Stochastic simulation of risk factor potential effects for software development risk management

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- Process for identifying system risk
- Base model
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## Introduction

- **Risk management**
  - **Risks arising from uncertainty**
    - Characterize risky scenarios and identify the factors in those scenarios

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>In time</td>
<td>When certain events may occur or the ability to react to them</td>
</tr>
<tr>
<td>In control</td>
<td>Inadequate authority to influence decisions or inconsistency in processes</td>
</tr>
<tr>
<td>In information</td>
<td>Inadequate or inaccurate information on which to base decisions</td>
</tr>
</tbody>
</table>

Apply uncertainty of factor to simulation model
Process for managing risks

1. Identify the risk factors
2. Model the system to incorporate the risk factors
3. Quantify risk factor uncertainties
4. Propagate the uncertainties
5. Sensitivity analysis
Identify risk factors

- Qualitative survey to use to identify potential effects

- Selection of risk factors based on importance

<table>
<thead>
<tr>
<th>Creeping user requirements</th>
<th>Lack of staff commitment, low morale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inaccurate cost estimation</td>
<td>Instability and lack of continuity in project staffing</td>
</tr>
<tr>
<td>Excessive schedule pressure</td>
<td>Lack of senior management commitment</td>
</tr>
</tbody>
</table>
‘Excessive schedule pressure’ factor

Excessive schedule pressure

- Lack of process discipline
  - If project schedule is compressed at the start,
  - Design effort
  - Defect generation rate

+ ++ Effort for quality-inducing activities (documentation, inspections, etc)

- -

Exhaustion
+ -

Productivity
+

Low morale
+

Creeping user requirement
+

If project schedule is compressed at the start,

Missed requirements
Relationship between factors

- Hypothesized influence diagram

* Lack of senior management commitment
  - Creeping user requirements
  - Excessive schedule pressure
    - Inaccurate cost estimation
  - Lack of staff commitment, Low morale
    - Instability and lack of continuity in project staffing
Reuse model Abdel-Hamid and Tvedt model

Focus on Software Development Risk Factors (SDRFs)

- Planned staffing
- Actual staffing
- Effort allocation
- Productivity
- Control
- Planning
- Work flow
- Quality manage
- Adjustment of job effort

Planned manpower, daily manpower, remaining planned manpower
Reflect experience of staffing for habituation to each activity
Work rate, experience, tracking and overhead, other sector
Adjust schedule
Flow of work product
Flow of errors and defects
Effort amount are update due to new work or rework
## Modeling SDRFs

### Potential effects modeled for each risk factor

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Effects</th>
<th>Multipliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement creep</td>
<td>Increased job size, Rework, Time at max, % of work, % of creep</td>
<td></td>
</tr>
<tr>
<td>Inaccurate cost estimation</td>
<td>Actual job effort more or less than effort provided by staffing and schedule</td>
<td>Size estimation inaccuracy</td>
</tr>
<tr>
<td>Excessive schedule pressure</td>
<td>Morale change, Fluctuating productivity, exhaustion, and higher error generation and weaker reviews</td>
<td>Change to morale for schedule pressure</td>
</tr>
<tr>
<td>Low morale, lack of staff commitment</td>
<td>Lower productivity, Increase in error generation, Attrition, Multiplier to productivity</td>
<td>Multiplier to error generation, Multiplier to attrition</td>
</tr>
<tr>
<td>Instability and lack of continuity in staffing</td>
<td>Attrition, Morale change, Lower productivity due to loss of expertise</td>
<td>Attrition, replacement delay, Change to morale for attrition</td>
</tr>
<tr>
<td>Lack of senior management commitment</td>
<td>Initial schedule compression, Understaffing, Lower morale after excessive schedule pressure and attrition</td>
<td>Multiplier to schedule, Multiplier to staffing, Change to morale for attrition, Maximum schedule extension</td>
</tr>
</tbody>
</table>

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Stochastic modeling construct (1/2)

- Requirement creep
  - Sample once at the beginning of each run
  - Modeled as characteristic of an entire project
  - Parameterize construct for new work due to requirements creep
    - Percentage of the estimated job size

![Graph](Image)

- Approximated by Weibull distribution
- Reached maximum at \( t_{\text{max}} \)
- \% of project duration
- \% creep after maximum

\[ t_{\text{cease}} \]
Effect of low morale on productivity

- Sample continuously during each run
- Modeled as a risk that may vary throughout a project

Logic for modeling the effect of low morale on productivity

IF(Morale<= 1 AND U(0,1) <=0.95)
   OR (Morale <=2 AND U(0,1) <= 0.85)
   THEN lognormal_distribution
ELSE IF (Morale<= 3 AND U(0,1) <=0.77)
   OR (Morale <=4 AND U(0,1) <= 0.67)
   OR (Morale <=5 AND U(0,1) <= 0.46)
   THEN Weibull_distribution
ELSE 1)
Model verification and validation

- Model’s structure
  - Reviewed by experts

- Model’s behavior
  - Value of risk factor
    - 5% underestimation

<table>
<thead>
<tr>
<th>Req. creep</th>
<th>Value</th>
<th>18%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morale</td>
<td>Very high Schedule pressure Very high</td>
<td></td>
</tr>
<tr>
<td>Staffing</td>
<td>4 people for 10 month Sr. mgmt Very high</td>
<td></td>
</tr>
</tbody>
</table>

- Actual project replication results

<table>
<thead>
<tr>
<th></th>
<th>Cost (days)</th>
<th>Duration</th>
<th>Defect density</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>836</td>
<td>220</td>
<td>1.06</td>
<td>32</td>
</tr>
<tr>
<td>Simulated</td>
<td>889</td>
<td>231</td>
<td>1.05</td>
<td>32</td>
</tr>
<tr>
<td>% difference</td>
<td>6.3</td>
<td>5.0</td>
<td>-0.9</td>
<td>0</td>
</tr>
</tbody>
</table>
Parameterized similarly to prototype project for experimentation

Most unpredictable and significant risk factors

Largest impact on cost

Confidence intervals on mean cost for actualized risk factors
Confidence intervals on mean duration for actualized risk factors

Major risk to project duration: Sr mgmt cmtmt lacking
Variation in project cost due to starting level of low staff morale

Variation in project cost due to starting level of low staff morale
Conclusion

- Use qualitative and quantitative survey on risk factors and their potential effect
- Support risk management by stochastic simulation
  - Risk analysis, risk management planning

Future work
- Development of models for software project risk management
- Relative influence of various risk factors
Discussion

Critiques
- Depend on statistical method
- Not specific for business area or projects
- Not sufficient validation of static structure of model
- Do not sensitivity analysis for project

Direction
- Analyze effect pattern of risk factors on cost, duration, size