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New Operational Risk Approach to Web Project Development

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Abstract: Advances in technology and the use of the Internet have had a massive and permanent influence on our lives. In this regard, there is growing concern about the type of development and the long-term quality of Web applications, which form the largest share of individual software developed today. Web applications is a new application domain that require an adaptation of many software engineering approaches or even the development of completely new approaches to make it possible to plan and iterate web application development processes and facilitate their continuous evolution. This in turn permits cost reduction, the minimization of risks and quality enhancement. Many failures associated with web projects are the consequences of poor awareness of the risks involved and the weak management of these risks. Although, many approaches have been proposed to overcome this shortcoming, there is still a huge gap between these approaches and actual industry needs. This research aims to improve web project risk management by proposing an operational risk approach to avoid risks in web projects development and improve the chances of managing critical risks beforehand. The study presents a case study of the practical applications of the proposed approach in an actual web project.

Key words: Operational risk, web project development, internet, web application

INTRODUCTION

The World Wide Web has had a massive and permanent influence on our lives. From the economic sector to the entertainment world, hardly any part of our daily lives has been unaffected by the World Wide Web, or Web for short (Ginige and Murugesan, 2001b). The current practices in Web application development and the increasing complexity and relevance of Web applications in many areas of our society, in particular in the efficient handling of critical business processes has provoked concerns about the long-term quality of Web applications, which constitute the largest share of individual software developed today (Deshpande and Hansen, 2001). A survey by the cutter consortium (Consortium, 2000) found that the main problem areas in Web application projects were the failure to meet business needs (84%), project schedule delays (79%), budget overruns (63%), lack of functionality (53%) and the poor quality of deliverables (52%). From the perspective of software engineering, the development of Web applications is a new domain (Glass, 2003). Despite some similarities to traditional applications, the special characteristics of Web applications require the adaptation of many Software Engineering approaches or even the development of completely new approaches to make it possible to plan and iterate web application development processes that facilitate. This leads to cost reduction, risk minimization and quality enhancements. Thus, the main target of web project management is to optimize the presentation of Information, its access and the functionality of a web application, as well as to organize all these domains risk management is an essential and significant component of project management (Murugesan *et al*., 1999).

Generally, the main reasons for delays or total failures of Web projects are traceable to a set of risks and problems as identified and constantly updated by Boehm (Boehm, 1998). Effective management of these risks currently appears to be the most important area of web project management (PMBOK Guide, 2000). Basically, Web project development is still in its infancy. Due to this, the lack of process models that can serve as a guideline for the development of web based applications is particularly serious. To circumvent this problem, contemporary process models that have been devised for the development of conventional software have been widely adapted for use (Pressman, 2005). For this reason, there is a need to improve appropriate risk management techniques for web projects to reap the maximum benefits and avoid potential pitfalls in the process of developing web application.

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KEY ASPECTS IN THE PROPOSED APPROACH

Essentially, our approach is designed from the data vendor's perspective. It is based on 2 key aspects.

Data vendor perspectives: The problems confronted by web project management are always related to providing the relevant stakeholders with a satisfactory solution within a certain schedule and budgetary limits. The propose of risk management is to minimize the risk of not achieving the objective of the project and that of the stakeholders who have a vested interest in it as well as to identify and exploit opportunities. We employed the client's requirement variable as proposed in Grunbacher and Seyff (2005) and inserted the challenges of web project development encounter by vendors as proposed in Grunbacher and Seyff (2005), Pressman (2005), Deshpande and Hansen (2001) and Reifer (2002) as means to include the vendor's perspective in our approach.

Characteristics of web projects: Since, web applications differ from conventional software applications, we consider the characteristics lacking in traditional application like non-linear navigation and characteristics that are of particular importance in Web applications as proposed in the literature (Balasubramaniam *et al*., 2002; Lowe, 2002; Whitehead, 2002). These characteristics constitute the reasons why many concepts, methods, techniques and tools of traditional software projects are either insufficient to meet the needs of Web projects or have to be modified in order to do so.

The development process for operational risk approach: The approach process is divided into 2 sections. The first section constitutes the theoretical definition. The main goal of the first part is to identify risk factors from web application vendors specialist then assess the relevancy of each risk factor to the characteristics of the web project that were obtained particularly for the web project. The second part is about managing operational risks and it concentrates on the utilization of Bayesian networks (BN) as a tool to explore the causal relationships between risk factors and its parent risk factor. It is proposed that such a causal model would be able to help risk managers understand the drivers of risk.

The first section comprises 4 phases: The first phase specifies the goals and targets of the project. The second phase involves the conduct of a survey to explore the risk factors confronting web projects from the vendor's specialist perspectives. The third phase uses the matrix created in the second phase to assess the relevancy of each risk factor to the characteristics of the web project. Once the matrix is populated, the 4th phase which involves validation is conducted. The results of the first section of our process are used as an input for the second section, which is subsequently used to transform the theoretical approach into an operational approach. In order to this, we utilized a probabilistic approach by means of a Bayesian Network. By utilizing this Bayesian network (BN), we can assess influence or dependence between risk factors and their parent risk factors to generate risk scenarios that would help us to reach our goal. Figure 1 depicts the development process of operational risk management.

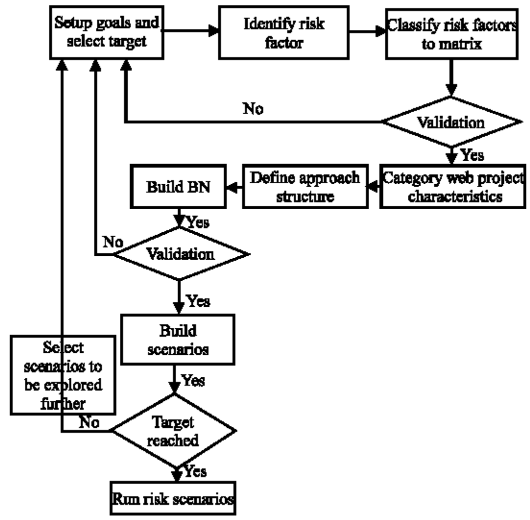

Fig. 1: The development process of operational risk approach

THE THEORETICAL OPERATIONAL RISK APPROACH

Next, we briefly explain each of the phases used to obtain the theoretical section for our operational risk approach.

Setup goals: To ensure that all significant risks are captured, it is necessary to know the objectives of the project and the organization. This is because objectives lie at the heart of context definition and they are linked to the risk management process via the criteria for measuring success (Grunbacher and Seyff, 2005). These criteria are used to measure the impact or consequences of those risks that might impact upon objectives. In other words, each risk can be described by its potential impact on agreed project goals and each stakeholder can use this information to rank the relevant risk from his perspective. As mentioned by Boehm (Boehm, 1998), the primary goal for a web project is to bring quality products to the market as quickly as possible.

Data collection: Next, we will briefly explain each of the processes used to identify risk factors in web project development.

Identification of risk factors in web project development. In this phase, we used a questionnaire to collect data on the relevant risks. The questionnaire encompasses different phases of project development and different groups of specialists staff associated with project development. In order to do so, it was necessary to focus on the company's web application development background. We sent the questionnaire to 158 specialists involved in web application development located in 32 different organizations within Jordan, Malaysia and the USA as well as to 22 consulting engineers and contractors within Jordan and Malaysia.

Questionnaire: The questionnaire included 5 parts:

- Information about the company and a general description of a specific project the participants had managed and found challenging from a risk management perspective.
- Description of the general characteristics of the projects and investigation into the motivations for OTS (Off-the-Shelf) components contributing to project characteristics.
- Description about general developmental processes.
- General description of tools used in web projects.
- Description of the risk management processes applied in the project and elicitation of specific incidents during the life of the project that were risky and challenging.
- To increase the reliability of our survey, the questionnaire also included a definition of concepts used in the questionnaire and questions pertaining to the respondents' personal history.

Identifying risk factors: We obtained 61 completed questionnaires back from the web application specialist and 4 completed questionnaires from the consulting engineers. Table 1 shows the general profile of our respondents from the 3 countries.

The analysis of the data revealed many risk factors identified by web project specialists and consulting engineers. There were 184 risk factors as well as the probability of their occurrence and their impact on activities and processes as a whole were identified. Since, the analysis of the results will be based on the success of project, it would be redundant to outline the complete list of 184 risk factors identified. Therefore, we decided to consolidate this list into a shorter one. The steps involved in the consolidation process were: First, the analysis of the list of 184 risk factors for web application development to identify and remove possible duplicates. Through this analysis, 137 risk factors were obtained. Second, these risk factors were compared with risk factors from the literature (Boehm, 1998; Deshpande and Hansen, 2001; Reifer, 2002; Balasubramaniam *et al.*, 2002; Lowe, 2002; Whitehead, 2002). From this comparison, a final set of 58 risk factors for web project applications were obtained. Some of these risk factors are particular for our survey. For our research, we coded each factor from F1 to F58. The complete list of the risk factors is outlined in Fig. 2.

Classifying risk factors: We analyzed 58 risk factors and ranked them based on the characteristics of the web projects. From the analysis, we obtained a matrix to classify the Web risk factors. Table 2 describes the classification matrix, the total risk factors for each characteristic and the number of times each risk factor was encountered.

Validation of risk factors: The third phase comprised the validation of risk factor obtained in the first phase. To carry out this validation, we compared our risk factors with risk factors from different domains from the literature (Boehm, 1998; Deshpande and Hansen, 2001; Reifer, 2002; Balasubramaniam *et al.*, 2002; Lowe, 2002; Whitehead, 2002). In addition, we sent draft transcripts of the results of classifying table to 12 specialists from Jordan and from Malaysia in order to obtain their views on the risk factors identified and to assess their agreement with the results.

Table 1: Questionnaires respondents

Jordan	32	web application specialist
	3	consulting engineers
Malaysia	24	web application specialist
	1	consulting engineers
U.S.A	5	web application specialist

F1	Built on emerging technologies and methodologies.
F2	Continually changing project /scope/objectives.
F3	Continually Users request changes.
F4	Complexity of designing models increases by using mobile devices.
F5	Customer had been actively involved in build decision of components.
F6	Development team unfamiliar with selected development tool.
F7	Developers are often no longer available.
F8	Design of Web pages is not supported by the technologies available on the market.
F9	Difficulty in defining the input and outputs of the system.
F10	Difficult in defining content and functional requirement.
F11	Difficult to navigate and find information.
F12	Difficulty in web applications maintenance.
F13	Difficulty of operation and simplicity.
F14	Duplication in content.
F15	Different sources are often not heterogeneous at various levels.
F16	Different hardware platforms which are often changed from project to project.
F17	Few details are known about the properties of component sources, content or functionalities.
F18	Frequent conflicts among development team members.
F19	Hardware not compatible with other systems and future versions.
F20	Hardware limitation to meet requirements.
F21	Hard to predict operational environment.
F22	Hard to term possible threats from competitors.
F23	High time pressure to market.
F24	High level of technical complexity.
F25	Immaturity of new technique.
F26	Lack of an effective web project management methodology and tools.
F27	Lack of defined user categories.
F28	Lack of Providing Data Privacy and Data Security.
F29	Lack of an effective web project cost, effort and size estimates tools.
F30	Lack of Design consideration such as reliability, safety, security.
F31	Lack of testing tool for web application.
F32	Lack of intellectual property rights.
F33	Lack of development team skills.
F34	Lack of top management support for the project.
F35	Lack of an effective web project risk tool.
F36	Large volumes of information.
F37	Legacy systems are poorly documented.
F38	Many external suppliers involved in the development project.
F39	Meet user's expectation to have accessibility around the clock, every day.
F40	No explicit objective about the web project.
F41	No explicit definition about the standard of project quality.
F42	Project manager do not have a clear vision.
F43	Project manager not experienced in the application area.
F44	Project manager not aware of the need to develop and maintain good working relationships with client.
F45	Products seldom tested comprehensively making products hard to control.
F46	Lack of aesthetics in content.
F47	Lack of cooperation inside the development team.
F48	Lack of communication among owners.
F49	Lack of understanding delivery medium concept.
F50	Lack of understanding on the roles and responsibilities of each team member.
F51	Some requirements are technically difficult to implement.
F52	Subgroups are not structured according to components but according to the expertise.
F53	Time and location from where the applications are accessed cannot be predicted.
F54	Too many departments involved in project.
F55	Very large number of component sources.
F56	Web developers have a variety of backgrounds, experience and age.
F57	eb developers have high degree of individuality.
F58	Web project teams are considerably young

Fig. 2: Risk factors in web project

OPERATIONAL RISK MANAGEMENT

So far, we have identified a set of risk factors that can be relevant to web project development from point view of web application vendor's specialist. However, the identification risk factors of the approach does not mean that it can be operational, i.e., that it can be used in an assessment process. Actually, we utilized Bayesian

Table 2: Classifying risk factors

Risk factors	Content	Navigation	Presentation	Social context	Technical context	Natural context	Development team	Technical infrastructure	Process	Integration
F1	X				X					X
F2	X								X	
F3	X		X					X	X	
F4										
F5	X									X
F6							X			
F7										X
F8								X		X
F9	X				X					
F10	X				X					
F11		X	X							
F12					X	X				
F13		X	X	X		X				
F14	X									
F15										X
F16					X			X		
F17										X
F18							X			
F19					X					
F20						X				
F21				X				X		
F22							X			X
F23									X	
F24					X			X	X	
F25					X			X		
F26	X	X	X				X			X
F27			X	X				X		
F28			X		X	X				
F29									X	X
F30			X	X		X				
F31	X				X			X		
F32			X		X	X				
F33							X			
F34										
F35							X		X	
F36	X	X	X	X						
F37										X
F38										X
F39			X	X	X	X				
F40	X	X								
F41	X				X					
F42							X			
F43							X			
F44							X			
F45										
F46	X		X	X						
F47							X			
F48							X			
F49		X			X	X				
F50							X		X	
F51									X	
F52							X		X	
F53						X		X		
F54							X			
F55										X
F56							X			
F57							X			
F58							X			
Risk Total	13	6	11	7	14	9	17	8	9	12

network tool to transform the theoretical approach into an operational approach.

In this research, we used a Bayesian network for 4 major reasons. The first is because of its comprehensive nature since, the knowledge structure must enable the representation of all relationships between risk factors as well as web project characteristics that are deemed risk factors. The second reason is because a BN is capable of linking the general applicability of our proposed approach to any Web project. The third reason is associated to its inherent flexibility as it can be applied to different situations according to the structures of different Web project domains and different types of data. Finally and perhaps most importantly, Bayesian Networks are direct representations of the world rather representations of reasoning processes.

Taking into account all this reasons we believe that BNs fit the explained requirements of our approach. To build BN for operational risk approach a 4-phase process (Fig. 1). First phase is involves the web project characteristics categorization. The second phase involves definition of an approach structure. Third phase involves building BN. Building BN phase involves graphical structure for Bayesian network and Definition of node probability. Fourth phase involves the validation.

Web applications characteristics category: The first phase involved in the construction operational risk management approach for a web project is to arrange the web project characteristics into 3 dimensions: product, usage and development. The utilization of these 3 dimensions is based on the ISO/IEC 9126-1 standard for the evaluation of software quality characteristics. Basically, product- related characteristics constitute the major building blocks of a Web application, consisting of content, the hyper textual structure (navigational structure) and presentation (the user interface). In line with the object-oriented paradigm, each of these parts not only have a structural or static aspect, but also a behavioral or dynamic aspect. In contrast to product related characteristics, the usage-related characteristics of Web applications is extremely heterogeneous. This mainly due to the fact that users vary in numbers and cultural background. Furthermore, devices have differing hardware and software characteristics and the time and location from where the application is accessed cannot be predicted. The usage of Web applications is therefore characterized by the necessity to continuously adapt to specific usage situations, the so-called ‘contexts’. Due to their fundamental need to adjust to contexts, usage-related characteristics are divided into 3 groups: social context, technical context and natural context. Finally, development-related characteristics refer to the necessary resources for web applications development such as development teams and technical infrastructure, the development process itself and the necessary integration of existing solutions. By assigning the different characteristics of Web applications to these 3 dimensions, we can observe their impact on the quality of Web applications. In other words, these characteristics can serve as a referral point for the definition of risk in a Web project. As a result of this phase a BN with 3 levels (dimensions, characteristics and risk factors) and with 3 network fragments was obtained (Table 3).

Definition of an approach structure: In this phase, we generated a new level in the BN based on the separation of the web application characteristics into necessary resources. In order to do this, we used the web applications characteristics of each dimension and other important resources of Web applications as proposed in the literature (Pressman, 2005; Deshpande and Hansen, 2001; Reifer, 2002; Balasubramaniam *et al.*, 2002; Lowe, 2002; Whitehead, 2002). Our aim was to establish which characteristic in a category had a direct influence on characteristics in the same category and eventually on characteristics in different categories. Each relationship is supported by a premise that represents the direct influence or dependence between a characteristic and its parent characteristic. Table 4 shows these relationships.

Building Bayesian network: A Bayesian Network (BN) is a way of describing the relationships between causes and effects and is made up of nodes and arcs. Nodes denote the random variables while directed arcs denote the probabilistic relationships between these variables. The collection of nodes and arcs is referred to as the graph or topology of the BN. In addition, each node has an associated probability table, called the Node Probability Table (NPT).

Graphical structure for Bayesian network: One advantageous aspect of BNs lies in their first graphical structure. Basically, this structure enables us to represent the components of complex probabilistic reasoning in an intuitive graphical format, making understanding and communicating easy for the mathematically challenged.

In this phase, we obtained the graphical structure for a Bayesian network that represents the relationship of direct influence among characteristics of web application in each dimensions and the attendant risk factors. Our aim was to establish which risk factors in one sub-network had a direct influence on other risk factors in the same sub-network and eventually on risk factors in other sub-networks. Each relationship is supported by principles that represent the direct influence or dependence between risk factors and its parent risk factors. Figure 3 depicts the graphical structure of the network.

Definition of node probability: In order to define node probability, we used the specialist’s response on the draft

Table 3: Characteristics category

Dimensions for web application characteristics	Characteristics of web application	Risk factors in each web application characteristics
Product	Content	F1,F2,F3,F5,F9,F10,F14,F17,F26,F31,F36,F40,F41,F46
	Navigation	F11,F13,F15,F26,F36,F40,F49
	Presentation	F1,F2,F3,F4,F11,F13,F26,F27,F28,F30,F32,F36,F29,F46,F53
Usage	Social context	F13,F27,F36,F39,F41,F45,F46,F49
	Technical context	F1,F9,F10,F12,F16,F19,F24,F25,F28,F31,F32,F39,F41,F49
	Natural context	F12,F13,F27,F28,F30,F32,F39,F49,F53
Development	Development team	F6,F7,F12,F18,F22,F26,F33,F35,F42,F43,F44,F47,F48,F50,F52, F54,F56,F57,F58
	Technical infrastructure	F1,F3,F8,F16,F21,F24,F25,F27,F53
	Process	F2,F3,F5,F23,F24,F29,F35,F38,F40,F45,F49,F51
	Integration	F1,F5,F7,F8,F15,F17,F22,F26,F29,F37,F38,F55

Table 4: Relationship in risk factors category

Dimensions for web application characteristics	Characteristics of web application	Important resources of web application	Risk factors in each web application characteristics
Product	Content	Document character	F1,F2,F3,F9,F10,F14, F26,F36, F46,F41
		Quality demands	F5,F31,F40,F41
	Hypertext	Non-linearity	F11,F13,F49
		Misinformation	F11,F13,F26,F36,F40
	Presentation	Aesthetics	F13,F27,F28,F30,F32,F46
		Self-explanation	F3,F11,F13,F26,F27
Usage	Social context	Spontaneity	F13, F39,F41F46
		Multiculturalists	F27,F36,F39
	Technical context	Quality of service	F9,F10,F24,F28,F31,F32,F41,F49
		Multi–platform delivery	F1,F12,F16,F19,F24,F25,F39,F49
	Natural context	Globality	F28,F30,F32,F53
		Availability	F12,F13,F20,F28,F39,F49
Development	Development team	Multidisciplinary	F18,F43,F44,F47,F48,F50,F52,F54,F56
		Young average	F6,F18,F33,F43,F44,F47,F50,F56,F58
		Community development	F18,F22,FF26,F35,F42,F48
	Technical infrastructure	In homogeneity	F3,F21,F27,F53
		Immaturity	F8,F21,F24,F25,F31
	Process	Flexibility	F2,F3,F24,F29,F53,F40,F50,F51
		Parallelism	F23,F50,F52
	Integration	Internal integration	F1,F5,F7,F8,F22,F26,F29,F37,F55
		External integration	F1,F15,F17,F22,F38,F55

transcript in the study. Three categories of risk factors were delineated. The high risk factor category comprised risk factors acknowledged to be more than 60% of the responses. The moderate risk factors category comprised of factors acknowledged to be less than 60% but more than 30% of the responses. Finally, the low risk factor category consisted of factors acknowledged to be less than 30% of the responses. Thus, for instance, the relative probability of Quality demand (QD) being ‘Low’ conditional on Total Risk (TR) being ‘Low’ is 0.8 and is represented as:

$$* \, p(QD = \text{‘Low’} \mid TE = \text{‘Low’}) = 0.8.$$

Since, the created BN algorithms have multiple states and each node has multiple parents, it is necessary to simplify the BN algorithms in order to reduce combinatory proliferation in the node probability table. In order to avoid this proliferation, we were compelled to introduce an artificial factorization of the BN structure, such as shown in Fig. 4.

Each column in a NPT represents a conditional probability distribution and therefore its values sum up to 1 (Jensen, 1996).

Formally, the relationship between 2 nodes is based on Bays’ rule (Jensen, 1996; Pearl, 1988):

$$P(X \mid E) = \frac{P(E \mid X)P(X)}{P(E)}$$

where,

p (X|E) = The posterior distribution and represents the probability of X given evidence E.

Once a BN is specified, evidence can be entered onto any node and probabilities for the remaining nodes are automatically calculated using Bays’ rule (Stamelos *et al*., 2003).

p (X) = The prior distribution and represents the probability of X before evidence E is given.

P (E|X) = The likelihood function and denotes the probability of E assuming X is true.

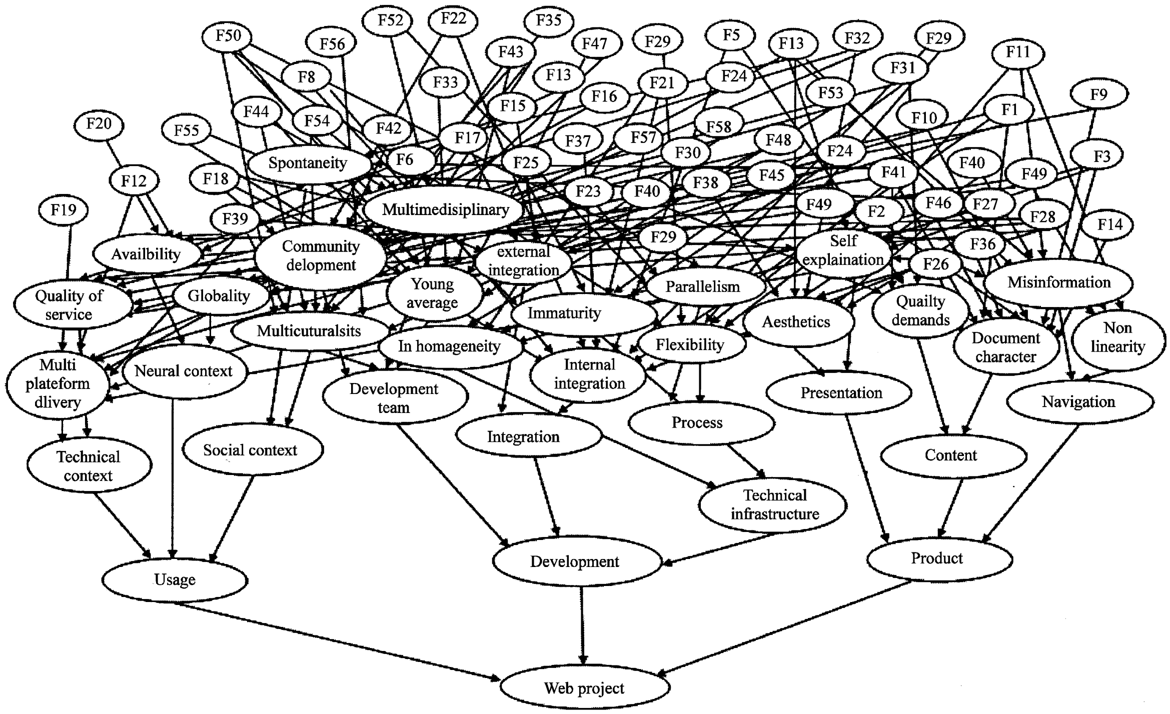

Fig. 3: Bayesian network graph

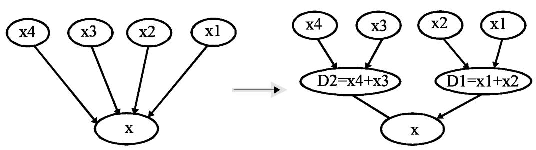

Fig. 4: Graph for risk factors representational fragment

Validation of bayesian network: The Bayesian network described and validated in this study, focuses on the web project risk identification. In order to assure the validity of the outcomes, data was gathered from only web application specialists and consultant engineers. The data compiled was then used to build and validate the Bayesian network presented herein.

BUILDING RISK SCENARIOS

It was observed that when Bayesian network graphs are categorized to sub network, choosing scenarios can be better organized as the overall complexity of each sub network and their input domains are reduced (Stamelos *et al*., 2003). This categorization into sub network is done by combining the existing relationships between sub-network risk factors and thereafter populating the nodes probability tables with the project's targets. As a result, such categorization increased our ability to observe and identify possible risk scenarios in a more scientific manner.

Once risk scenarios are building and if there is no consensus among experts on the risk scenarios involved, the process reverts to the previous step until a consensus is reached. This underlines the fact that constructing a Bayesian network is an iterative process designed to obtain accurate results in order to facilitate the attainment of project targets.

VALIDATION

To empirically validate our approach, we performed a case study. The case study aimed to automatically build another BN based on gathered data from experiments; the respondents comprised 17 final year students from the School of Computer Sciences, University Sains Malaysia, who were involved in developing a web project. The objective of the project was to build an e-learning portal for their school.

Data was gathered by asking each student to identify risk factors associated with project development. An analysis of the data revealed that the students identified a diverse set of risks Although, some of these risks shared a common strand such as vague project requirements or the lack of a detailed plan for the project, a vast majority of the risks were highly project dependent and specific in nature. Examples of the latter type of risks include team members lacking project specific skills, the lack of a standard and explicit definition of project quality as well as the absence of top management support for the project. However, since, the identification of these risks were based on the student's personal experiences, knowledge and perceptions, it was imperative that the results be independently verified to validate the findings. Consequently, we requested the project managers to evaluate the students responses based on their perceptions and personal experiences.

The case study comprised of 2 steps which are sequentially delineated as follows:

- The analysis of all identified risk factors and the ranking factors with characteristics necessary resources. This was followed by rankings these factors based on the characteristics of the web project. Finally arraying of these factors under the respective web project dimension namely the product, usage and development dimensions.
- The identified risk factors were then fed into a Bayesian network tool BayesLab. The network's structure was automatically obtained using the Necessary Path Condition algorithm (Steck and Tresp, 1999). In addition, prior and conditional probabilities were automatically generated using the EM-learning algorithm (Lauritzen, 1995).

The experiment generated the following outcomes. First, all the risk factors identified in step one were able to be interpreted according to the operational risk approach procedure. Second, there were clear differences in prior and conditional probabilities between both BNs.

These results suggest that the probability as to which risk factors have an impact and their causal relationships with one another seem to differ from one project to another depending on participants and project targets.

CONCLUSION

This study has outlined the results of an investigation wherein a dataset from different Web project domains and from different countries was used to develop an operational risk management process for web project that will be used to identify and manage risks in web project development. In order to achieve this aim, an operational risk Bayesian network was built using feedback received from specialist in web application vendors from different web project domains. In order to validate our operational risk approach we decided to build automatically another BN solely based on data proprietor's opinions/ perceptions to be compared to the BN elicited by vendors. Differences between these BNs were identified.

Plans for further research include:

- Additional case studies with data proprietors perspectives to obtain more data to be used to generate a BN automatically and to validate our approach process.
- Combing BN build from vendors perspectives with BN build from proprietors perspectives to in order to have a unique BN structure that encompasses the necessary probability tables. Such a BN would be able to better collate data on the perception of risk factors from both and vendor perspectives and thus could be more effective than contemporary models in performing Web project risk management.

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