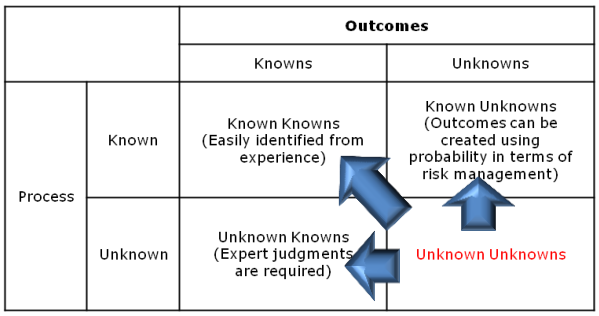


Figure 1 - Knowns and unknowns quadrant form

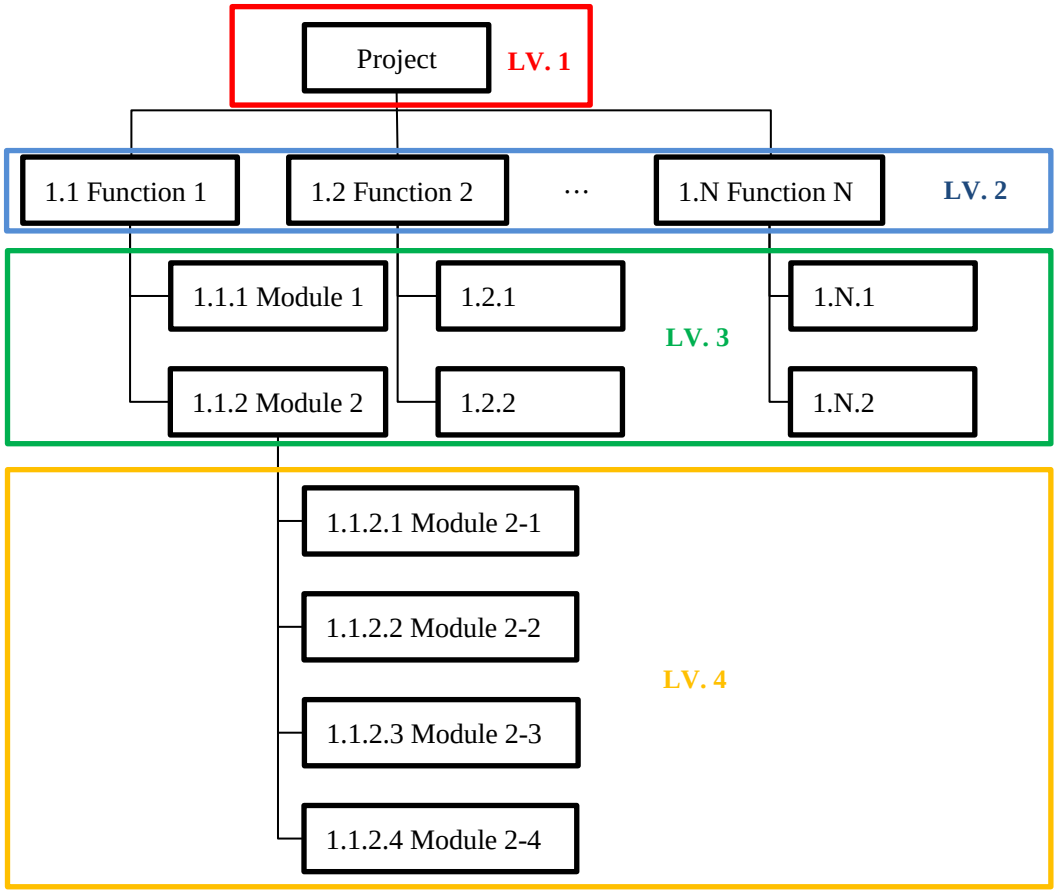


Figure 3 - Deliverables-based WBS

Appendix B

Table A1 - Unadjusted Function Point Calculation (Pressman, 2009)

Category	3-Point Estimation			Expected Count	Weight Factors			Sub Total
	OP	ML.	Pess.		Simple	Average	Complex	
EI	No.	No.	No.	{1*(Pess.)+4*(ML.)+1*(OP.)} / 6	3	4	6	(Expected Count) * (One of Weight Factors)
EO	No.	No.	No.	Same as above	4	5	7	Same as above
EQ	No.	No.	No.	Same as above	3	4	6	Same as above
ILF	No.	No.	No.	Same as above	7	10	15	Same as above
EIF	No.	No.	No.	Same as above	5	7	10	Same as above
Grand Total (UFP)								Sum of sub total

Table A2 – ISBSG Regression Equations (ISBSG, 2010)

Category		Equations	Values
Project Delivery Rate (PDR)		$C*Size^{E1}*Maximum\ Team\ Size^{E2.}$ OR the fixed value of PDR.	Number of hours per FP
Effort		PDR*UFP	Hours
Duration	If team size is known	(Effort / team size) / Number of hours worked per person per month	Calendar months
	If team size is unknown	$0.370*Effort^{0.328}$	

Table A3 – Project Delivery Rate based on Programming Language and Multi-Platform (ISBSG 2010)

	Minimum	10%	25%	50%	75%	90%	Maximum	Mean
ABAP	4.2	6.5	7.8	9.6	14.6	20.3	34.3	12.1
C	1.8	1.9	2.2	3.9	10.1	13	31.3	7.7
COBOL	3.4	4.7	8.3	20.3	37.8	43.2	49.1	22.8
C#	1.9	5.7	8	13.7	22.8	32.2	48.8	16.7
Java	3.1	5	5.7	6.4	8.1	11.8	17.1	7.4
Lotus Notes	1.5	1.9	2.9	3.7	5.1	7.8	11.9	4.5
PL/1	8	12.5	15.6	20.8	26.8	46.8	61.8	24.9
PL/SQL	0.8	1.4	1.7	4.2	6.7	10.7	14.3	5.1
Visual Basic	0.9	2.5	4.2	8.6	18.6	36.8	60.9	14.1
3rd Generation Language	4.8	7.8	10.9	17.3	22.7	30	38	17.8
4th Generation Language	3.6	6	7.8	8.7	12.5	19.2	35.7	11.3
5th Generation Language	6.5	8.8	11.5	17.2	22	25.1	31.8	17.4
Other	1.1	3.1	4.8	7.4	10.4	14.8	27.4	8.7

Table A4 - Simulation Results for Size Estimation and Pessimistic Duration of WBS Level 3

WP	Min UFP	25% UFP	Mean UFP	75% UFP	Max UFP	Effort (Hours)	Duration (Month)
1.1.1	40.07	55.33	59	62.46	73.42	506	1.0
1.1.2	47.76	61.39	65	68.79	83.15	557	1.1
1.1.3	31.47	45.96	50	54.07	67.12	438	0.8
1.1.4	31.47	45.96	50	54.07	67.12	438	0.8
1.1.5	28.55	40.90	44	47.10	57.07	382	0.7
1.2.1	50.5	61.87	65	68	77.75	551	1.0
1.2.2	57.33	70.14	74	77.68	91.83	629	1.2
1.2.3	37.14	44.38	47	49.53	58.11	401	0.8
1.2.4	22.76	31.57	34	36.45	46.63	295	0.6
1.2.5	22.76	31.57	34	36.45	46.63	295	0.6
1.2.6	22.76	31.57	34	36.45	46.63	295	0.6
1.3.1	93.95	110.94	115.67	120.37	136.72	975	1.8
1.3.2	64.82	83.03	89	94.66	112.12	767	1.5
1.3.3	22.76	31.57	34	36.45	46.63	295	0.6
1.3.4	54.55	63.39	66	68.49	76.15	555	1.1
1.4.1	81.7	95.61	100	104.57	119.22	847	1.6
1.4.2	62.83	81.22	88	94.42	113.96	765	1.4
1.4.3	23	35.81	40	44.19	56.84	358	0.7
1.4.4	20.12	28.42	31	33.66	42.31	273	0.5
1.4.5	22.81	35.88	40	43.97	58.09	356	0.7
1.5.1	80.71	90.90	94	97.13	106.94	787	1.5
1.5.2	84.69	98.21	102	105.53	115.94	855	1.6
1.5.3	24.62	37.68	43	48.04	65.36	389	0.7
1.5.4	26.19	37.04	42	46.64	61.47	378	0.7
1.6.1	23	35.81	40	44.19	56.84	358	0.7
1.6.2	22.49	31.30	34	36.74	45.03	298	0.6
1.6.3	35.83	43.42	46	48.49	55.75	393	0.7
1.6.4	20.12	28.42	31	33.66	42.31	273	0.5
1.7.1	54.51	73.10	80	86.95	107.64	704	1.3
1.7.2	22.49	31.30	34	36.74	45.03	298	0.6

Appendix 2

Figure B1 – Overall research model

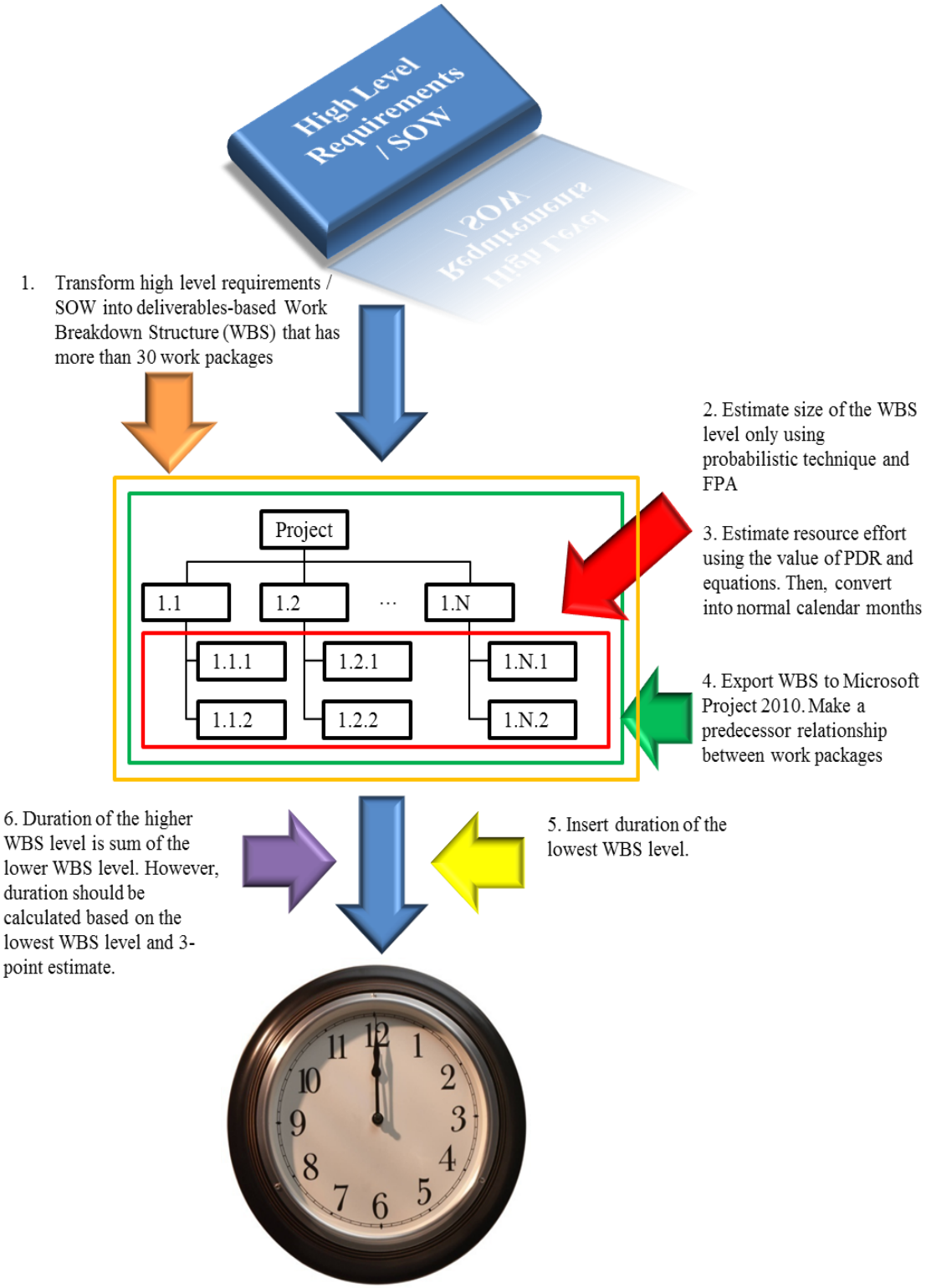


Figure B2 – Inventory project WBS

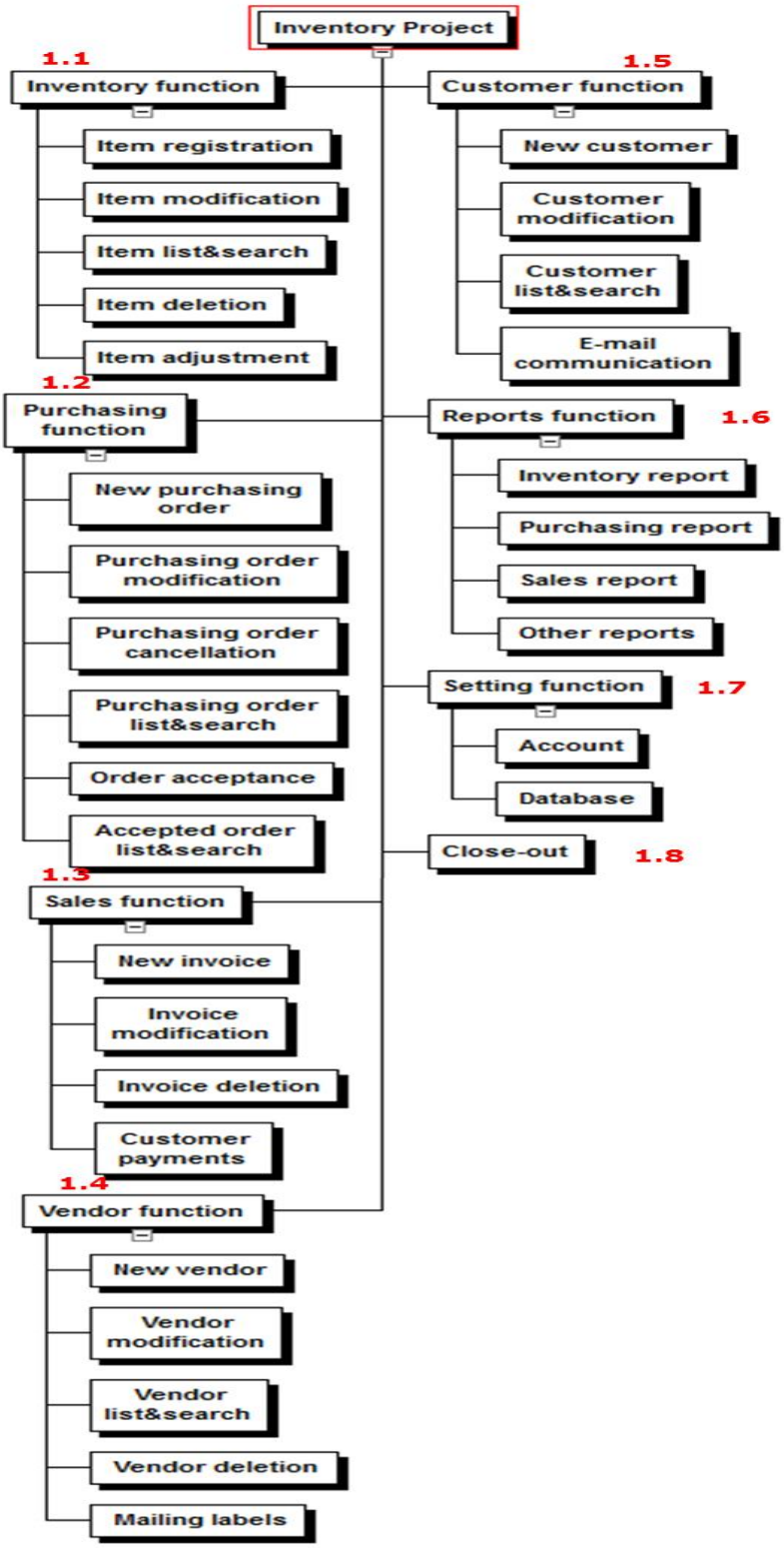
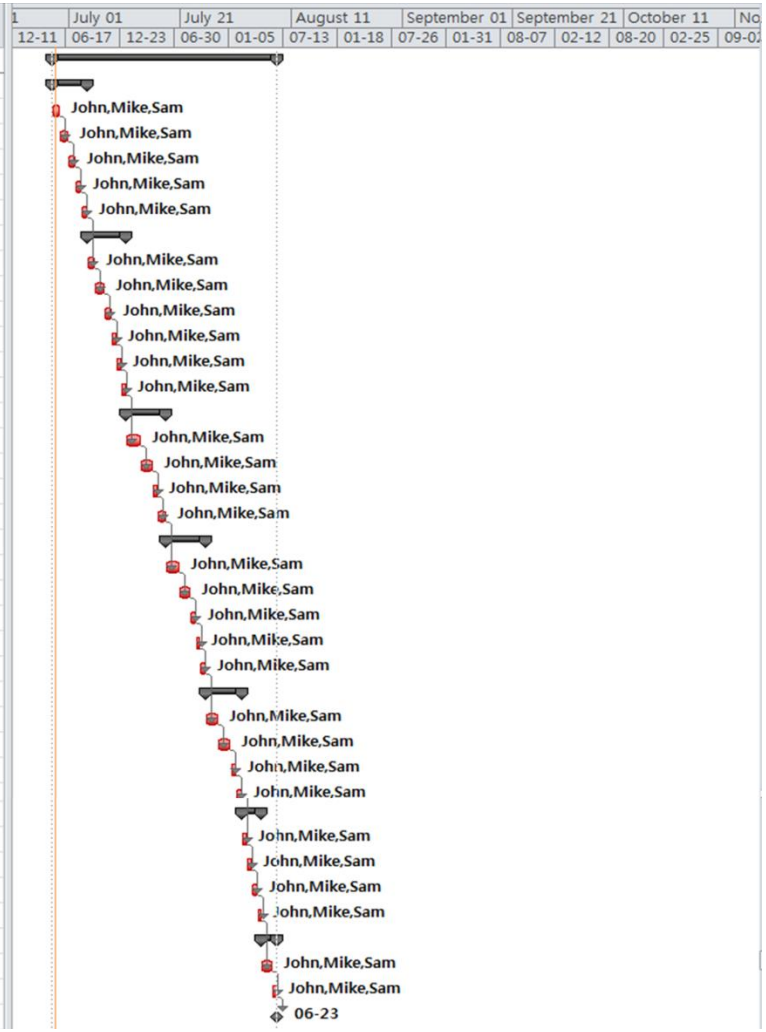


Figure B3 – Critical activities and duration of WBS level two & entire project

Task Name	Duration	Start	Finish	Predecessors	Resource Names
Inventory Project	**28 mons**	**2012-05-01**	**2014-06-23**		
Inventory function	**4.4 mons**	**2012-05-01**	**2012-08-30**		
Item registration	1 mon	2012-05-01	2012-05-28		John,Mike,Sam
Item modification	1.1 mons	2012-05-29	2012-06-27	3	John,Mike,Sam
Item list&search	0.8 mons	2012-06-28	2012-07-19	4	John,Mike,Sam
Item deletion	0.8 mons	2012-07-20	2012-08-10	5	John,Mike,Sam
Item adjustment	0.7 mons	2012-08-13	2012-08-30	6	John,Mike,Sam
Purchasing function	**4.8 mons**	**2012-08-31**	**2013-01-11**		
New purchasing order	1 mon	2012-08-31	2012-09-27	7	John,Mike,Sam
Purchasing order modification	1.2 mons	2012-09-28	2012-10-31	9	John,Mike,Sam
Purchasing order cancellation	0.8 mons	2012-11-01	2012-11-22	10	John,Mike,Sam
Purchasing order list&search	0.6 mons	2012-11-23	2012-12-10	11	John,Mike,Sam
Order acceptance	0.6 mons	2012-12-11	2012-12-26	12	John,Mike,Sam
Accepted order list&search	0.6 mons	2012-12-27	2013-01-11	13	John,Mike,Sam
Sales function	**5 mons**	**2013-01-14**	**2013-05-31**		
New invoice	1.8 mons	2013-01-14	2013-03-04	14	John,Mike,Sam
Invoice modification	1.5 mons	2013-03-05	2013-04-15	16	John,Mike,Sam
Invoice deletion	0.6 mons	2013-04-16	2013-05-01	17	John,Mike,Sam
Customer payments	1.1 mons	2013-05-02	2013-05-31	18	John,Mike,Sam
Vendor function	**4.9 mons**	**2013-06-03**	**2013-10-16**		
New vendor	1.6 mons	2013-06-03	2013-07-16	19	John,Mike,Sam
Vendor modification	1.4 mons	2013-07-17	2013-08-23	21	John,Mike,Sam
Vendor list&search	0.7 mons	2013-08-26	2013-09-12	22	John,Mike,Sam
Vendor deletion	0.5 mons	2013-09-13	2013-09-26	23	John,Mike,Sam
Mailing labels	0.7 mons	2013-09-27	2013-10-16	24	John,Mike,Sam
Customer function	**4.5 mons**	**2013-10-17**	**2014-02-19**		
New customer	1.5 mons	2013-10-17	2013-11-27	25	John,Mike,Sam
Customer modification	1.6 mons	2013-11-28	2014-01-10	27	John,Mike,Sam
Customer list&search	0.7 mons	2014-01-13	2014-01-30	28	John,Mike,Sam
E-mail communication	0.7 mons	2014-01-31	2014-02-19	29	John,Mike,Sam
Reports function	**2.5 mons**	**2014-02-20**	**2014-04-30**		
Inventory report	0.7 mons	2014-02-20	2014-03-11	30	John,Mike,Sam
Purchasing report	0.6 mons	2014-03-12	2014-03-27	32	John,Mike,Sam
Sales report	0.7 mons	2014-03-28	2014-04-16	33	John,Mike,Sam
Other reports	0.5 mons	2014-04-17	2014-04-30	34	John,Mike,Sam
Setting function	**1.9 mons**	**2014-05-01**	**2014-06-23**		
Account	1.3 mons	2014-05-01	2014-06-05	35	John,Mike,Sam
Database	0.6 mons	2014-06-06	2014-06-23	37	John,Mike,Sam
Close-out	0 mons	2014-06-23	2014-06-23	38	John,Mike,Sam



The Impact of Regulatory Changes on IS Strategy: An Exploratory Study

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Abstract

While a large number of papers have examined Information Systems Strategy and the various factors that impact it, there are a number of areas that have been largely overlooked. One of these is the role of government regulation on the planning and implementation of IS strategy. In this paper we present a preliminary examination of the impact of the regulatory environment on IS strategy and assert that meeting the demands of the regulatory requirements is a driver in an organization's IS strategy. This assertion is based on findings from multiple case studies performed in several industries. In addition, the study found that regulatory requirements can have both a direct and indirect effect on IS strategy.

Keywords: IS strategy, Regulatory Environment, Case Study

1. INTRODUCTION

As is the case in many advanced economies, the regulatory environment within the United States is in a near constant state of flux. Various regulations are passed annually, some of them focused on particular industries, such as FDA changes on testing drugs, while other have widespread impact, such as the Sarbanes-Oxley act of 2002 which required all publically traded firms in the United States to change their financial reporting, or face penalties including jail time. Regardless of the reach of the regulations, or the penalties associated with them, the organizations impacted by the regulations must make the necessary changes to their internal policies and procedures to ensure compliance.

Even if there are no changes in the regulations, it is possible an organization may have to meet additional regulatory requirements. For instance, if a company has gone through a merger or acquisition (M&A) recently, they may need to document compliance with regulations that they were not subject to prior to the merger or acquisition. This could be from extending their reach into a new market, or from simply expanding within their own market.

Regardless of the reason for meeting regulatory requirements, the necessity for compliance has a direct impact on the information systems of the

organization. Modern organizations rely extensively on their information systems to enforce policies, procedures, and to provide the data to prove that they are in fact following their documented policies (Drucker, 1992; Porter 1987; Mehta & Hirschheim, 2004).

These changes in regulations, or in the need for regulatory compliance, can come about without warning or planning. This fact can lead to problems for IS planners (Granderson, 1999). The IS strategy is supposed to be developed to support the business strategy, and while the businesses strategy may not be impacted by changes to regulations, the businesses could certainly be. If the business has a sudden need to document something new, it is likely that the information systems group will be involved in meeting this requirement.

The purpose of this study is to explore the impact that changes in the regulatory environment can have on IS strategy. As this is not an area that has been explored extensively, this research undertook multiple case studies to examine this question. The rest of the paper is organized as follows. Section 2 presents a review of the relevant literature in both information systems and management is undertaken. Section 3 discusses the case study methodology used in this research. Section 4 presents the data collected and an analysis of the case studies. Finally section 5 contains the conclusions and presents calls for future research.

2. LITERATURE REVIEW

In order to examine the impact of the regulatory environment on a firm's IS strategy we have to define what we are referring to when we mention IS strategy. IS strategy has traditionally been viewed as supporting the business strategy (see for example, Henderson and Venkatraman (1993)). To understand IS strategy, therefore, we must first define strategy from a broader business perspective. While strategy has been conceptualized in multiple ways (Ackoff, 1970; Barney, 1991; Mintzberg, 1987; Porter, 1996), for this paper we focus on Mintzberg's view of Strategy, as a shared organizational perspective on how to achieve organizational goals (Mintzberg, 1987).

Building on Mintzberg's (1987) perspective of business strategy, Chen et al (Chen, Mocker, Preston, & Teubner 2010 pg. 237) defined IS strategy as "an organizational perspective on the investment in, deployment, use and management of information systems" and conceptualized IS strategy in terms of the shared view of IS within the organization. This definition is intentionally broad to encompass not just the technology, but the people and processes related to the technology. This definition fits our need for examining the effect of regulation on the broader organizational information systems and not just the technology.

Based on the above definitions, when we use the term IS strategy and discuss the impact of regulation on IS strategy, we are referring to a broad concept. In discussing the impact of regulation on IS strategy we are indicating that regulation has an impact on the organizational use of IS including the investment, deployment and management of the information systems.

Research has also noted that aligning the IS strategy with the business goals is critical to creating value with IT investments (Grant, 2003). Lai and Chung (2002) note that even issues as seemingly simple as data communication must take the business environment into account when it comes to planning and implementing technology to support the business.

Regulatory Impact

There is some literature that has examined the impact of regulations on the operations of a business (Peterson, 2009; Swartz, 2005). While it is not necessarily in the area of Information Systems, the impact of regulation can certainly be noted within IS.

Banks (2005) noted that the Health Insurance Portability and Accountability Act (HIPAA) of 1996 has had an outsized impact on the operations of medical practices across the United States. The author also notes that the mandates from HIPAA still present challenges when it comes to the actual implementation, particularly for information systems. Thompson and Dean (2009) also note difficulties with IS in health care.

Research has also noted the impact of regulatory uncertainty on businesses. Engau and Hoffmann (2011) note that in the face of regulatory uncertainty, firms may engage in four different

strategies (avoidance, reduction, adaptation and disregard). In this instance, the paper specifically examined the impact of the Kyoto accords on carbon emissions for companies and how they adapt to these. However, many of the impacts from Kyoto would require companies to somehow track their carbon emissions. This would be done through information systems. Depending on the tack taken by the company, the impact on the IT organization could be unexpected. For instance, if the firm pursued a disregard strategy, and suddenly could no longer ignore the regulation, there would likely be a sudden demand for a system to track the carbon emissions, which would likely not be a system that was within the organization.

Indeed, in many cases with regulations, a system must be developed specifically to address the concern that exists because of the regulation. Santos et al (Santos, Alfonso, Mendizabal and Dayrit 2011) discuss the implementation of a chemical management system specifically to address a regulatory concern.

In terms of U.S. businesses, arguably the most significant example of the impact of regulation on IS is Sarbanes Oxley or SOX as it has become known. In the wake of several corporate scandals (e.g. Enron, MCI-Worldcom, and Tyco) SOX legislation was passed in 2002 requiring an increased level of assurance in the quality of corporate financial information. SOX mandates additional internal controls over corporate information to ensure the validity and accuracy of financial information reported both the government and the markets. SOX thus impacted the need for companies to track their financial information (Khatri and Brown 2010). While on the surface this seemed like accounting oriented legislation, it soon became evident that SOX would have a large impact on information systems because IS is the infrastructure for producing and storing this corporate accounting and financial information.

It is nearly impossible to successfully develop or audit internal controls and financial reports without understanding the computer-based information system (Cegielski, 2008). SOX thus increased the importance of controls over the accounting information systems and IT infrastructure (Walters, 2007), where management's responsibility for internal controls (Section 404 of SOX) and the accuracy of financial report information (Section 302) are explicitly identified. Given that the reliability of financial information is dependent on an organization's IT (Fox and Zonneveld, 2003), competence in IT is a requisite condition for SOX compliance (Walters, 2007). As stated by Chan (2004, pg 33), SOX compliance "requires an integrated evaluation of automated, IT-dependent, and manual controls in relation to each other".

Based on this literature review, we know that regulations impact companies, the question is do they plan for it and how does it impact them?

3. METHODOLOGY

Before introducing the methodology, some background information on this study is necessary. The authors became interested in this topic separately while working on different qualitative case studies. While undertaking extensive interviews with individuals involved in IT decision making at various companies, both authors noted that the individuals being interviewed would frequently note the impact of regulations on their operations within information systems. The authors followed up on these points during the interviews, which provided the basis for this study.

The authors used a multiple case study methodology for collecting data. Interviews were conducted with multiple individuals within multiple organizations in different industries. In all 29 people in 4 organizations were interviewed as part of this study. A complete list of the camouflaged companies and individuals interviewed can be found in Appendix A. In total, data was collected from four companies: Part Co, Motor Co, Manufacturing Co and Life Co. This methodology is well suited to exploring how and why questions in research (Yin, 1994). In each of the studies conducted, the authors utilized the best practices of data analysis, as exemplified in Dube and Pare (2003).

Each subject in this study was interviewed using a semi-structured interview guide at least once for a minimum of an hour. The interview guides used are presented in Appendix B. Interviews were recorded and transcribed to facilitate data analysis. Once the interviews were transcribed, the raw data was analyzed using well-established case study methods (Yin, 1994). Specifically, the data was examined and coded for occurrences of either changes in the regulatory environment and for impact of

regulation on the organization's information systems.

Several steps were taken to ensure reliability and validity. First, triangulation was used by using a semi-structured interview guide to elicit consistent information across multiple interviews at each cite (Yin, 1994). Second, multiple forms of data were collect when available, such as documentation or related web sites to confirm information from interviews. Third, based on the data analysis, a case write up for each company was conducted and validated by primary contacts at the case sites (Yin, 1994). Any discrepancies identified were resolved by re-analyzing related data and then resubmitting changes to the primary contacts to ensure the accuracy of the data.

4. RESULTS

What became clear during the data analysis of these cases was that the companies interviewed all had felt an impact on their IS strategy resulting from regulatory changes. What also became clear from the data was that these changes came in and, in some instances, radically reshuffled the strategic priorities for the IS group.

The first case study took place at Manufacturing Co. This company is a maker of a variety of home and building products in the mid-western United States. The company had followed a growth by acquisition strategy for a number of years, but had never integrated the systems of the various acquired companies. As a result, every one of the acquired companies had it's own accounting, sales, manufacturing and billing systems. The CIO noted one of the issues cased by this situation:
"You're also losing your customer competitive edge because now you're also forcing your customers to work at the … least common denominator of technology capability that you have".

This lead to numerous problems for the customers of Manufacturing Co, all of whom were also companies (Manufacturing Co did not sell directly to consumers). Specifically, if they placed an order for parts that were made by different entities within the corporate whole (i.e. from different companies that had been acquired over the years) there was no way to give the customer a single order number (as each sales system in the company would generate its own) and there was no way to coordinate shipping of the products, because the systems could not talk to one another. As one of the IT managers noted:
"It's all different brands and all different order management systems that require configurations…"

This situation created problems for the customers and for the company itself. From the customers' standpoint, it was a problem to track their orders and to pay for their orders, and it was impossible to ensure that the material they ordered would come at the right time. For Manufacturing Co, it was impossible to tell who their best customers were. Each customer existed in multiple sales systems, with no ties between the systems. It was also impossible to cross sell to customers because parts were listed in multiple stand alone systems, and the sales people couldn't see that every customer who purchased part A might also need parts B and C from different companies within the corporate whole.

To address the problems that this was causing for the business, Manufacturing Co decided that it needed to implement an Enterprise Resource Planning (ERP) system. This single system would tie together all of the different operating entities in the company, and would replace a patchwork of individual systems with a single stand-alone system. While this was designed to help the company as a whole, it would also be a boon for the IS department. The IS group would no longer be responsible for maintaining hundreds of different systems – rather they could maintain a single system, with a single customer master and a single parts list. The project was slated to take a number of years, but it was viewed as being an excellent investment and one that was critical for the overall corporate strategy of presenting a single face to the customer.

Despite the strategic and practical importance of the ERP initiative for the company, the entire plan was placed on hold not long after Sarbanes Oxley was passed. The company was suddenly much more concerned with meeting the new regulatory requirements, and so bumped the various compliance projects to the top of the list. As the CIO at Manufacturing Co noted:
"Sarbanes Oxley started … four years ago and just consumed so much time of everybody. And [the ERP project] just kept getting put off and put off and put off and put off."

The strategy for the company had not changed. The importance of presenting a single face to the customer had not changed. But suddenly, rather than being focused on the systems changes that were required for this, the IS group was scrambling to implement system changes to meet compliance with SOX. The irony of course is that implementing an ERP would have made compliance significantly easier as well as meeting all of the corporate strategic goals – but it would have taken too long.

Of course, even when regulations don't change, they can dictate the IT or business strategy for a company to a certain extent. The second company in the study was Life Co, a drug development firm in the mid-western United States. Life Co performs lab testing and delivers drug development and testing services to major pharmaceutical companies around the world. Some of these services can include "first in man" drug testing, as well as drug compound development. Because of the nature of their business, they are heavily regulated. As one IS manager at Life Co noted:
"And what ends up happening is we are a regulated life science company... The FDA would like to see everything documented and documents significantly to prove that not only that we did what we said we were gonna do but that in fact the subject that we said was there, was truly the subject that was there."

Thus, the moves made by the IS department were dictated as much by regulation as by the strategic goals of the company. Even though they were accustomed to operating within this environment, they encountered a new set of regulatory problems when they expanded their operations by buying another company in the same line of business. As one of the CIO noted:
"One of the problems that was introduced with [the acquired company] … because it was so close [geographically to Life Co] - was the fact that subjects would apply for studies … [at] both [acquisition] and [headquarters]… there's very specific [FDA] regs around doing clinical studies [for new drug compounds], as far as once you've done the study, there's got to be a washout period [to flush the drug compounds from the subjects systems]."

The problem that they encountered was that subjects would participate in a drug study at one location and then try to participate in a study at the second location. The regulations in place had not changed, but the company's expansion suddenly put them in a position where they needed to comply with a new regulation. This requirement forced them to come up with a systematic way of documenting for the FDA that they were, in fact, compliant with the applicable regulations. This was not a requirement that the company had every worried about meeting before, because they had never had to manage two drug testing facilities that were in close proximity to one another. As in the first example, the companies goals had not changed, but the regulatory environment forced the IS group to engage in a new project to meet regulatory requirements.

MotorCo presents another example of the impact of SOX on an organization. MotorCo is a subsidiary of a large multi-national corporation headquartered in the Midwest United Sates that makes a variety of electric motors. As a result of SOX, during 2002 MotorCo was tasked with making sure the processes and infrastructure was in place for the information systems to support SOX compliance.

This required substantial planning and effort on the part of the IT department to ensure the information systems could support the required audit trail for the information required to meet the SOX compliance standards. For example, corporate wide there were over forty different ERP systems and each one needed to be evaluated to ensure SOX could be complied with.

In another example, PartsCo a manufacturer of automobile parts engaged in merger activity related to changes in regulation. On December 21, 2000 the EPA signed federal regulations creating strict new standards for diesel engine emissions that began taking effect in 2007. As a result, PartsCo acquired a German company (GermCo) with expertise and proprietary technology related to diesel engine emissions.

Prior to the implementation of the new federal regulations, PartsCo produced a substantial portion of the emission systems for Chrysler, and when Chrysler was purchased by Daimler-Benz, PartsCo was concerned about maintaining the relationship. As a result, PartsCo purchased a minority stake in GermCo because GermCo had an established relationship with Daimler-Benz.

Use of diesel engines is much more prevalent in Europe and the minority stake in GermCo provided PartsCo with access to intellectual

capital and technology related to diesel engine emissions that would help them meet the EPAs new requirements. PartsCo thus purchased the remaining interest in GermCo to be the sole owner of the company.

In this situation, the IS didn't change directly to meet the needs of the regulatory requirements like MotorCo was required to. Instead the information systems were impacted indirectly in the need to assimilate the newly acquired company into the consolidated organization. Further, the IS infrastructure had to be put in place to ensure consolidated financial statements could be produced to meet annual and quarterly SEC requirements.

Limitations

As with all research, this study has limitations. First, a common limitation of all case studies is limited generalizability beyond the individual cases studied. As noted by Lee and Baskerville (2003), however, case study research generalizes via theory.

Second, only companies within the United States were used for this study. Both of these issues could limit how widely the results from this study can be applied directly to other situations. However, it seems reasonable that these findings would apply in other areas of the world as well. Anywhere the regulatory environment impacts the information that companies need to generate and store will likely see similar phenomena.

5. CONCLUSIONS AND FUTURE RESEARCH

From our analysis of the case studies, we conclude that the regulatory environment the company operates within impacts IS strategy in both a direct and indirect fashion. Some regulations, such as SOX, require firms to directly plan out changes to the information technology and processes to ensure compliance. In the case of SOX, companies had specific requirements for information that they need to track and the ways in which they need to report it. Because of the nature of financial reporting, this had a direct impact on the IS strategy as all of this information is tracked electronically. Thus, to be in compliance, the systems must track specific data, in a specific way for specific reports. This, of course, did not line up with the way that financial data was tracked at the majority of publicly traded firs, requiring changes to both policies and procedure – and the systems that supported them both.

SOX is interesting, in that it impacts all publically traded companies, rather than just those in a specific industry (such as drug development). However, this legislation is not unique – there are other legislative mandates (Health care as an example) that will likely impact all businesses within the US, and there could certainly be others internationally.

Other regulatory changes may also impact IS strategy but in a more indirect fashion, such as through the need to assimilate merger and acquisition activity for SEC or FDA compliance. In either case, the data also points to the fact that these regulatory changes impacted the pursuit of an IT strategy. In the case of Manufacturing Co, this was detrimental to the pursuit of a strategy specifically designed to solve a business problem. In the cases of Life Co and Motor Co, the resources they dedicated to solving the problems had to be taken from somewhere within the organization. As most organizations within the US currently run very lean operations, it is likely that this meant that projects elsewhere in the company were delayed.

While these problems are likely encountered on a regular basis by companies, little has been done to examine the actual impact. One stream of research for the future would be measuring the impact of regulatory changes on IS strategy in a more systematic way. This could include both case and survey methodologies to gather data from a wider sample and to more carefully measure the impact.

Another area for future research would be examining methods by which these impacts may be mitigated. Obviously, these changes cannot be predicted with any clarity, and are outside the control of the IT department. In addition, once the changes are made, there can be no question about meeting the new requirements. It's not optional – it's legally required. Thus, the question becomes what changes can be made to IS strategy, or possibly to IS departments, within the organization to make it easier to adapt to these external forces. What can be done to help IS departments keep regulatory changes from derailing their pursuit of an IS strategy?

It is possible that service oriented architectures (SOA) would help with this problem, as prior research has suggested that SOA can help IS departments be more flexible and efficient (Weigand, Jan van den Heuvel & Hiel 2011). Specifically, they note that SOA can help companies be more adaptive by allowing for more rapid changes in shifting markets. While this has not been examined in this specific context, it should also be examined in future research.

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Appendix A: Companies and Interviews

List of Interviews – PartCo	Tenure with Company
Senior V.P. and CIO	5
V.P. Information Technology	6
V.P. of Technology Infrastructure and Operations	6
V.P. Worldwide Operations	21
V.P. and G.M. CVE& Specialty Products	3.5
V.P. Truck & Industrial Products	25
Director, Technology Integration	15
Director of LVS Finance	14
Director of Program Management Office; LVS IT	20
Manager of Business Systems Solutions, North America	7

List of Interviews - MotorCo	Tenure with Company
V.P. of Information Technology	33
Director of Engineering Administration & Systems	20
Director of Information Technology	21
Director of Marketing and eBusiness	10
Director of Oracle Application Development	26
Director of eBusiness	8
eBusiness Leader	8
Director of Oracle Programming	15
Manager of Engineering Systems	19
I.T. Program Manager	7
Program Manager, Engineering/Configurator	11

List of Interviews - Manufacturing Co
Former Sector CIO
IT Relationship Manager
Manager - Production Systems

List of Interviews – Life Co.
VP for Information Systems
IT Project Manager
Business Analyst
Finance Project Manager
Business Relationship Manager

Appendix B: Interview Questions

As noted in the paper, the authors collected this data during two separate qualitative studies. Thus, two sets of questions are included below.

Guide 1:

1. Tell me about (*M&A Event*).
    a. What was the history of *(M&A Event)*?
    b. What type of M&A event was it? (*Handout*)
    c. What was the timeline of (*M&A Event*)?
    d. What was your role in *(M&A Event)*?
    e. When did it begin in (*M&A Event*)?

2. Thinking about (*M&A Event*), which was a (*merger of equals/acquisition*), what strategy or strategies were used to integrate the information systems after the merger?
    a. Strategies from literature.
3. You chose to use a (*unified/diverse*) approach for the information systems. Why did you choose to do it that way?
    a. What factors influenced the decision?
4. How were the systems integration projects structured after the merger?
    a. Was there a single, overall integration project?
    b. (*If yes to a*) Within this project, were there subprojects?
    c. If so, how were the systems grouped together?
        i. Was it by system type (*handout*)?
        ii. Geographic region?
        iii. Legal entity?
        iv. Other?
    d. (*If no to a*) Were there multiple systems projects?
    e. If so, how were the systems grouped together?
        i. Was it by system type (*handout*)?
        ii. Geographic region?
        iii. Legal entity?
        iv. Other?
5. Did this (*unified/diverse*) strategy for integrating the IS in the merger work well?
    a. Why would you say it did/did not work as well as hoped?
6. Did the systems projects undertaken for the merger go smoothly?
    a. Why would you say it did/did not work as well as hoped?
7. What were your lessons learned from this experience?
8. Before we finish, I wanted to talk about my understanding of some of the characteristics of the (*M&A event*).
    a. *Understanding of these factors will be based on the interview with the CIO*:
        i. The type of merger (*handout*)
        ii. The size of the organizations
        iii. The IT governance approach of the acquirer (*handout*)
        iv. The IT governance approach of the target (*handout*)
        v. The IT infrastructure of the acquirer (*handout*)
        vi. The IT infrastructure of the target (*handout*)
        vii. Other factors

Guide 2:

Semi-Structured Interview Guide

Interviewee: _____ Date: _____

Title: _____ Company: _____

Job Description/Area of Expertise: _____

1. Introduction
a. Explain Project
i. Background of Researcher(s)
ii. Project addresses IS alignment
1. Compares traditional alignment model with TAGA
2. Assess generalizability of TAGA
3. Developed the dimensions of external change
4. Examines the role of IS in enabling organizational adaptation
iii. Discuss Human Subjects Committee Form
1. All interviews are VOLUNTARY
2. All interviews are CONFIDENTIAL
3. Have interviewee sign and date form
4. Provide interviewee with copy
b. Interview Overview
i. This interview will ask questions related to IS alignment in your organization.
ii. Questions will address the alignment factors
1. External Environment
2. Management Decisions (data collection only)
3. Strategic Intent (goals)
4. Strategic Initiatives (means)
5. Organizational Structure
6. IS Strategy
7. IS Structure
iii. Interviewees will be asked to identify and describe change events in each of the alignment factors, including what triggered the changes and any relationships between the changes and other alignment factors.
iv. Interview should take 60 to 90 minutes.

2. Interview Questions

Phase I
Interview Data to Collect for Proposition 2
Degree of Formal IS Planning Process (H2) Answer
Is there a formal IS Planning Process? Yes No
Policies and procedures greatly influence the process of strategic information systems planning within our firm. (Segars and Grover 1999) 1….2….3….4….5

We utilize formalized planning techniques in our strategic information systems planning process. (Segars and Grover 1999) 1….2….3….4….5
Our process for strategic planning is very structured. (Segars and Grover 1999) 1….2….3….4….5
Written guidelines exist to structure strategic IS planning in our organization. (Segars and Grover 1999) 1….2….3….4….5
The process and outputs of strategic IS planning are formally documented. (Segars and Grover 1999) 1….2….3….4….5

Degree of Formal IS Strategy (H3) Answer
Is there a formal IS strategy? Yes No
Policies and procedures greatly influence the formulation of IS strategy within our firm. (adapted from Segars and Grover 1999) 1….2….3….4….5
We utilize a formalized process for developing our IS strategy. (adapted from Segars and Grover 1999) 1….2….3….4….5
Our process for developing our IS strategy is very structured. (adapted from Segars and Grover 1999) 1….2….3….4….5
Written guidelines exist to establish an IS strategy in our organization. (adapted from Segars and Grover 1999) 1….2….3….4….5
The IS strategy is formally documented. (adapted from Segars and Grover 1999) 1….2….3….4….5

List change events that have occurred in the last 10 years. (Important for all Phases)(A change event is defined as any change that resulted in a strategic or structural change to the organization)
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.

Complete for each change event listed

Describe the change event.

What caused the change (Trigger)?

Why was the change significant to the organization (impact)?

Did the change event impact other alignment factors? (Use back of page if additional space is needed)
Alignment Factor Impact on Factor
Management Event (for data collection purposes only)

Strategic Intent

Strategic Initiative

Organizational Structure

IS Strategy

IS Structure

Additional comments?