Requirements Engineering & Management

Core Activities – Documentation III

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Agenda

1. Ambiguities in Natural Language Requirements
2. Techniques for Avoiding Ambiguity

1. Ambiguities in Natural Language Requirements

Ambiguity

D Ambiguity is

1. **a** : the quality or state of being ambiguous especially in meaning (see ambiguous)
   b : a word or expression that can be understood in two or more possible ways : an ambiguous word or expression
2. : uncertainty

- **Synonyms**:
  Obscurity, ambiguousness, mysteriousness
- **Antonyms**:
  Clarity, clearness, obviousness, plainness

[http://www.merriam-webster.com/dictionary/ambiguity]

Ambiguity in Natural Language

- Natural language is **inherently ambiguous**.
- An ambiguously documented requirement has **more than one valid interpretation**.
  → Different persons might interpret such a requirement differently.
- Two main reasons:
  - **Underspecified requirements**: i.e. missing details, vagueness, …
  - **Defective specified requirements**: e.g., use of different words that sound alike, ….
- **Goal**: Document requirements unambiguously.
  → All **stakeholders** with (almost) the **same knowledge** about the system and its context **interpret** the requirement **in the same way**.

Underspecified Requirements

E **R55**: The system shall display the map **quickly**.

- "quickly" is considered **vague**, as it admits **borderline cases**.
- A **response time of 1 second** is neither clearly quick nor clearly slow.
- Conceptual analysis and empirical investigation cannot provide an answer: The response time might be considered
  - **fast** for a map visualization on a **desktop computer**.
  - **slow** for a visualization during a **car racing competition**.

→ **Vague, underspecified statements lead to ambiguity!**

Based on [Berry et al. 2003]

Defective Specified Requirements – Ambiguities

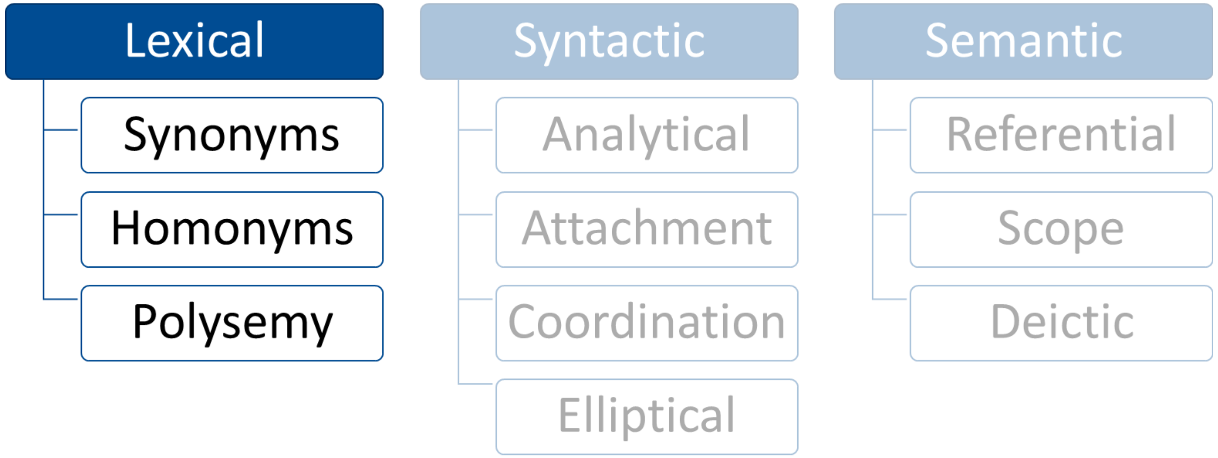
- **Lexical**
  - Synonyms
  - Homonyms
  - Polysemy
- **Syntactic**
  - Analytical
  - Attachment
  - Coordination
  - Elliptical
- **Semantic**
  - Referential
  - Scope
  - Deictic

Hint: A given ambiguity may be of more than one kind.

Based on [Berry et al. 2003]

Lexical Ambiguity

- Lexical ambiguity is caused by **words with more than one meaning**.
- Types of lexical ambiguity:
  - Synonyms
  - Homonyms
  - Polysemy



Synonyms and Homonyms

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- **Synonyms**

  Synonyms are different words (letter sequences) with the same meaning.

E "car/automobile", "small/little", "sick/ill"

- **Homonyms**

  Two or more words, which are spelled in the same way but have different meaning.

E **Bank**:

1. a river bank
2. a money bank
3. a banked curve

Polysemy (1)

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Polysemy (in general)

- Polysemy occurs when a word has several related but different meanings with the same etymology.
- Polysemy is a specialization of a homonym.

E

Wood:

1. a material made out of trees
2. a small forest
3. a golf club

Based on [Berry et al. 2003]

Lexical

Polysemy (2)

Systematic Polysemy

Systematic polysemy is due to the lack of distinction that is commonly made between classes like type and unit, product and process, count and mass, etc.

E Her writing was flawless.

Lack of distinction between process and product: Here writing can refer to the act of writing (process) or to what she has written (product).

E Please, buy this vase.

Lack of distinction between type and unit:
Here vase can refer to a certain vase
or a certain type of vase.

Lexical

Based on [Berry et al. 2003]

Syntactic Ambiguity

- Sometimes also called **structural ambiguity**.
- At least two **valid syntax trees** can be assigned to the same sentence.
- The sentence has several **different meanings**.

E **R2**: The user enters the access card with the access code.

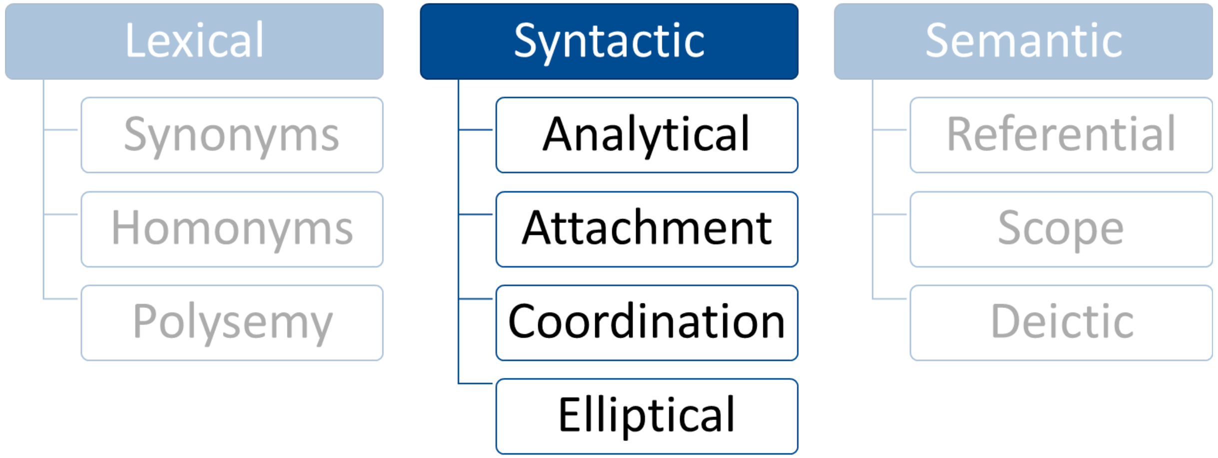
Interpretation 1: The user enters his access card and, in addition, his access code into the system.

Interpretation 2: The user enters his access code by making use of his access card, i.e. the access card contains the access code.

Based on [Berry et al. 2003]

Types of Syntactic Ambiguity

- Analytical ambiguity
- Attachment ambiguity
- Coordination ambiguity
- Elliptical ambiguity



Based on [Berry et al. 2003]

Analytical Ambiguity

Analytical ambiguity occurs when some part of the sentence can have **more than one role** within the sentence.

E The **British race car driver** did a good job.

Interpretation 1: The British (race car driver) did a good job.

Interpretation 2: The (British race car) driver did a good job.

Syntactic

Based on [Berry et al. 2003]

Attachment Ambiguity

Attachment ambiguity occurs when some part of a sentence can be **attached to more than one other part** of the sentence.

E **R2**: The user enters the access card with the access code.

Interpretation 1: The user enters his access card and, in addition, his access code into some system. (“with the access code” attaches to “**enter**”)

Interpretation 2: The user enters his access code by making use of his access card, i.e. the access card contains the access code. (“with the access code attaches to “**access card**”)

Syntactic

Coordination Ambiguity (1)

Coordination ambiguity occurs when **more than one conjunction (e.g. and, or)** is used in a sentence or when a **conjunction is used with a modifier**.

E

More than one conjunction:

R24: (1) If a window of the car is damaged **and** (2) the interior surveillance of the car detects an intruder **or** (3) a door of the car is opened without a car key, the safety system shall raise an alarm.

Interpretation 1:

“**and**” stronger than “**or**”: [(1) and (2)] or (3)

Interpretation 2:

“**or**” stronger than “**and**”: (1) and [(2) or (3)]

Syntactic

Coordination Ambiguity (2)

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E Conjunction is used with a modifier:

R39: The alarm shall consists of a **short** acoustic signal **and** visual signal.

Interpretation 1: "**short**" stronger than "**and**":
(short acoustic signal) and visual signal

Interpretation 2: "**and**" stronger than "**short**":
short (acoustic signal and visual signal)

Syntactic

Based on [Berry et al. 2003]

Elliptical Ambiguity

Elliptical ambiguity occurs when it is **not clear if a sentence contains an ellipsis** (an omission of one or more words) or not.

E Dave sees a taller man than Joe.

Interpretation 1: No ellipsis

Dave sees a man who is taller than Joe.

Interpretation 2: Ellipsis

- Dave sees a taller man than Joe **sees**.
- Dave sees a man who is taller than the man who is seen by Joe.

Syntactic

Based on [Berry et al. 2003]

Semantic Ambiguity

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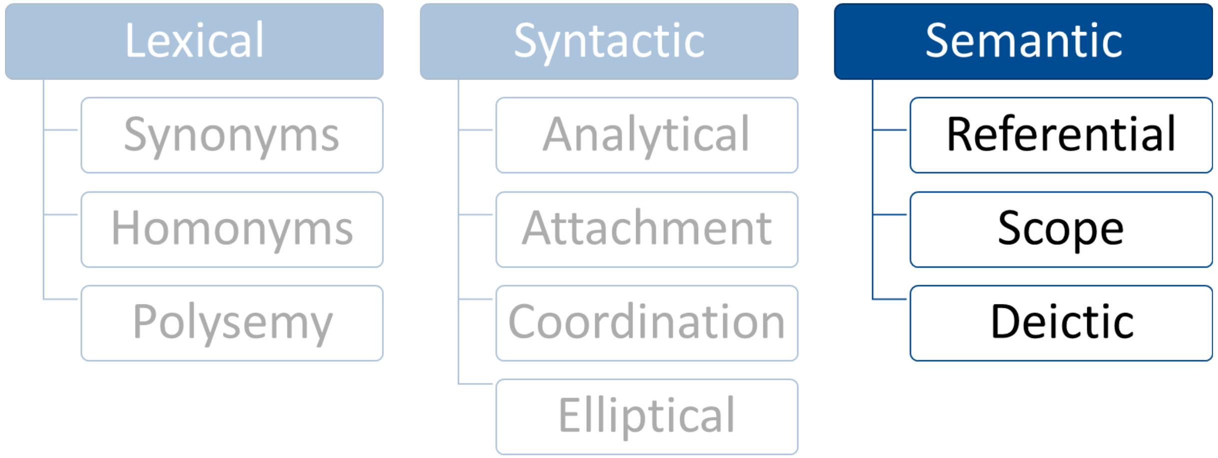
- Semantic ambiguity occurs if a sentence has **more than one interpretation** in the specific context, **even if it contains no lexical or syntactic ambiguity**.

- Semantic ambiguity can be caused by:
  - Scope ambiguity
  - Referential ambiguity
  - Deictic Ambiguity



Based on [Berry et al. 2003]

Scope Ambiguity

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- Occurs when using **quantifier operators** such as a, all, some, etc. and **negation operators** such as no, not, etc.
- These operators can enter into different scoping relations with other phrases.

Scope ?

E R3: **All** users enter **a** coupon code.

Interpretation 1:

All users enter **the same** coupon code.

Interpretation 2:

Each user enters **a, perhaps different**, coupon code.

Semantic

Based on [Berry et al. 2003]

Referential Ambiguity

- **Antecedent**: A referenced word or phrase.
- **Anaphora**: Refers back to a previous expression in the same or in a previous sentence.
- **Referential ambiguity**: The antecedent to an anaphora cannot be clearly determined.

Antecedents

E **R42**: The customer inserts the **access card** into the card reader and enters a **personal identification number** (PIN) at the keypad. If **this** is invalid, the system shall deny the access.

Anaphora

→ **Is the access card or the PIN invalid?**

Semantic

Based on [Berry et al. 2003]

Deictic Ambiguity

Deictic ambiguity occurs when a word can have **more than one reference point in the situation** where it is used.

E **Everyone thinks he is nice.**

Interpretation 1: Everyone considers himself to be a nice person.

Interpretation 2: Everyone considers a specific male person to be a nice person.

Based on [Berry et al. 2003]

Semantic

2. Techniques for Avoiding Ambiguity

Three Techniques

- **Recommendation**: Be **aware** of ambiguities and be **careful** in writing or in inspections.
- In addition:
  - Glossaries
  - Syntactic requirements patterns
  - Controlled languages

→ **Using these techniques reduces the risk of writing ambiguous natural-language requirements.**

Glossaries (1)

D A glossary is a **collection of technical terms**, which are part of a language (terminology). A glossary defines the **specific meaning** of each of these terms. A glossary can additionally contain **references to related terms** as well as **examples explaining** the terms.

Possible **structure** of a glossary entry:

- **Term**: name of the term
- **Definition**: definition text
- **Synonyms**: synonym, […]
- **Related terms**: term, […]
- **Examples/counter-examples**: references to examples/counter-examples

Glossaries (2)

E

Term:	Route
Definition:	A specific way from a starting point to a destination
Synonyms:	Itinerary
Related Terms:	Alternative route (specialization)
Examples/Counter-examples:	[Link to a map showing an example route]

Benefits of Glossaries

Explicitly defining important terms helps to **reduce or avoid the following risks**:

- Different stakeholders **do not know the meaning** of a term and interpret the term differently.
- Different stakeholders **interpret** a term they are familiar with **differently** based on their specific knowledge.
- Different interpretations exist but are **not known**.
- Different stakeholders use **different terms** for the **same real-world object**.
- Different stakeholders use the **same term** for several **different real-world objects**.

- Using glossaries can prevent lexical ambiguities, but only if everyone in the project / organization uses the glossary as a main reference.

Syntactic Requirements Patterns (1)

D A syntactic requirements pattern defines a **syntactic structure** for documenting requirements in natural language and **defines the meaning** of keywords used in the pattern.

E

[<When?> <Under what conditions?>] — THE SYSTEM <system name> { SHALL | MIGHT | SHOULD } { <process> | PROVIDE <whom?> WITH THE ABILITY TO <process> | BE ABLE TO <process> } <object> — [<additional details about the object>]

Based on [Rupp 2009]

Syntactic Requirements Patterns (2)

E

[<When?> <Under what conditions?>] — THE SYSTEM <system name> { SHALL | MIGHT | SHOULD } { <process> | PROVIDE <whom?> WITH THE ABILITY TO <process> | BE ABLE TO <process> } <object> — [<additional details about the object>]

- **[]**: Use the constituent optionally.
- **{}**: Choose one of the given phrases.
- **<>**: Fill out the constituent.
- Define a suitable semantic for given phrase, e.g.:
  - **Shall**: Requirement has to be implemented.
  - **Might**: Requirement is optionally implemented.
  - **Should**: Implementation of the requirement is highly recommended.

Syntactic Requirements Patterns (3)

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E

[<When?> <Under what conditions?>]	THE SYSTEM <system name>	SHALL / MIGHT / SHOULD	<process> / PROVIDE <whom?> WITH THE ABILITY TO <process> / BE ABLE TO <process>	<object>	[<additional details about the object>]

When?

- **R114**: If the glass break detector detects the damaging of a window, **THE SYSTEM SHALL** inform the operation office.

Process **Object**

Controlled Languages

D A controlled language defines, for a specific domain, a **restricted natural language grammar** (syntax) and a **set of terms** (including the semantics of the terms) to be used with the restricted grammar in order to **document statements** about the domain.

Advantages of using a controlled language in requirements engineering processes:

- Easy to understand
- Less ambiguity
- Verifiability of documented expressions

Definition of Controlled Languages (1)

Four steps for defining a controlled language:

1. Elicitation of statements
2. Clarification and definition of technical terms
3. Standardization of the statements
4. Classification of the statements

- 1. → List of fact-related, colloquial statements
- 2. → Set up of usage rules for technical terms
- 3. → Set up of sentence patterns
- 4. → Classification of standardized statements according to their type (modelling)

[Ortner 1997; Schienmann 2002]

Definition of Controlled Languages (2)

- **Predication**:

  E.g., software is immaterial.

- **Pointing action**:

  E.g., this is a computer.

- **Multiple predicates**:

  E.g., a customer is a person who buys the goods of a company.

1. Elicitation of statements

↓

2. Clarification and definition of technical terms

↓

3. Standardization of the statements

↓

4. Classification of the statements

Definition of Controlled Languages (3)

- **Subordination**:

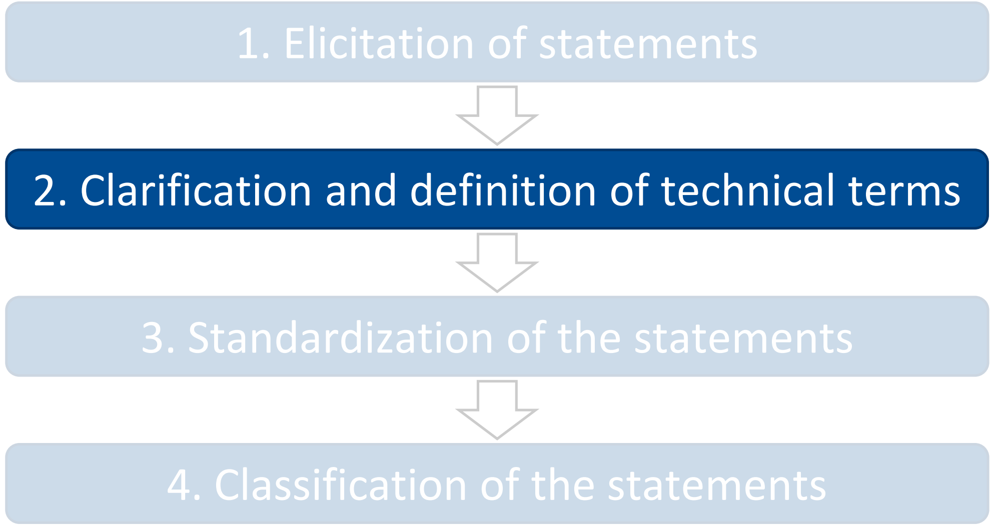
  e.g., $x \in \text{employee} \rightarrow x \in \text{person}$

- **Equivalence**:

  e.g., $x \in \text{library card} \leftrightarrow x \in \text{user card}$

- **Contrariness**:

  e.g., $x \in \text{software} \rightarrow$
  $x \notin \text{hardware}$



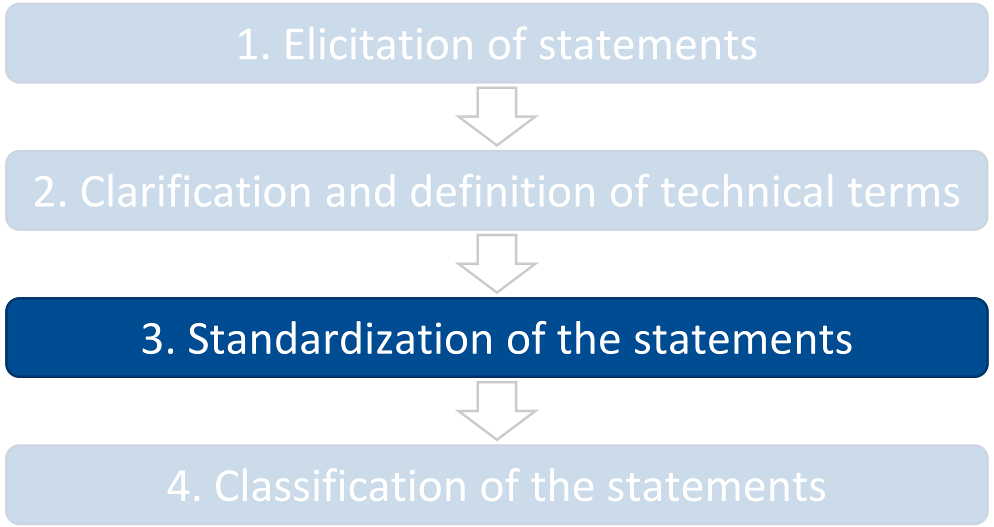
Definition of Controlled Languages (4)

- **Participation**:
  - [object] HAS AN [object]
  - e.g., user HAS A user status
- **Inclusion**:
  - [object] IS AN [object]
  - e.g., periodical IS A collected edition
- **Partition**:
  - [object] CONSISTS OF [object]
  - e.g., collected edition CONSISTS single editions

1. Elicitation of statements
2. Clarification and definition of technical terms
3. Standardization of the statements
4. Classification of the statements

Definition of Controlled Languages (5)

- **Ability**:
  - [person] CAN [action]
  - e.g., user CAN borrow book
- **Process**:
  - [action] RESULTS FROM [action]
  - e.g., indexing book RESULTS FROM inventorying book
- **Rule**:
  - IF [event] AND [condition] THEN [action]
  - e.g., IF book returned AND lending period exceeded THEN reminder charges



Definition of Controlled Languages (6)

- **Attribute**:
  e.g., user HAS A user status
- **Inheritance relationship**:
  e.g., periodical IS A collected edition
- **Aggregation**:
  e.g., collected edition CONSISTS OF single editions
- **Method**:
  e.g., user CAN borrow book

1. Elicitation of statements
2. Clarification and definition of technical terms
3. Standardization of the statements
4. Classification of the statements

Summary

- Requirements expressed and documented in natural language are inherently susceptible to ambiguity.
- An ambiguously documented requirement has more than one valid interpretation.
- Vague and underspecified requirements also lead to ambiguity.
- There are several kinds of ambiguity. We distinguish between lexical, syntactic, and semantic ambiguity. Each kind of ambiguity has different sub-types.
- Reduction of potential ambiguities can be achieved by glossaries, syntactic requirements patterns, controlled languages.

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Image References

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

[2] Provided by Microsoft Office

Legend

D Definition

E Example

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Vielen Dank für Ihre Aufmerksamkeit

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