TAMRI: A Tool for Supporting Task Distribution in Global Software Development Projects

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Outline

- Motivation
- Model Overview
- Application Scenarios
- The TAMRI Tool
- Summary and Outlook
Motivation: Task Allocation

Software development processes have to be allocated to distributed sites

n tasks to m sites → up to m^n different assignments theoretically possible

Task allocation has to consider abilities at sites and communication overhead

In practice: often task allocation by cost and availability only → High development risks
## Challenges of Task Allocation Decisions

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multiple goals</strong></td>
<td>Cost reduction (assign to low-cost sites), development time (reduce communication overhead), development quality (assign to experts), closeness to markets…</td>
</tr>
<tr>
<td><strong>Multiple influences</strong></td>
<td>E.g., expertise at sites, proximity to customer, time zone difference, cultural distance, communication need…</td>
</tr>
<tr>
<td><strong>Organization-specific contexts</strong></td>
<td>Different weight on goals, other influencing factors, differences in importance of influences…</td>
</tr>
<tr>
<td><strong>Uncertainty</strong></td>
<td>Not all characteristics of remote sites are known; uncertainty in predicting human behavior</td>
</tr>
</tbody>
</table>

Not handled by existing planning approaches

→ Research goal: Build decision support model addressing these challenges
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TAMRI Overview

Goal: Task allocation based on multiple criteria

- Based on specific project characteristics and general organizational experience, make suggestions for task assignment
- Task allocation has to consider multiple goals and criteria

Input:
Values for influencing factors (actual characteristics of project, tasks, sites), weighted goals

Organizational knowledge:
- Influencing factors
- Causal relationships

Identified in empirical study

Decision model

Output:
Assignment suggestions
Empirical Study: Influencing Factors

Study goal
Which factors influence project goals in GSD?

Study design
Literature study and interviews with 10 practitioners

Result: Model for evaluating assignment
Influences of task assignment on goals

Model describes causal relations under uncertainty → Bayesian Networks
Bayesian Networks are used for modeling causal relationships under uncertainty. Values for each causal relationship are determined by probabilistic tables.

Example:

TAMRI: Table values were determined through:
- study results
- own estimations
- and mathematical functions

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TAMRI Overview

Input:
Values for influencing factors

Evaluation model
- Describes the results of concrete assignment on goals
  → Bayesian Networks

Output:
Assignment suggestions

Optimization algorithm
- Uses assignment evaluation
- Identifies optimal assignment
- Based on algorithm of distributed systems (optimal assignment of tasks to processor nodes)

Evaluation model

Results of empirical study

Distributed Systems Algorithm
TAMRI Overview

Evaluation model uses Bayesian Networks (BN)
• BN for execution tasks at site: What is the impact on goals if task A is assigned to site 1?
• BN for transmission overhead: What is the impact of overhead for transmitting information between task A at site 1 and task B at site 2?
• BNs can be instantiated for every assignment of tasks to sites
• Result: not single values but probabilistic distribution
TAMRI Overview

Optimization algorithm: Randomization

For \( n \gg 1 \) (\( n=1000 \))
- Pick random values for every impact function based on statistical distributions
- Execute distributed system algorithm
- Store optimal assignment

Input:
- Execution impact (site, task)
- Transmission impact (site, site, task, task)

Output:
- Optimal assignment

Input: Values for influencing factors

Output: Weighted list of assignment suggestions

Results of empirical study
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Scenario Overview

Tasks:

Sites:

Task Allocation Scenario (1)

Scenario 1

Component development & testing

- Development is done at A, testing needs to be assigned to B or C
- Follow-the-sun possible between A and C
- Higher familiarity at B
- Cost rate no criterion
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Tool Implementation: Scenario 1

Factors are organization-specific and can be changed easily in the implementation.

Weight is placed on development time: follow-the-sun with C slightly prioritized.

Tasks and sites can be added.

Characteristics of development task:
- Financial costs
- Time
- Quality

Characteristics of testing task:

Factors specific to site A:

Factors specific to site B:

Factors specific to sites with respect to testing task:

Weigh is placed on quality: assignment to familiar site suggested.
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Task Allocation Scenario (2)

Scenario 2

Development and testing of 3 components

- All tasks can be assigned freely
- Different coupling between components (1↔2: high, 1↔3, 2↔3: low)
- Expertise for development at A, testing at B
- Low labor costs at C, possibility of follow-the-sun
Results Scenario 2

Priority: quality and cost

Due to complexity, significance in results not so high (best assignment only optimal in 16% of runs)

However, general suggestions can be derived from result list

- Development should be done at A
- It is generally better to do testing at B than at C
- But single testing tasks could also be done at C
### Summary: Characteristics of TAMRI Model

<table>
<thead>
<tr>
<th>Multiple goals</th>
<th>Different goals can be weighted and aggregated into one impact function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple influences</td>
<td>Large number of different influencing factors can be specified in Bayesian Networks</td>
</tr>
<tr>
<td>Organization-specific context</td>
<td>Bayesian Network concept allows for easily exchanging networks without having to change underlying algorithms; Bayesian Networks can be adapted to organization-specific goals, influencing factors, weights</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Bayesian Networks can describe causal relationships under uncertainty; results can be produced without having to specify all input parameters; model output reflects uncertainty by providing multiple suggestions</td>
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## Future Research

| Adaptation of model to specific contexts | Bayesian Networks are based on empirical study with input from various types of GSD  
- Model needs to be adapted to specific environments / organization |
| Evaluation | The model has only been evaluated in hypothetical scenarios  
- Future work: evaluation in real-world context  
- Will practitioners accept “black-box” model? |
| Eliciting organizational knowledge | Underlying assumption: knowledge about organization is very detailed (e.g., cultural differences between sites can be classified)  
- Methods for eliciting knowledge have to be found |
| Process for decision support | The decision model has to be integrated into an organizational task allocation process  
- Includes roles, responsibilities, sub-processes for eliciting knowledge, determining influencing factors… |
Thank you for your attention!

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