Specifying Safety Requirements with GORE Languages

- Presented by: Moniky Ribeiro (smsr@cin) -

Requirements Engineering Lab
http://cin.ufpe.br/~ler
Advisor: Prof. Jaelson Freire de Castro

Adapted from the slide of SBES'17

Specifying Safety Requirements with GORE Languages





Jéssyka Vilela   Jaelson Castro   Luiz Martins   Tony Gorschek   Carla Silva

Outline

- Introduction
- Research Methodology
- Research Questions
- Conceptual Foundation
- Conceptual Model
- Features founded
- Comparison of GORE languages
- Conclusions
- References

Introduction

- Article: https://dl.acm.org/citation.cfm?id=3131175
- Conference: http://www.lia.ufc.br/~cbsoft2017/en/xxxi-sbes/
- Authors:
  - Jéssika Vilela
    - Universidade Federal do Ceará (UFC) and Universidade Federal de Pernambuco (UFPE) and IFCE - Campus Quixadá
    - jffv@cin.ufpe.br

Introduction

- Authors:
  - Jaelson Castro
    - Universidade Federal de Pernambuco (UFPE)
    - jbc@cin.ufpe.br
  - Luiz Eduardo G. Martins
    - Universidade Federal de São Paulo (UNIFESP)
    - legmartins@unifesp.br

Introduction

- Authors:
  - Tony Gorschek
    - Blekinge Institute of Technology (BTH)
    - tony.gorschek@bth.se
  - Carla Silva
    - Universidade Federal de Pernambuco (UFPE)
    - ctlls@cin.ufpe.br

Introduction - Safety-critical Systems

Nancy G. Leveson is a leading American expert in system and software safety. She is Professor of Aeronautics and Astronautics at MIT, United States. She is author of the book Safeware(1995).

Introduction - Safety-critical Systems

- Safety-critical systems (SCS) are those composed of a set of **hardware**, **software**, **processes**, **data** and **people** whose **failure** can result in **accidents** that cause **environmental damage**, **financial loss**, **injury to people** and **even loss of lives.**

- Problems in the **specification** of safety-critical systems have been identified as a **major** cause of many **accidents** and safety-related **catastrophes**.

Introduction - Safety-critical Systems

- In safety **requirements** specification, there are **many** relationships among safety concepts that must be **identified** and **specified**.

- **Achieving** an adequate representation of safety-critical **systems** requirements is quite fundamental for a **successful** safety **analysis**.

Introduction - Safety-critical Systems

- **Safety** concerns should be considered **early** in the development process, especially in the **RE** phase.

- An **elaborated** requirements engineering (RE) **approach** is **crucial** in the development of SCS in order to **meet** time, cost, and quality goals in SCS development.

Introduction - Safety-critical Systems

- Despite the need of **addressing** safety concerns **early** in the development process there is **no** consensus on the features an RE language must **provide** to support the description of such systems.

- In order to **improve** the safety requirements specification it is necessary to define a **conceptual foundation** as well as the **features** that requirements **languages** should have to support this task.

Introduction - Gore* Languages

- The **GORE** paradigm is based on the identification of **system goals** and the transformation of those goals into **requirements** providing a **completeness criterion** for the **requirements specification**, i.e...

“[...] the ***specification is complete if all stated goals are met by the specification***.”

*Goal-Oriented Requirements Engineering

Introduction - Gore Languages

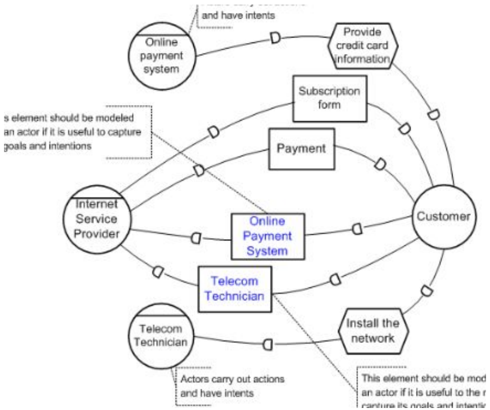
- There is a variety of goal modeling frameworks, techniques, or methodologies.
  - **I***
  - **KAOS (Keep All Objects Satisfy)**
  - **GRL (Goal-oriented Requirement Language)**
  - **NFR (Non-Functional Requirements)**
  - GBRAM, **Tropos**, AGORA...

More used [3]

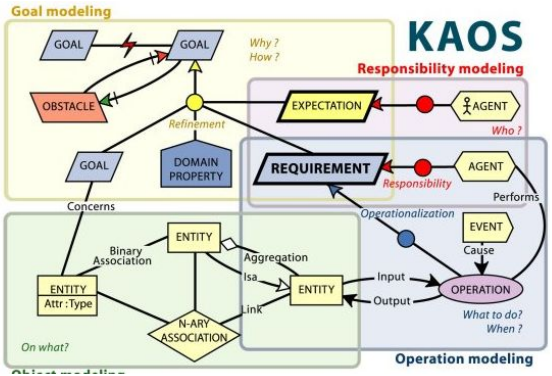
- The choice of languages to be ranked in this paper considering the mapping of horkoff et al. [3]

Introduction - Gore Languages

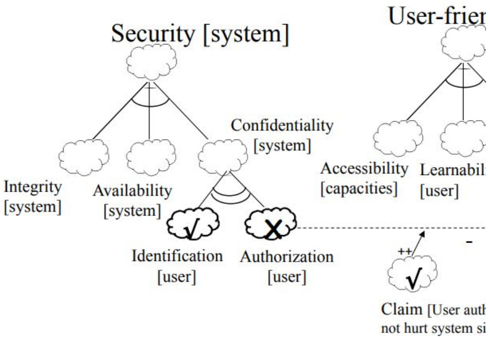
I*



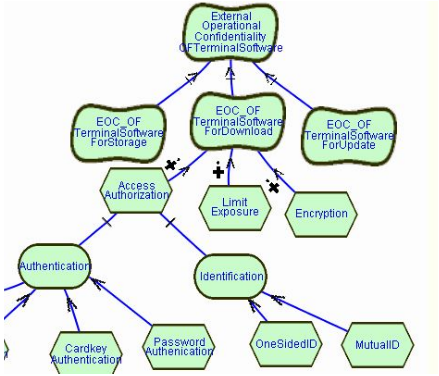
KAOS



NFR



GRL



Research Methodology

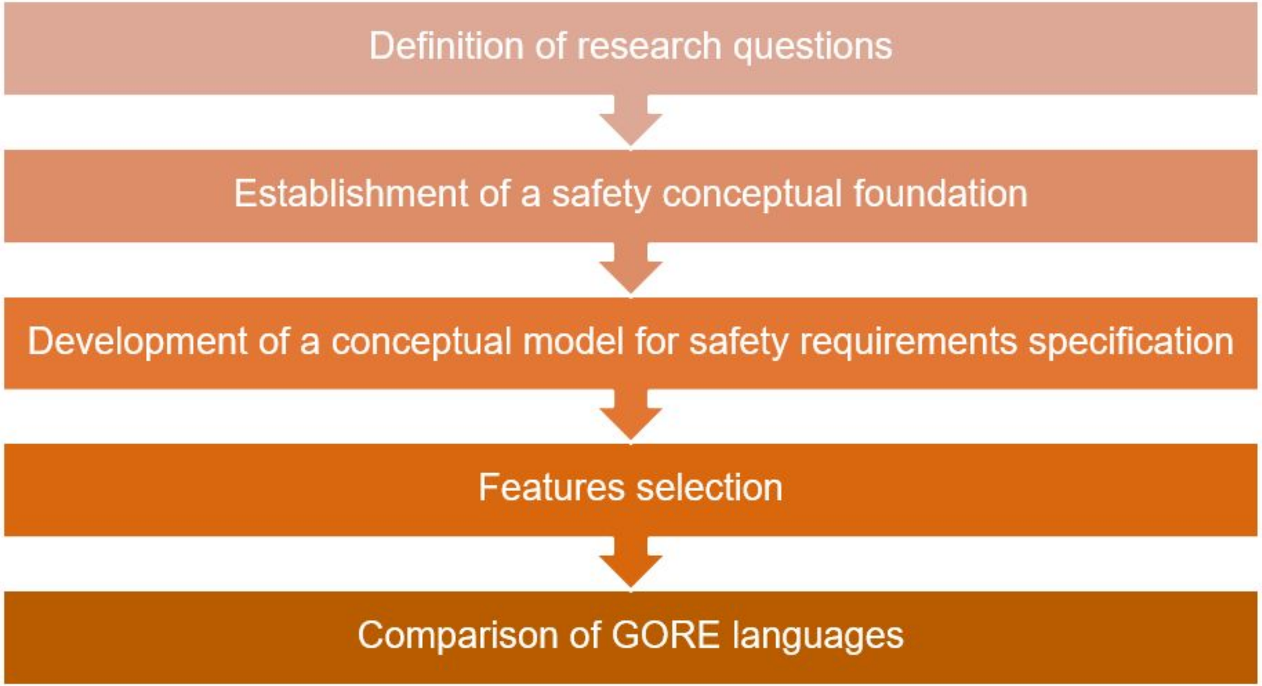


Figure 1. [4]

Research Questions

RQ1: What is the conceptual foundation for safety requirements specification in RE process?

RQ2: What are the main features that requirements languages should support in terms of safety requirements specification?

RQ3: What are the similarities and differences among GORE languages support for the features of RQ2?

RQ1 - Conceptual foundation for safety requirements specification in RE process

#	Source	Type
1	ISO 61508	Generic standard
2	ISO 26262-6	Automotive standard
3	ISO/IEC 25010	Generic standard
4	ISO/IEC 9126	
5	ISO 15998-1	Machinery standard
	ISO 15998-2	
6	ISO 20474-1	Machinery standard
7	ECSS-E-HB-40A	Space standard
	ECSS-E-ST-40C	
8	ISO-13849-1	Machinery standard
	ISO-13849-2	
9	MIL-STD-882C	Defense standard
	MIL-STD-882D	
	MIL-STD-882E	
10	ISO/TR-14639-1	eHealth standard
	ISO/TR-14639-2	
11	Vilela et al.	SLR
12	Martins and Gorschek	SLR
13	Zoughbi et al.	Journal Paper
14	Markovski et al.	Conference Paper

Figure 2. [4]

RQ1 - Conceptual foundation for safety requirements specification in RE process

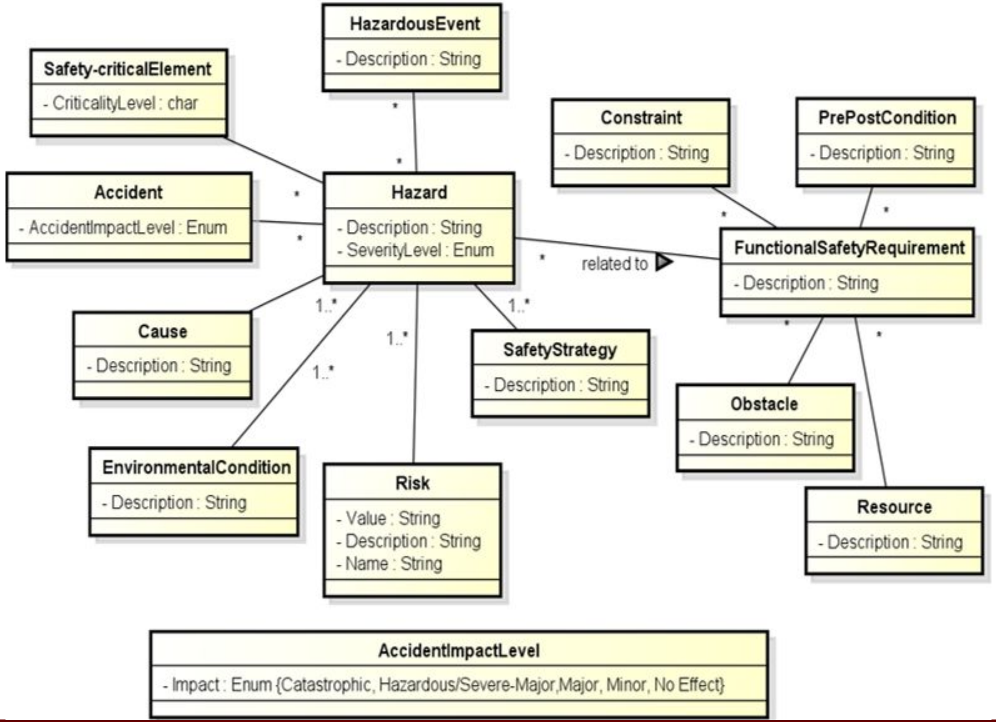


Figure 3. [4]

RQ2 - Features that requirements languages should support in terms of safety requirements specification

#	Feature	Source/Inspiration
1	Modeling of accident	[8][13][47][48]
2	Modeling of hazard	[8][13] [47][48]
3	Modeling of cause of hazard	[8][13] [47][48]
4	Modeling of environmental condition	[8][13] [47][48]
5	Modeling of functional safety requirement	[8][13] [47][48]
6	Representation of constraint	[13][14][15] [47][48]
7	Representation of obstacle	[13][14][15] [47][48]
8	Representation of pre and post condition	[13][14][15] [47][48]
9	Allow to represent the relationships among hazards, their causes, the environmental conditions and the functional safety requirements in a graphical form	[8][16]
10	Ability to specify how a particular event affects system safety	[10][12] [47][48]
11	Ability to specify the criticality level of safety-critical elements or the element's contributions to failure conditions	[17][18] [47][48]
12	Model and reasoning of safety strategies	[8][10][12]
13	Ability to model resources	[10][12]
14	Modeling of accident impact level	[8][10][12] [47][48]
15	Support of textual description of safety requirements	[8] [47][48]

Figure 4. [4]

Description of Features

- 1 - Modeling of **Accident** (Core information)

Accident: an **undesired** and **unplanned** (but **not** necessarily **unexpected**) event that results in (at least) a specified **level** of **loss** (including loss of human life or injury, property damage, environmental pollution, and so on.

"**The definition of accident event is important because it influences the approach taken to increase safety**" [1]

Description of Features

- 1 - Modeling of **Accident** (Core information)

Insulin Infusion Pump System (IIPS):

Overdose, underdose.

Automated Car:

Description of Features

- 2 - Modeling of **Hazard** (Core information)

Hazard: system state or set of conditions that, together with a particular set of worst-case environmental conditions, will lead to an accident (loss).

Hazard analysis: The second activity most referenced by the studies [2]: 30 studies (52.63%). Consists in examining the system specification to identify potentially dangerous situations that may lead to an accident.[2]

Description of Features

EXAMPLE

- 2 - Modeling of **Hazard** (Core information)

Insulin Infusion Pump System (IIPS):

Any parts of the machine break inside the patient's body

Automated Car:

Description of Features

- 3 - Modeling of **Cause of Hazards** (Core information)

Cause of hazard: reason that produces hazard as effect. They occur due to environmental hazard, procedural hazard, interface hazard, human factor or system cause.

Insulin Infusion Pump System (IIPS):

Insulin reservoir cracked.

Description of Features

- 4 - Modeling of **Environmental Condition** (Core information)

Environmental condition: the state of the environment. The set of factors including physical, cultural, demographic, economic, political, regulatory, or technological elements surrounding the system that could affect its safety .

Insulin Infusion Pump System (IIPS):

Any idea?

Description of Features

- 5 - Modeling of **Functional Safety Requirement** (Core information)

Functional Safety Requirement: The requirement to prevent or mitigate the effects of failures identified in safety analysis.

Insulin Infusion Pump System (IIPS):

Any idea?

Description of Features

- 6 - Representation of **Constraints**

  Constraint: describes how the software must be designed and implemented providing additional information regarding requirements that must be met in order to a given goal to be achieved.

Insulin Infusion Pump System (IIPS):

The insulin reservoir must be a common syringe found in the regular market.

Description of Features

- 7 - Representation of **Obstacle** (Core information)

Obstacle: denotes the reason why a goal failed consisting in behaviors or other goals that prevent or block the achievement of a given goal.

Insulin Infusion Pump System (IIPS):

The warning alarm of low battery may cause that another alarm, such as malfunction alarm, to fail if they two need to sound in the same time.

Description of Features

- 8 - Representation of **Pre and Post Condition**(Core information)

Pre/Post Condition: describes actions that must be executed before or after some scenario.

Insulin Infusion Pump System (IIPS):

Pre -> The system must to verified if the pump have insulin before that initiate the infusion.

Description of Features

- 9 - Allow to **represent** the **relationship** among **hazards**, their **causes**, the **environmental conditions** and the **functional safety requirements** in a **graphical** form

- 10 - Ability to specify **how** a particular **event** affects system safety

Description of Features

- 11 - Ability to **specify** the **criticality level** of safety-critical **elements** or the element’s contributions to failure conditions

Criticality level of safety-critical element: indicates the degree of criticality of a safety-critical element on some predefined scale.

Examples of standards:

In RTCA DO-178B the safety standards categories are: “A”, “B”, “C”, “D”, “E”. In IEC 61508: “SIL 1”, “SIL 2”, “SIL3”, “SIL4”.

Description of Features

- 12 - Model and reasoning of safety **strategies.**

- 13 - Ability to model **resources**.

  Resource: assets, such as money, materials, staff, documents, etc., provided or used by a person or organization in order to achieve some goal.

  EXAMPLE

  Insulin Infusion Pump System (IIPS): Syringe, Stepper motor.

Description of Features

- 14 - Accident impact level

Accident impact level: the accident can have five levels of impact : Catastrophic, Hazardous/Severe-Major, Major, Minor or No Effect.

Insulin Infusion Pump System (IIPS):

Any parts of the machine break inside the patient’s body has catastrophic impact.

Description of Features

- 15 - Support of a textual description of safety requirements

RQ3 - Comparison of Gore Languages

- Papers adopted to evaluate the language

Language	Paper adopted	Tool
i*	[23] ERIC, S. K. Social modeling for requirements engineering. Mit Press, 2011.	OpenOme
KAOS	[24] DARDENNE, Anne; VAN LAMSWEERDE, Axel; FICKAS, Stephen. Goal-directed requirements acquisition. Science of computer programming, v. 20, n. 1-2, pp. 3-50, 1993.	RE-Tool
NFR	[25] MYLOPOULOS, John; CHUNG, Lawrence; NIXON, Brian. Representing and using nonfunctional requirements: A process-oriented approach. IEEE Transactions on software engineering, v. 18, n. 6, pp. 483-497, 1992.	OME
GRL	[26] AMYOT, Daniel; MUSSBACHER, Gunter. Development of Telecommunications Standards and Services with the User Requirements Notation. In: Workshop on ITU System Design Languages, 2008.	OME

Figure 5. [4]

RQ3 - Comparison of Gore Languages

	Feature	i*	KAOS	GRL	NFR Framework
1	Modeling of accidents	N	P (Obstacle)	N	N
2	Modeling of hazards	N	P (Obstacle)	N	N
3	Modeling of causes of hazards	N	P (Sub-obstacles)	N	N
4	Modeling of environmental conditions	N	Y (Trigger conditions)	N	N
5	Modeling of functional safety requirements	Y (Tasks)			Y (Operationalizations)
6	Representation of constraints	Y (Contribution Links)			
7	Representation of obstacles	N	Y (Obstacle)	N	N
8	Representation of pre and post conditions	N	Y (pair Precondition, PostCondition)	N	N
9	Allow to represent the relationships among hazards, their causes, the environmental conditions and the functional safety requirements in a graphical form	N	N	N	N
10	Ability to specify how a particular event affects system safety	Y (Sofgoals and Contribution Links)			
11	Ability to specify the criticality level of safety-critical elements or the element's contributions to failure conditions	N	N	N	Y (Priority "!" symbol in softgoals)
12	Model and reasoning of safety strategies	Y (Sofgoals and Contribution Links)			Y (Operationalizations and Contribution Links)
13	Ability to model resources	Y (Resource Element)			Y (operationalizations)
14	Accident impact level	N	N	N	N
15	Support of textual description of safety requirements	N	N	N	N

Figure 6. [4]

RQ3 - Comparison of Gore Languages

- All surveyed approaches lack explicit modeling constructs to express how hazards can occur in the system, the accidents, their impact and how they can mitigated.
- KAOS better supports some features in relation to the other languages
- The features not supported by KAOS are either not supported by i*.
- i* and GRL have similar coverage.
- NFR is the least appropriate language to specify the requirements of safety-critical systems.

Conclusions

- The safety concepts and features outlined in this paper may be used by requirements engineers to represent the results of a preliminary safety analysis (PSA).
- In a complete safety analysis, a richer set of attributes and relationships are specified. In this paper, we are concerned with the core concepts that are available in the RE process.
- The high level specification of such safety concepts may be used by safety engineers as an input of a rigorous and detailed safety analysis in the preparation of reports for system certification.

References

1. Nancy Leveson. Safeware: System Safety and Computers. ACM, 1995.

2. Jéssyka Vilela, Jaelson Castro, Luiz Eduardo G. Martins, and Tony Gorschek. Integration between requirements engineering and safety analysis: A systematic literature review. Journal of Systems and Software, v. 125, pp. 68-92, 2017. DOI: https://doi.org/10.1016/j.jss.2016.11.031

3. Jennifer Horkoff, Tong Li, Feng-Lin Li, Mattia Salnitri, Evellin Cardoso, Paolo Giorgini, John Mylopoulos, and Joao Pimentel. Taking goal models downstream: a systematic roadmap. In: Eighth International Conference on Research Challenges in Information Science (RCIS), 2014. pp. 1-12. DOI: 10.1109/RCIS.2014.6861036

4. Jéssyka Vilela, Jaelson Castro, Luiz Eduardo G. Martins, Tony Gorschek, and Carla Silva. 2017. Specifying Safety Requirements with GORE languages. In Proceedings of the 31st Brazilian Symposium on Software Engineering (SBES'17). ACM, New York, NY, USA, 154-163. DOI: https://doi.org/10.1145/3131151.3131175

Specifying Safety Requirements with GORE Languages

- Moniky Ribeiro (smsr@cin) -

Requirements Engineering Lab
http://cin.ufpe.br/~ler
Advisor: Prof. Jaelson Freire de Castro

Adapted from the slide of SBES'17