How risks affect a project duration

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Abstract

In a fast-changing world, industry and especially software industry faces the challenge of more and more demanding clients in terms of quality, delays, etc.. One mean to achieve this goal is to use risk management.

In our research, we focused on how risks affect the duration of a project and how we can foreseen this duration at the beginning of a project. In this document we expose a method to calculate the distribution of a project duration depending on risks.

1. Introduction

In a fast-changing world, where clients are more and more demanding in terms of quality and delays, using risk management in projects is a powerful tool to have a better control on them.

A risk can be defined as an evenement that is not certain and that can affect the project objectives (definition translated from [1]).

Interest in risk management has grown heavily in the nineties. Following the lead of B.Boehm [2] and his SPIRAL, risk-centered methods have been developped like Riskman or Risk-IT [5]. The risk management has grown mature and is now a full part of standards like CMM(I) [6] or SPICE [3] which were first designed for software industry and that have widened their scope.

Risk consequences can be of different natures : cost, delays or quality for example. Time constraint often being very important in software development, we choose to focus on this kind of consequences. The topic we specially address is the estimation of how much risks affect the duration of a project. We set up a method that permit to calculate the distribution of project duration depending on the risks and now we try to include the same with dependency between risks. The goal of these methods is to give indications to project managers about the real duration of their projects.

In this document, we first give an overview of the risk management process, then we explain in short terms how our method works and then the steps towards a method including dependencies between risks.

2. Risk Management Process

Different methods have been developed to manage risks but even if the approach is not exactly the same we can guess that the underlying process converges. The risk management process can be split in five main phases that as described in figure 1.

The strategy definition phase consists in deciding on which classes of risks, process or activities of the process we will focus on, which documents to use etc.

The analysis phase is the very heart of the process. Here we identify risk, evaluate them by giving them an occurrence probability, an impact and sometimes other characteristics. After that we prioritize risks in order to focus on the risk the most dangerous for the project.

During the treatment phase, we define actions to prevent the risks occurrence, limit their impact or to correct risk effects afterwards.

The control phase takes place all along the project. One of its objective is to follow-up risk and actions evolution and to relaunch analysis and/or treatment phases periodically or if the need arises.

Capitalization is not always present but allows a return

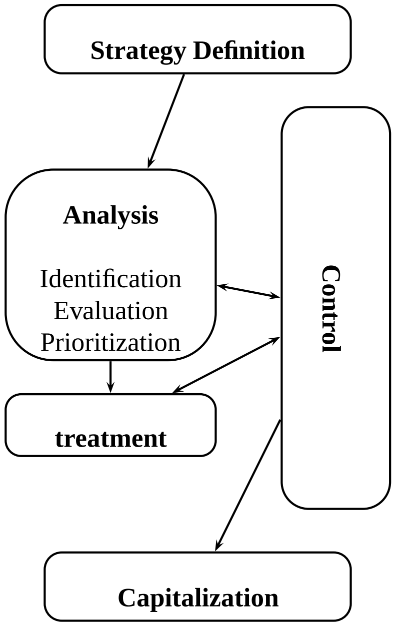


Figure 1. Risk Management Process

of experience for other projects. We can capitalize both on the risks of the project and on the process itself.

All the activities of the process defined by B.Boehm in the first place can be found here.

3 Calculate Project Duration Depending on Risks

In this section, we present the method we set up to calculate the probabilistic distribution of a project duration depending on its risks. This method relies on an original evaluation of the risks and on a specific description of the project.

Risk evaluation can be performed by different methods. The simplest method consists in giving an occurrence probability and an impact of each risk for the whole project. More evolved methods propose the use of bayesian probabilities, probability distribution for each probability and a lot more possibilities as you can find in Vose's book [7] that could be difficult to use.

We then propose a method a bit less simple than the first but simpler than the others. We give a probability and an impact(delay) for each risk and each activity. This got two advantages : The probability and the impact fits better to reality and we take in account the scope of each risk.

The description of the project we choose is a PERT [4] chart because it's a widely spread formalism that is simple enough.

The PERT chart we use can be seen as a graph and more precisely a DAG (Directed Acyclic Graph) of the process where activities are represented by vertices labeled by the normal duration of the activity.

Our method consists in two steps : calculate the distribution of each activity and then calculate the global distribution of the project.

A distribution is a set of couples (value, probability). If the sum of the probabilities of all the element of a distribution is equal to 1 then we speak of total distribution

3.1 Activities Distributions

To calculate the distribution we need to introduce the case notion. A case is a possible combination of risks. To represent a case we use a set of occurring risk.

For each case and a given activity we can calculate a case impact and a case probability.The case impact is the sum of the impacts of the occurring risks for this activity.

$$I(c,a) = \sum_{r \in c} imp(r,a)$$

The case probability is the product of the probability of all the occurring risks and of the probability of the other risks not to occur ($1-$ probability to occur).

$$P(c,a) = \prod_{r \in c} proba(r,a) * \prod_{r \notin c} 1 - proba(r,a)$$

The activity distribution is then built by adding the couples (d(a)+I(c,a),P(c,a)) of all the possible cases in the set.d(a) is the nominal duration of the activity a. If theres no couple with value d(a)+I(c,a) then add the couple in the distribution else increase the probability of the already-in couple by P(c,a).

The obtained distribution is total.

3.2 Global Distribution

Now that we have all the distribution activities, we will combine them using the structure of the PERT chart. The main idea is to calculate the distribution of time from a node in the graph till the end of the project. To do so, we need to add distributions on the same path in the graph and to maximize distributions if there are more than one path starting from a node.

These operations are made as follows :

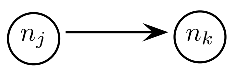
$$
\begin{aligned}
Sum \quad &: \quad \forall(i1,p1) \in D1, (i2,p2) \in D2, \\
&\quad\;\; add(D, (i1+i2, p1p2)) \\[1em]
Max \quad &: \quad \forall(i1,p1) \in D1, (i2,p2) \in D2, \\
&\quad\;\; add(D, (max(i1,i2), p1p2))
\end{aligned}
$$

where add works like in the building of activities distributions.

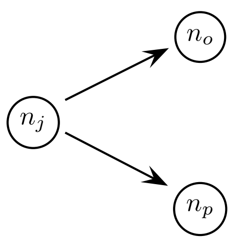
The global distribution can be built using an inductive method on the PERT chart.

If the node is the final node then the global distribution is $(0,1)$. Indeed, the duration to go to the final node will always be 0.

If the node possesses only one outgoing transition and if you consider $D = Global\_Dist(n2)$ is known then $Global\_Dist(n1) = Sum(Dist(a), D)$



If the node possesses 2 outgoing transitions and we consider $D2 = Global\_Dist(n2)$ and $D3 = Global\_Dist(n3)$ known then : $Global\_Dist(n1) = Max(Sum(D(a), D2), Sum(D(b), D3)$



Finally if there are n outgoing transitions we do the same but we extend the function Max to n elements. We first maximize 2 distributions and then maximize it with the third, and so on.

To calculate the global distribution of the project we evaluate the global distribution of the starting node of the PERT chart.

4. Towards Risk Dependency

The precedent method is useful but relies on a strong hypothesis : Risks are independent. Even if this hypothesis is often used (It simplifies probabilistic operations a lot), it resides far from reality. To improve the method presented afore, we tried to define what dependencies between risks can be and what can we do to calculate duration distribution in this case.

4.1 Risk Dependency

In the literature, the few articles we found that treat both of risks and dependency are mathematical ones that deal with correlation. We choose another approach in considering only on occurrence dependencies. We consider that risks can affect other risks only when they occur. We then distinguish different kind of dependency :

- Creation : when a risk occurs a new risk appears ;
- Destruction : a risk occurrence implies that a risk disappears;
- Inhibition : When a risk occurs, a risk is inhibited during a certain amount of time;
- Modification : when a risk occurs , the probability, the impact or both increase or decrease.

The dependencies between risks can be represented in a dependency graph. Its a graph in which nodes represent risks (or eventually couples risk/activity) and transitions (different kinds) represent the dependencies.

4.2 Towards a Method

At the time, we write this contribution, our method that calculates duration distribution using our dependency model is not completely set up but is on the verge of being so. We give here the main problems we were confronted to and what formalism we choose.

The main problem is time. Indeed, as the risks are dependent, the moment a risk occurs as well as the order in which risks appear is very important. To deal with this problem, we choose to consider time as discrete and that during a unit of time risk are independent. It means, for example, that two risks that occurs in the same unit of time are considered simultaneous.

An other problem is that we cant consider parallel activities separately. The project and his evolution should be considered as a system whose state changes.

All this observation leads us to think of the use of Markovian graphs. The next step consists in the definition of which information we need to characterize a state of our system and the methodology to build the graph.

Once the graph is built, we can built a distribution in adding for each final node a couple (time, p) where p is the probability to access this node id est the product of the probability of each taken transition from the initial node.

5 Conclusion

Knowing how long a project should be is very interesting at the beginning of a project. Its what our method does.

The given results should not been taken as truth but more as an indication.

The work we have done is interesting but needs two things. The first thing to do is to finish the second method but we aren't too far of that. The second thing and not the less important is to validate our models. This is difficult because a project is unique and is executed only once. The solution may comes by the fact that the PERT chart can also be used to describe process and the risk evaluation method can also be applied on processes. Indeed processes are repeatable for most of them and so we can have more data to validate our method.

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