UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

Requirements Engineering & Management

Goals

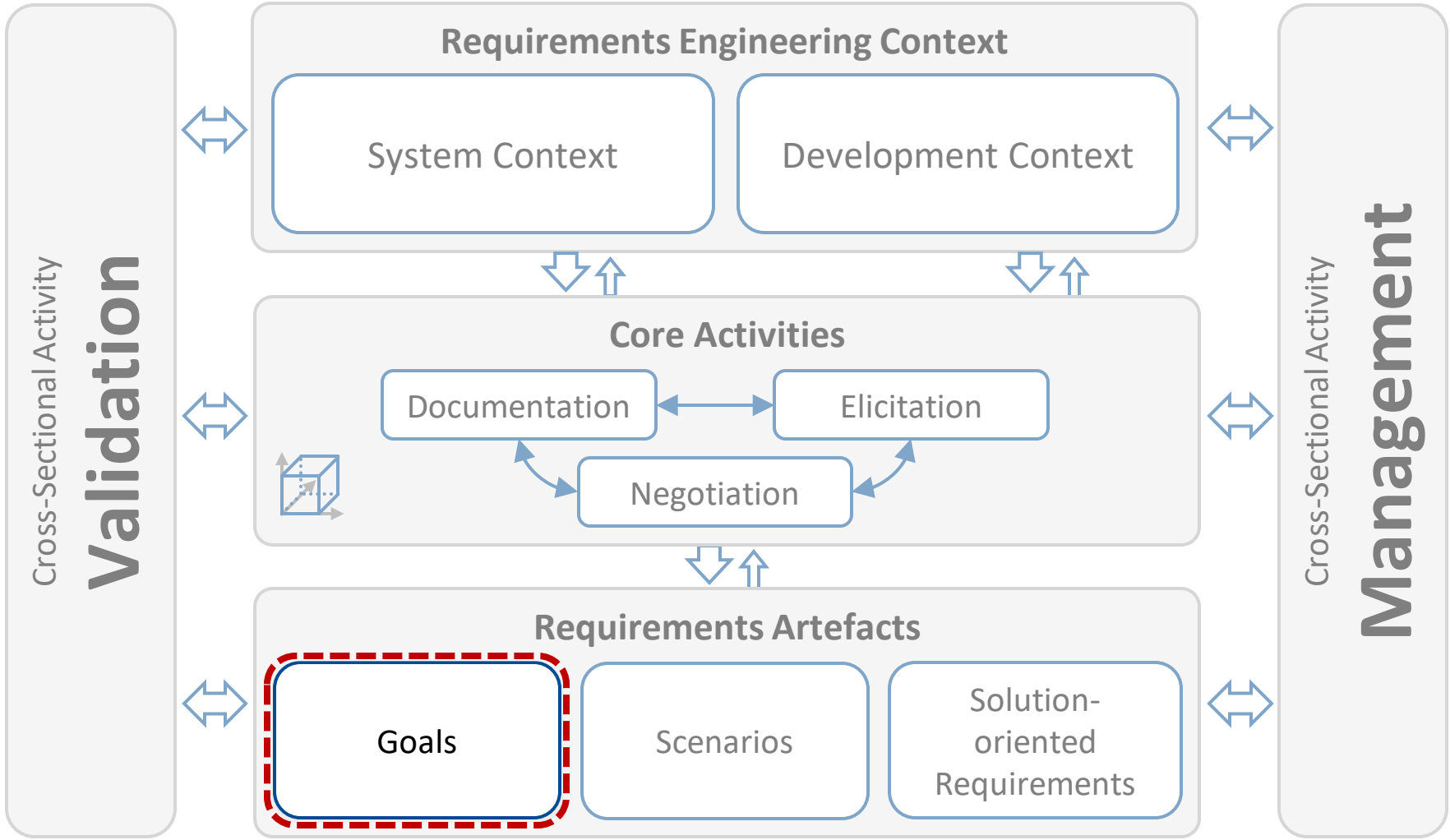
Prof. Dr. Klaus Pohl

PALUNO
The Ruhr Institute for Software Technology

Agenda

1. Introduction to Goals
2. Goal Modelling
3. Goal Dependencies
4. Documenting Goals in Natural Language
5. Benefits of Goals

Framework for Requirements Engineering

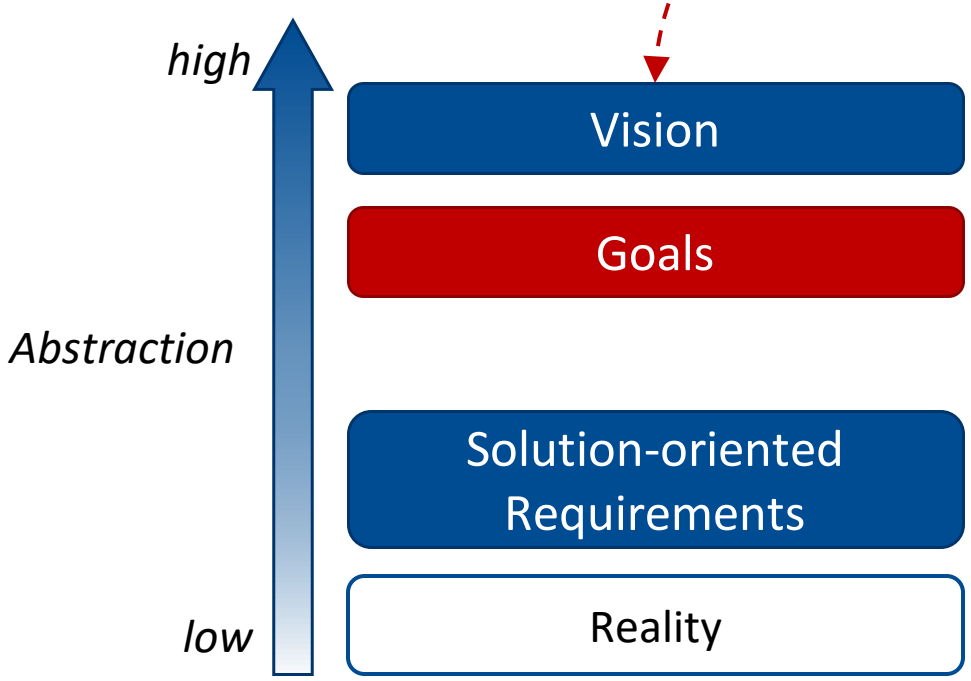


1. Introduction to Goals

Goals Refine the Vision

"First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth"

Vision of J.F. Kennedy in 1961



- G_1: No human being shall be harmed.
- G_2: The system shall be able to land on the moon.
- G_3: The system shall be able to return to the earth.
- …

Definition: Goal

D A goal describes a **high level objective** of one or more stakeholders **about a property** of the **system to be developed** or the **development project**.

E Goals for a car navigation system:

- G1: The system shall guide the driver to a desired destination automatically.
- G2: The response time of the system shall be 20% lower compared with the predecessor system.

Goals for a university library system:

- G2 : The system shall be used by students and employees.
- G5: The system shall allow employees to use the library printers directly from their work place.

2. Goal Modelling

Definition: Goal Model

D A **goal model** is a conceptual model that documents goals, their decomposition into sub-goals and goal dependencies.

Languages and Methods (1)

- A **goal modelling language** defines the **syntax** and **semantics** of modelling constructs **for creating goal models**.
- A **method** for goal modelling consists of:
  - Goal modelling language
  - Rules, procedures and guidelines to create goal models
  - Management practices for applying the method (esp. for evaluating the quality of the constructed models)

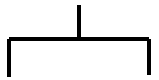
Languages and Methods (2)

- **Examples of goal modelling languages:**
  - AND/OR Trees
  - Goal Requirements Language (GRL) [GRL 2009]
  - ITU-T Z.150 Standard: User Requirements Notation (URN) [ITU 2011]
- **Examples of methods:**
  - Goal-based Requirements Analysis Method (GBRAM) [Antón 1996]
  - Goal-driven Change Method (GDC) [Kavakli 1999]
  - i* Framework / Tropos [Yu 1993, Yu 1995, Yu 1997, Dalpiaz et al. 2016, Bresciani et al. 2004]
  - KAOS Framework [Dardenne et al. 1993, Van Lamsweerde 2009]
  - Non-functional Requirements (NFR) Framework [Chung et al. 1996]

AND/OR Goal - Trees

D An AND/OR goal **tree** consists of **nodes** representing **goals** and **directed edges** representing **AND-decomposition** and **OR-decomposition** relationships between the goals. Each node (except of the root node) is related to **exactly one super-goal**.

Graphical notation indicates **type of decomposition (AND/OR)**.

- Notation for AND-Decomposition: 
- Notation for OR- Decomposition: 

AND-Decomposition (1)

D The decomposition of a super-goal G into a set of sub-goals G_1, …, G_n with $n \geq 2$ is an AND-decomposition if and only if **all sub-goals** G_1, …, G_n **shall be satisfied** in order **to satisfy the super-goal** G.

E The following goal (G_1) has been defined for a navigation system:

G_1 : Comfortable and fast navigation to the destination.

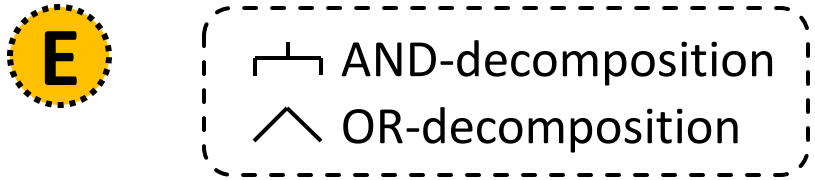
The goal G_1 is **decomposed** into the following three sub-goals by means of an **AND-decomposition**:

$G_{1.1}$: Automatic navigation according to user-specific parameters.

$G_{1.2}$: Automatic re-routing to avoid traffic jams.

$G_{1.3}$: Easy entry of the destination.

AND-Decomposition (2)



G_1: comfortable and fast navigation to destination

$G_{1.1}$: automatic navigation

$G_{1.2}$: circumnavigating traffic jams

$G_{1.3}$: easy entry of destination

OR-Decomposition (1)

D The decomposition of a super-goal G into a set of sub-goals G_1, …, G_n with $n \geq 2$ is an OR-decomposition if and only if **satisfying one of the sub-goals** G_1, …, G_n **is sufficient for satisfying the super-goal** G.

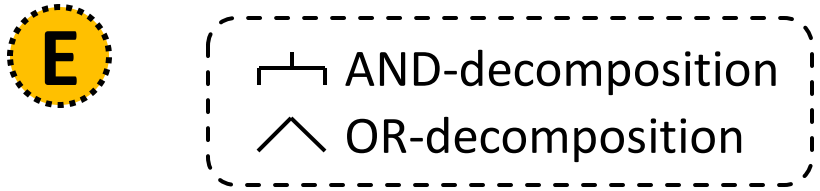
E $G_{1.2}$: Automatic re-routing to avoid traffic jams.

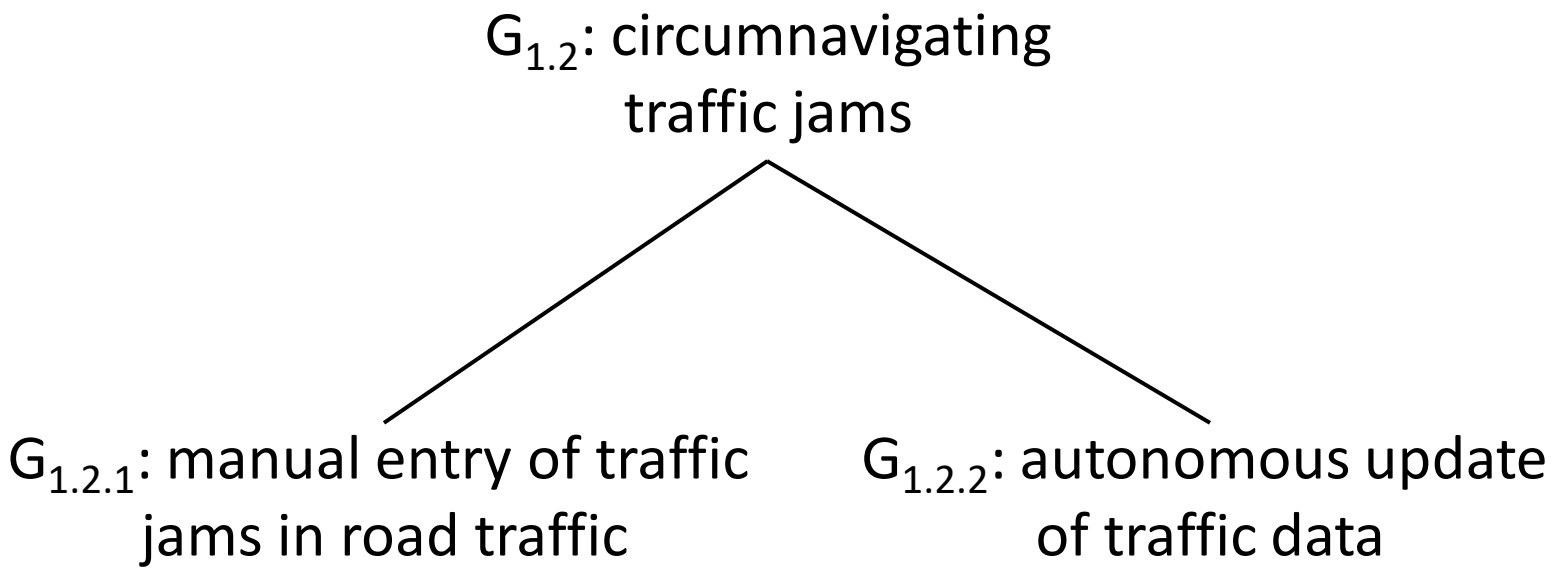
The goal $G_{1.2}$ is **decomposed** by an **OR-decomposition** into the following two sub-goals:

$G_{1.2.1}$: Manual entry of traffic jams in road traffic.

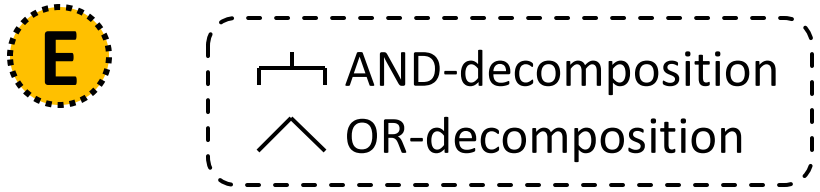
$G_{1.2.2}$: Autonomous update of traffic data.

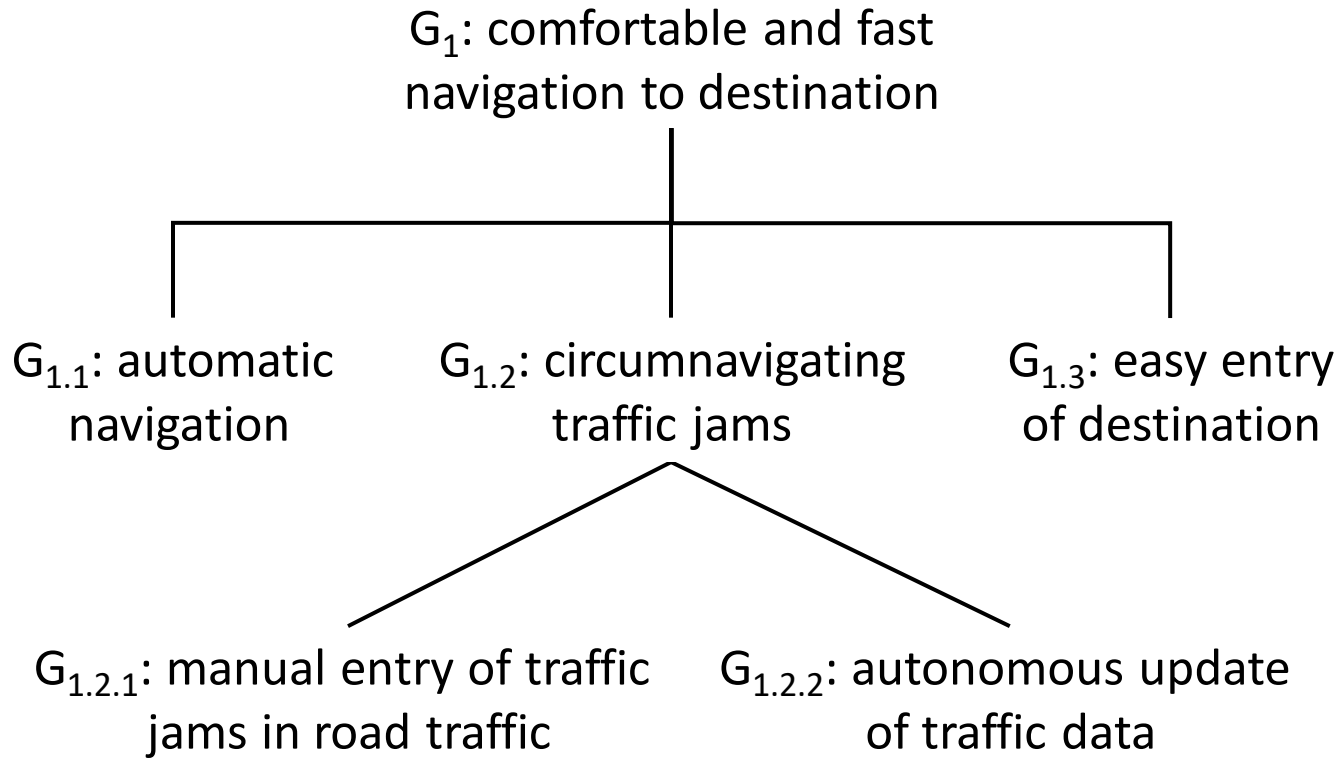
OR-Decomposition (2)





AND/OR Goal Trees



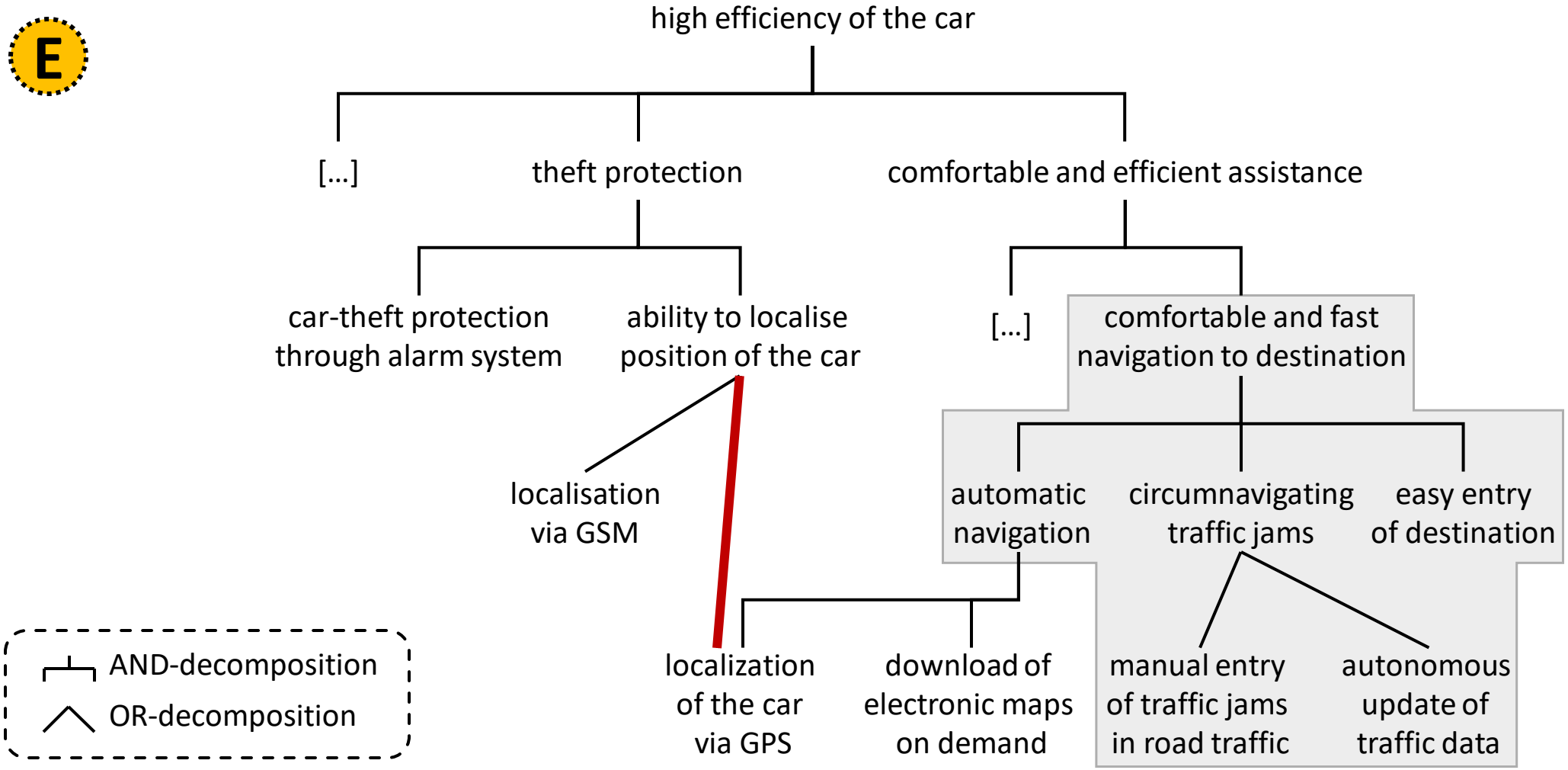


AND/OR Goal Graphs (1)

D An AND/OR goal graph is a **directed, acyclic graph** with **nodes that represent goals** and **edges** that represent **AND-decomposition** relationships and **OR-decomposition** relationships between the goals.

- Some sub-goals contribute to the satisfaction of more than one super goal.
- AND/OR graphs are **acyclic**.

AND/OR Goal Graphs (2)

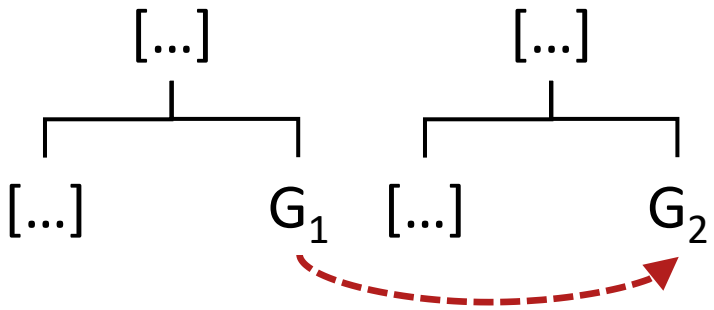


3. Goal Dependencies

Requires Dependency (1)

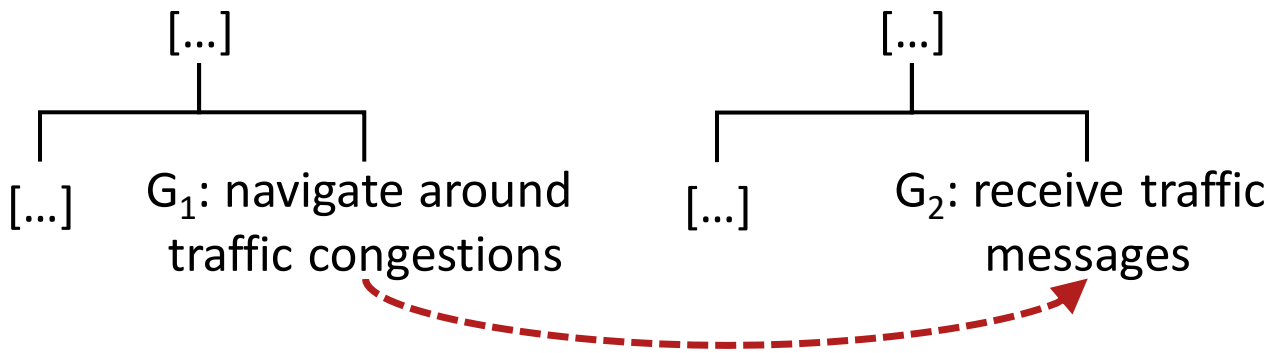
D A goal G_1 requires a goal G_2 if the **satisfaction** of G_2 **is a prerequisite** for satisfying G_1.

Notation of a requires dependency:



Requires Dependency (2)

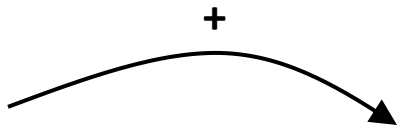
- G1: The system shall navigate the driver around traffic congestions.
- G2: The system shall be able to receive traffic messages.
- **G1 requires G2 under the specific context assumption**: The capability of receiving traffic massages is a prerequisite for calculating a route around traffic congestions.

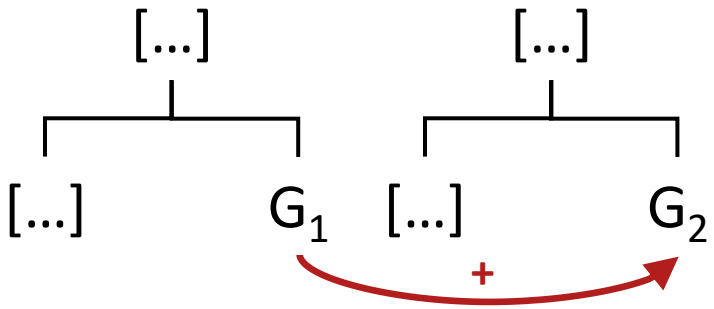


Support Dependency (1)

D A goal G_1 supports a goal G_2 if the **satisfaction** of G_1 **contributes positively** to satisfying G_2.

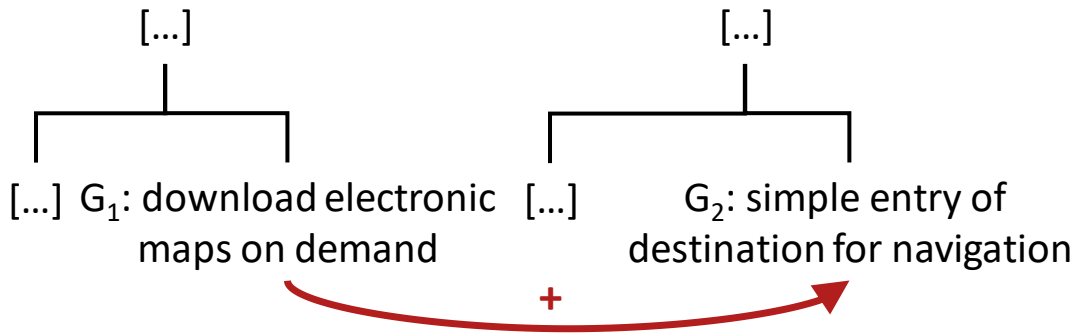
Notation of a support dependency:





Support Dependency (2)

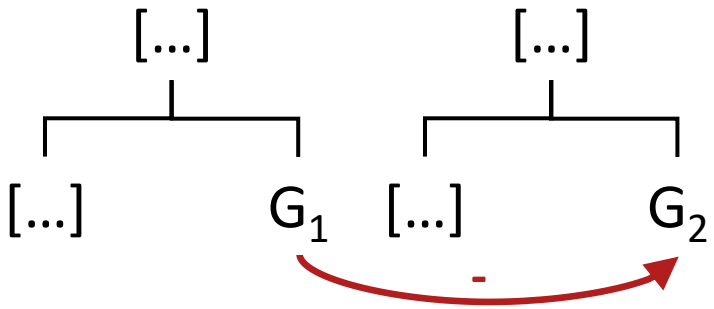
- G1: The navigation system shall be able to download electronic maps on demand.
- G2: The system shall allow simple entry of the destination for navigation.
- **G1 supports G2 under the specific context assumption**: download of electronic maps will support the driver when entering a new driving destination within an area not covered by the previously available maps.



Obstruction Dependency (1)

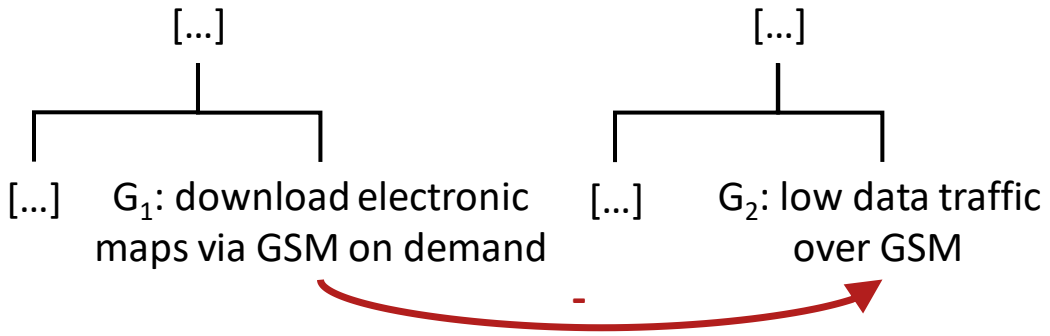
D A goal G_1 obstructs a goal G_2 if **satisfying** G_1 **hinders the satisfaction** of G_2.

Notation of an obstruction dependency:



Obstruction Dependency (2)

- G1: The navigation system shall be able to download electronic maps via the GSM network on demand.
- G2: The data traffic over the GSM network caused by the navigation system shall be as low as possible.
- **G1 interferes with G2 under the specific context assumption**: downloading electronic maps over the GSM network causes significant additional data traffic over GSM.



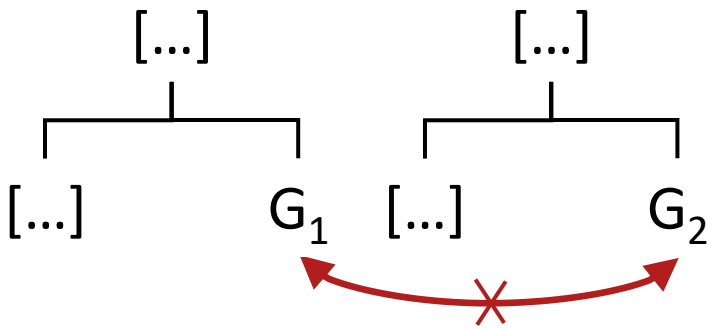
Conflict Dependency (1)

D A conflict exists between a goal G_1 and a goal G_2 if

(1) satisfying G_1 excludes the satisfaction of G_2 and

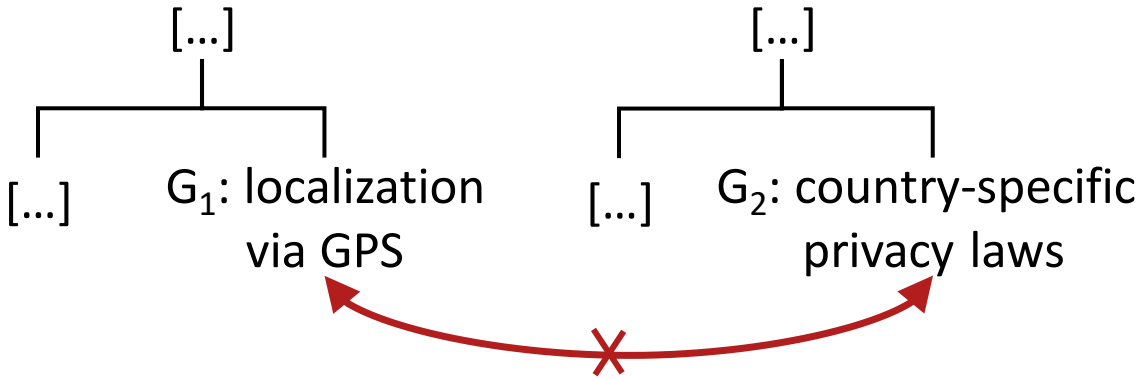
(2) satisfying G_2 excludes the satisfaction of G_1.

Notation of a conflict dependency:



Conflict Dependency (2)

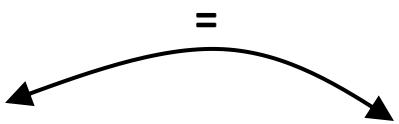
- G1: It shall be possible to localize the car via GPS.
- G2: The country-specific privacy laws shall be considered.
- G1 and G2 are **conflicting under the specific context assumption**: national privacy laws forbid the localization of cars via GSP by a third party.

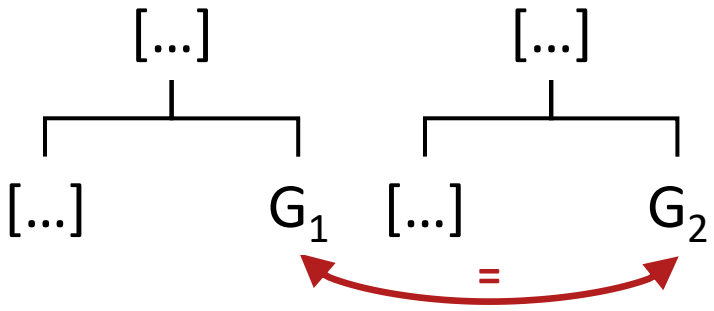


Goal Equivalence Dependency (1)

D Two goals G_1 and G_2 are equivalent (with respect to goal satisfaction) if **satisfying** the goal G_1 **leads to the satisfaction** of the Goal G_2 **and satisfying** the goal G_2 **leads to the satisfaction** of the goal G_1.

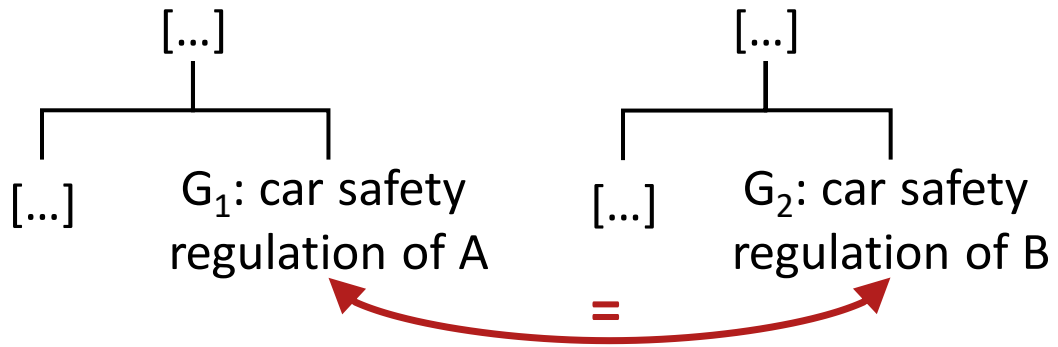
Notation of a goal dependency:



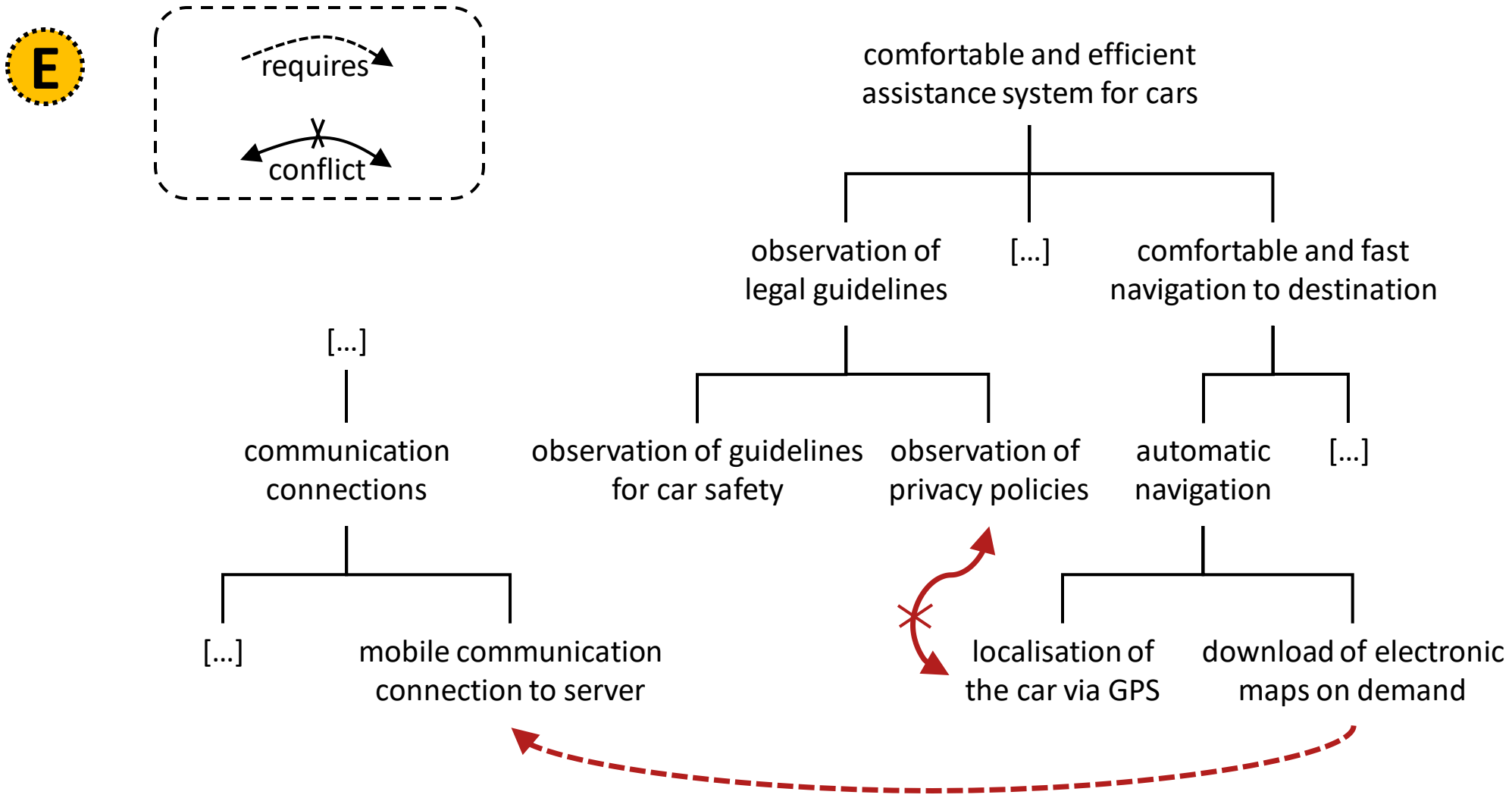


Goal Equivalence Dependency (2)

- G1: The system shall comply with the car safety regulations of country A.
- G2: The system shall comply with the car safety regulations of country B.
- G1 and G2 are **equivalent under the specific context assumption**: the safety regulations of country A and country B are identical (e.g. country A and country B have jointly defined the safety regulations)



Goal Dependencies: Example



4. Documenting Goals in Natural Language

Rule 1 - Document Goals Concisely

Avoid unnecessary phrases, filler and repetition.

Goal G1:

Expert users as well as inexperienced users shall be able to use the system. Inexperienced users shall be able to use the system without having knowledge about the predecessor system. Furthermore, an inexperienced user shall be able to use the system without any training. For any user, it has to be self-evident how to use the system. It has to be possible to use the system even without knowledge of similar systems.

Improved definition of G1:

The users shall be able to use the system without training and/or knowledge of the previous system.

Rule 1

Rule 2 - Use Active Voice

- **Avoid** using the passive voice. Use **active voice** instead.
- Active voice **enhances understandability** and clearly names the **actor**.

Goal G2:

The duration of creating the quarterly reports shall be cut down by half compared with the predecessor system.

Improved definition of G2:

The user shall be able to create quarterly reports in half of the time needed using the current system.

Rule 2

Rule 3 - Document the Intention Precisely

- It should be possible to **check objectively** (later on) whether the implemented system **satisfies the goals or not**.
- Documenting goals in an objectively checkable way is not always desirable or possible (e.g. for softgoals).

Goal G3:

The system shall lead to an improved workflow in the company.

Improved definition of G3:

The system shall speed up the workflow for order processing by at least 20%.

Rule 3

Rule 4 - Decompose High-level Goals

If a goal is too abstract, it should be **decomposed into more concrete sub-goals** during the requirements engineering process.

Goal G4:

Increase driving safety.

Improved G4:

The goal G4 is decomposed into the following sub-goals by means of an AND-decomposition:

- G4.1: Reduce the braking distance on slippery roads by 20%.
- G4.2: Ensure the vehicle remains steerable using braking manoeuvres.

Rule 4

Rule 5 - State the Additional Value of the Goal

- Clearly describe the **additional value** the goal offers to the **stakeholders**.
- Describe the intended additional value as **precisely** as possible.

Goal G5:

The navigation system shall provide an intuitive way of entering the destination of a trip.

Improved definition of G5:

The navigation system shall support the driver to enter the desired destination without being distracted from driving.

Rule 5

Rule 6 - Document Rationales for a Goal

- Provide a **brief and precise description** of the **reasons** for introducing the goal.
- Knowing the **rationale** for introducing a goal **facilitates discussions** about the goal itself and supports the identification of additional goals.

Goal G6:

The system shall offer an intuitive user interface.

Improved definition of G6:

The system shall offer an intuitive user interface, since 80% of its users use the system only once or twice a month.

Rule 6

Rule 7 - Avoiding Unnecessary Restrictions

- **Avoid constrains** for potential **realizations** of the system.
- Only define **restrictions** if they are imposed by **law** or a **contractual document**.

Goal G7:

The response times of the system shall be reduced by 10% by optimizing the time for data transfers.

Improved definition of G7:

The response times of the system shall be reduced by 10%.

Rule 7

Rule 7 – Hints to Avoid Unnecessary Restrictions

If a stakeholder demands a specific solution or expresses a specific constraint for the realization of the system, apply the following steps:

- **Elicit** the actual, solution/constraint-free **super-goal** behind the demand/specific solution **by asking "why"** questions.
- For the super-goal, try to **identify** viable **solution alternatives**.
- **Document** the identified, alternative solutions as sub-goals of the solution-free super-goal **using an OR-decomposition**.

7 Rules for Documenting Goals

1. Document goals concisely (but not to briefly)
2. Use active voice
3. Document stakeholder's intention precisely
4. Decompose high-level goals
5. State the additional value of the goal
6. Document rationales for a goal
7. Avoid defining unnecessary restrictions

Template for Documenting Goals (1)

	No.	Section	Content / Explanation
ID	1.1	Identifier	Unique identifier of the goal.
	1.2	Name	Unique name for the goal.
Management	2.1	Authors	Names of the authors who have worked on the goal description.
	2.2	Version	Current version number of the documentation of the goal.
	2.3	Change history	List of the changes applied to the documentation of the goal.
	2.4	Priority	Indication of the importance of the described goal according to the prioritisation technique used.
	2.5	Criticality	Criticality of the goal, e.g. for the overall success of the system.
Context	3.1	Sources	Denomination of the sources ([stakeholder | document | system]) from which the goal originates.
	3.2	Responsible stakeholder	The stakeholders responsible for the goal.
	3.3	Stakeholders benefiting	The stakeholders benefiting from the satisfaction of the goal.

Template for Documenting Goals (1)

No.		Section	Content / Explanation
Goal Definition	4.2	Goal description	Description of the goal.
	4.3	Super-goal	Reference to the super-goal(s).
	4.4	Sub-goals	References to sub-goals including the type of decomposition (AND/OR).
	4.5	Other goal dependency	Further dependencies with other goals such as “requires”, “conflict”, etc.
	4.6	Associated scenario	References to scenarios that describe the satisfaction of the goal or a failure to satisfy the goal.
Relationships	5.1	Use cases	Relationships of the goal to use cases.
	5.2	Scenarios	Relationships of the goal to other scenarios than mentioned in “Associated scenario(s)”.
	5.3	Solution-oriented requirements	Relationships of the goal to solution-oriented requirements.
	5.4	Other artefacts	Relationships of the goal to other artefacts.
Misc.	6.1	Supplementary information	Additional information regarding the goal.
	6.2	Open issues	A list of notes regarding the documentation of the goal.

Template for Documenting Goals: Example

No.		Section	Content
ID	1.1	Identifier	G-2-17
	1.2	Name	Automatic navigation
Management	2.1	Authors	Peter Miller, Dan Smith
Context	3.1	Source	William Garland (product manager)
Goal Definition	4.2	Goal description	The system shall automatically direct the driver to the desired destination.
	4.3	Super-goal	G-2-2: Comfortable and fast navigation to the destination
	4.4	Sub-goals	G-2-25: Localisation of the car via GPS (OR) G-2-26: Download of electronic maps on demand (OR)
	4.5	Other goal dependency	Conflict with G-1-45: Reduce costs for cars Support of G-1-37: Technological leadership in the automotive segment of medium-sized vehicles

Note: Only some slots have been filled in the example.
For the complete template for goal documentation, please refer to the previous slides.

5. Benefits of Goals

Benefits of Goals for Elicitation

- Foundations for requirements elicitation:
  - Stakeholders often **make goals explicit**.
  - Stakeholders' goals provide a **good basis** for eliciting scenarios and solution-oriented requirements.
- Goal-oriented requirements elicitation:
  - Goals support the **systematic** elicitation of requirements by focusing on the desired satisfaction of the defined goals.
- Identification and evaluation of **alternative realizations** (via goal decomposition).
- Refinement of the vision:
  - Goals help to **refine the system vision** at an abstract level.

Benefits of Goals for Negotiation

Supporting conflict identification and resolution:

- Goal models can be used to **identify** and **resolve conflicts** at an **early stage** of the requirements engineering process.
- **Conflicts in solution-oriented requirements** often result from goal conflicts between different stakeholders.
- **Negotiate about the goals first** (it is easier than achieving an agreement on detailed requirements with a goal conflict behind).

Benefits of Goals for Validation

- Validation of goals first:
  - Sufficient **agreement about the goals** should be **checked** before validating detailed requirements associated to the goals.
- Validity of requirements:
  - Stakeholders check whether a goal is **satisfied** if the system realizes the related requirements.
  - If a goal cannot be satisfied by realizing the associated requirements, the requirements may be **incomplete** or have some other type of **defect**.

Benefits of Goals for Documentation

- Checking the requirements for **completeness**:
  - Documented requirements should satisfy the defined goals.
- Avoiding **irrelevant** requirements:
  - Check whether a requirement is not related to a goal and whether it does not contribute to satisfy a goal.
- **Structuring** of requirements documents:
  - Requirements documents can be organized according to the decomposition structure of the goals.
- **Access paths to requirements**:
  - Each documented requirement should contribute to the satisfaction of one (or several) goals.
  - Goal models can be used as logical access paths to requirements.

Benefits of Goals for Management

- **Prioritization** of requirements:
  - Start the prioritization of the requirements related to the high-level goals.
  - Priorities are then “inherited” or refined along the refinement relationships of the goals.
- **Traceability** of requirements:
  - Explicitly document relationships between a goal and the requirement(s) which satisfy (partially) the goal.

Summary

- A goal describes a high level objective of one or more stakeholders about a property of the system to be developed or the development project.
- Goals can be hierarchically decomposed using AND/OR-decomposition.
- AND/OR trees and graphs are goal modelling languages which nicely visualize the decomposition of goals into sub-goals.
- Positive and negative influences between goals can be documented as dependencies.
- Natural language documentation of goals should use appropriate templates.
- Consider the 7 rules when documenting goals using natural language.
- Goal-orientation has several benefits for the requirements engineering activities.

Literature (1)

[Bresciani et al. 2004] P. Bresciani, A. Perini, P. Giorgini, F. Giunchiglia, und J. Mylopoulos: Tropos: An Agent-Oriented Software Development Methodology, Autonomous Agents and Multi-Agent Systems, Vol. 8, No. 3, S. 203–236, Mai 2004.

[Chung et al. 1996] L. Chung, B. A. Nixon, E. Yu: Dealing with Change – An Approach using Non-Functional Requirements. Requirements Engineering, Vol. 1, No. 4, Springer, Berlin, Heidelberg, 1996, pp. 238-259.

[Dardenne et al. 1993] A. Dardenne, A. van Lamsweerde, S. Fickas: Goal-Directed Requirements Acquisition. Science of Computer Programming, Vol. 20, No. 1-2, Elsevier Science, Amsterdam, 1993, pp. 3-50.

[Dalpiaz et al. 2016] F. Dalpiaz, X. Franch, und J. Horkoff, „iStar 2.0 Language Guide“, arXiv:1605.07767, Mai 2016, Accessed on: Feb. 20, 2018. URL: http://arxiv.org/abs/1605.07767

[GRL 2009] Goal-oriented Requirements Language (GRL): GRL Ontology. http://www.cs.toronto.edu/km/GRL; accessed on 09/09/2009.

Literature (2)

[ITU 2011] International Telecommunication Union (ITU-T): Recommendation Z.150 (02/2011) – User Requirements Notation (URN) – Language requirements and framework. Geneva, 2011.

[Kavakli 1999] E. Kavakli: Goal-Driven Requirements Engineering – Modelling and Guidance. PhD. Thesis, University of Manchester, Institute of Science and Technology, Manchester, 1999.

[Rolland and Salinesi 2005] C. Rolland, C. Salinesi: Modeling Goals and Reasoning with Them. In: A. Aurum, C. Wohlin (Eds.): Engineering and Managing Software Requirements. Springer, Heidelberg, 2005, pp. 189-217.

[Van Lamsweerde 2001] A. van Lamsweerde: Goal-Oriented Requirements Engineering – A Guided Tour. In: Proceedings of the 5th IEEE International Symposium on Requirements Engineering (RE'01), IEEE Computer Society Press, Los Alamitos, 2001, pp. 249-263.

Literature (3)

[Yu 1993] E. Yu: An Organisational Modelling Framework for Multiperspective Information System Design. In: J. Mylopoulos et al. (Eds.): Requirements Engineering 1993 – Selected Papers, Tech Report DKBS-TR-92-2, Department of Computer Science, University of Toronto, Toronto, 1993, pp. 66-86.

[Yu 1995] E. Yu: Modelling Strategic Relationships for Process Reengineering. Ph.D. Thesis, Department of Computer Science, University of Toronto, Toronto, 1995.

[Yu 1997] E. Yu: Towards Modeling and Reasoning Support for Early-phase Requirements Engineering. In: Proceedings of the 3rd International Symposium on Requirements Engineering (RE'97), IEEE Computer Society Press, Los Alamitos, 1997.

[Yu and Mylopoulos 1994] E. Yu, J. Mylopoulos: Understanding "Why" in Software Process Modelling, Analysis, and Design. In: Proceedings of the 16th International Conference on Software Engineering (ICSE'94), IEEE Computer Society Press, Los Alamitos, 1994, pp. 159-168.

Literature for Further Reading

[Antón 1996] A. I. Antón: Goal-Based Requirements Analysis. In: Proceedings of the 2nd International Conference on Requirements Engineering (ICRE ‘96), IEEE Computer Society, Washington, DC, USA, 1996, pp. 136-144.

[Van Lamsweerde 2009] A. van Lamsweerde: Requirements Engineering: From System Goals to UML Models to Software Specifications. Wiley, West Sussex, 2009.

Image References

[1] Licensed by http://www.iconshock.com/

[2] Provided by Microsoft Office

Legend

Definition

Example

UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

Requirements Engineering & Management

Vielen Dank für Ihre Aufmerksamkeit

PALUNO
The Ruhr Institute for Software Technology