Enhancing Executive Decision Making in IT Governance via Adaptive Visualization

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ABSTRACT

Information technology (IT) not only has a huge impact on the way businesses operate but also can create strategic advantages to the businesses. Board and executives (from now on will be referred as executives) realize that information and technology that support it represent their enterprises' most valuable assets but unfortunately often least understood by them. The need for assurance about the value of IT, the management of IT-related risks and increased requirements for control over information are now realized. IT governance is undoubtedly a requirement in the modern world of business computing. Executives understand and accept that IT governance is their responsibility. There are numerous best practice frameworks which provide guidance to implement IT governance. However, these frameworks contain only textual guideline but not how IT governance information should be presented in order to aid executives' decision making in IT governance. Even though COBIT is considered one of the most widely accepted IT governance frameworks, it also faces the same drawback just mentioned. This paper explores COBIT and the area of enhancing information representation using visualization to reduce cognitive load and increase executives' understanding of IT governance information. This paper proposes the model of adaptive visualization to enhance executive decision making in IT governance. This model encourages interaction between executives and IT governance data providers as well as proactive IT governance practice. It also offers personalization capability to fit user profile and preference.

Keyword: IT Governance, Executive, Adaptive Visualization

I. Introduction

Information technology (IT) not only has a huge impact on the way businesses operate but also can create strategic advantages to the businesses. Over the years, information technology (IT) has increased importance to organizations. The result was reflected on the overall global IT spending which had reached $3.4 trillion in 2008 alone (Van Hoy, Biscotti, Hahn, Hale, & Low, 2009). The IT spending of each organization is in fact must be responsible by board and executives (from now on will be referred as executives) of that organization. Executives realize that information and technology that support it represent their enterprises' most valuable assets but unfortunately often least understood by them. The need for assurance about the value of IT, the management of IT-related risks and increased requirements for control over information are now realized. However, IT management complexity, technology dependency and cost are few of many reasons that inhibit efficient IT management. This is resulting in frequent failure of IT implementations; in which, they are unable to meet expected contributions (Applegate, Austin, & Soule, 2009). IT governance is undoubtedly a requirement in the modern world of business computing. Executives understand and accept that IT governance is their responsibility. There are numerous best practice frameworks which provide guidance to implement IT governance. However, these frameworks contain only textual guideline but not how IT governance information should be presented in order to aid executives' decision making in IT governance. Even though COBIT is a considered one of the most widely accepted IT governance frameworks, it also faces the same drawback just mentioned. This paper explores COBIT and the area of enhancing information representation using visualization to reduce cognitive load and increase executives' understanding of IT governance information. It proposes the model of adaptive visualization to enhance executive decision making in IT governance. This model encourages interaction between executives and IT governance data providers as well as proactive IT governance practice. It also offers personalization capability to fit user profile and preference.

II. Background

IT governance is a concept to ensure organization IT to deliver value. Effective IT governance would result in successful IT operations (Bernroider, 2008; Hardy, 2006; Weill & Broadbent, 1998; Weill & Ross, 2004). Overall corporate governance concerns on ensuring all business resources usage are effective by constant performance measuring, monitoring, directing and controlling (Applegate et al., 2009; Lainhart, 2000). Governance practices also provide necessary assurance and guidance to business to guarantee the objectives. In order to achieve this, executions of governance practices need authority to do so. Thus, governance is responsibility of executives (Applegate et al., 2009; Lainhart, 2000). IT governance is a part of corporate governance to direct IT operations and ensure the alignment with organizational strategies and objectives (ITGI, 2003).

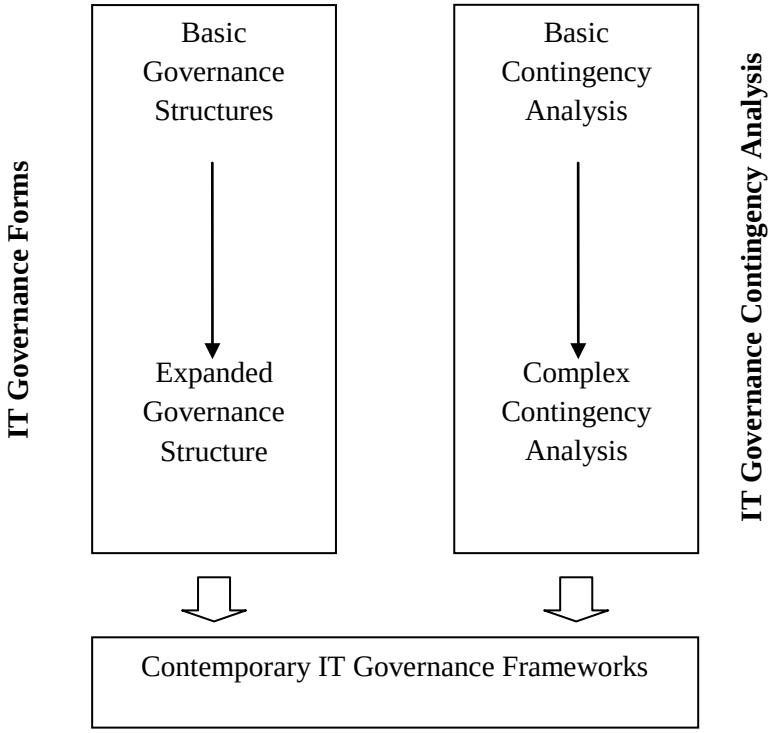
COBIT (Control Objectives for Information and related Technology) is one of the most widely accepted IT governance frameworks. COBIT is developed by ITGI (IT Governance

Institute) based on best practices. ITGI is a not-for-profit organization that leads global business community in IT governance. COBIT provides guiding framework of how each area should be done, as processes. COBIT document does not give explicit details on the IT governance and leave it to the practitioner to decide.

Researches in IT Governance

Current IT governance research focuses on IT-related decision right and location of control power (Brown & Grant, 2005). The two main sub-areas of this topic were described by Brown & Grant (2005). First, the "IT governance forms" concerns with the structure of decision-making process. Second, the "IT governance contingency analysis" concentrates on understanding how the structure fits the organization. This is done by extensive analysis of why firm picked a particular framework and see the governance performance of the firm. The two research areas are developed in parallel as illustrated in Figure 1.

Figure 1: Conceptual Framework for IT Governance Research (Brown & Grant, 2005)



Nevertheless, most IT governance literature is focused at the organizational or inter-organizational level on the firm behavior. The focus on the governance processes and tools themselves are limited and challenging.

COBIT Framework Analysis

COBIT had divided IT governance concept into five key areas that firms need to govern IT (Hardy, 2006; Webb, Pollard, & Ridley, 2006). Those areas are;

1. Strategic alignment: to align IT strategies to the business strategies
2. Value delivery: using IT to add value to the firm thus creating competitive advantages

3. Risk management: to identify and address IT-related risks of the firm
4. Resource management: to manage required and sufficient resource to create and operate IT
5. Performance management: to measure and monitor IT performance to ensure proper alignment

In order to achieve effective and address all five areas, IT governance practices need involvement from many stakeholders inside and outside organizations. Each group of stakeholder needs to perform different roles and COBIT provides different set of products and publications that fit the group as shown in Table 1.

Table 1: Cobit Product Matrix by Audience (Adapted from ITGI (200X))

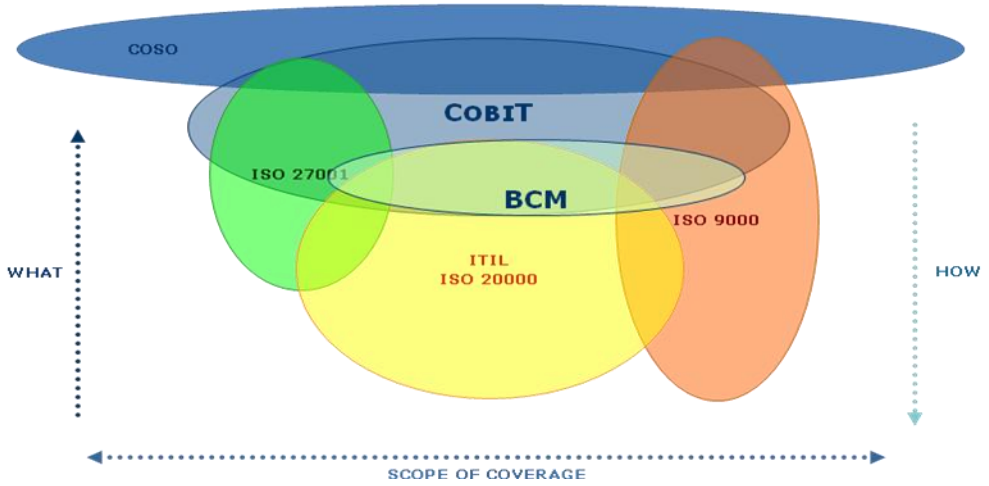
COBIT Product Matrix Main Audience(s) — Publications	C-suite	IT Management	IT Professionals	Assurance	Security	Governance	Academics
1) *Board Briefing on IT Governance, 2nd Edition*	✓	✓				✓	
2) *Information Security Governance: Guidance for Boards of Directors and Executive Management*	✓	✓			✓	✓	
3) COBIT 4.1		✓	✓	✓		✓	✓
4) *IT Governance Implementation Guide: Using COBIT and Val IT, 2nd Edition*		✓	✓	✓		✓	
5) *COBIT Control Practices: Guidance to Achieve Control Objectives for Successful IT Governance, 2nd Edition*		✓	✓	✓		✓	
6) *IT Assurance Guide: Using COBIT* (based on Assurance Testing Steps)		✓		✓			
7) *COBIT Quickstart, 2nd Edition*		✓	✓	✓		✓	
8) *COBIT Security Baseline, 2nd Edition*	✓	✓	✓		✓		
9) Val IT (all volumes in the *Enterprise Value: Governance of IT Investments* series)	✓	✓				✓	✓
10) *Unlocking Value: An Executive Primer on the Critical Role of IT Governance*	✓	✓	✓	✓	✓	✓	
11) *IT Control Objectives for Sarbanes-Oxley, 2nd Edition*		✓	✓	✓	✓	✓	✓
12) *IT Control Objectives for Basel II*		✓	✓	✓	✓	✓	✓
13) *Aligning COBIT 4.1, ITIL v3 and ISO/IEC 27002 for Business Benefit*		✓	✓	✓	✓	✓	
14) *COBIT User Guide for Service Managers*		✓	✓			✓	
15) *Guide to Managing and Controlling Application Controls Using COBIT*		✓	✓	✓	✓	✓	
16) COBIT Mapping Series (detail)		✓	✓	✓	✓		

There are five COBIT publications intended for executives or C-suite as shown in Table 1. “Board Briefing on IT Governance” is the fundamental document addressing IT governance concepts. This comprehensive guide aims not only to explain but also provide basic tools to aid executive to setup and operate IT governance practices in their organization. The tools are included checklist, executive question sets and templates. The “Information Security Governance: Guidance for Boards of Directors and Executive Management” and “COBIT Security Baseline” explain information security concepts in business language to inform responsibility and create awareness at executive level. The “Val IT” and “Unlocking Value: An Executive Primer on the Critical Role of IT Governance” intend to help executives in realizing and sustaining value from IT. All 5 COBIT executive publications are high level descriptive guidelines.

Apart from those five COBIT publications, other COBIT main publication including COBIT 4.1 itself which includes guide for policy and procedure development. It is emphasized on compliance and business-IT alignment. COBIT also provides simple implementation guide which is a roadmap and tool kit to implement IT governance. All COBIT products represent high level framework guideline to create, maintain, sustain IT practices by the act of governance.

The intention of COBIT framework is to give high level guidance but not the exact details of how-to (ITGI, 2003). Thus, COBIT is usually used with other frameworks to serve total need of the organization. COBIT is fully aligned with COSO's internal control framework which is the de facto standard for corporate governance. COBIT provides control objectives to IT governance which aligned with ITIL/ISO20000 in IT management, ISO/IEC27001 in IT security management and ISO9000 series in procedural standards. The concept of business continuity management is also largely integrated with COBIT principles. COBIT also provides detail mapping between various IT frameworks in term of IT processes, information criteria and IT resources (COBIT Mapping documents) as shown in Figure 2.

Figure 2: Scope of Frameworks (Beveridge, 2007)



Current State of IT Governance Practices at Executive Level

A recent survey on IT governance had found IT governance success largely depend on top level executive participation (PricewaterhouseCoopers, 2008). However, top level executives have perception that IT governance is IT executive job (CIO and similar) (PricewaterhouseCoopers, 2008). The same survey also mentions about large IT alignment as well as communication gaps between IT and business. Another research is done earlier to confirm IT governance critical success factors and the top two factors include executive commitment and communication issue (PricewaterhouseCoopers, 2006). This research is done prior to the survey thus showing the two issues are still crucial.

IT Governance from Executives' Point of View

In order to understand insufficient participation of non-IT executives, we proposed a systematic view of executive in managing firms' IT. System theory in management refers to

the work of Forrester (1994) which model entire organization into interconnected systems. Mental models refer to human-constructed image representing the mechanics of how the world works (Senge, 1990). Executives are at the top of organizations and they are likely to see things in holistic view. Executive may see the organization as interaction system between firm's resources and the environment. The interaction may consume and produce information where executive will use to interact with the system.

IT governance scopes down to the practices relate to certain resource and information. IT governance may be one of many important management practices they have to address. IT governance communication must be able to grasp sufficient attention to executive as needed. For instance, executive may monitor and sense for organizational issues by executive information system. Thus, important IT-related issue must be able to draw sufficient attention from executive when needed. This is not to compete with issues from other areas but the system design must have proper way to prioritize and display the relevant information.

In order to improve communication to executives, it is required to understand their perception and thinking process in IT governance practice. However, these challenges are not addressed by COBIT framework. IT complexity, fast-paced business environment and requirement for quality participation are combined to complicate the situation for executives. IT governance practices can be improved if proper tools are presented to reduce difficulty of the situation. The next section will discussed the concept of visualization and how it can improve this situation by enhancing capability of executives' mental model.

Information Visualization in IT Governance

Information visualization refers to a concept that use visual (graphic) to reduce the load of human brain (Zhang, 1998). In managerial task, the related data and information may be in a great volume. Appropriate visualization will be able to represent large amount of data, and its dimensions, in a visual form. It may not intend to give exact accuracy but to synthesis the data to see them as a whole (Zhang, 1998). This concept matches with executive responsibility in IT governance.

IT governance practices compose of various decision tasks involving large dimension of data. Decision tasks could be simple and straightforward or complex without obvious answers. For instance, COBIT framework highlights on objective alignment of the IT with business as the origin of IT success. Decision tasks in IT alignment area often involve multi-dimensional information. The uses of proper information representation give direct effect on decision process quality (Vessey & Galletta, 1991). Thus, it would be possible to create visualization to aid these decision tasks. Visualizations may help executives to get better insight from the information. Thus, allowing them to better understand. These factors are initial requirement to increase their involvement and participation (Jarvenpaa & Ives, 1991).

There are evidences of modern information visualization usage in IT governance area with success (Bellone, Basquiat, & Rodriguez, 2008). Despite this fact, past literature had shown limited number of visualization research in IT governance.

The next sections will discuss about theoretical background for information visualization and design framework.

Information Visualization Theoretical Background

Advanced technology and innovation allow people to create various kinds of information representation utilizing computer graphic. The branch of information visualization is not new and constantly progressing due to the technology. New technologies enable us to explore new kind of visualization, for instance, hologram, interactive chart, etc.

Information visualization has been developed extensively in physical science yet the field still needs tremendous study (Johnson et al., 2006). The research of visualization in business context also follows the same trend (Tegarden, 1999). As tools become more sophisticated, practitioners as well as researchers are using more variety of visualization and need further analysis.

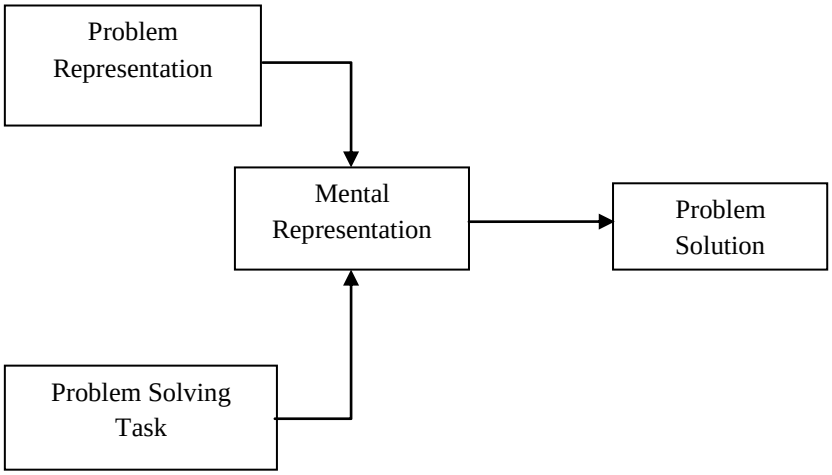
The field of information visualization is multidisciplinary by nature. The related disciplines include graphics, statistical modeling, cognitive science, data theories and many others. Theories in visualization are proposed in many levels. In order to propose a design framework, we proposed an integrated theory of cognitive fit (Vessey, 1991).

Cognitive fit theory proposed the human problem solving model to include many factors to represent in human brain. The central element is the mental representation of the overall process while constructing components are problem representation and problem solving task. Another component is problem solving skill which is problem solver dependent. The mental representation resembles mental model from system theory. This mental representation will be in human working memory when making decision. The outcome of the model is the solution to problem (Vessey, 1991).

The theory states that, if there are information representation fits occurs in those factors, it would result in higher performance to the task (Vessey, 1991). Main argument of this theory relies on psychology literature that human make decision as processes but may use different processes in different tasks (Vessey, 1991). Fitness refers to how well the problem solving elements match problem solving process. If problem representation matches the task, it will lead the problem solvers to use similar problem solving processes. If one can represent the problem in familiar way, the problem solver will not need to transform the mental representation to fit their usual problem solving process for the specific task. Thus, cognitive load of problem solver would reduce and resulting in higher performance in problem solving.

This theory applies directly to visualization concept. Proper information representation in each element is positively related to decision performance, having the problem representation fit as the strongest link (Vessey, 1991). The fit is named “cognitive fit”. The basic model of this theory is shown in Figure 3.

Figure 3: General Problem Solving Model (Vessey, 1991)



There are numerous empirical works supporting cognitive fit theory. The literatures had shown theory application in many contexts, starting with the original paper which compares basic information representation model between table and graph (Vessey, 1991) and also about information retrieval (Vessey & Galletta, 1991). More recent studies had further extended in geographical information system context (Dennis & Carte, 1998), expertise management system (Huang et al., 2006) and software management (Shaft & Vessey, 2006).

The cognitive fit theory is a respectable theory to use for information representation performance testing. This research proposes the use of this theory in IT governance visualization context. The next section will demonstrate the development of an executive question which aligns with cognitive fit theory and COBIT.

III. Research Framework

If we further consider into the Board Briefing document, the framework only gives descriptive information of executive responsibilities and practices. The list of activities includes asking questions and making decisions. There is a list of executive questions which help executive to focus. Thus, IT governance practice assumes board requirement to sufficiently understand the answers to those questions to make wise decisions. We will select just one executive question, as an example, to explain our research framework of enhancing executive decision making in IT governance via adaptive visualization.

Considering the question, “How well enterprise and IT portfolio align their objective?”, this is a straightforward question but not simple to answer. It is required matching between business strategy plan and IT strategy plan. The required information is ranged from highly business-oriented to more technical. This specific question requires executives to comprehend the information. In addition, it is normal for business strategy as well as technology to change in short time period (Applegate et al., 2009). This is one of the questions that required more than business knowledge to understand and realize value of each alternative. The initial analysis shows some of these questions which non-IT executives need to make IT decisions. One may argue that non-IT executives do not need technical

knowledge; however, the literature shows the opposite (Jarvenpaa & Ives, 1991; Teo & Ang, 1999).

Cognitive Fit Theory

This question can be framed using cognitive fit theory. This executive question can be considered as a decision task; thus, it can be mapped into the cognitive fit model.

1. Problem Solving Task Characteristics

According to COBIT framework, information relates to solve this problem usually involve investigation IT strategic plan as well as business strategies and priorities. COBIT had provided control objective and process guideline to develop IT strategy plan that ensure proper alignment in their PO1 process. COBIT had proposed three KPIs to demonstrate objective alignment, portfolio alignment and the delay of updates.

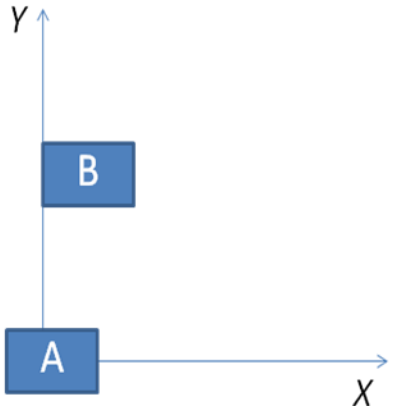
Considering when executives want to find out about "how much" IT and business align in their organizations. Whenever they identify the value of alignment from KPIs, the natural next question is where and why IT does not perfectly align. At this point, the three KPIs will not answer these questions.

According to cognitive fit theory, executives have to read the IT strategic plan and mentally create representation of the alignment with business strategies. They have to understand the plan, filtering out technical perspective and extract alignment information. However, the actual practice may result in numerous reports and meetings to get executives to understand the plan, then able to create sensible mental representation of the relationship between IT and business. This practice is inefficient and time-consuming; thus, it may end up that executives will not just bother about and leave it to only IT executive, the CIO. Nevertheless, the amount of information is not changed. It is still IT strategic plan, business strategies and priorities.

2. Fitness Characteristics

According to cognitive fit, the textual data representation of KPIs and reports may not fit the mental representation of IT alignment problem. Alignment is a concept borrowed from physical world to spatially evaluate position arrangement between two or more physical objects with certain references. Cognitive fit theory argues that psychology literature categorize data into two categories, images or words (Vessey, 1991). Applied this into our context, we can simulate the representation of alignment problem in text and picture as in Figure 4.

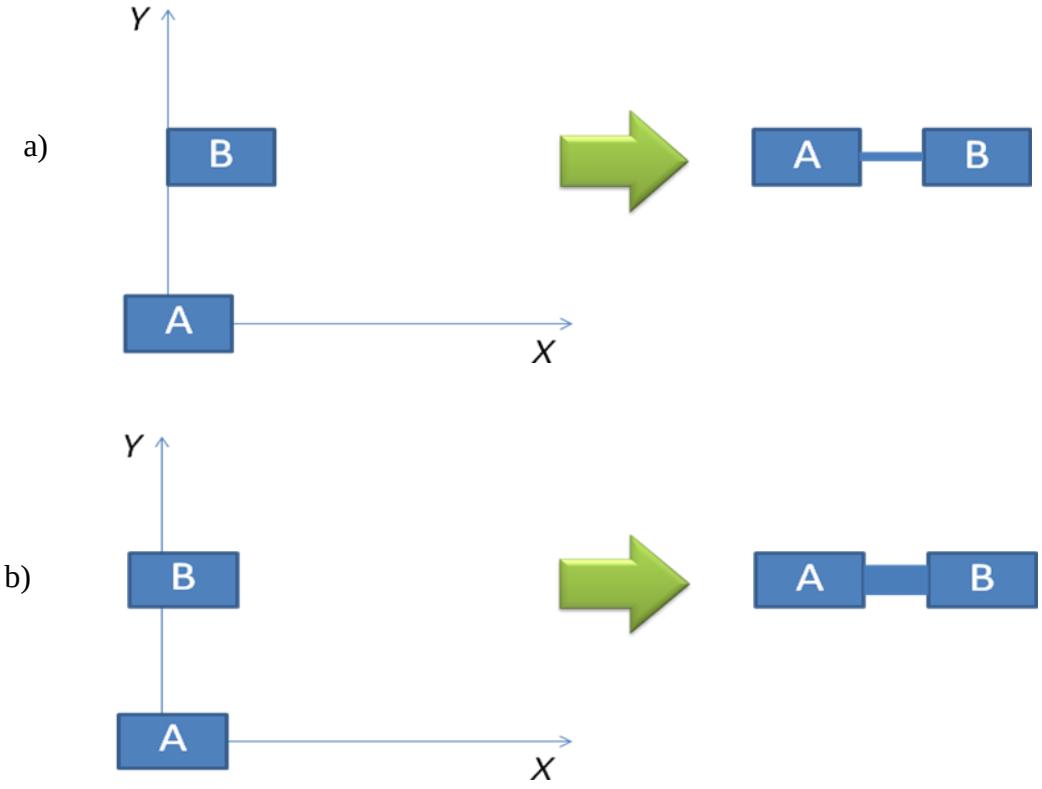
Figure 4: Simulation of alignment problem representation

Question: How well A align with B by reference of Y?	
Textual Representation	Graphical Representation
There are two items, A and B. Both are horizontal rectangular shape and equal in size of 3x2 units. The items are placed at different position in 2-dimension space. The center of item A is at coordinate (X_A= 0, Y_A = 0) while item B's center is at coordinate (X_B = 1.5, Y_B = 4)	

Both textual and graphical representations contain same information. Textual representation requires problem solver to create mental representation that simulates real world objects. On the other hand, the graphical representation presents the problem in similar way real world objects would be. Alignment problem solving process can be described as a spatial problem since it requires problem solver to spatially relate information and compare. Thus, graphical representation is a better choice to represent this problem because it would be able to demonstrate "topological and geometric relations among the components of problems" (Larkin & Simon, 1987). In other words, the graphical representation gives "cognitive fit" to the alignment problem.

We could expand the graphical representation to further encode the alignment value into relation. The graphical representation in Figure 4 still load problem solver's working memory in associating the position. Thus, we can use a line to demonstrate the linkage between two items as analogy for alignment. One can demonstrate the effectiveness of this alteration with similar matter with the above comparison. In this case, we can remove the reference since this new representation does not require problem solver to associate item's positions. We have shown this modification in Figure 5.

Figure 5: Altered Graphical Representation

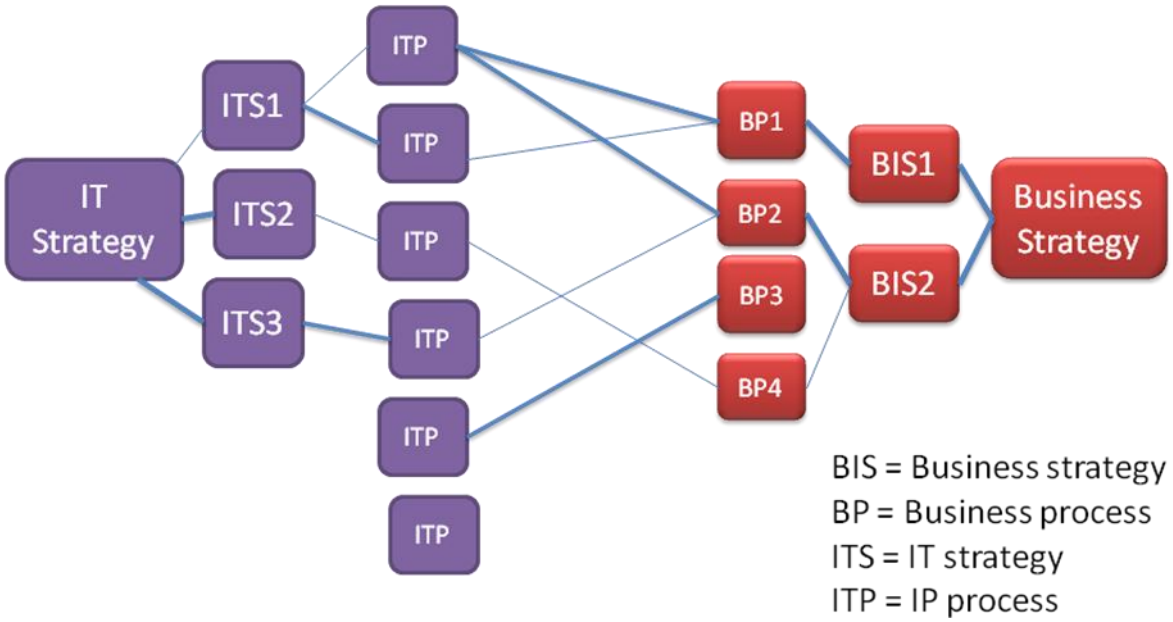


We use line thickness to represent higher level of alignment. We will call the altered graphical representation in Figure 5 as "alignment map". We could expand this concept to represent multiple level of alignment.

3. Visualization Design

Based on cognitive fit theory and COBIT framework, we propose visualization for IT-Business alignment problem representation in Figure 6. COBIT framework indicates three KPIs in planning process (PO1); however, this visualization intends to demonstrate the alignment from operational point of view. As a result, we have altered the alignment linkage to be at process level rather strictly limited to strategy level.

Figure 6: IT-Business Strategy Mapping Diagram: An example to IT governance visualization

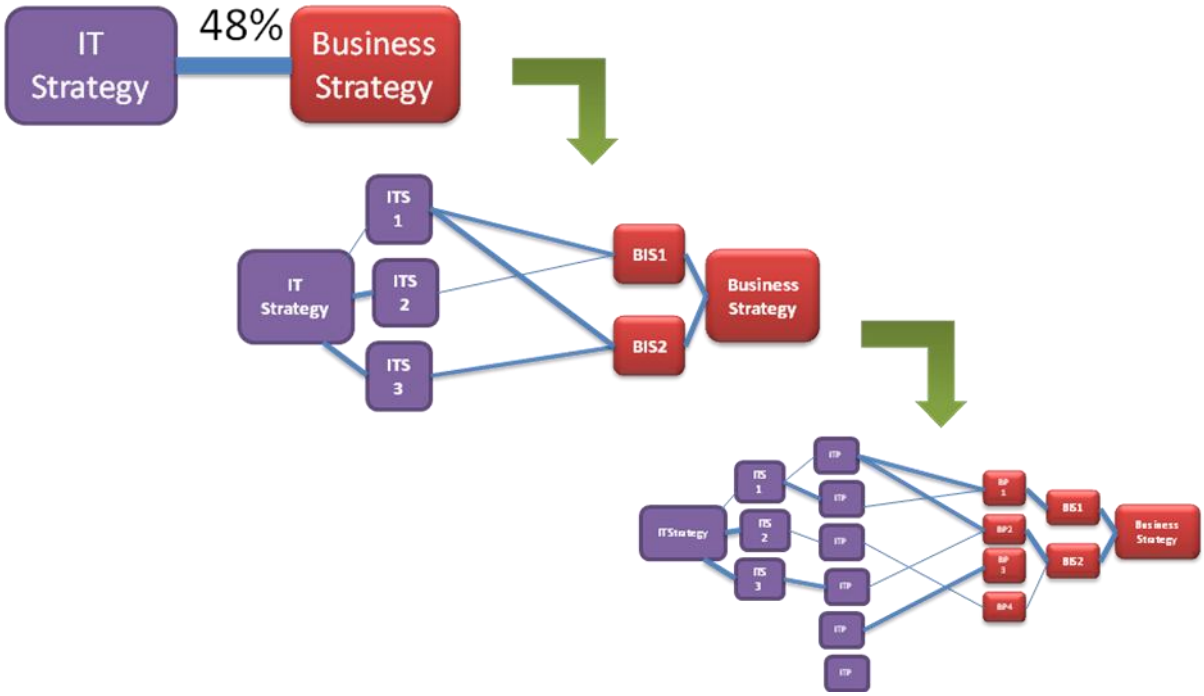


In Figure 6, linkages between IT strategy and business strategy have been shown in this diagram. The mapping can be developed statically with plans or dynamically during audition or updates of plans. The thickness of line show consistency between items, in other word, thicker links imply better alignment. Optional labels maybe add to give alignment values.

The idea behind this design is based on basic principle of metaphor usage. The word alignment gives general sense in spatial which are possible to use map representative. Nevertheless, careful use of metaphor is required to avoid limitation incurred from selected metaphor (Nielsen; Norman, 1990). This visualization can be developed further to offer simplified of this mapping and provide on-demand information whenever requested. This would help reduce cognitive load (Zhang, 1998). It would be able to use it within other corporate control visualization, such as, dashboard.

Visualization in IT governance will help executive to capture needed information on time. Instead of going through or attending numerous meetings, the relevant information will be at finger tip. In addition, the information can be provided in on-demand basis which will increase information availability. This concept is presented in Figure 7.

Figure 7: Hierarchical On-Demand IT-Business Strategy Mapping Diagram



In addition, we may increase the fitness to each decision makers by offer personalization to the system. Executive can customize the interface to what they want, either more detailed or just overview. The interaction and personalization is the further alteration to the framework and may need separate empirical investigation.

This visualization can be done only with standardized alignment framework in the organization. The process of evaluate and quantify strategy alignment is beyond the scope of this study. There are a number of tools and frameworks that address this specific issue; for instance, the adaptation of business scorecard in IT alignment usage (Grembergen, 2003).

Other visualizations can be designed to serve other parts of IT governance practice. The pattern of decision making can be identified and combined analysis of all required information can be achieved. Further analysis on executive IT governance decision pattern and taxonomy may reveal more generic visualization framework in this particular area.

IV. Conclusion

IT governance as well as visualization themselves are multi-disciplinary areas. IT governance relates to corporate governance, organizational behavior, operational research, organizational communication, group decisions and many others. Visualization also relates to wide range of areas, including, but not limited to, cognitive science, communications, human-computer interaction, decision making and decision process, psychology and computer graphic. Thus, various theories and thinking paradigms are emerging from the fields. While this is a tremendous research opportunity, its dynamics will cause various debates in both academic and practitioner world.

Further research works await this conceptual study. We need to test the visualization empirically to pilot our full scale research in other areas of IT governance. Investigation on using different visual variables must be reviewed to see different effect and may result in better fitness; for instance, the use of textual integration in this example visualization. This must be evaluated to see if it is really improve the situation or just another ineffective load in memory. The result of further investigation will solidify the framework. In addition, this is an implication for visualization effectiveness measurement. Unfortunately, the issue is still being debated in academia (North, 2006). Also, measurement for cognitive fit would require further analysis in psychology literature. Alternative choices are to measure decision quality or decision satisfaction and confidence for effectiveness or to measure information at output directly. Comparison between current practices and with visualization application may help further evaluate the effectiveness as well.

Adaptive visualization has been introduced but not sufficiently investigated in this study. This concept is applied from information theory and information hiding concept in business intelligence. The application is intended to reduce cognitive load and to show relevant message while providing detailed information on demand. While the inclusion of the feature may stimulate interactions with system, the effect of the inclusion of this concept must be investigated in order to see whether and how it would affect decision performance on IT governance.

From IT governance perspective, the design framework will need to be further investigated in IT governance concept; for instance, the effectiveness in the use of process-level linkage against COBIT's recommended KPIs. The relationship between different processes and KPIs of IT governance will be another area to investigate as well as an opportunity to visualize.

Further work is needed to cover other aspects of strategic alignment area. Other executives' IT alignment decision tasks must be investigated in order to identity common and difference characteristics. This work is required to form a complete visualization framework for this area. An extension of this framework beyond strategic alignment is required. COBIT indicates four more areas to explore, including, value delivery, risk management, resource management and performance measurement. Investigations of all areas are required to form an integrated visualization framework for IT governance.

Without complete these research works, these issues will pose as limitations for this particular conceptual research.

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