Using Simulation to Evaluate Global Software Development Task Allocation Strategies

SPIP (Software Process Improvement and Practice) 2007

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Introduction (1/2)

- Global Software Development (GSD)
  - Software teams, working on the same project or system, collaborate across national boundaries
  - Advantages
    - Reduction in development cost and time
    - Better use of scarce resources
  - Disadvantages
    - Require more communication and coordination
Introduction (2/2)

- Follow-the-sun strategy
  - 24-hours development
    - Reduce the cycle time by 20-35% in ideal case
    - Difficult to coordinate
      - Require much more communication and coordination

- Research goal
  - Provide simulation model to find better task allocation strategies to reduce the cycle time
GSD Simulation model (1/6)

- Important factors for GSD
  - Fundamental factors
    - Primary characteristics of GSD projects
      - Communication problems, coordination and control problems, cultural, language, and time zone differences
  - Strategic factors
    - PM should address them for managing a GSD project
      - Development site, product architecture, task allocation strategy, distribution overhead, distribution effort loss
  - Organizational factors
    - Concerned with new form of development team - global teams
      - Relationship and trust between team members affects to coordinate effectively
GSD Simulation model (2/6)

- GSD model has three high-level components
  - Discrete Event Simulation (DES) model for describing the flow of the activities
  - System Dynamics (SD) for describing the project environment
  - Interaction Effect (IE) model

- DES model
  - Site-specific DES represents
    - Different process steps
    - Different time zones
  - Global DES determine overall project progress
GSD Simulation model (3/6)

- SD model
  - Global SD sub-model
    - Captures the overall project environment such as planning and controlling activities
      - Control
        - Receives information about the project progress
        - Evaluates whether adjustments to the schedule or the work rate are needed
      - Planning
        - Monitors and identifies the workforce level required to meet the overall project schedule
      - Human Resources
        - Act as an interface between the HRn modules for each development site
GSD Simulation model (4/6)

- SD model (Cont’d)
  - Site-specific SD sub-model
    - Represents aspects that may be different between development sites
    - Consists of four modules
      - Human Resource (HR) deals with human resource management
      - Manpower allocation (MP) assigns workforce to different activities
      - Productivity (PD) models the productivity rate at a particular site
      - Quality Assurance (QA) models defect generation, detection, and correction rates
GSD Simulation model (5/6)

- Interaction Effect (IE) model
  - Comes into play when staffs from different sites need to collaborate
    - Interaction effect on productivity rate (PD module in site-specific SD model)

Causal diagram for productivity under GSD
GSD Simulation model (6/6)

- GSD model structure for two development sites

Diagram showing the relationship between Human Resource, Planning, Control, Global SD, Workforce Needed, and Total Tasks Completed, along with the interaction effect of Site-specific DES at Site 1 and Site 2. The diagram also includes symbols for HR (Human Resource), MP (Manpower Allocation), PD (Productivity), QA (Quality), and various other elements related to site-specific SD and workforces.
Model results (1/7)

- Experimental design
  - Example project has Two site GSD and five phases
- Strategies
### Model results (2/7)

- **Ideal case**
  - Without any GSD factors

- **Real case**
  - With all GSD factors

- Duration when using follow-the-sun is 70% of the time it takes using single-site

- Follow-the-sun took about 37% longer than single-site

- Module-based is the shortest
## Model results (3/7)

- Identify factors that have strong impact on duration for each task allocation strategy
  - Factor levels and descriptions

<table>
<thead>
<tr>
<th>Factors</th>
<th>Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>2</td>
<td>within walking distance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not within walking distance</td>
</tr>
<tr>
<td>Time-zone (Percent Overlap of Work Hours)</td>
<td>2</td>
<td>No overlap working hour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100% overlap working hour</td>
</tr>
<tr>
<td>Culture</td>
<td>2</td>
<td>Same</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Different</td>
</tr>
<tr>
<td>Language</td>
<td>2</td>
<td>Same</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Different</td>
</tr>
<tr>
<td>Distribution Overhead</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Member Familiarity</td>
<td>2</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Team Meeting</td>
<td>2</td>
<td>Infrequent: every 8 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequent: every 4 months</td>
</tr>
</tbody>
</table>

- Proxy measure for communication frequency (shorter distance = higher communication frequency)
- Different time-zone means less overlap working hour
- National culture between two development sites (related to the location of development sites)
- Official language between two development sites
- Additional effort/time required when tasks are distributed across sites including artifact transfer and knowledge transfer.
- The degree that members are familiar with one another (i.e. work together before = high)
- The frequency of team meeting during the course of the project
Model results(4/7)

- **Follow-the-sun strategy**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Schedule</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% overlap</td>
<td>Increase</td>
<td>Reduce development time/day</td>
</tr>
<tr>
<td>High distance</td>
<td>Increase</td>
<td>Reduce communication frequency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>=&gt; Low productivity</td>
</tr>
<tr>
<td>High Dist. Overhead</td>
<td>Increase</td>
<td>Increase effort</td>
</tr>
</tbody>
</table>
Module-based strategy

<table>
<thead>
<tr>
<th>Main Factors</th>
<th>Schedule</th>
<th>Cause</th>
</tr>
</thead>
</table>
| 100% overlap          | Decrease | Overlap doesn’t have impact on development time/day  
Synchronous communication=>high productivity |
| High Dist. Overhead   | Increase | Increase effort                            |
Model results (6/7)

- Phase-based strategy

<table>
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<th>Schedule</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% overlap</td>
<td>Decrease</td>
<td>Synchronous communication=&gt;high productivity</td>
</tr>
<tr>
<td>High Dist. Overhead</td>
<td>Increase</td>
<td>Increase effort</td>
</tr>
</tbody>
</table>
Model results(7/7)

- Summary on experiments
  - Different factors affects duration for each task allocation strategy in unique ways

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Most Important Factors on schedule</th>
</tr>
</thead>
</table>
| Follow-the-Sun       | % Overlap (+)
                     | Distribution overhead (+)
                     | Distance (+)          |
| Module-based         | Distribution overhead (+)                              |
                     | % Overlap (-)                                          |
                     | Familiarity (-)                                        |
| Phase-based          | Distribution overhead (+)                              |
                     | % Overlap (-)                                          |
                     | Culture (+)                                            |
Conclusion

**Contribution**

- Use a GSD model to evaluate the choice of task allocation strategy and its impact on project duration
  - Capture and assess the impact of a number of real-world factors that have been presented in the literature
  - Help project managers to determine which type of GSD configuration is likely to work best for their particular situation
    - Different factors affect duration for each task allocation strategy in unique ways
Discussion

- Trend on software process simulation
  - New development process instead of waterfall process
    - ex) GSD, extreme programming, and so on
  - Identification of factors on schedule and effort
    - Derive the value of factors from various literatures

- Related with research topic
  - Resource allocation policies for multi-projects in one organization
    - Analyze the result of experiments with various policies
Model results

- Phase-based strategy
  - Interaction between overlap and meeting frequency on schedule

<table>
<thead>
<tr>
<th>Overlap</th>
<th>Frequent Meeting</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>Reduce effort and increase duration</td>
</tr>
<tr>
<td>100%</td>
<td>Decrease both effort and duration</td>
</tr>
</tbody>
</table>