

Human Resource Allocation for Secure Software Development

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Abstract: Demand of software capabilities in both private and public organizations insists there is a need to provide trustworthy software. Risk management should be incorporated with the software development process for high quality deliverable. Time and cost consideration, different kind of factors consideration in risk management will provide efficient result. The growth of Internet poses different kinds of spiteful threats into the mix by providing harmful attacks that browbeats the dependency of software processing on the network for distributed applications. In addition to this, factors related to human resources should also be involved in the trustworthy software development process. Factors related to human resource involves behavioral habits of a person, psychological factors of that person, variety of skills that he/she has, learning capability, and experience in related field. In this paper, important factors related to software trustworthiness have been discussed. By including more additional factors in risk management process will provide efficient throughput.

Index Terms: Risk management, CMMI, Trustworthiness, Human resource risk factors, Bayesian network

1. INTRODUCTION

Nowadays, as the modern society becomes increasingly dependent on software, the cost and effect of software failures could be destructive. Developing software systems have enormous significance that can be exactly trusted. In software development processes, risk management is an important one. The management of any organization aims to achieve its objective by monitoring and reducing risks, whether working in the public sector or private sector.

Risk could significantly increase or impede the ability of an entity to achieve its present or future business objectives. Risk management is a main concept associated with the safety and financial integrity of an organization, and its strategic development, risk assessment. The risks must be identified, analyzed, monitored and managed so that they are maintained in particular limit, accepted by the entity's management. Risk management process is still in progress and the results are generated in the aspect of accepting, eliminating or reducing risks that affect the achievement of objectives. The aim is to optimize the entity's exposure to risk in order to avoid threats, prevent losses and utilize opportunities.

Integrated Risk Management (IRM) deals with the risks associated with different kind of levels in the organization such as strategy, tactics and covering both threat and opportunity. The effective implementation of the IRM can produce a number of advantages to the organization which are not present in the typical limited scope risk process. Nowadays risk management process is increasingly appreciated and recognized in the aspect of theory and practice which means, increasing the number of specialists in the field, and increasing the interest of managers within organizations to design and implement effective risk management systems to meet the objectives. IRM system operates with wide categories of risk, such as personnel risk, financial risk, legal risk, etc., with different risk connected to various activities, risk related to various operations or transaction. Furthermore, external risks may affect the development of the overall entity or creating one or more activity executed within the organization.

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Human Resource Management (HRM) is the process of recruitment, selection of workers, providing proper induction and orientation, delivering the proper training to improve skills, assessment of worker, providing proper compensation and benefits, inspiring, keeping proper relations with labor, maintaining workers' welfare, safety and health with respect to labor laws of diligence state or country. HRM deals with the process of managing the people from a macro perspective point. HRM can be defined as the process of governing people in an organization in a well-structured manner.

The Capability Maturity Model Integration (CMMI) is defined as the process model which concludes a clear explanation of what an organization should do to enhance the performance. It consists of five "Maturity Levels" or three "Capability Levels," the CMMI enumerates the most significant key factors that are required to produce good products, or provide proper services, and wraps them all up in a comprehensive model. The CMMI also helps us to detect and achieve measurable business goals, build better products, keep customers happier, and ensure that workers are working as efficiently as possible.

The aim of [1] this research work is to implement risk recognition and risk reduction strategies in global software development (GSD). GSD systematic literature reviews (SLR) research focuses on finding what research has been conducted in the area and to deduce if the SLRs furnish appropriate risk and risk reduction advice to give guidance to organizations involved with GSD. [2] Proposed a trustworthy software security requirements behavior model can be used to make web services and applications secure and trustworthy. Authors of [3, 4, 5] defined trustworthiness in the aspect of software industry, and also summarized some suggestions about trustworthy software research methods. Developing trustworthy software is a multifaceted problem of security engineering, software engineering and risk management. Thus, making secure software starts with predominant software engineering practices, increased with sound technical practices, and supported by risk management practices that boost trustworthy software development [6]. In order to develop trustworthy software, a structured process risk control is required. [7] This paper demonstrated that a significant relationship existed between risk and project success. [8] This paper investigates an adaptive system of integration technical risk assessment model, which is based on Bayesian belief networks coupled with parametric models. This model gives statistical information for decision makers, enhancing risk management of complex projects.

2. RISKS IN SOFTWARE DEVELOPMENT

Risk in Software development project is defined as the product of the risk factor surrounding a software development project and the impact associated with failure. The factors which threaten the success of software development are the cause of emerging uncertainty surrounding a software development project. These factors are known as "risk factors" which affects the effective completion of a development project.

Various aspects of human being involvement and its impact in a software development process are termed as human factors. The human factor is the element which is responsible for the effective team formation in the development process. People have many choices to set targets in life by considering different options what they have. These choices will be influenced by the psychological factors. This will be useful for modeling the human factors in risk management.

3. NECESSITY OF RISK MANAGEMENT

Minimizing project risks is important in software development process. Investigation on risk management in software development has especially concentrated on forming instructions for different tasks. It helps to avoid project failure due to improper schedule, budget constraints and dissatisfaction of customer expectations. Risk management handles the project in the aspect of risk identification and rectification in order to develop control measures. Rectification may not mean abandoning the task that involves risk. The tasks which are rated as high risk tasks are essential to register the uniqueness of the product over other competitive products

in the market. The main motivation of risk management is to identify all possible risks associated with that project, evaluate their severity, and impacts, and then to decide control actions. Minimizing unpredicted issues which are arising during the course of the project is the main idea behind risk management. Improper planning in risk control may lead to tempestuous completion of the project. Software development risk management involves in the process which is used to derive the preventative strategy in order to complete the project within the specified limit of time and money. It may lead to reduce project cost and time required to complete the project and to increase the quality of the product. Improper risk management may lead to loss of revenue and customer satisfaction which causes negative impact on the product. Once the risk factors are successfully recognized and evaluated, the next step is to control the risk.

4. HUMAN RESOURCE FACTORS IN RISK MANAGEMENT

Every industry is involved with software area which provides automation in real time applications in an efficient manner. So there is a need to develop trustworthy software for various fields. Software development is the process which is based on human based intellectual activity. During implementation, various issues especially issues related to appropriate representation of developers participating in the development processes may be occur.

As well-known software development is a human-centered process, the process and the performance is influenced by human factors. Effect of human factors in the development process may be customer oriented (influencing the software development market) or developer oriented i.e. (Influencing the development process) and finally having a distinguishable impact on success by being a manager. Human factors associated with the development process can be viewed from different aspects such as psychological, cognitive, management and technical. Different human factors may influence different levels of impact in the process and it may vary from organizational to individual. Even though human factors have specific importance in software development, it should not be overlooked in risk management process which may lead to improper assessment. So there is a need to identify and describe the human factors in an efficient manner to avoid the potential losses associated with the risk. In the following sections we are going to see the factors which are noticeable with respect to software development. In the following we discuss those factors which appear to be the most important with respect to software development.

4.1. Productivity

Persons involved in the development process can be represented in terms of their productivity. Productivity can be explained as the amount of output per unit of input. Time required to complete the process can be derived from the relationship between person's productivity and time taken by the person.

Personal productivity of a person will vary according to the time. In order to fix the productivity of a person, productivity of a person over a long time period should be taken into consideration. Otherwise it leads improper assessment.

4.2. Skills, Experiences and Learning

Individual experiences and skills have strong influence on the personal productivity. Skill can be defined as the ability of a person to a task. Skills can be categorized based on domain and the phase of its production. Phase of production deals with the stages of development process such as designing, coding, testing. And also experience plays an important role in productivity. Experience will help to handle uncertainty arising during the development process. So experience has a significant influence in the process of solving the problems.

From experience, one can develop his/her skills. So experience is the basement to develop skills. This approach is also known as learning by doing. Doubling the experience productivity can be increased in an

efficient manner. Learning plays an important role in developing the skill. Applying the learned tricks in real time application turns into experience. Applying the learned tricks in an efficient manner will lead to a way to develop our skills. Learning capacity is the key factor to introduce changes in the product. By learning new technologies, one can incorporate the advancement in the existing product. Integrating new technologies in the product will be used to enhance the uniqueness of a product. Customer satisfaction can be provided by doing this. Learning capability of a person is directly proportional to the productivity of that person.

4.3. Emotional Factors

Experience deals with long term positive influence on the process associated with the development. In the process of development there may be short term fluctuations which will lead to a serious problem. Negative emotions are the key factors which are indirectly proportional to the productivity. Various emotions related with the human are enjoyment, hope, relief, pride, gratitude, boredom, anxiety, or disappointment. Negative emotions will lead to a negative impact on the productivity.

Emotions can be influenced by the task, Possibility of doing and other characteristics according to the situation. With respect to boredom, it may lead to reduce self-motivation, involving in various activities which in turn reduce the quality and performance of the product. Internal motivation is associated with the thinking of person about the work or project. It cannot be compensated with the extra hours working. It may lead to failure of the project in unpredicted manner.

There is a contradictory mediator in emotions. For example, anxiety may increase the exterior motivation although there is a chance of blocking the activities of a person. Contradictory mediator will produce significant impacts on the product according to the situation. In order to avoid failure due to lack of intrinsic motivation, leadership quality of the team head should be high. Leadership quality should deal with decentralizing the work among team members, increasing intrinsic motivation among team members, perfect scheduling of task, Punctuality, Appraising the activities of team members, Proper communication with the members. Partiality influences the leadership style in negative manner. 'Stress can be defined as the factor related to disturbing perception. The causes of stress can be workload, misunderstanding, etc. If the person is not recognized for his/her work, it will lead a person in negative manner which reduces his/her intrinsic motivation and thus in turn become the key factor for stress.

4.4. Entity Factors

Interpersonal relationships can be categorized into 2 categories. First category deals with the social relationship such as coordination between the team members, communication between the members, leadership style, and horizontal coordination. This type of interpersonal relationship will be considered as official one. Second category is deals with personal relationship between the team members and this will be considered as informal. Team cohesion will be achieved if there is job satisfaction and well group atmosphere. Good team cohesion will lead to improved productivity. Team cohesion can be achieved with the help of good leadership quality. Coming to the size of the team, separation of team members should be done in a conditional manner. Because smaller team size will lead to reduction in self-motivation among team members and larger team size will lead to reduce proper communication and allocation of work. Proper communication between the team members is an important key factor to complete the project successfully. Improper communication will lead to reduction in quality of the product. Culture is also a significant factor in risk management which influences the productivity. Persons from different countries, states, and districts may be present in a team. Cultural diversity leads to the influence of different languages in the process. Different languages may affect the system performance because of improper communication.

5. BAYESIAN NETWORK BASED RISK ASSESSMENT

Trustworthiness of software is an important key factor to satisfy the customer expectations. Trustworthiness of a product depends upon the risk management involved in the various stages of process. Risk associated with the development may lead to decline in trustworthiness. Software process network model can be constructed based on the following processes: Planning, Requirement, Design, Development, Testing and Implementation. Risk can be occurred during any of these processes. Risk involved in these stages may have different types of impact on the product. According to that trustworthiness of the product will vary. Risk is nothing but the product of probability of risk factor and the impact of the risk.

$$\text{Risk} = \text{Probability of risk factor} * \text{Impact of the risk.}$$

In this paper risk factor deals with the uncertainty associated with the human factors which involved in the software development process. There are many human factors involved in the software development process such as psychological factors, skills, learning capacity of a person, productivity of a person, leadership quality of a person, Experience of a person etc. These factors have different levels of impact on the outcome of a project. So there is a need weigh the factors according to its impact on the product.

If the entire factor's impact is considered equally while evaluating the risk, it may lead to improper risk assessment. Bayesian network model based risk assessment is introduced in this paper. Different types of human factors have different probability of risk on the product. So in order to estimate trustworthiness of a product there is a need to calculate joint probability of all human factors on the product. Bayesian network model is used here to evaluate the joint probability of risk factors on the product. Bayesian network model is the combination of graphical theory model and probability model. Graphical model involves the process in which complicated system will be decomposed into number of smaller nodes to make the evaluation easy. After analyzing the smaller nodes in the system, they should be combined in order to make a decision about the system. For this purpose probability model is integrated with the graphical model in Bayesian network model. Join probability of 2 variables can be defined as,

$$P(A/B) = P(B/A)P(A)/P(B) \quad (1)$$

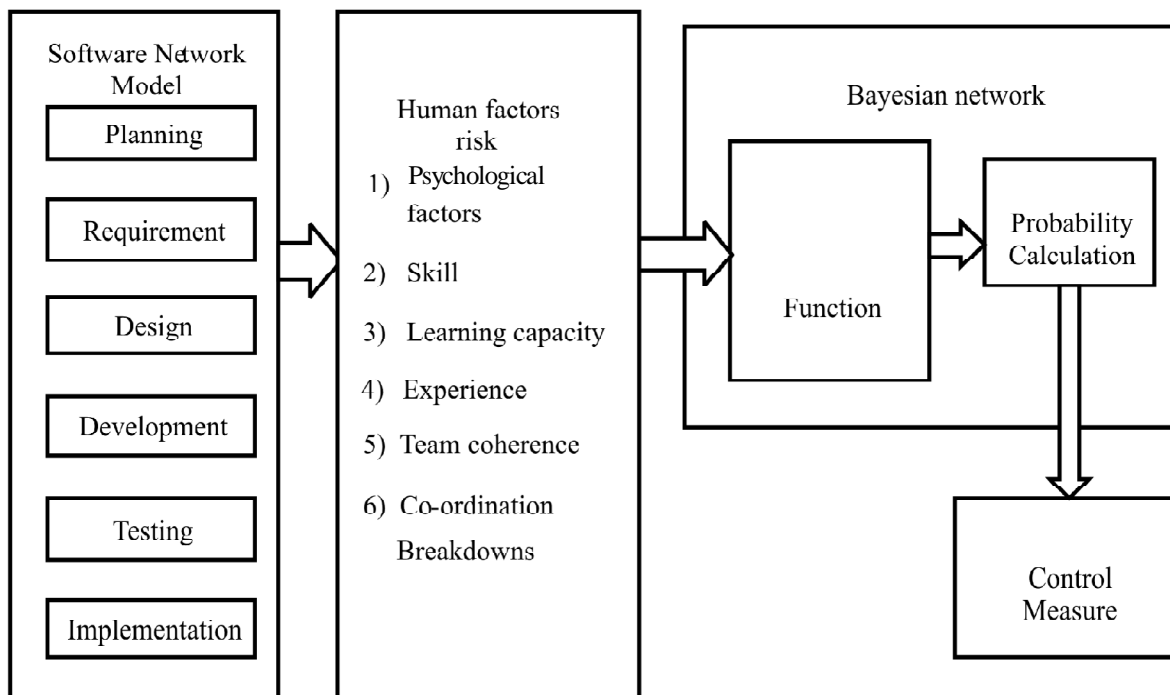


Figure 1: Over all architecture of risk assessment in software development process

Risk is defined as the product of probability of risk occurrence and impact of risk on the product. Probability of risk occurrence can be calculated using Bayesian network model. Probability of risk occurrence is the product of experimental impact value calculated from Bayesian network and risk identification weighing function in the aspect of cost, time, CMMI. It can be expressed as,

$$P_{ij} = P_{ij}^* \cdot RI_j = P_{ij}^* \cdot f^1(Cost_j, Time_j, CMMI) \tag{2}$$

Where P_{ij} represents the probability of risk occurrence, RI_j is the risk identification effectiveness, P_{ij}^* is the experimental value calculated from Bayesian network Impact of risk factor can be defined in terms of impact of sub deliverables in sub process which is defined as the product of experimental impact value calculated from Bayesian network and risk control weighing function based on time, cost, CMMI. Impact of risk factor can be expressed as,

$$I_{ij} = I_{ij}^* \cdot RC_j = I_{ij}^* \cdot f^2(Cost_j, Time_j, CMMI) \tag{3}$$

Where I_{ij} represents the impact of risk, RC_j is the risk control effectiveness, I_{ij}^* is the experimental value calculated from Bayesian network. The occurrence of risk R_{ij} can be expressed as,

$$R_{ij} \sim B(1, P_{ij}) \tag{4}$$

Total risk can estimated as follows:

$$E_{tot,j} = \sum_{i=1}^{\#} (R_{ij} \cdot I_{ij}) = \sum_{i=1}^{\#} (R_{ij} \cdot RI_j (Cost, Time, CMMI) \cdot I_{ij}^* \cdot RC_j (Cost, Time, CMMI)) \tag{5}$$

Trustworthiness affected by the process risk can be expressed as

$$T_{Risk} = (T_1, \dots, T_5)_{1 \times 5} \cdot W_{5 \times 1} = (E_{tot,1}, \dots, E_{tot,6})_{1 \times 6} \cdot \begin{pmatrix} IM_{1,1} & \dots & IM_{1,5} \\ \dots & \dots & \dots \\ IM_{6,1} & \dots & IM_{6,5} \end{pmatrix}_{6 \times 5} \cdot \begin{pmatrix} \omega_1 \\ \vdots \\ \omega_5 \end{pmatrix}_{5 \times 1} \tag{6}$$

Where, impact element $IM_{m,n}$ indicates the level of the m^{th} sub-deliverable's impact on the n^{th} trustworthiness attribute.

Trustworthiness can be affected by process quality and risk factors associated with the development process. Trustworthiness should be evaluated by considering both process quality and risk factors. Process quality can be expressed as,

$$T_{PQ} = f^p = (Cost, Time, CMMI) \tag{7}$$

Trustworthiness can be evaluated from the difference between trustworthiness affected by process quality and risk reduction.

$$T = T_{PQ} - T_{Risk} \tag{8}$$

Thus the constraints considered to calculate trustworthiness of a product leads to provide effective risk management process. In our study Human resource based risk is the key factor behind the risk management process. Better risk management process involved in the development process helps to avoid complete cancellation of a product and will lead to register the uniqueness in the market.

6. RESULTS AND DISCUSSION

From the analysis of the several of articles of distributed software systems, we included four new risk areas to the existing eight risk areas. The risk possibilities of the risk areas are ranges in to Low, Medium, and High. On the basis of the impact of risk areas, they are categorized.

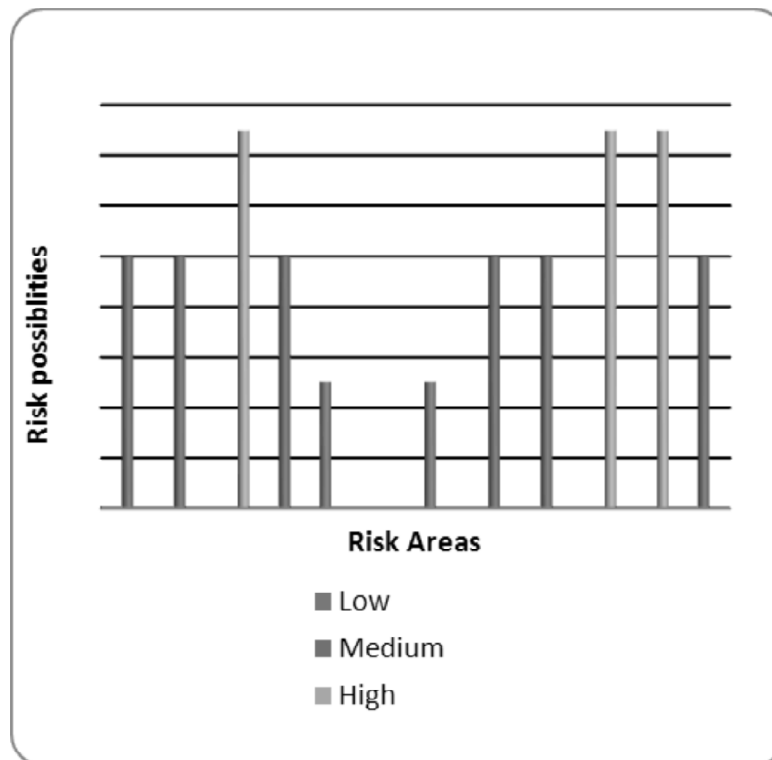


Figure 2: Risk characterization

Affinity/Reduce negative aspect

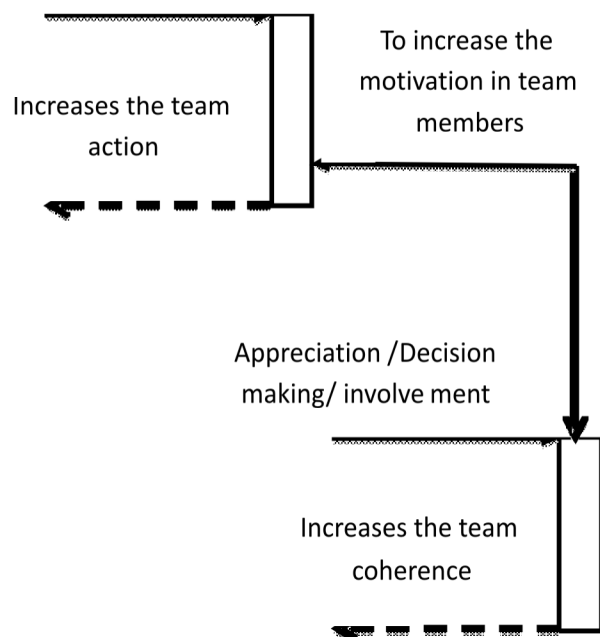


Figure 3: Team coherence

The first added risk area is Loss of team coherence. Team members must be coordinate with themselves for the success of the system. The project manager should try to reduce negative thoughts on the project among team members.

The next proposed risk area is Coordination breakdowns. The customer and the organizations break downs can be minimized by the communications between the units of the organization and end users.

Vertical and Horizontal coordination breakdowns are controlled by the proper communication between the top, middle, low levels of management. To promote the coordination between the team members, the work charts are used to store ongoing task of the members. The work charts are controlled by the project manager and it can be easily access by all the members of teams. The procedural values of the task units are stored in database for the future use.

The Time zone difference is the main proposed risk area, which is having the greatest impact on the coordination of the distributed software system. Face to Face meetings in a common work place is not possible in the distributed software development. The virtual face to face meeting can be easily done with the help of teleconferencing. Each of the several difference zones makes the difference in timings. Coordinating the different zone team members is a difficult process. Knowing of the time zone difference around the world is needed. So we propose a web tools for the successful meeting in distributed environments. The time charts is prepared by selecting the date, month, year of the meeting.

6.1 Risk Managerial Techniques

Risk manager should try to understand the personal variables risk such as application knowledge, Educational Qualifications and technical variables risk such as software knowledge, hardware knowledge.

The ability of the staffs on the distributed work environment should be identified by the risk manager and appropriate procedural activities should be implemented to minimize t he effects of the risk .After finding the risks, he should try to minimize its impact on productivity.

6.2. Configuration Management Techniques

Configuration management (CM) is the process of complete recording and updating of information that describes an organization's product. The purpose of Software Configuration Management is to increase and maintain the reliability of the product. Software Configuration Management involves identifying configuration settings, controlling, recording and reporting status about the changes in configuration. The changes in the product are introduced by the developer in order to satisfy the user requirements. End user stratifications increase the organizations productivity. Requirements of end users will be changed continuously.

7. CONCLUSION

In this analysis, we have proposed Bayesian based risk assessment in software development process in which additional risk factors associated with human resource are included. The proposed system first identifies the risk factors associated with human resource. There are many risk factors associated with human resource. Each of these risk factors are weighed and taken in account to evaluate the risk associated with the development process. Bayesian based risk assessment process model is introduced in this paper. Risk control techniques are applied to the problem identified in the evaluation stage. Risk managerial techniques, Configuration management techniques are the important resolution techniques in the distributed software system .The proposed risk assessment technique performs better because the factors considered to evaluate the risk have great influence on the productivity of the system.

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