Universidade Federal de Pernambuco

GO2S: a systematic process to derive the behavior of context-sensitive systems from requirements models

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Outline

- **Introduction**
  - ☐ **Context**
  - ☐ **Motivation and Rationale**
  - ☐ **Objectives**

- **Proposal**

- **Evaluation**

- **Contributions and Future works**

- **References**

Why use context?

- **Context in "Person-Person" Interactions**

➢ It improves the quality of conversations and interactions.
   ✓ It helps to solve ambiguities and conflicts.
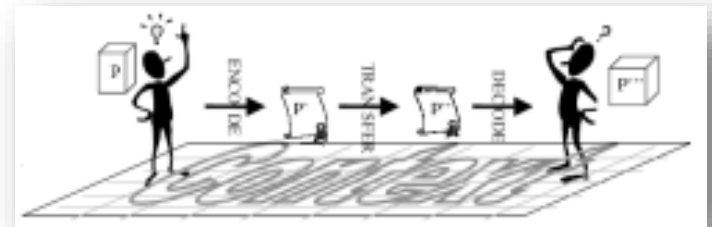
➢ It helps to understand situations, actions and events.
   ➢ Ex: "Close the window"
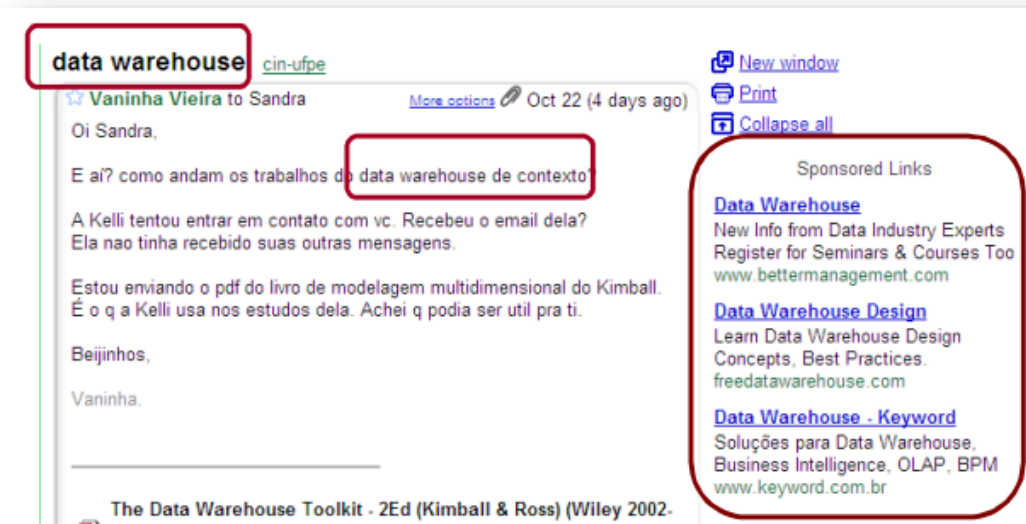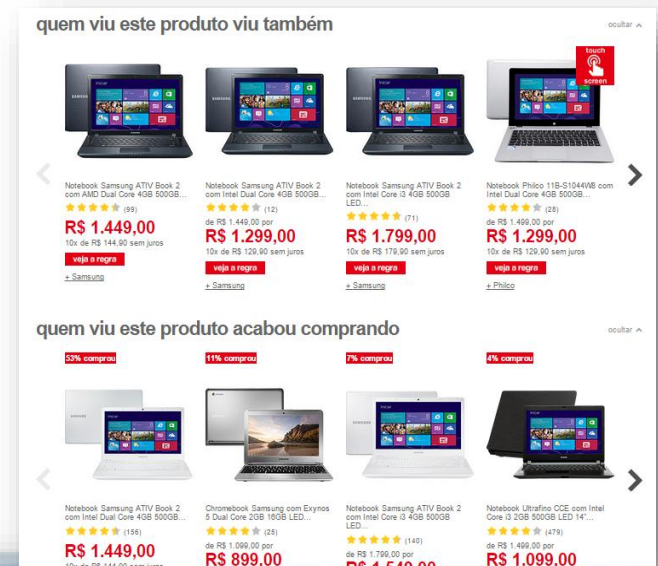
➢ Drives actions and behaviors.
   ➢ Ex: Movies x Football Stadium.

Why use context?

- ## Context in " Human-Computer" Interactions

➢ Expanded form of communication.
  ✓ Without the need for explicit user intervention.

➢ It allows system adaptation:
  ✓ Enables / disables functionalities;
  ✓ Provides services and information relevant
  to the situation.

Why use context?

- **Context in "Computer-Computer" Interactions**

➢ It helps the communication between devices.
    ➢ Ex: Smart Homes.
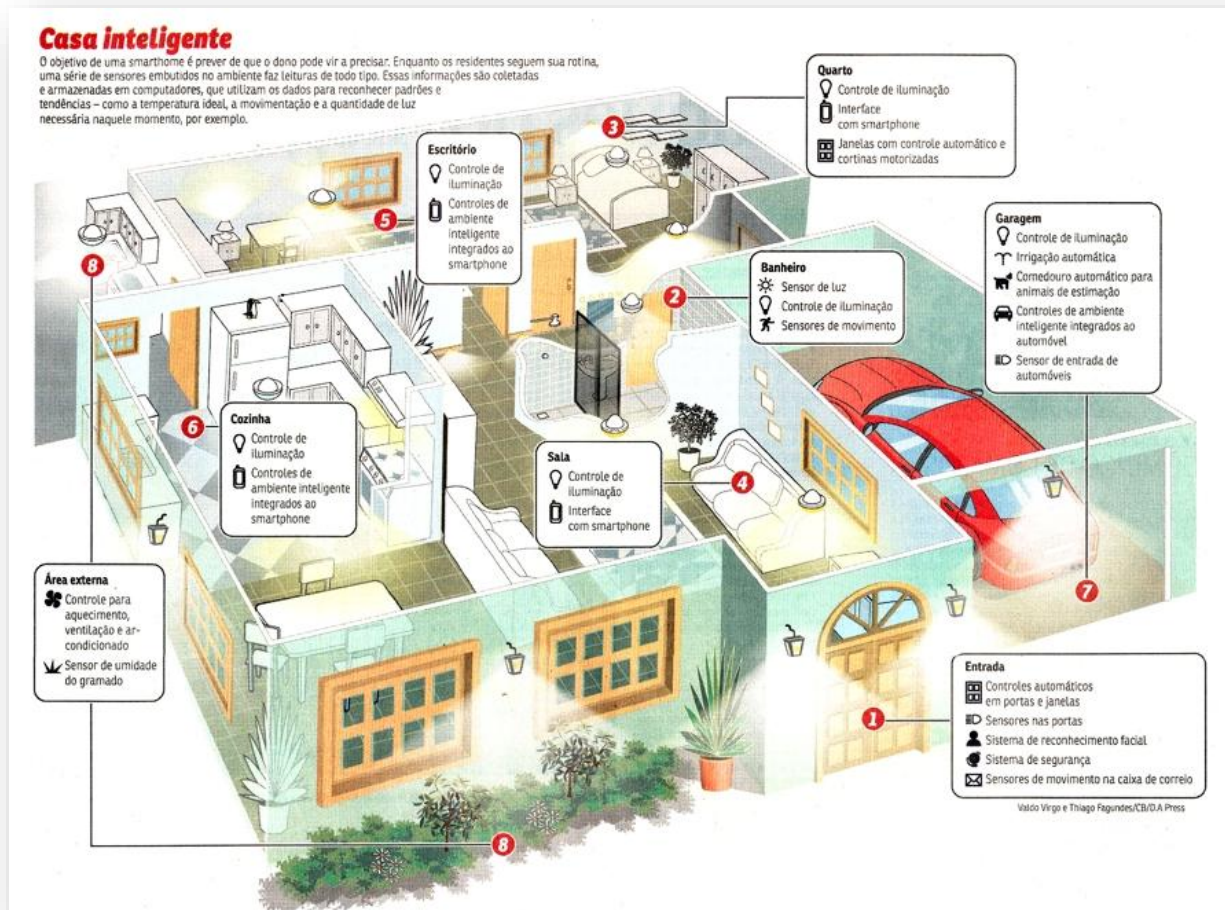
Context-sensitive systems (CSS)

- **GORE Definition (ALI; DALPIAZ; GIORGINI, 2010)**
  - ☐ **"Context is a partial state of the world that is relevant to an actor's goals."**

- **Applications that use context to provide services and relevant information.**

- **CSS must have the following characteristics:**
  - ☐ **Monitoring**
  - ☐ **Awareness**
  - ☐ **Adaptability**

- **CSS are flexible, able to act autonomously on behalf of users and dynamically adapt their behavior.**

Motivation and Rationale

- **Challenge:** to enable computer systems to change their behavior according to the analysis of contextual information.

- **Benefits (CLEMENTS et al., 2002):**
  - the models can be used as a communication channel among stakeholders during system-development activities;
  - they improve the confidence that the context-sensitive system will be able to achieve its goals;
  - reasoning can be supported allowing the analysis of properties:
    - system's completeness;
    - correctness;
    - other quality attribute.

Motivation and Rationale

- **Software-development organizations frequently begin their activities with one of these alternative starting points:**
  - **requirements or architectures - often adopting a waterfall like development process.**

- **Non-Functional Requirements (NFRs) affect both the structural and behavioral aspects of the system (architecture).**

Objectives

Research question:

How can we obtain the behavior of context-sensitive systems from requirements goal models considering their non-functional requirements?

Objectives

- **Goal 1: Systematic process for deriving the behavior of context-sensitive systems from requirements models;**

- **Goal 2: systematic approach for the specification of monitoring and adaptation tasks;**

- **Goal 3: metamodel to relate the requirements, architectural design, context and behavior in a unified approach;**

- **Goal 4: Illustration of the applicability;**

- **Goal 5: Empirical evaluation of the process through a controlled experiment.**
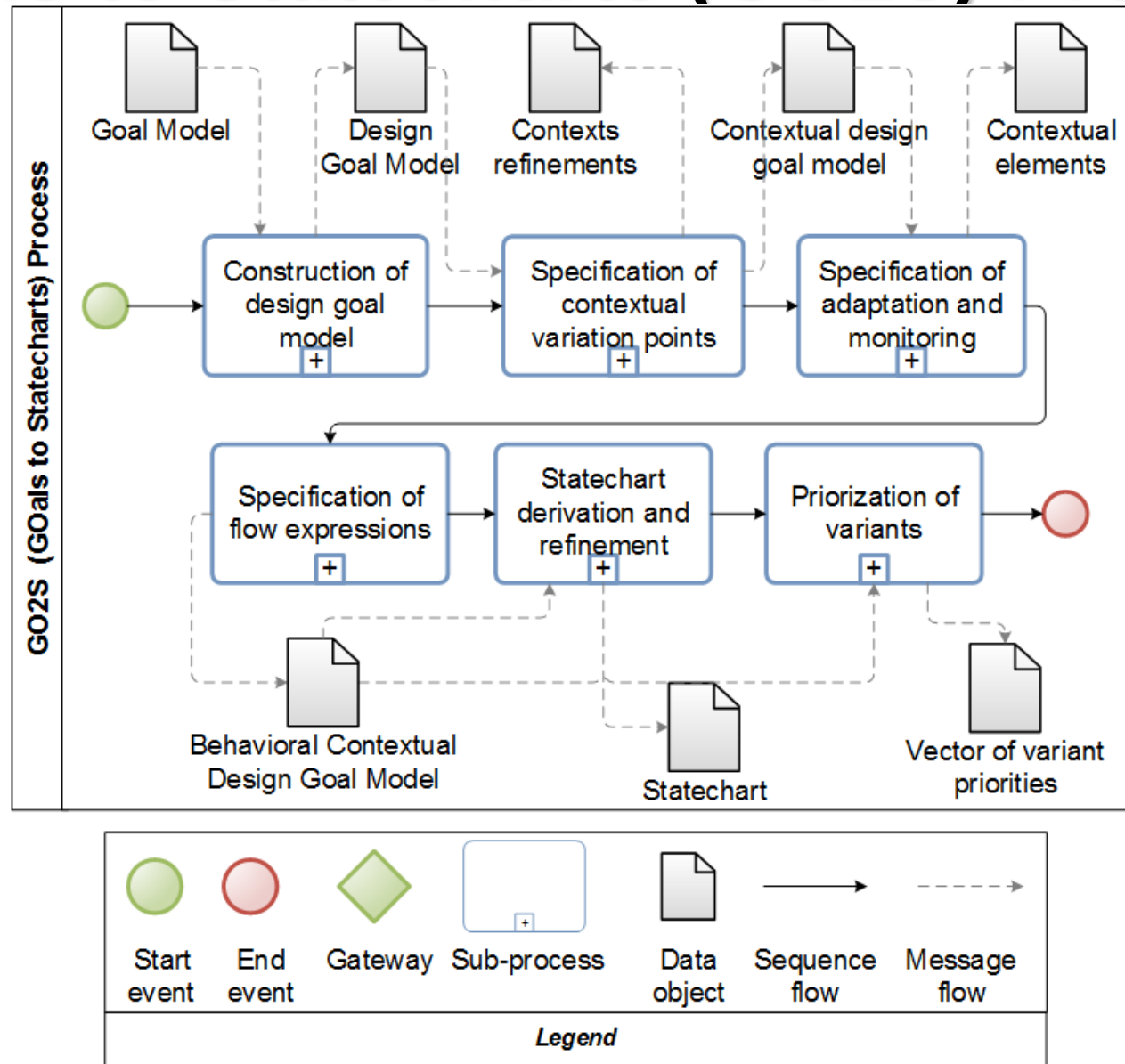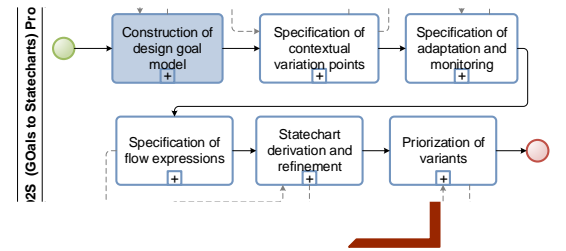
GOals to Statecharts (GO2S) Process

**Figure 3.1: The GO2S process for deriving the behavior of context-sensitive systems.**

GO2S Process: Activity 1

Construction of Design Goal Model (DGM) (PIMENTEL, 2014)

- Goal: Refine a goal model with new design elements
- Input: A goal model
- Steps:
  - ☐ 1: Identify design tasks and constraints
  - ☐ 2: Perform the NFR analysis
  - ☐ 3: Include the design tasks that operationalizes the NFRs in the goal model
- 4: Assign Tasks

GO2S Process: Activity 1
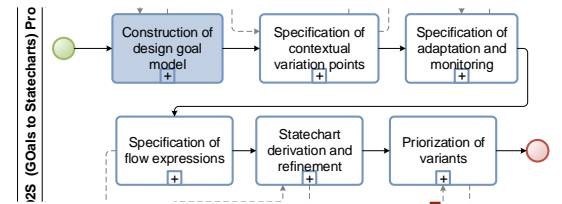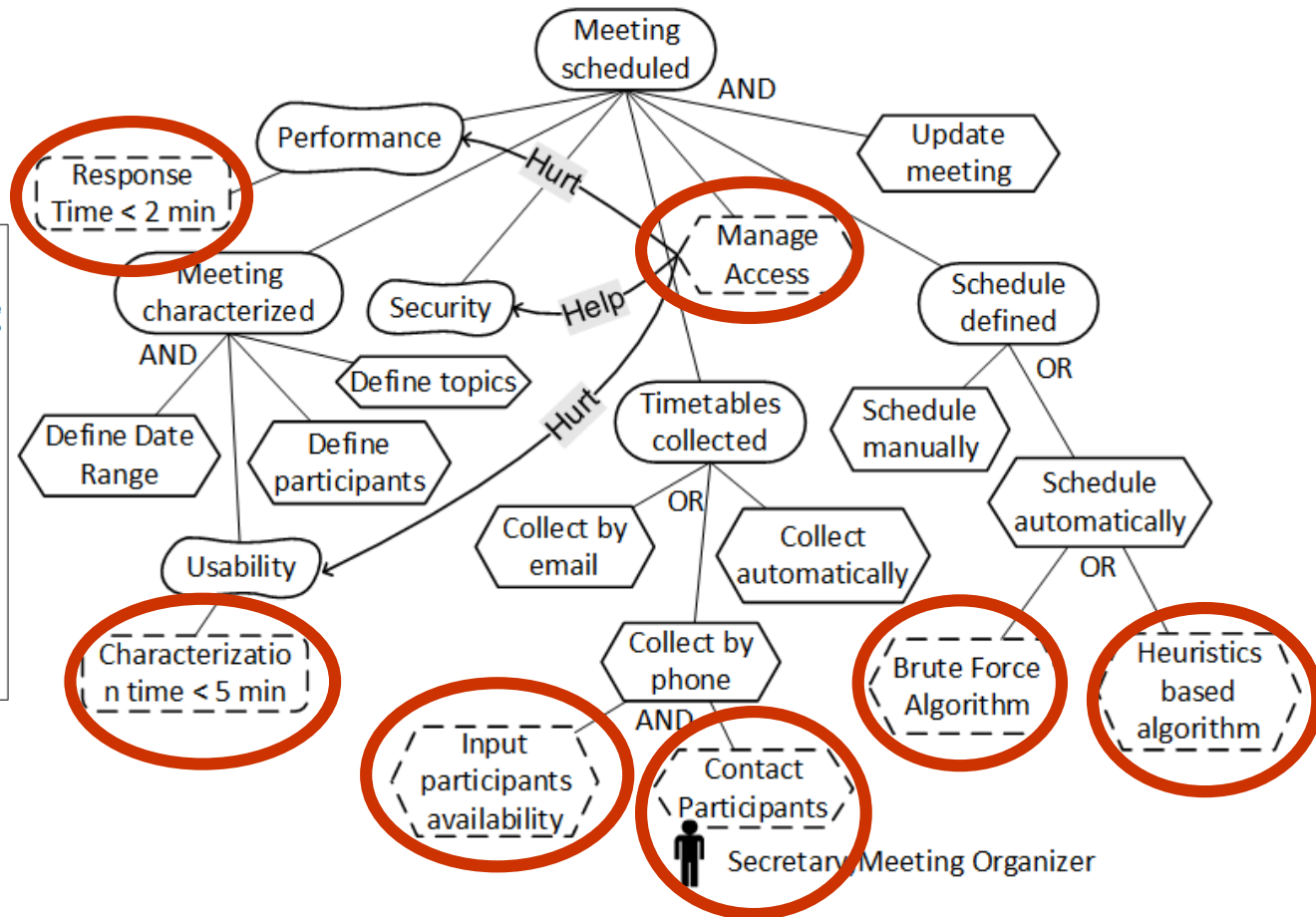

Construction of Design Goal Model (DGM) (PIMENTEL, 2014)
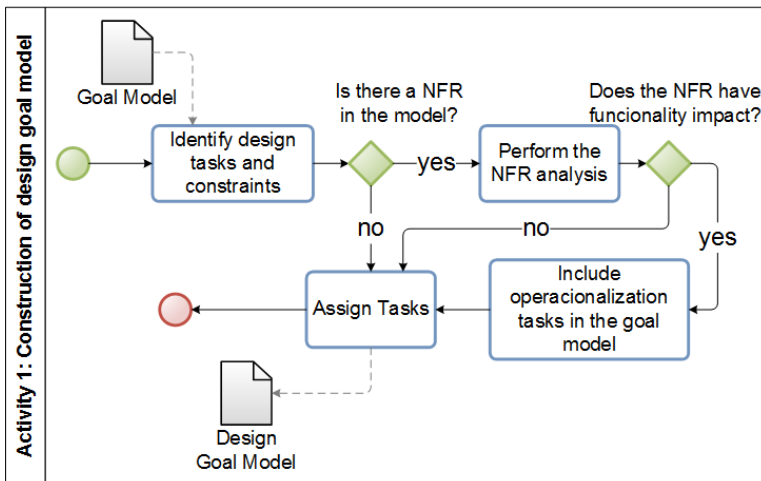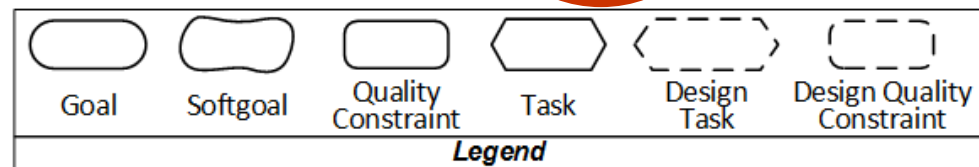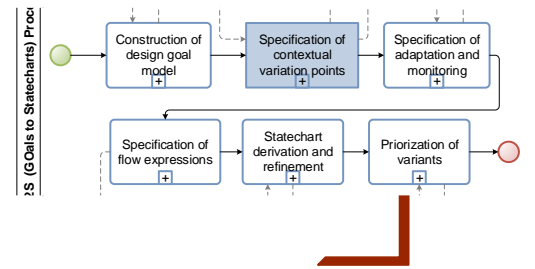

Figure 3.2: Steps of Construction of Design goal model activity.
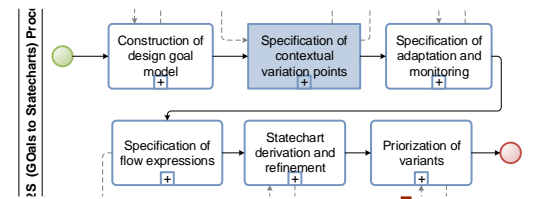
GO2S Process: Activity 2

- **Goal:** Refine a design goal model with contextual variation points

- **Input:** A design goal model

- **Steps:**
  - ☐ 1: Identify and specify the contextual variation points
  - ☐ 2: Refine contexts

- **Outputs:**
  - ☐ Contextual design goal model
  - ☐ Contexts refinements

GO2S Process: Activity 2

- **Specification of contextual variation points (ALI, 2010)**
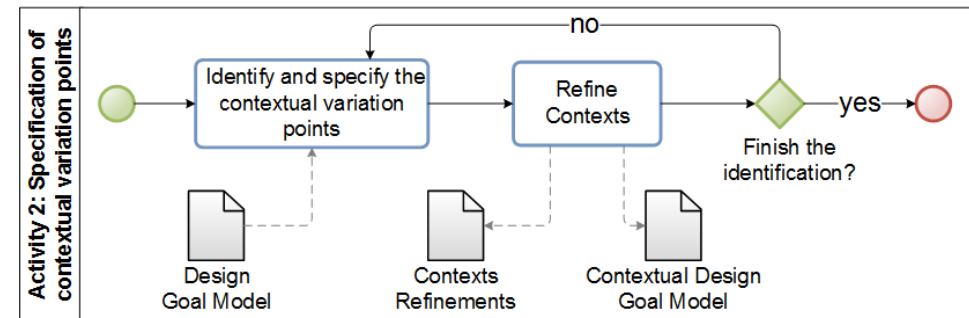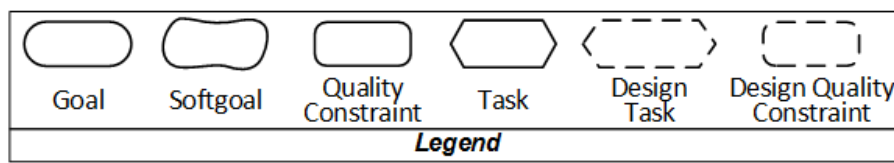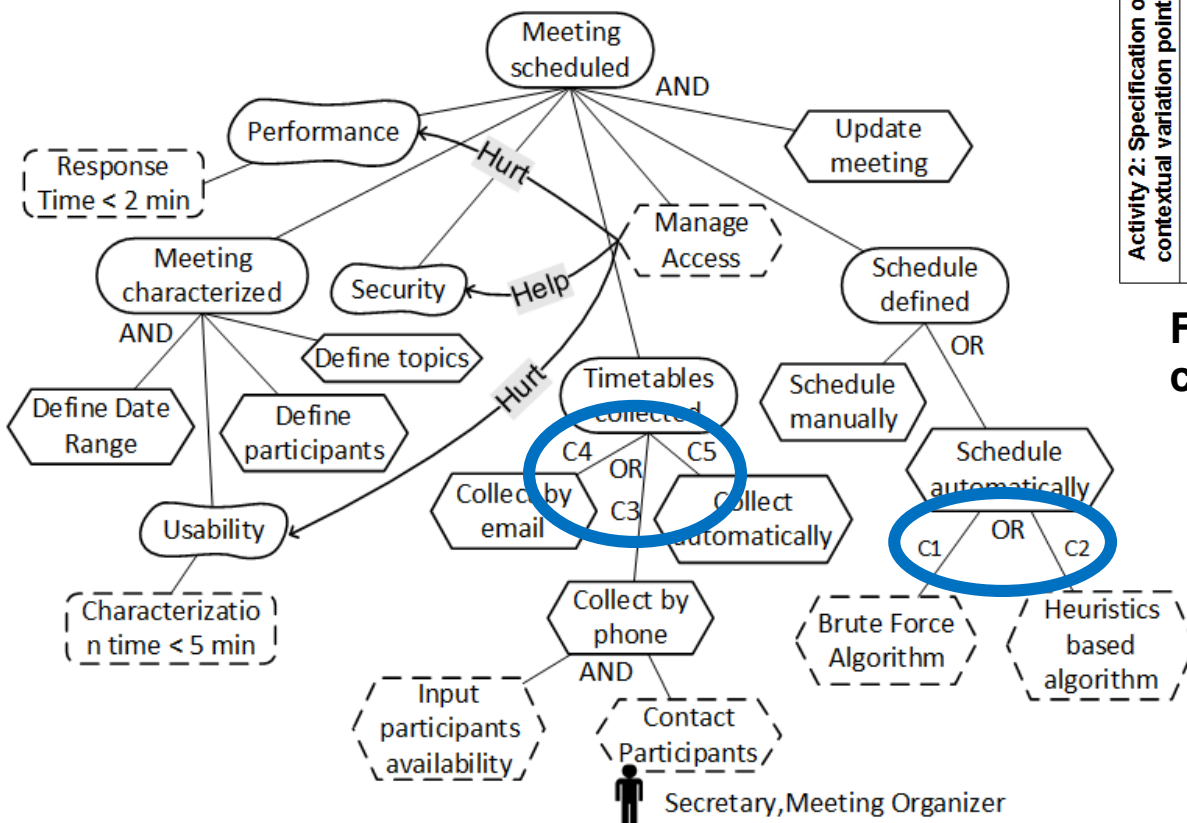

Figure 3.4: Steps of Specification of contextual variation points activity.

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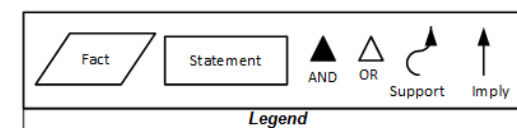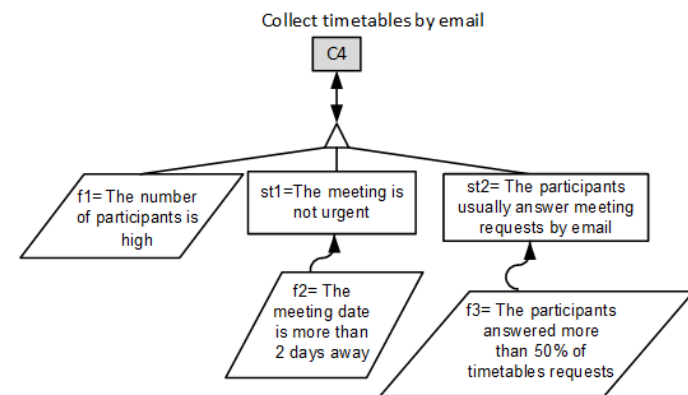
GO2S Process: Activity 3

Specification of adaptation and monitoring
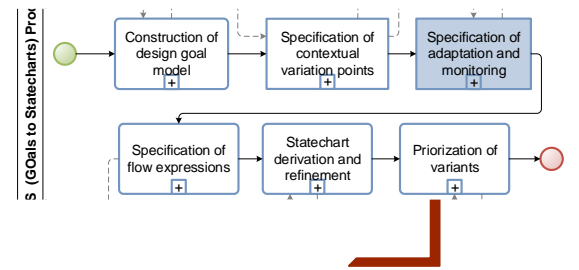
- Goal: Refine the contextual DGM with elements necessary for the specification of

- adaptation DTs as well as the monitoring

- Input: Contextual design goal model

- Steps:

  - □ 1: Define the critical requirements that requires adaptation

  - □ 2: Represent the adaptation management

    - 2.1: Add a new design task in the root node for adaptation management

    - 2.2: Add design tasks in the parent node previously created for the management of each requirement that must be monitored and adapted

    - 2.3: Add design tasks to represent the adaptation strategies for each monitored

GO2S Process: Activity 3
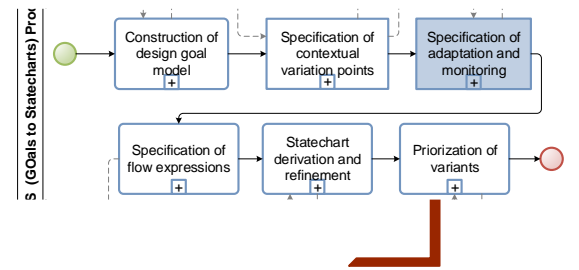
- **3:** Associate each adaptation design task with a context label

- **4:** Refine each context

- **5:** Identify the dynamic contextual elements

- **6:** Represent the context monitoring
  - ☐ 6.1: Add a new design task in the root node
  - ☐ 6.2: Add design tasks to monitor each dynamic contextual element

- **7:** Specify the equipments/technology necessary to monitor the contexts

- Outputs:
  - ☐ Contextual design goal model refined
  - ☐ Contexts Refinements

GO2S Process: Activity 3

S (GOals to Statecharts) Pro[cess]
Construction of design goal model
Specification of contextual variation points
Specification of adaptation and monitoring
Specification of flow expressions
Statechart derivation and refinement
Priorization of variants

■ **Specification of adaptation and monitoring**

Figure 3.6: Steps of Specification of adaptation and monitoring activity.

Activity 3: Specification of adaptation and monitoring

GO2S Process: Activity 3

Process flow: Construction of design goal model → Specification of contextual variation points → Specification of adaptation and monitoring → Specification of flow expressions → Statechart derivation and refinement → Priorization of variants

Monitoramento

- Monitor context
  - AND
  - Monitor response time
  - Monitor meeting date
  - Monitor Participants agenda
  - Monitor number of conflicts
  - Monitor Timetables responses

....

■ **Specification of adaptation and monitoring**

Adaptação

- Manage adaptation
  - AND
  - C6 / C7
  - Manage schedule adaptation
    - OR
    - C9 / C8
    - Reconfigure Schedule
    - Step Back
  - Manage performance adaptation
    - OR
    - C10 / C11
    - Delegate (Software Architect)
    - Add new server

...

Activity 3: Specification of adaptation and monitoring

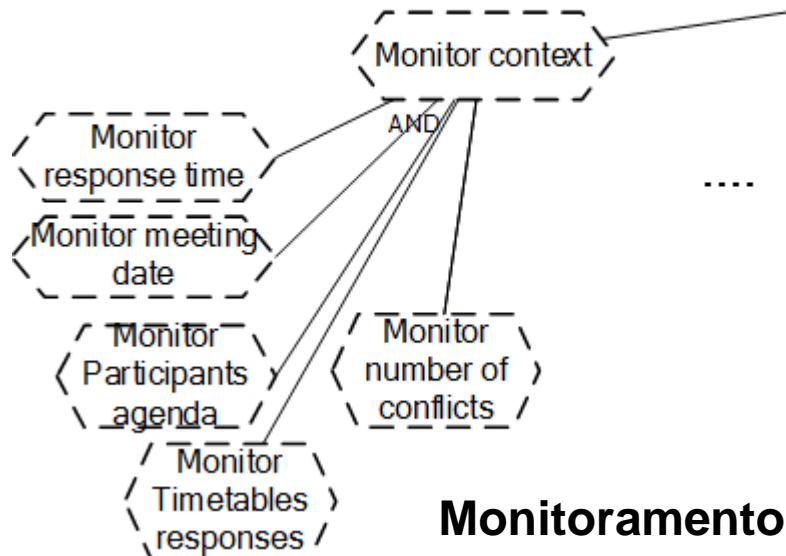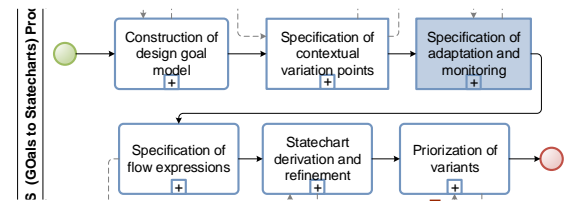Contextual Design Goal Model → Define the requirements → Adaptation needed? — yes → Represent the adaptation management → Associate each design task with a context label → Identify the dynamic contextual elements → Represent the context monitoring → Identify the equipment/technology needed →

Contexts Refinements

Contextual Design Goal Model with monitoring points

Contextual Elements

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GO2S Process: Activity 4

- **Specification of flow expressions (DALPIAZ, 2013)**

- Goal: Refine the contextual design goal model with flow expressions that represent the execution order of elements in the model

- Input: Contextual design goal model refined

- Steps:
  - 1: Assign an identification (ID) for each goal and task in the goal model
  - 2: Determine the flow expressions
  - 3: Specify idle states

- Output: Behavioral contextual design goal model

GO2S Process: Activity 4

- **Specification of flow expressions (DALPIAZ, 2013)**

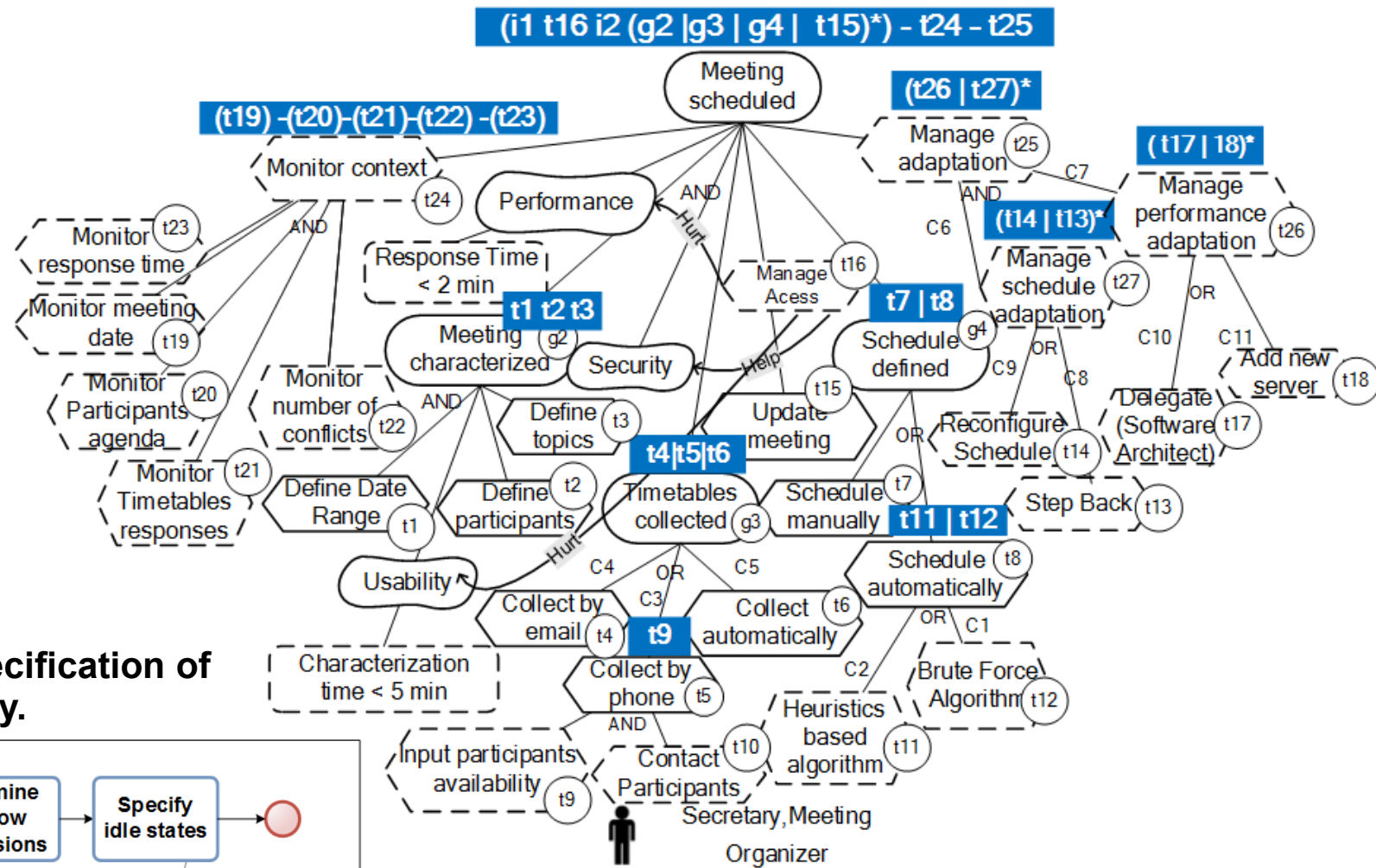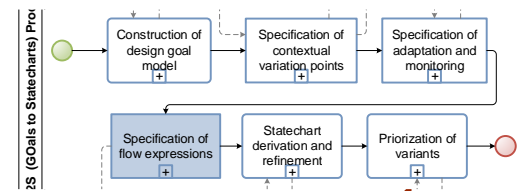**Figure 3.8: Steps of Specification of flow expressions activity.**
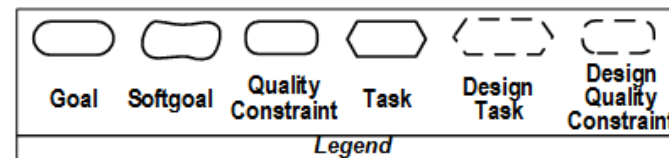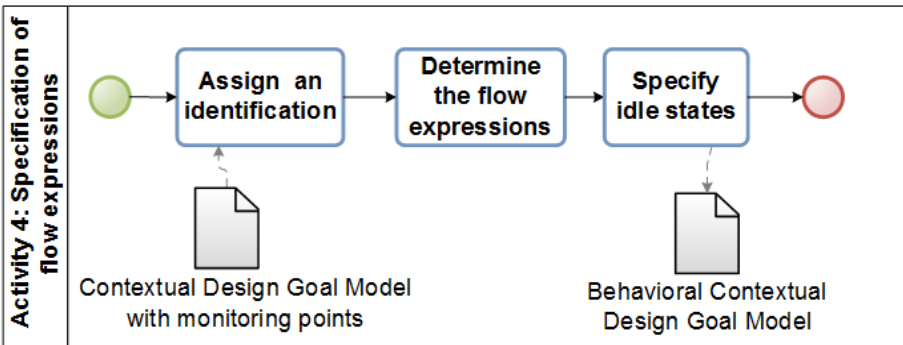
GO2S Process: Activity 5
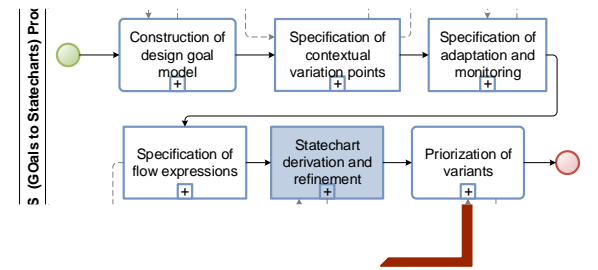
- **Statechart derivation and refinement (PIMENTEL, 2014)**

- Goal: Obtain the statechart and perform the refinements

- Input: Behavioral contextual design goal model

- Steps:

- 1: Generate the statechart using the derivation patterns:

  - 1.1: Create a state for each goal and task following the hierarchy of the design goal model

  - 1.2: If necessary, create idle states to model situations where the system is waiting for user interaction or for a given context to hold.

- 2: Specify transitions in the statechart

- Output: Statechart

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GO2S Process: Activity 5

S (GOals to Statecharts) Pro

| Construction of design goal model [+] | Specification of contextual variation points [+] | Specification of adaptation and monitoring [+] |
| Specification of flow expressions [+] | Statechart derivation and refinement [+] | Priorization of variants [+] |

■ **Statechart derivation and refinement (PIMENTEL, 2014)**

Activity 5: Statechart derivation and refinement

Behavioral Contextual Design Goal Model

Generate the statechart → Specify transitions

Statechart

Statechart refined

Figure 3.10: Steps of Statechart derivation and refinement activity.

Figure 3.11: Statechart Derivation Patterns.

Sequential tasks: ABC

A → B → C

Alternative tasks (triggered): A | B | C

A
B
C

Concurrent tasks: A - B - C

A | B | C

One or more executions: (AB)+

A → B
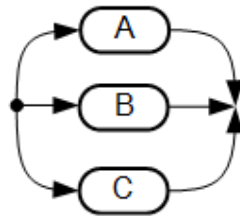
Zero or more executions: (AB)*

A → B

Optional execution: (AB)?

A → B

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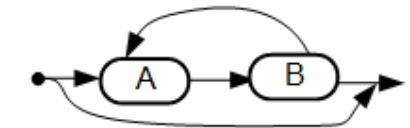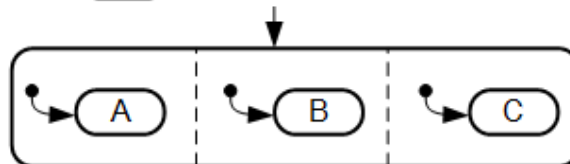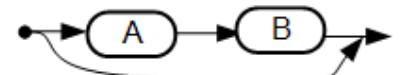
Statechart derivation and refinement
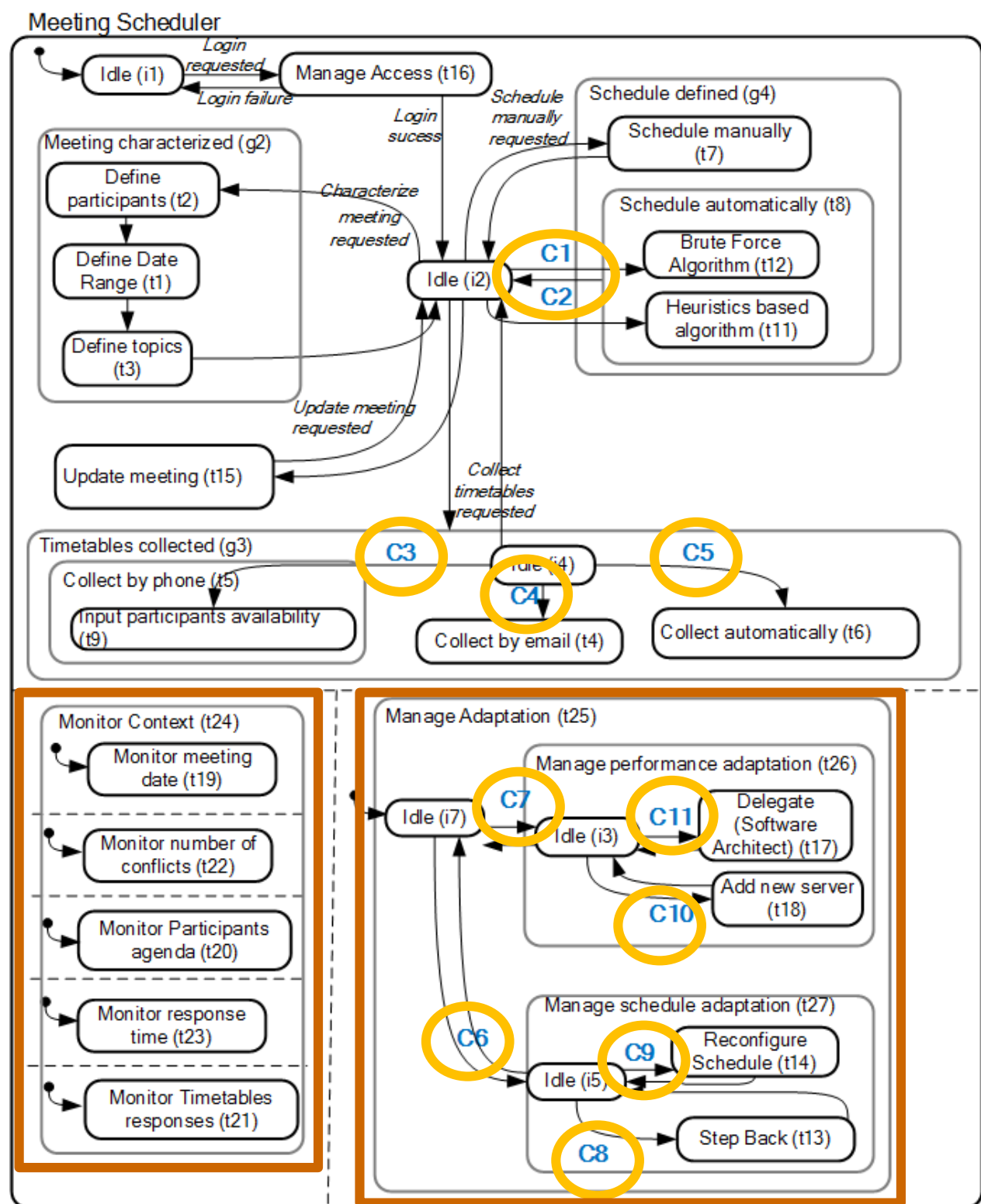
Figure 3.18: Statechart of meeting scheduler example.

GO2S Process: Activity 6
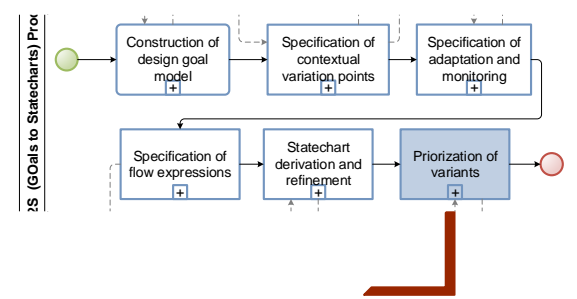
- **Goal:** When more than one context holds prioritize variants

- **Input:** Behavioral contextual design goal model

- **Steps:**

  - ☐ 1: Define the preferences for variants over each NFR
  - ☐ 2: Determine the weights of each NFR
  - ☐ 3: Synthesize the results
  - ☐ 4: Verify the consistence

- **Output:** Vector of variants priorities

Figure 3.19: Steps of Prioritization of variants activity.

GO2S Process: Activity 6
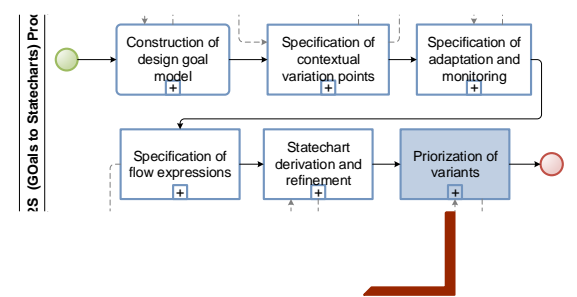
■ **Prioritization of variants (SANTOS, 2013)**
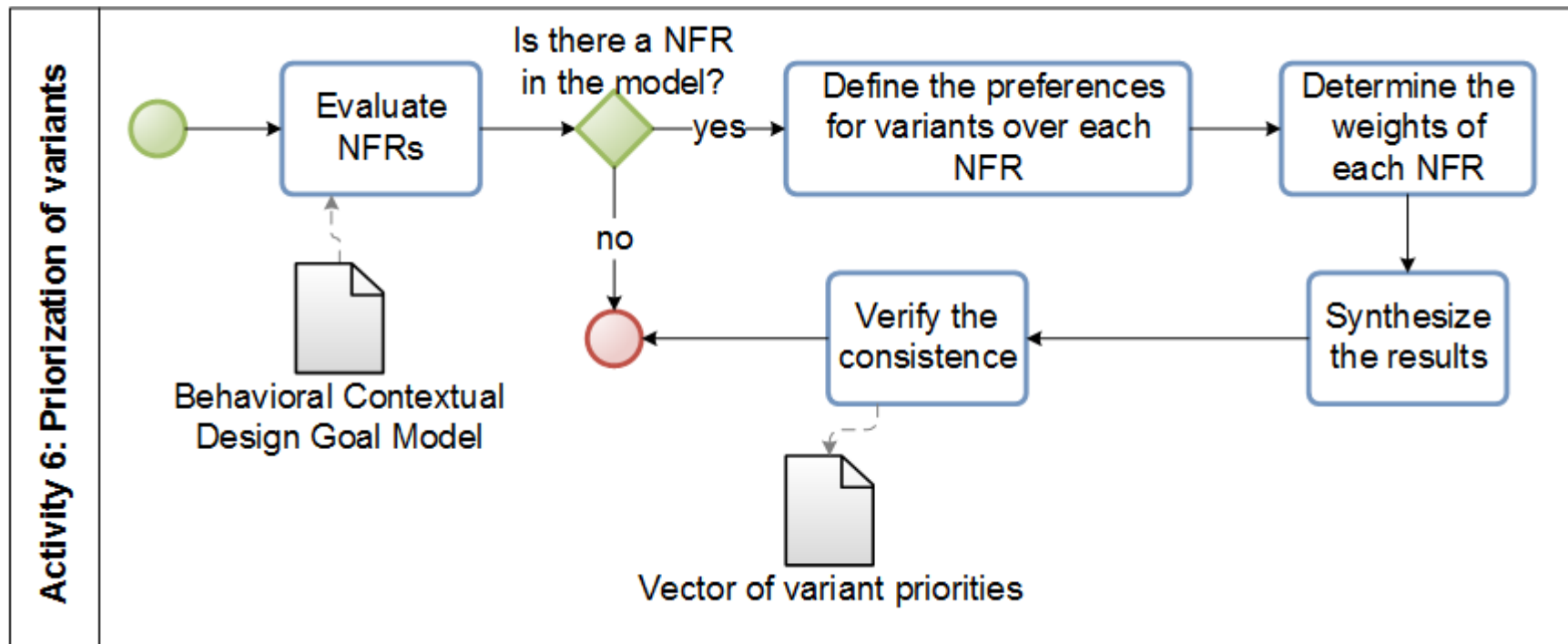
Figure 3.19: Steps of Prioritization of variants activity.

GO2S Process: Activity 6

GO2S (GOals to Statecharts) Pro...

| Construction of design goal model + | Specification of contextual variation points + | Specification of adaptation and monitoring + |

| Specification of flow expressions + | Statechart derivation and refinement + | Priorization of variants + |
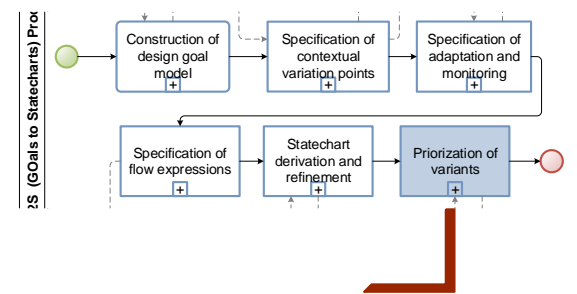
Variants and their contribution for the NFRs.

Alternatives/Criteria	Usability	Security	Performance
var3=Collect by phone	=	-	+
var4=Collect by email	+	+	-
var5=Collect automatically	++	++	++

Mapping from NFRs Contributions to AHP values (SANTOS, 2013).

	++	+	=	-	--
++	1	3	5	7	9
+	0,33	1	3	5	7
=	0,20	0,33	1	3	5
-	0,14	0,20	0,33	1	3
--	0,11	0,14	0,20	0,3	1

Final Ranking (synthesis).

Variant priority	0.14	0.19	0.67	

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Evaluation

Evaluation

- **In order to evaluate our proposal we designed a controlled experiment.**
  - **We conducted a multi-test within an object study since we examined a single object (the GO2S process) across a set of subjects.**

- **We followed the framework proposed by WOHLIN et al. (2012) for performing experiments in software engineering.**

Evaluation – Scoping

Goal of the experiment.

Analyze	the GO2S process for deriving statecharts from goal models of context-sensitive systems.
For the purpose of	evaluation.
With respect to	the time to implement, syntactic correctness, structural complexity, behavioral similarity and cognitive complexity (DIJKMAN et al., 2011) (MIRANDA; GENERO; PIATTINI, 2005).
From the point of view of	undergraduate, master's and doctoral students.
In the context of	students of a requirements engineering undergraduate and graduate course, with some industry expertise, implementing the GO2S process in an example.

Evaluation – Operation

- **The time spent to execute the experiment was 22hrs.**
  - ☐ **Classes about goal model, statecharts theory and tool: 8hrs**
  - ☐ **Oral argumentation: 3hrs**
  - ☐ **Training about the process: 4hrs**
  - ☐ **Dry run: 4hrs**
  - ☐ **Experiment: 3hrs**

- **The total time was approximately 132 hours:**
  - ☐ **time spent in meetings for decision-making**
  - ☐ **the preparation of the project**
  - ☐ **Answering questions of students and correcting all projects**
  - ☐ **the time spent on preparing slides, the material used in the experiment and the time required to analyze the results.**

Evaluation – Analysis & interpretation

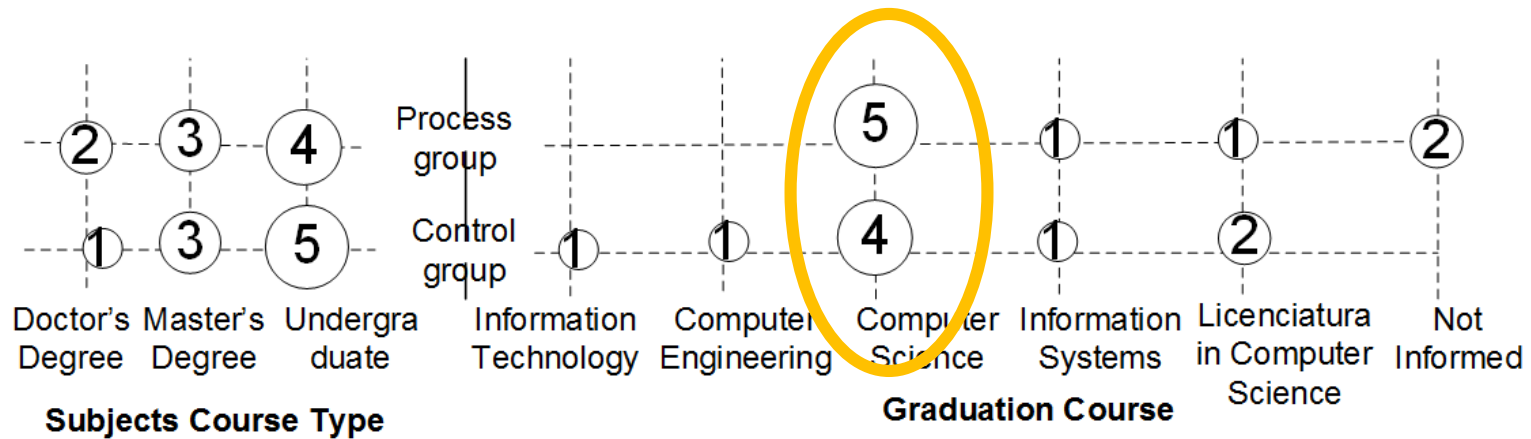Figure 5.1: Subject's Profile.
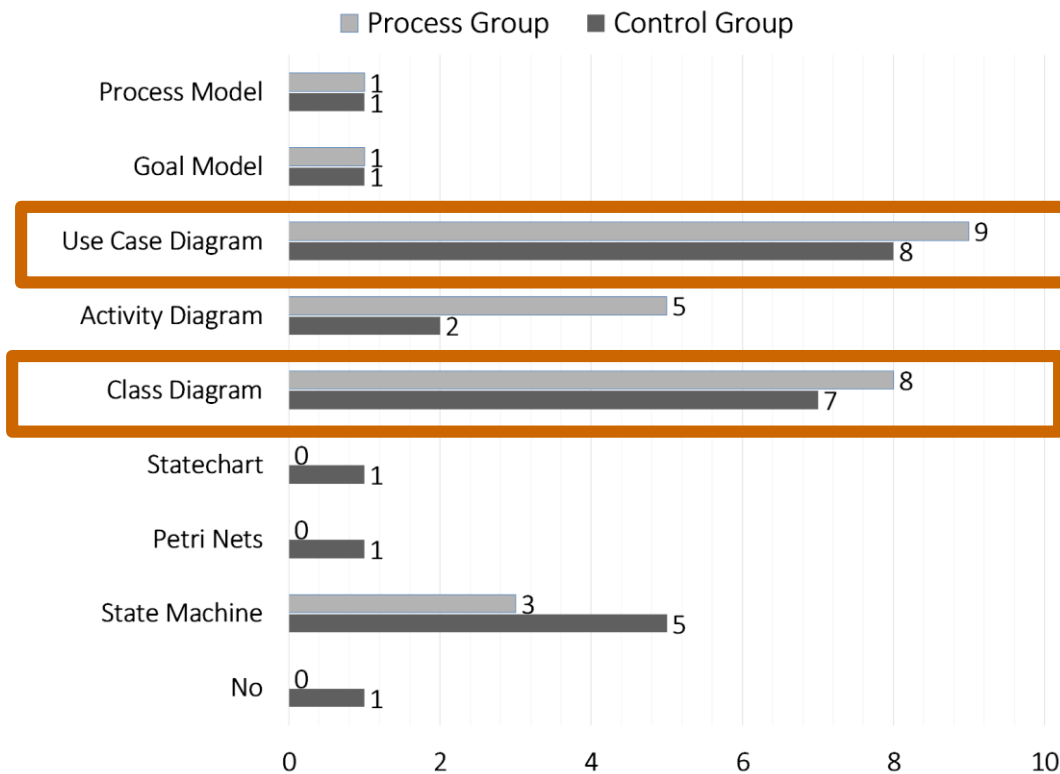
Evaluation – Analysis & interpretation

Figure 5.2: Experience in behavior modeling.

Figure 5.3: Proficiency in behavior modeling languages.
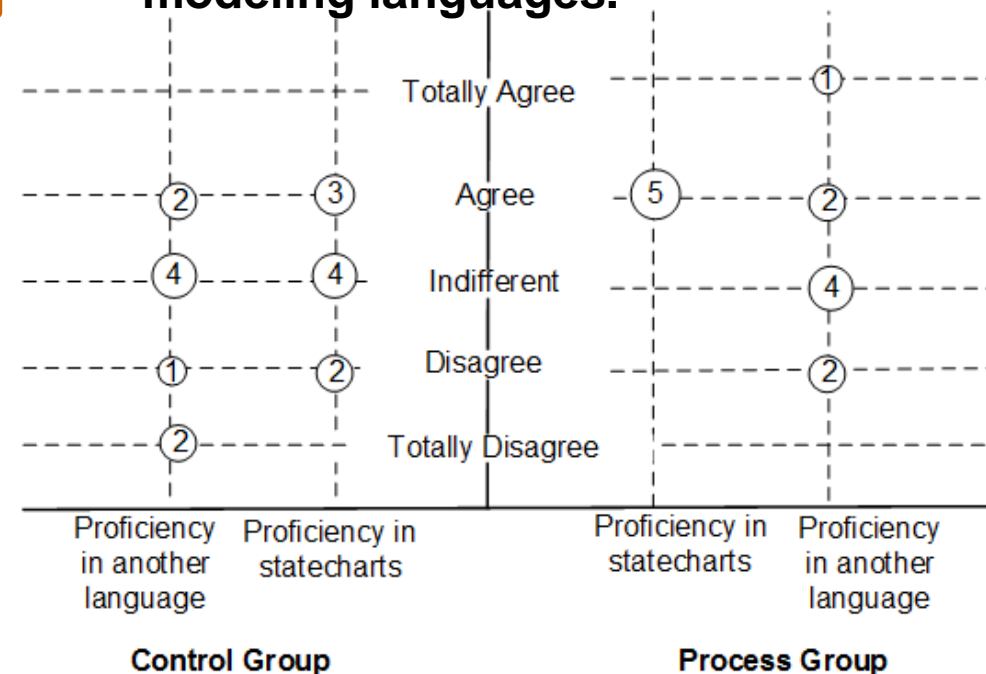
Evaluation – Analysis & interpretation
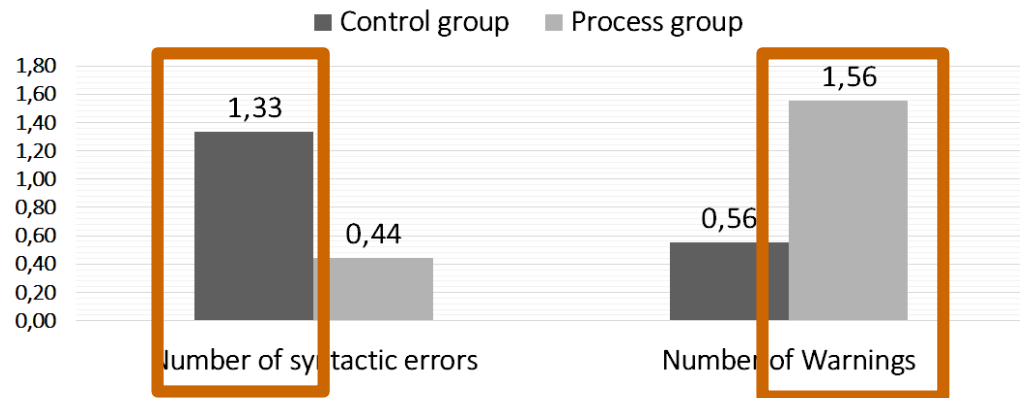
Figure 5.4: Syntactic correctness.
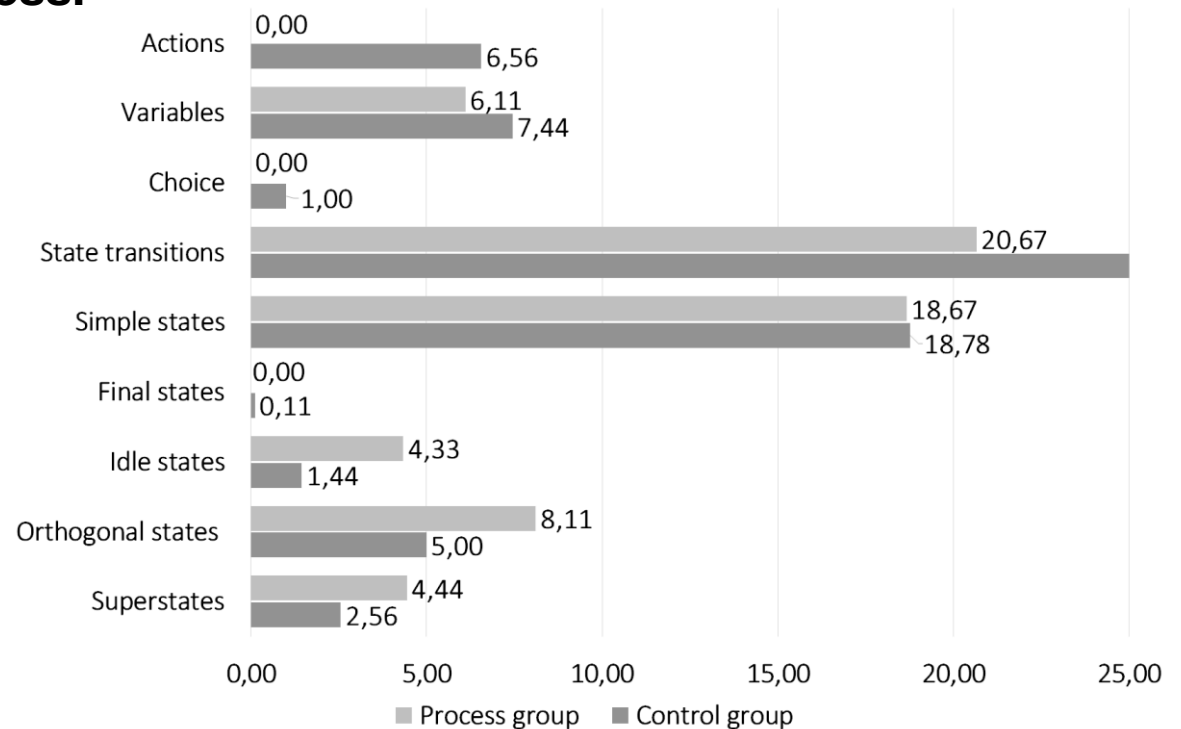
Figure 5.5: Structural complexity.

Evaluation – Analysis & interpretation
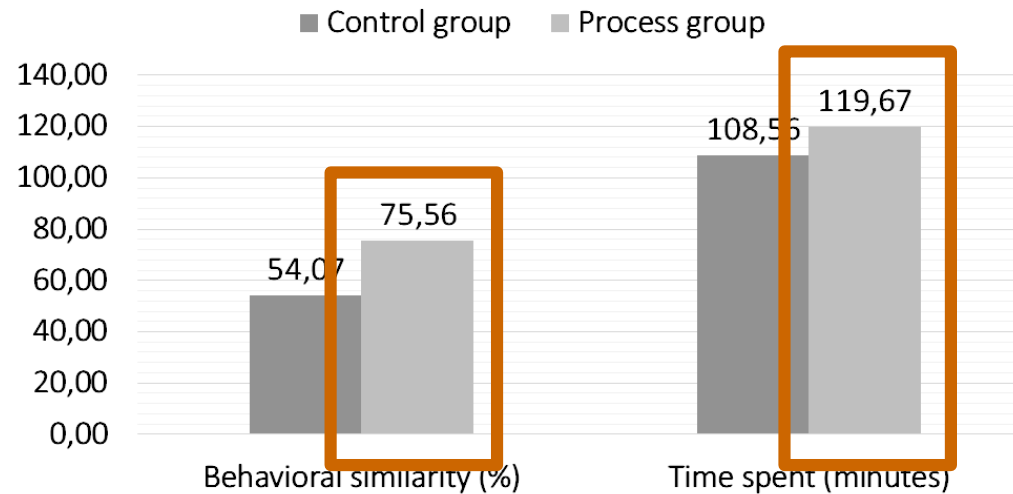
Figure 5.6: Behavioral similarity and time spent.

Evaluation – Analysis & interpretation

Table 5.2: Statements used to evaluate cognitive complexity.

#	Statement
1	The process for statecharts derivation from goal models is understandable.
2	Step 1 is easy to understand.
3	The notation of goal model is easy to understand.
7	Step 3 is easy to understand.

Table 5.3: Results of cognitive complexity.

#	TD (%)	D (%)	I (%)	A (%)	TA (%)	NA (%)
1				66.67	33.33	
2		11.11		88.89		
3			55.56	44,44		
7	11.11	33.33	22.22	33.33		

Threats to Validity and Ethics

- **Internal Validity:**
  - ☐ **We tried to mitigate the selection bias** (random assignment).
  - ☐ **Both groups received the same goal model and system specification** (mitigate unhappiness or discouragement).
  - ☐ **We attempted to mitigate the history and maturation effects by making observation at a single time point.**

- **Conclusion Validity**
  - ☐ **We tried to improve the reliability of treatment implementation** (using the same treatment, training, and instructor for all subjects of the process group).
  - ☐ **We also attempted to improve the conclusion validity by randomly choosing the subjects of both groups** (promoting heterogeneous groups).

Threats to Validity and Ethics

- **Construct Validity:**
  - ☐ **We carefully designed our study.**
  - ☐ **We chose objective measurements that did not depend on who was administering the test.**
  - ☐ **The subjects performed a dry run.**

- **External Validity:**
  - ☐ **The limited number of subjects does not allow to generalize outside the scope of the study.**

- **Ethics**
  - ☐ **We addressed the ethical principles that form the core of several research ethics guidelines and codes (VINSON; SINGER, 2008):**
    - ■ **informed consent**
    - ■ **beneficence**
    - ■ **confidentiality**

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Contributions

- **A systematic process for deriving the behavior of context-sensitive systems, expressed as statechart, from requirements models, specified as goal models.**

- **Specification of monitoring and adaptation tasks in a contextual design goal model.**

- **The behavioral contextual design goal model.**

- **The GO2S metamodel.**

- **Illustration of use GO2S (ZNN exemplar).**

- **Evaluation: controlled experiment (Smart Home).**

Future Works

- **Develop a case tool to implement the process.**

- **Apply the process in complex systems.**

- **New controlled experiments.**

- **Reasoning of context-sensitive systems (statecharts).**

- **Architectural views in our process.**

Summary of publications

- **VILELA, J.; CASTRO, J.; PIMENTEL, J.; SOARES, M.; LIMA, P.; LUCENA, M. Deriving the behavior of context-sensitive systems from contextual goal models. 2015. 30th ACM/SIGAPP Symposium On Applied Computing (SAC). April 2015. In press.**

- **VILELA, J.; CASTRO, J.; PIMENTEL, J.; LIMA, P. On the behavior of context-sensitive systems. 2015. 18 Workshop em Engenharia de Requisitos (WER 2015). April 2015. In press.**

- **DERMEVAL, D.; VILELA, J.; BITTENCOURT, I.; CASTRO, J.; ISOTANI, S.; BRITO, P.; SILVA, A. Applications of ontologies in requirements engineering: a systematic review of the literature. In: Requirements Engineering Journal, 2015, pp.1-33.**

- **DERMEVAL, D.; VILELA, J.; BITTENCOURT, I.; CASTRO, J.; ISOTANI, S.; BRITO, P. A Systematic Review on the Use of Ontologies in Requirements Engineering. In: Simpósio Brasileiro de Engenharia de Software (SBES), 2014, pp. 1-10.**

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