Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

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Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

Agenda

- Motivation
- The i* Framework
- Mapping COSMIC-FFP to PRiM
- Measuring COSMIC-FFP with PRiM
- Non-functional Measurements
- Conclusions and Future Work
Agenda

- **Motivation**
- The $i^*$ Framework
- Mapping COSMIC-FFP to PR$i$M
- Measuring COSMIC-FFP with PR$i$M
- Non-functional Measurements
- Conclusions and Future Work
Motivation

- In the latest projects where you have been involved, did you use the current system as a starting point?
  - We did
  - We used the current system as a starting point
    - Maintain most of the existing functionality
    - Improve some non-functional requirements
    - Fulfil new organizational goals

- Use of Business Process Reengineering practices
  - We defined PRiM, a Process Reengineering $i^*$ Method

- Development of software systems can be viewed as an exercise of reengineering
Motivation

- **Traditional reengineering activities**
  - Model an the existing system
  - Generate solutions
  - Evaluate solutions

- **Some existing methods**
  - Support some of the reengineering activities
  - Mention/Not mention the term “reengineering”

- **PRiM: A Process Reengineering i* Method**
  - Works during the requirements stage
  - Uses the i* Framework to represent requirements
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

**PRiM: a Process Reengineering $i^*$ Method**

**Phase 1**
Analysis of the Current Process

**Phase 2**
Construction of the $i^*$ Model of the Current Process

**Phase 3**
Elicitation of Requirements for the New System

**Phase 4**
Generation of the Alternative System Solutions

**Phase 5**
Evaluation of the Alternative System Solutions

**Phase 6**
Specification of the New Software System

Current Process

New Software System
PRiM: a Process Reengineering $i^*\text{ Method}$

- Evaluation of Alternatives
  - Structural Metrics
  - Non-functional requirements
  - How to measure the functional size?
    - COSMIC-FFP

Phase 5

Evaluation of the Alternative System Solutions
Agenda

- Motivation
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Using the PR/M method to Evaluate Requirements Models with COSMIC-FFP

The i* Framework
The i* Framework

Registrar

Student

C-Registration System

Professor

Actor

Goal Dependency

Using the PR/M method to Evaluate Requirements Models with COSMIC-FFP
Using the PRM method to Evaluate Requirements Models with COSMIC-FFP

The $i^*$ Framework
The i* Framework

Using the PR/M method to Evaluate Requirements Models with COSMIC-FFP
Using the PR/M method to Evaluate Requirements Models with COSMIC-FFP

The * Framework

Registrar

Student

C-Registration System

Professor

Actor

Goal Dependency

Task Dependency

Resource Dependency

Softgoal Dependency

Student information

Remote access instructions

Remote access is enabled

Secure remote access to the System

Course registration

Grades report card

Student information is maintained

Submit student grades

Courses are selected

Courses are selected

Remote access is enabled

Remote access is enabled

Remote access is enabled

Remote access is enabled

Submit student grades

Courses are selected

Courses are selected

Courses are selected

Courses are selected

Courses are selected

Courses are selected

Remote access is enabled

Secure remote access to the System

Secure remote access to the System

Student information

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Submit student grades

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- The $i^*$ Framework
- **Mapping COSMIC-FFP to PRiM**
- Measuring COSMIC-FFP with PRiM
- Non-functional Measurements
- Conclusions and Future Work
Mapping COSMIC-FFP to PRiM

Matching of COSMIC-FFP and PRiM Concepts

- PRiM Definition of \( i^* \) models
- COSMIC-FFP Basic concepts
- MAPPING of Structural Concepts

Definition of a COSMIC-FFP Structural Metric

- PRiM Structural Metric Basic Form
- COSMIC-FFP Structural Metric
Defining $i^*$ Models with PRiM

- **Objective:**
  - Build the $i^*$ Model of the Current Process
    - Social or Socio-Technical

- **Strategy:**
  - Analyse the Current Process
  - Document the Current Process into DIS
  - Building the Operational $i^*$ Model:
    - Descriptive goals
    - Obtained by applying rules over the DIS tables
    - Resources and Tasks
  - Building the intentional $i^*$ model
    - Prescriptive goals
    - Obtained from the organization needs and expectations
    - Goals and Softgoals
Defining $i^*$ Models with PRiM

- **Detailed Interaction Script (DIS)**
  - Scenario-based notation for documenting the Current Process
  - One DIS for each activity

**DIS 3: Modify a Professor**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Registrar</td>
<td>enters Professor ID</td>
<td></td>
<td></td>
<td>Professor ID</td>
<td>C-Registration System</td>
</tr>
<tr>
<td>2</td>
<td>C-Registration System</td>
<td>retrieves the professor information</td>
<td>Professor data</td>
<td></td>
<td></td>
<td>Database</td>
</tr>
<tr>
<td>3</td>
<td>C-Registration System</td>
<td>displays the professor information</td>
<td></td>
<td>Professor data</td>
<td></td>
<td>Register</td>
</tr>
<tr>
<td>4</td>
<td>Registrar</td>
<td>enters the modified professor data</td>
<td></td>
<td>Professor data</td>
<td></td>
<td>C-Registration System</td>
</tr>
<tr>
<td>5</td>
<td>Registrar</td>
<td>When changes are complete, the Registrar selects 'save'</td>
<td>C-Registration System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>C-Registration System</td>
<td>updates the Professor information</td>
<td>Professor data</td>
<td></td>
<td>Database</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>C-Registration System</td>
<td>displays error message</td>
<td>Error message</td>
<td></td>
<td>Register</td>
<td></td>
</tr>
</tbody>
</table>

**Postcondition:** The Registrar has modified the professor data
Transformation Guidelines: from DIS to *

Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

Detailed Interaction Script (DIS) to * Model

Conditions
Activity
Action
Resource
Actor

Goal Dependency
SR Task
Resource Dependency
Actor

COSMIC-FFP Basic concepts
MAPPING of Structural Concepts
PRiM Structural Metric Basic Form
COSMIC-FFP Structural Metric

PRiM Definition of * models
Defining \( i^* \) Models with PRiM

Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

- **COSMIC-FFP**
  - Analyses the functional processes
  - Considers three kinds of actors:
    - Users or Engineered Devices
    - System Boundary
    - Persistent Storage
  - Identifies the data movements implied:
    - Entry
    - eXit
    - Read
    - Write
### Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

<table>
<thead>
<tr>
<th>No</th>
<th>ID. of Requirements</th>
<th>Process descriptions</th>
<th>Triggering event</th>
<th>Sub-process Description</th>
<th>Data Group</th>
<th>Data movement Type</th>
<th>Cfu</th>
<th>ΣCfu</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.2.2.1</td>
<td>Modify a professor</td>
<td>Registrar selects the &quot;modify a Professor&quot; activity</td>
<td>Registrar enters Professor ID</td>
<td>Professor ID</td>
<td>E</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2.2.2.4</td>
<td></td>
<td></td>
<td>The system retrieves the Professor information</td>
<td>Professor data</td>
<td>R</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The system displays the Professor information</td>
<td>Professor data</td>
<td>X</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The Registrar enters the modified Professor data</td>
<td>Professor data</td>
<td>E</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>When changes are complete, the Registrar selects 'Save'</td>
<td>This is not a distinct data movement. It only indicates that the Entry of the data (see above) is completed</td>
<td>This will be omitted from now on in all other use cases</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The system updates the Professor information</td>
<td>Professor data</td>
<td>W</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Display error message</td>
<td>Message</td>
<td>X</td>
<td>1</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>
Mapping of Structural Concepts

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PRiM
Definition of \( i^* \) models

COSMIC-FFP
Basic concepts

MAPPING of Structural Concepts

PRiM
Structural Metric Basic Form

COSMIC-FFP
Structural Metric
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

Mapping of Structural Concepts

- **Entry**: Entry to a data group from a user via a boundary.
- **eXit**: Exit from a data group to a user via a boundary.
- **Read**: Data grouped read from a persistent storage via a boundary.
- **Write**: Data grouped write to a persistent storage via a boundary.

**PRiM**
- Definition of *i* models

**COSMIC-FFP**
- Basic concepts

**MAPPING of Structural Concepts**

**PRiM Structural Metric Basic Form**

**COSMIC-FFP Structural Metric**
PRiM: Structural Metrics

- **Objective:**
  - Evaluate non-functional properties of the models

- **Technique:**
  - Actor-based metrics and Dependency-based metrics

\[ P(M) = \sum_{d \in D} \left( \text{filter}M(d) \times \text{correctionFactor}M(a,b) \right) \]

\( \text{filter}_M: D \rightarrow [0, 1] \) a function that assigns a weight to every dependency

\( \text{correctionFactor}_M: A \rightarrow [0, 1] \) a function that corrects the weight of the dependency considering its depender and the dependee.

\( \text{lim}t_p(D) \rightarrow [1..||A||] \) a function that normalizes the result obtained (if needed)
**COSMIC-FFP: Structural Metric**

Functional Size \( (M) = \sum_{d \in D} \frac{\text{functional_size}(d)}{\text{limit}_P(D)} \)

\[
\text{functional_size}(d) = \text{filter}_M(d) \times \text{correctionFactor}(d)
\]

\[
\text{filter}_M(d) = \begin{cases} 
1, & \text{if } d \in \text{Resource} \\
0, & \text{otherwise}
\end{cases}
\]

\[
\text{correctionFactor}_M(a,b) = \begin{cases} 
1, & \text{if } a \in \text{Boundary and } b \in \text{User} \\
1, & \text{if } a \in \text{User and } b \in \text{Software} \\
1, & \text{if } a \in \text{Boundary and } b \in \text{Persistent Storage} \\
1, & \text{if } a \in \text{Persistent Storage and } b \in \text{Boundary} \\
0, & \text{otherwise}
\end{cases}
\]

\[
\text{limit}_P(D) = 1
\]
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Using the PRISM method to Evaluate Requirements Models with COSMIC-FFP
Using the PRM method to Evaluate Requirements Models with COSMIC-FFP
### Activities Descriptions

#### Activities List

<table>
<thead>
<tr>
<th>Order</th>
<th>Activity Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Logon</td>
</tr>
</tbody>
</table>

#### Properties for the Activity

- **Activity Name:** Logon
- **Activity Description:** Activity that happens when the actor access the login form.
- **Precondition:**
- **Postcondition:**
- **Triggering Events:** Actor types his/her name and password on the login form.

#### Actions

<table>
<thead>
<tr>
<th>Order</th>
<th>Action Initiator</th>
<th>Action</th>
<th>Consumed Resource</th>
<th>Produced Resource</th>
<th>Provided Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Willie Coll...</td>
<td>Actor enter name and pass...</td>
<td>User data</td>
<td>Schedule item data</td>
<td>Student data</td>
</tr>
</tbody>
</table>

Check Resources Allocation
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP.
Using the PRiM method to evaluate requirements models with COSMIC-FFP
Using the PRIM method to Evaluate Requirements Models with COSMIC-FFP

### Actors and Goals Identification

#### Actors Main Goals

<table>
<thead>
<tr>
<th>Actor</th>
<th>Main Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billing System</td>
<td>Bills are managed</td>
</tr>
<tr>
<td>C-Registration System</td>
<td>Online registration is possible</td>
</tr>
<tr>
<td>Courses Catalog</td>
<td>Courses information is managed</td>
</tr>
<tr>
<td>Database</td>
<td>Course information is stored</td>
</tr>
<tr>
<td>Mail System</td>
<td>Mails are send</td>
</tr>
<tr>
<td>Professor</td>
<td>Courses are undertaken</td>
</tr>
<tr>
<td>Registrar</td>
<td>Information about users is maintained</td>
</tr>
<tr>
<td>Student</td>
<td>Be registered to courses</td>
</tr>
<tr>
<td>Wilfrid College User</td>
<td>Information is managed online</td>
</tr>
</tbody>
</table>

#### Goal Description

Main Goal Description:

Main Goal Extended Name:

#### Actor Decomposition

<table>
<thead>
<tr>
<th>Actor</th>
<th>Operational Model</th>
<th>Intentional Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
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**Generation of the Operational i* Model**

### Activity List

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</tr>
<tr>
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<td>Add a professor</td>
</tr>
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<td>3</td>
<td>Modify a professor</td>
</tr>
<tr>
<td>4</td>
<td>Delete a professor</td>
</tr>
<tr>
<td>5</td>
<td>Select courses to teach</td>
</tr>
<tr>
<td>6</td>
<td>Add a student</td>
</tr>
<tr>
<td>7</td>
<td>Modify a student</td>
</tr>
<tr>
<td>8</td>
<td>Delete a student</td>
</tr>
<tr>
<td>9</td>
<td>Create a schedule</td>
</tr>
<tr>
<td>10</td>
<td>Modify a schedule</td>
</tr>
<tr>
<td>11</td>
<td>Delete a schedule</td>
</tr>
<tr>
<td>12</td>
<td>Close registration</td>
</tr>
<tr>
<td>13</td>
<td>Submit grades</td>
</tr>
<tr>
<td>14</td>
<td>View report card</td>
</tr>
</tbody>
</table>

### Conditions Definition

- **Activity Precondition:**
- **Associated Precondition:**
- **Activity Triggering Event:**
- **Associated Action Task:**
- **Activity Postcondition:**
- **Associated Postcondition:**

### Automatic Generation of i* Model

- Generate Operational Model
- Clear Operational Model

**Actors:** Operational i* Model | Intentional i* Model
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

Generation of the Operational i* Model

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<td>Submit grades</td>
</tr>
<tr>
<td>14</td>
<td>View report card</td>
</tr>
</tbody>
</table>

Activity Precondition:

Activity Triggering Event:

Activity Postcondition:

Automatic Generation of i* Model

Generate Operational Model

Clear Operational Model

Save
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP
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Using the PRI Method to Evaluate Requirements Models with COSMIC-FFP

Evaluation using COSMIC-FFP

Select the i* Models to Evaluate

<table>
<thead>
<tr>
<th>Model</th>
<th>Kind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational i* Model</td>
<td>OPERATIONAL</td>
</tr>
<tr>
<td>Intentional i* Model</td>
<td>INTENTIONAL</td>
</tr>
<tr>
<td>Alternative A</td>
<td>ALTERNATIVE</td>
</tr>
<tr>
<td>Alternative B</td>
<td>ALTERNATIVE</td>
</tr>
</tbody>
</table>

System Boundaries

Users:
- Professor
- Registrar
- Student
- Willie College User
- Billing System

Application Boundary:
- C-Registration System
- Course Catalog System
- Mail System

Persistent Storage:
- Database

Evaluate Architecture

<table>
<thead>
<tr>
<th>Id</th>
<th>Activity</th>
<th>Entry</th>
<th>Create</th>
<th>Read</th>
<th>Write</th>
<th>Chg</th>
</tr>
</thead>
</table>

Evaluate
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

**Evaluation using COSMIC-FFP**

- **Select the i* Models to Evaluate**
  - Model: Operational *M Model, Operational *M Kind
  - Kind: OPERATIONAL, INTENTIONAL
  - Alternative A, ALTERNATIVE
  - Alternative B, ALTERNATIVE

- **System Boundaries**
  - Users:
    - Professor
    - Registrar
    - Student
    - Willie College User
    - Billing System
    - Course Catalog System
  - Application Boundary:
    - C-Registration System
    - Mail System
  - Persistent Storage:
    - Database

- **Evaluate Architecture**
  - Id, Activity, Entry, exit, Read, Write, Ctrl

- **Evaluate**
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP

**Evaluation using COSMIC-FFP**

**Select the i^2 Models to Evaluate**
- Operational i^2 Model: OPERATIONAL
- Intentional i^2 Model: INTENTIONAL
- Alternative A: ALTERNATIVE
- Alternative B: ALTERNATIVE

**System Boundaries**
- Users:
  - Professor
  - Registrar
  - Student
  - Willie College User
- Application Boundary:
  - Registration System
  - Course Catalog System
  - Mail System
- Persistent Storage:
  - Database

**Evaluate Architecture**

<table>
<thead>
<tr>
<th>Id</th>
<th>Activity</th>
<th>Entry</th>
<th>exit</th>
<th>Read</th>
<th>Write</th>
<th>Ctrl</th>
</tr>
</thead>
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**Evaluate**
Using the PRiM method to Evaluate Requirements Models with COSMIC-FFP
Agenda

- Motivation
- The $i^*$ Framework
- Mapping COSMIC-FFP to PRiM
- Measuring COSMIC-FFP with PRiM
- Non-functional Measurements
- Conclusions and Future Work
Non-functional Measurements

- **Operational $i^*$ Model:**
  - The Registrar maintains Student Data
  - The Registrar maintains the Professor Data
  - The Student and the Professor access the System for other purposes

- **Alternative A:**
  - The Student modifies the Student Data
  - The Professor modifies the Professor Data

- **Alternative B:**
  - The Registrar is the only actor that access the System
  - The Student and the Professor request the Registrar
## Evaluation of the Alternatives

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Cfsu</th>
<th>Ease of Communication</th>
<th>Process Agility</th>
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<td>Operational $i^*$ Model</td>
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Agenda

- Motivation
- The $i^*$ Framework
- Mapping COSMIC-FFP to PRiM
- Measuring COSMIC-FFP with PRiM
- Non-functional Measurements
- Conclusions and Future Work
Conclusions

- **Our Proposal:**
  - Adapting the COSMIC-FFP measurement process model to PRiM
  - Validation of the results:
    - COSMIC-FFP results by replicating case studies
    - Non-functional properties by generating alternatives

- **COSMIC-FFP enriches PRiM:**
  - It is a standardized measurement process for evaluating the functional size
  - It provides knowledge and experience:
    - Questions for validated COSMIC-FFP functional processes
    - Guidelines for the identification of the data movements types
Conclusions

- PRiM enriches COSMIC-FFP:
  - Use of a unique i* requirements model for representing functional and non-functional requirements
  - Guidelines for generating alternatives
  - Guidelines for defining structural metrics for evaluating non-functional properties

- i* actors types provide implicit identification of the Data Groups
  - **Entry** = depender (human) and dependee (software)
  - **eXit** = depender (software) and dependee (human)
  - **Read** = depender (software) and dependee (database)
  - **Write** = depender (database) and dependee (software)

- Tool support available: J-PRiM
Future Work

- Address other metrics based on the functional size
  - Software Product Lines

- Further specification facilities
  - Study how to get the class diagrams in addition to the use cases from $i^*\text{-PRiM}$
Thank You

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Everything about $i^*$ is at: http://istar.rwth-aachen.de/