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Improving Self-adaptive Systems Conceptual Modeling

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Outline

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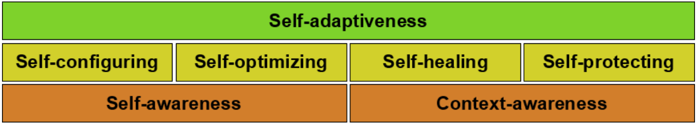
1. Work Contextualization
2. Modeling Approach
3. Approach Evaluation
4. Final Considerations

Conceptual Background

Self-adaptive Systems (SaSs) are able to adapt or (re)organize their behavior at runtime in response to contextual changes [1, 2].

- They operate under uncertainty conditions [3].
- They have intrinsic properties [4].



Conceptual modeling is the act of creating models that describe problem structures independently of the solution strategy [5].

- Abstract representations of a situation under investigation [6].
- Aid to understand the situation in which a problem occurs [7].
  - Useful for requirements analysis.

Motivation and Objective

- SaSs conceptual modeling deal with requirements uncertainty, contextual changes, and behavior adaptations.
- Model quality is related to its capability in providing the same understanding for stakeholders [8].
- Conceptual models are built by humans, therefore, their quality heavily depends on the humans expertise.

This is not a good software engineering practice!

This work proposes a modeling approach that provides higher-level abstractions for building SaSs conceptual models (metamodel) and procedures for capturing the concepts from SaSs requirements (process).

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Related Works

- There are three main concerns in the founded papers:

  adaptation establishes means to model different adaptation aspects [9, 10, 11, 12, 13, 14];

  context defines metamodels to support context requirements modeling [15, 16, 17];

  uncertainty deals with the uncertainty inherent to SaSs [18, 19].
- These papers support conceptual modeling by providing metamodels related to SaSs.
- A metamodel itself does not specify how to extract abstractions from requirements.

> Besides proposing a metamodel, this approach defines a process to guide the SaSs conceptual modeling.

Outline

Requirements Specification

- The RELAX [20] language was chosen to specify the requirements.
  - Structured natural language sentences.
  - Enriched with operators and uncertainty factors.

Requirement Example:

The SmartCar SHALL plan AS FEW AS POSSIBLE refuelings AFTER trip starts.

ENV: SmartCar; Roadmap.

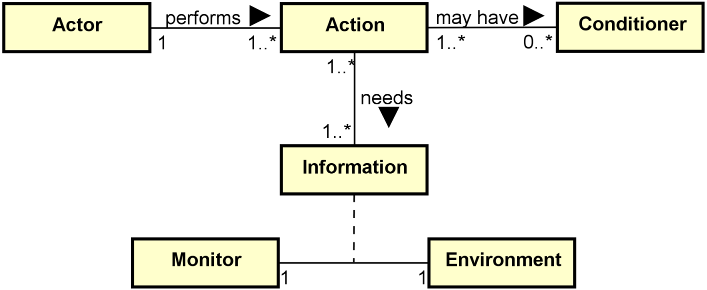
MON: Service Sensor; Consumption Sensor.

REL: Service Sensor monitors Roadmap to provide information about fuel stations.
Consumption Sensor monitors SmartCar to provide information about fuel autonomy.

DEP: Does not apply.

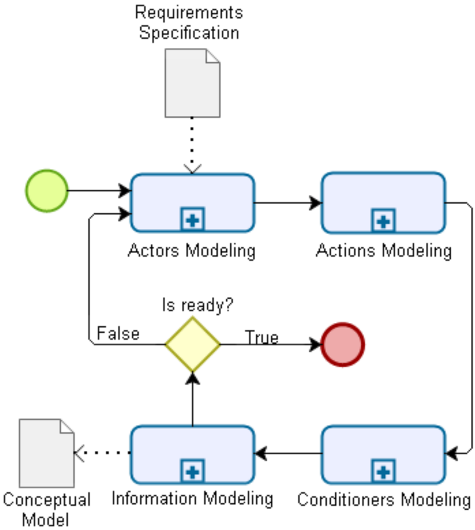
Conceptual Model Metamodel

The metamodel defines higher-level abstractions for creating conceptual models from requirements written in the RELAX language.



Conceptual Modeling Process

The process defines a way to instantiate the metamodel for creating conceptual models from requirements written in the RELAX language.

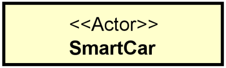


Actors Modeling

Procedures:

1. Read the text written before modal operators.
2. Identify the actors that perform actions.
3. Create a class for each identified actor.
4. Assign to each class the ≪`Actor`≫ stereotype.

Example:

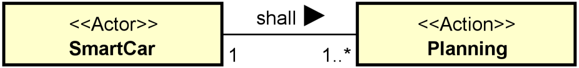


Actions Modeling

Procedures:

1. Read the text written between modal operators and temporal or ordinal operators.
2. Identify the actions related to the requirements behavior.
3. Create a class for each identified action.
4. Assign the ≪Action≫ stereotype to action classes.
5. Create an association between the actors and their actions.

Example:

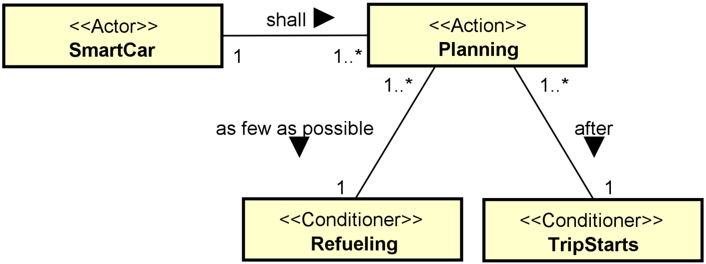


Conditioners Modeling

Procedures:

1. Read the text written after temporal or ordinal operators.
2. Identify the events, counters, states, or timers that condition the actions.
3. Create a class for each identified conditioner.
4. Assign the ≪Conditioner≫ stereotype to conditioners classes.
5. Create an association between the actions and their conditioners.

Example:



Information Modeling I

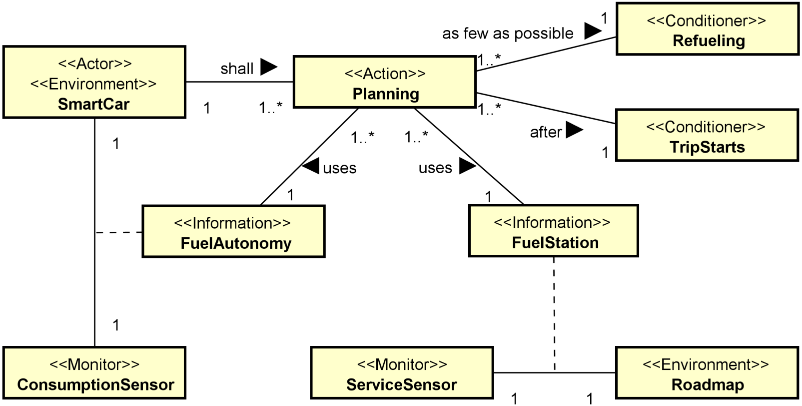
Procedures:

1. Read the text written in uncertainty factors.
2. Identify the environments specified in ENV.
3. Create a class for each identified environment.
4. Assign the ≪`Environment`≫ stereotype to environment classes.
5. Identify the monitors specified in MON.
6. Create a class for each identified monitor.
7. Assign the ≪`Monitor`≫ stereotype to monitor classes.
8. Create an associative class for each relation between MOM and ENV specified in REL.
9. Assign the ≪`Information`≫ stereotype to information associative classes.

Information Modeling II

10. Create an association between the actions and their support information.

Example:g



Outline

Experiment Planning I

- Proposed approach effectiveness evaluation.
- Experiment with software engineering students.
- Conceptual model building from a SaSs requirement.
- Information retrieval metrics to measure effectiveness [21].
- F-scores analysis of two groups:
  - experimental group (proposed approach);
  - control group (ad hoc approach).

Hypothesis:

- $H_0 : \mu_{\textit{F-Score}_{\textit{Experimental}}} = \mu_{\textit{F-Score}_{\textit{Control}}}$
- $H_1 : \mu_{\textit{F-Score}_{\textit{Experimental}}} \neq \mu_{\textit{F-Score}_{\textit{Control}}}$

Variables:

Independent the proposed and the ad hoc modeling approaches.

Dependent the effectiveness.

Experiment Planning II

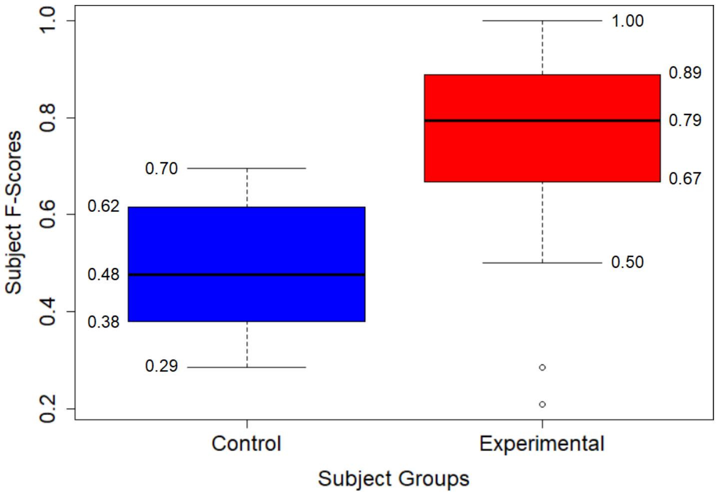
Subjects:

- Software engineering undergraduate students with similar skills.
- Students that had attended software analysis and design classes.
- 36 subjects group by according their maturity in the course.
- Randomly and equally allocated into the groups.

Roadmap:

1. Read about conceptual modeling with UML.
2. Read about requirements specification with RELAX.
3. Read about conceptual modeling approaches.
4. Model of a requirement written in RELAX.
5. Answer the evaluation questionnaire.

Results and Analysis I



Results and Analysis II

- The medians show that the experimental group had a better performance than the control group.
- The experimental group lower quartile is greater than the control group upper quartile.
- Regarding groups spreads, there is no significant difference between them.
- The experimental group has two outliers.

Normality Test (Shapiro-Wilk):

- $W_{\textit{F-Score}} = 0.968 > W_{(0.05,36)} = 0.935$
- $\textit{P-value}_{\textit{F-Score}} = 0.377 > \alpha = 0.05$
- The sample comes from a normal population.

Hypothesis Test (T-test):

- The two-tailed *P-value* is 0.0003 ($\alpha = 0.05$).
- The difference is considered statistically significant.

Outline

Conclusions

- The experiment results:
  - allow to accept the alternative hypothesis.
  - show that the proposed approach is effective.
- These conclusions are restricted by the scope of this experiment.
- The main contributions are:
  - the metamodel that provides higher-level abstractions;
  - the process that defines how to instantiate the metamodel.
- The main limitation is related to generality:
  - the approach currently requires RELAX as the language for writing requirements;
  - the experiment was limited to a single scenario and a sample from a restricted population.
- In future works, the authors intend to address these limitations.

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Thank you!

Questions?

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