Requirement Engineering

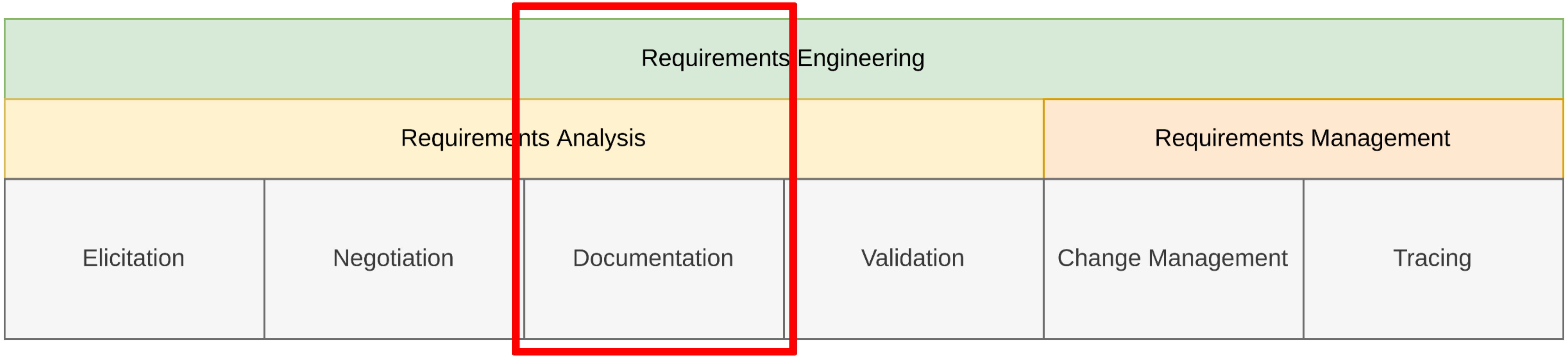
Lecture 4: Requirements Documentation

Part 2

Prof. Dr. Benjamin Leiding
Anant Sujatanagarjuna

General Requirements Engineering Process

Overview



Requirements Engineering

Requirements Analysis

Requirements Management

Elicitation

Negotiation

Documentation

Validation

Change Management

Tracing

Lecture 4: Requirements Documentation

Content

1. Types of Requirements
2. Textual Requirements Specification

TYPES OF REQUIREMENTS

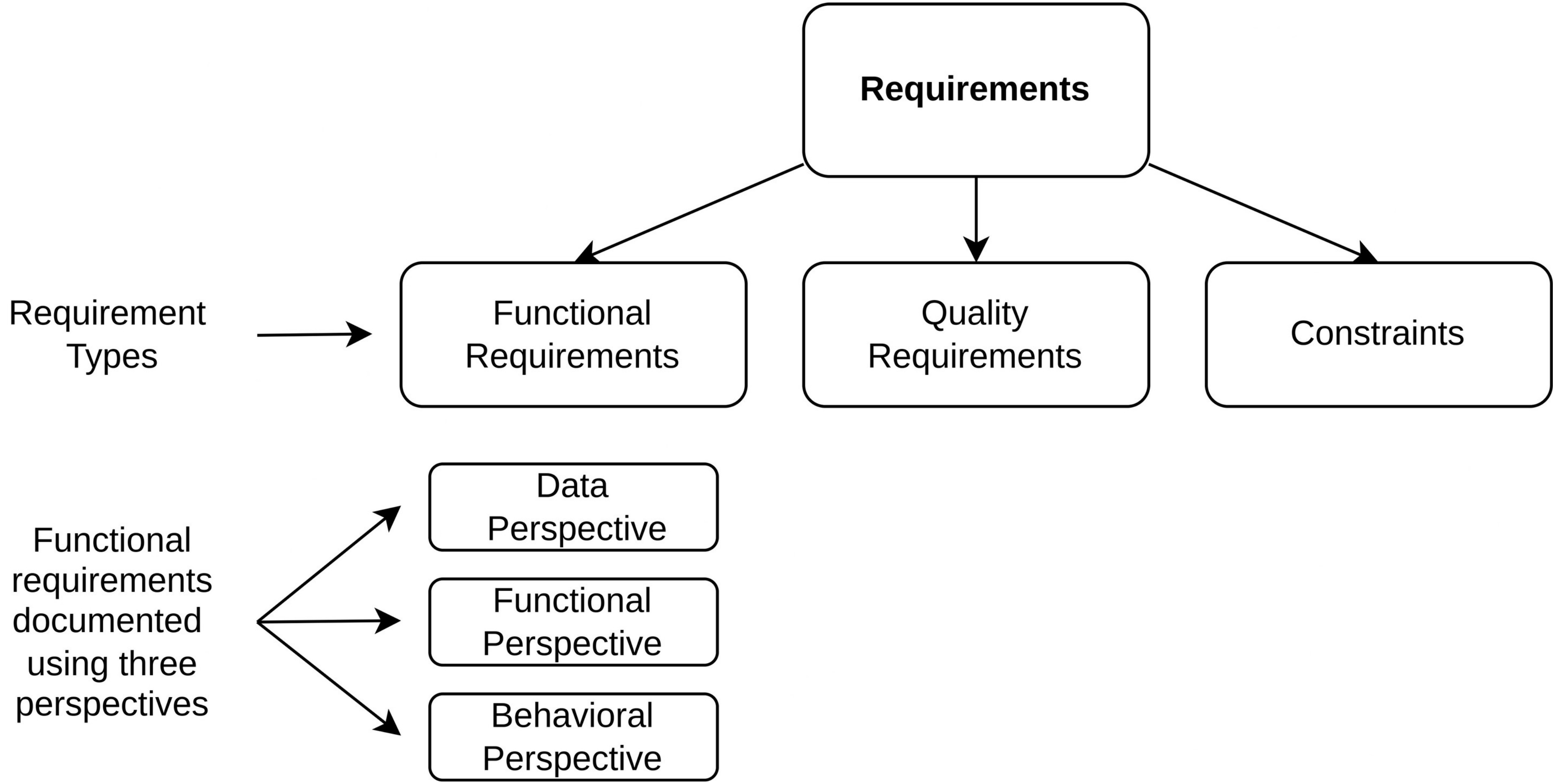
Types of Requirements

Motivation

- Different types of requirements must be documented for a complete requirements documentation.
- These requirements types differ with respect to:
  - adequate specification techniques
  - their importance for different types of systems

Types of Requirements

Functional Requirements



Types of Requirements / Functional Requirements

Data Perspective

- All systems need to deal with data
  - Data on customers, articles, etc.
  - Multimedia, e.g., videos, songs, etc.
  - …

- Information must be adequately structured and represented:
  - Which information / data items are relevant to the system?
  - Which information / data items are at the boundary of the system?

Types of Requirements / Functional Requirements

Data Perspective – Representing Data

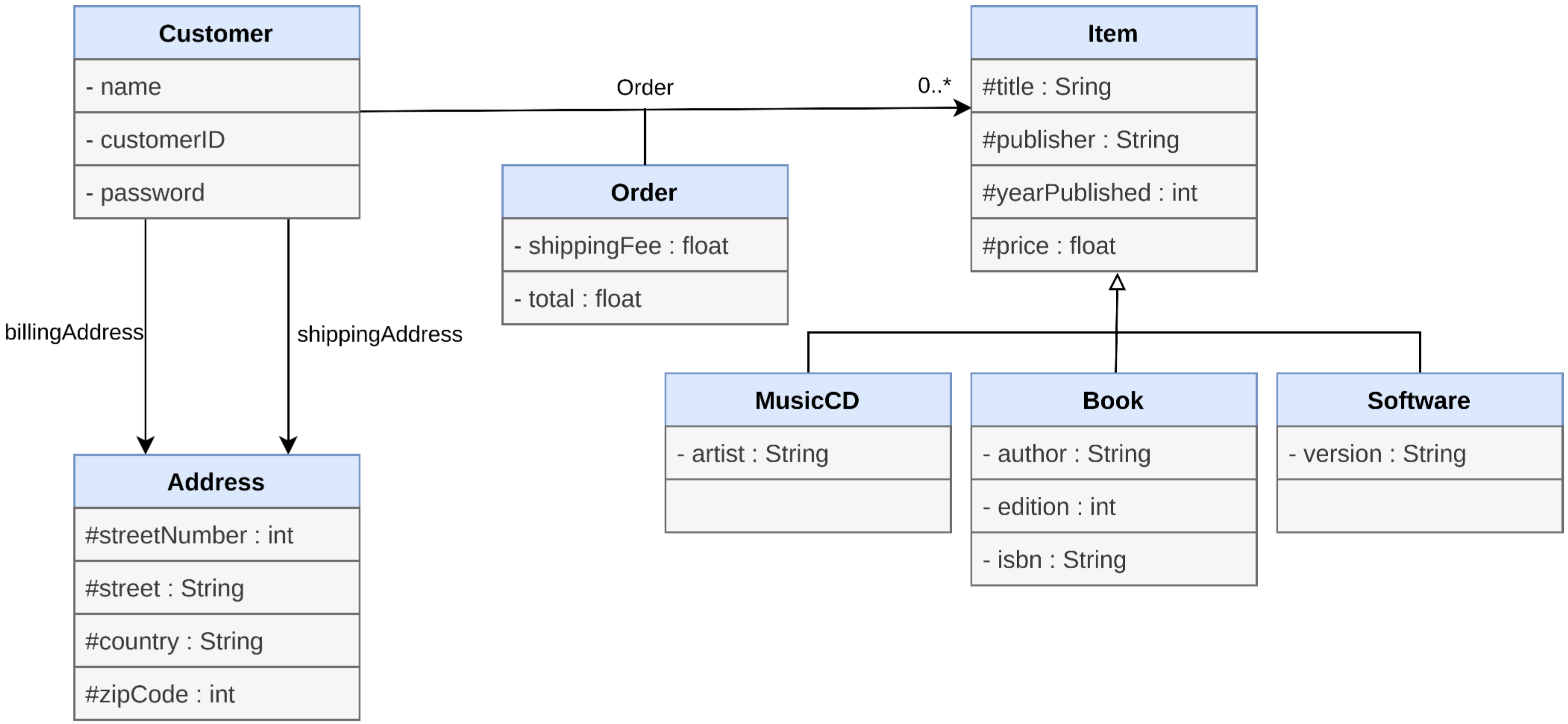
- UML class diagrams
- Context diagrams
- Data dictionary

Note:

- the data specified in the requirements need not be directly related to the implementation
  - same information, but different structure possible
  - e.g. attributes versus classes may change strongly
- In information systems understanding the data is a key driver !

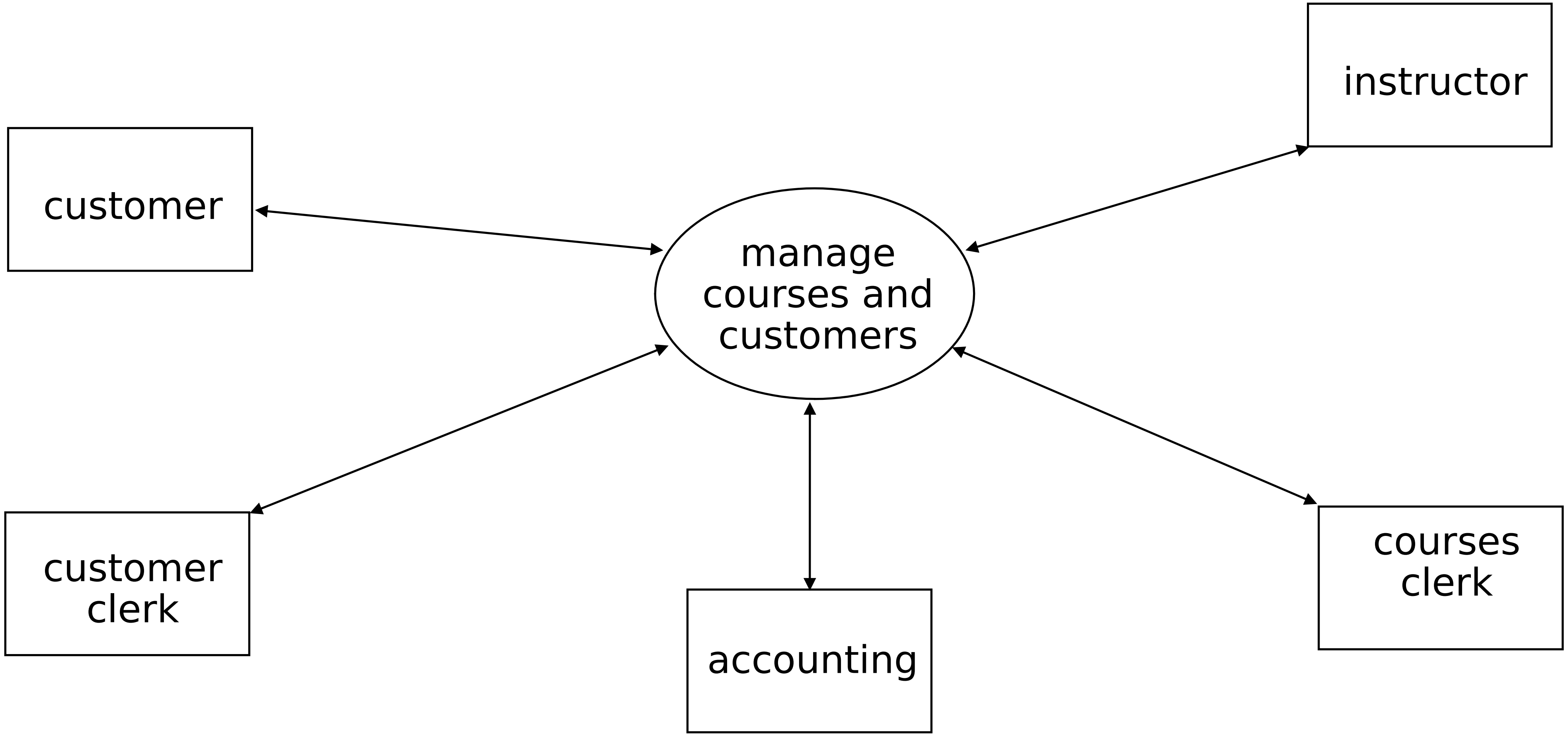
Types of Requirements / Functional Requirements

Data Perspective – Book Shop UML Example



Types of Requirements / Functional Requirements

Data Perspective – Context Diagram Example



Types of Requirements / Functional Requirements

Behavioral Perspective

Behavioral requirements describe what a system will do (with the data):

- how input information is transformed into state information and output information
- sequences of interaction of the software system with its environment (people, software, hardware)

System behavior is important on various levels:

- **Business processes** - describe the fundamental flow of activities in an enterprise
- **Task level** - describe the interaction of people with a software system on a coarse grained level (e.g., define new customer)
- **Stimulus / response** - describe interactions

Types of Requirements / Functional Requirements

Behavioral Perspective – Specification Techniques

Many different techniques were developed for specifying this:

- Textual Use Cases
- Business Process Modeling Languages
- Scenario-Based Modeling Approaches
- Event-Based Modeling Techniques

The techniques can be categorized along the following dimensions:

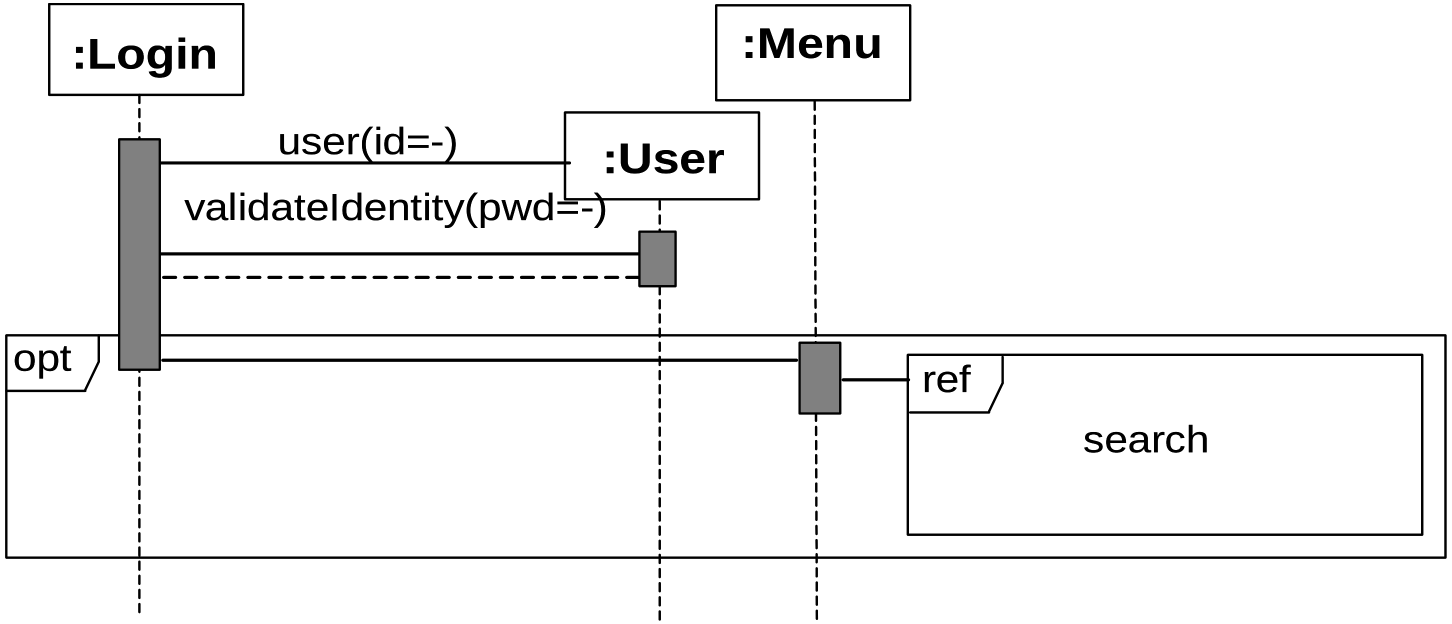
- **data-flow** (-transformation) vs. **stimulus-/response**
- **complete** description vs. **prototypical** description

Types of Requirements / Functional Requirements

Behavioral Perspective – Specification Techniques

The UML provides different approaches:

- Use Case Diagram
- State Machine Diagram
- Activity Diagram
- Sequence Diagram



Types of Requirements / Functional Requirements

Interface Requirements

- The interface takes apart interior and exterior
- Interfaces are defined by the project context
- Different types of interfaces:
  - User interfaces (Human-Machine Interface)
  - Software Interfaces
  - Hardware-related interfaces

Types of Requirements / Functional Requirements

Interface Requirements – User Interface

- Interface Description must describe
  - Layout
  - Look & Feel
  - Category of Interface (WIMP, ASCII-based, tactile, …)
  - Interaction sequences
  - ..

- Usability aspects are specific to this type of interface
  - Person (e.g., impairements, knowledge)
  - Situation
  - Task
  - …

Types of Requirements / Functional Requirements

Interface Requirements – Software Interface

- Interfaces to other software interfaces are defined based on
  - Identification of service, i.e., how to find it
  - The protocol (how to interact)
  - The data format(s), e.g., how to exchange data

- Typically use of standard protocols, like
  - Web-Service
  - HTTP
  - …

But also possible → Data file is written to a specific location and read by another program

Types of Requirements / Functional Requirements

Interface Requirements – Hardware Interface

Hardware interfaces are often:

- Time critical
  - Protocol specification must include timing information

- Specified close to hardware (e.g. addressing)
  - Hardware-based → service identification may be given in bits and bytes

- Other than that, usually hardware interfaces are like a software interface
- Mapping software information to the physical world is done by hardware!

Types of Requirements

Non-Functional & Quality Requirements – Definition

1 Quality requirements **define qualitative attributes** of the whole system, a single function or a group of functions, i.e. how good a system shall do the things it is supposed to do.

2 Non-functional requirements are used to **encompass all kinds of *not* functional requirements** for a system:

- quality requirements should be related to the functional requirement or group of requirements they are relevant to
- development constraints should be captured separately
- project aspects should be clearly separated from product aspects

Types of Requirements

Non-Functional & Quality Requirements – Definition

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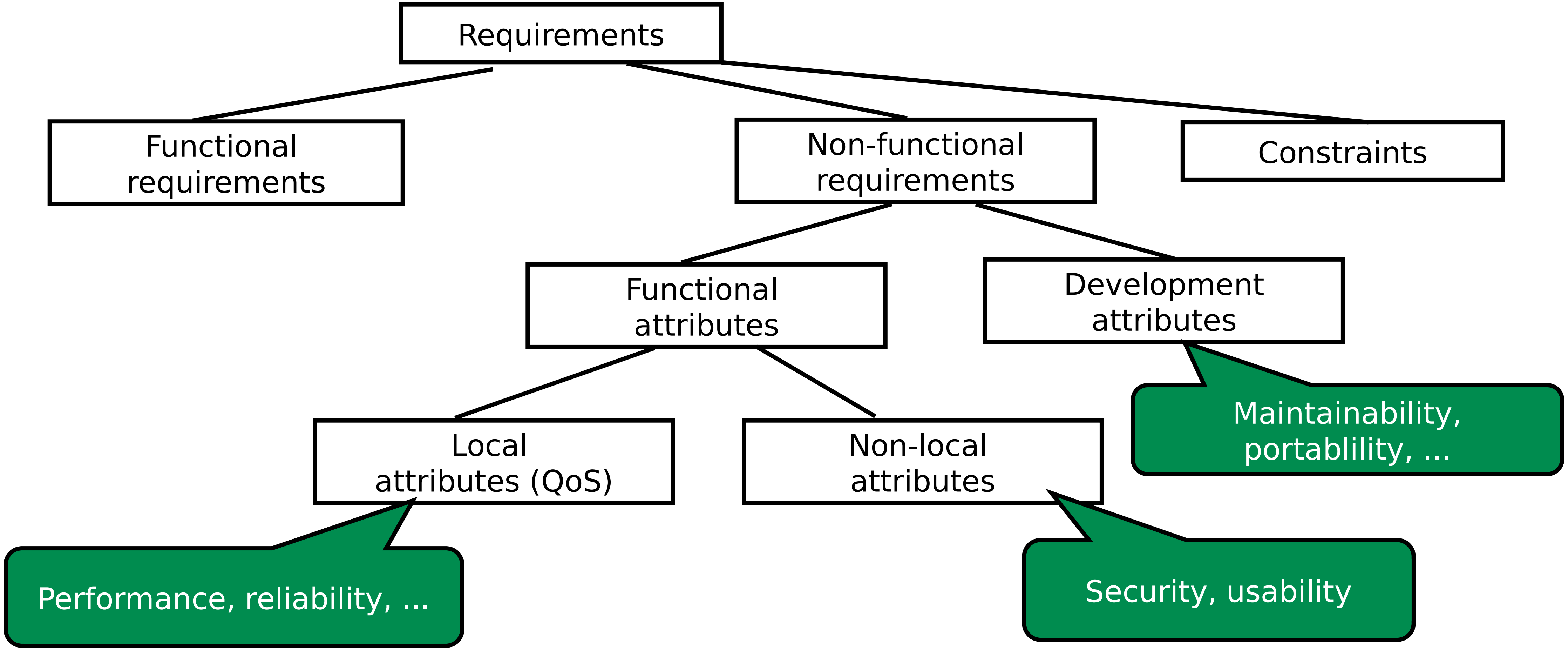
- project aspects should be clearly separated from product aspects

The term non-functional requirements is depreciated (according to IEEE)

Types of Requirements

Non-Functional & Quality Requirements – Kinds of Requirements



Types of Requirements

Non-Functional & Quality Requirements – Product Quality (ISO 9126 / DIN 66272)

- Functionality
  - Adequacy
  - Security
  - Precision of calculation
  - Interoperability
  - Conformity with standards
- Reliability
  - Maturation
  - Fault tolerance
  - Recovery
- Usability
  - Comprehensibility
  - Learnability
  - Operability

Types of Requirements

Non-Functional & Quality Requirements – Product Quality (ISO 9126 / DIN 66272)

- Efficiency
  - Time response
  - Resource Consumption
- Changeability
  - Analyzability
  - Modifiability
  - Stability
  - Verifiability
- Portability
  - Adaptivity
  - Installability
  - Conformity with standards
  - Replaceability

Types of Requirements

Non-Functional & Quality Requirements – Example „*Performance*“

- User level → The user can create accounts with only **two** interactions
- System task level → The creation of an account (pressing of the „system availability“ button) takes max. 0.5 seconds

→ Derived non-functional requirement result from the interplay between both levels.

TEXTUAL REQUIREMENTS SPECIFICATION

Lecture 4: Requirements Documentation

Content

1. Types of Requirements
2. Textual Requirements Specification
    1. **Ambiguity**
    2. Guidelines
    3. Syntactic Requirements Patterns

Textual Requirements Specification

Advantages of Natural Language

Three essential advantages

- Universal
  - Can be used in any problem area or domain
- Flexible
  - Allows arbitrary abstractions and refinements
- Comprehensible
  - Can (potentially) be understood by any stakeholder

Textual Requirements Specification

Mixing Concepts

- Mixing of the ***three*** perspectives (data/structural, function, behavioral) in functional requirements
- Often even mixed with quality requirements
- Example
  - The glass break detector at the window detects that the pane has been damaged, the system shall inform the security service within 2 seconds at the least.
  - Structural: glass break detector, window, pane, system, security service
  - Function: detects, inform the security service
  - Behavior: if damaged, shall inform
  - Quality: 2 seconds

→ Mixing concepts is a bad idea

Textual Requirements Specification

Separation of Functional and Quality Aspects

At least separate functional and quality aspects

- Functional
  - The glass break detector at the window shall detect if the glass pane is damaged.
  - If the detector detects damage to the pane, the system shall inform the security service.

- Quality
  - The system shall inform the security service within 2 seconds after detecting the damage.

Textual Requirements Specification

Ambiguity

A requirement is **ambiguous**, if it allows more than one interpretation even though the relevant context (other requirements, application domain, software system) is known.

Textual Requirements Specification

Ambiguity – Why should we care?

- Ambiguity is a common problem
- Ambiguity is often overlooked, as an interpretation is chosen unconsciously
  - Cause: Ambiguity as „under-specification“ is a typical phenomenon of natural language. The solution of ambiguity is an (often unconscious) cognitive process taking context (e.g. shared situation) or other cues (e.g. nonverbal) into account.
  - The „most likely“ interpretation of a requirement is chosen unconsciously, thus the interpretation causing the least contradictions with already known requirements, domain attributes or standards is chosen.
  - Because requirements can be controversial, this – in contrast to the common, verbal everyday communication – is not an optimal strategy! Contradictions must be discussed with the parties and must be solved.
- Ambiguity can be a sign for incompleteness!

Textual Requirements Specification

Ambiguity – Impact on Software Engineering

- Consequences show up very late
  - During integration of software components
  - During acceptance test
  - During usage of the software
- Are ambiguous requirements a frequent problem?
- Result of a survey with specification techniques:
  - Omissions and conflicts in specifications are noticed more often than ambiguities
  - Ambiguities are rather self-interpreted and more often misinterpreted than other types of defects
  - RE specific ambiguity: a frequent problem
  - Linguistic ambiguity: a rare problem

Textual Requirements Specification

Ambiguity – Categories

Conscious ambiguity:

- Client wants to keep requirements open e.g. **usual** in public projects

Unconscious ambiguity:

- Client expects a certain interpretation of the requirement, ambiguity occurs as the expectations of customer and client are not shared

Linguistic ambiguity:

- Inherent attributes of the natural language „Flying airplanes can be dangerous”

RE specific ambiguity:

- Arises from interpretation of a requirement via background knowledge (other requirements, domain, etc.)

Textual Requirements Specification

Ambiguity – Types of Ambiguities

Vagueness:

- Continuum of interpretations, diffuse classification, summarized version of the interpretation available
  - The text editor has to respond to user input in the adequate time
  - *Are 10 seconds still adequate?*

Generality:

- Continuum of interpretations, but exact classification, summarized version of the interpretation is available
  - The ATM system shall increase the market coverage of the bank company XYZ by at least 5%
  - *No charge for ATM transactions, user interface should require as few user interactions as possible …*

Textual Requirements Specification

Ambiguity – Types of Ambiguities

Genuine Ambiguity:

- Countable number of interpretations, no summarized version of the interpretation available, thus immediate clarification needed
  - Lexical: A term with several, in most cases related meanings
    - When the user presses the L- and R-button simultaneously,
      alarm is turned off → *The current alarm or the ability to sound alarms?*
  - Syntactic: Structure of a sentence is not clear without ambiguity
    - The customer enters a card with a code → *Is the code read from the card or is it typed in?*

Textual Requirements Specification

Ambiguity – Types of Ambiguities

- Semantic: A sentence can be translated into several logic terms
  - An alarm must be triggered if an aircraft is identified as hostile and has an unknown mission or in case the aircraft is able to reach the protected airspace within 5 minutes → *Is the „and“ or the „or“ the stronger binding operator?*
- Referential: A reference to an object is ambiguous to a previous sentence or subordinate clause. Is caused by nouns and pronouns.
  - The customer enters a card and a numeric personal code. If it is not valid then the ATM rejects the card. → *Card or code not valid?*
  - *[…] The product shall show all roads predicted to freeze. Reference of “all roads”?*

Textual Requirements Specification

Ambiguity – Types of Ambiguities

- Discourse ambiguity = A requirement is ambiguous in relation to other requirements.
- Example 1:
  - (A1) *When the XYZ button is pressed, the Head-up Display (HUD) shows the aircraft‘s current coordinates.*
  - (A2) *When the aircraft is not airborne, the HUD shows the current weather conditions.*

    → *Will the coordinates be displayed if the XYZ button is pressed and the aircraft is currently not airborne?*
- Example 2:
  - The first dunning letter has to be created after 2 weeks and the second after 4 weeks. At that time the system is also sending a notice to the responsible official in charge. → *Is the notice send after 2 or after 4 weeks? (or after 6 weeks?)*

Textual Requirements Specification

Typical Quality Problems

- Most requirements documentation is still done using text
- Typical quality problems of requirements
  - **Too restrictive:** requirements are described that unnecessarily restrict the range of possible interpretations
  - **Unnecessary:** single users request highly specialized functions, or the requirement does not contribute to the software systems goals.
  - **Inconsistent:** with goals of the software system, standards, directives, etc.
  - **Redundant:** with other information (in the requirements document)

Textual Requirements Specification

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→ *Style Guide*

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    2. **Guidelines**
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Textual Requirements Specification

Guidelines – Style Guide for the Specification of Requirements

Objectives:

- Requirements are easier to read and thus easier to understand
- Our style guide handles the most frequent problems, project-specific extensions may be reasonable
- Directives should be consolidated in a company-specific style guide

Textual Requirements Specification

Guidelines – Style Guide

- Short sentences, because of the limitation of the human short-term memory
- Describe only one requirement per sentence, avoid „and“
- Avoid jargon, use abbreviations sparingly
- Short paragraphs (max. 7 sentences)
- Use lists, instead of listing sentences
- Use terminology consistent; repetition of words is welcome!
- Avoid nested logic terms

  If X or Y is given in case Z, but not..

  ⇒ Use pseudo code or decision tables

Textual Requirements Specification

Guidelines – Example

Bad

Users attempting to access the ABC database should be reminded by a system message that will be acknowledged and by page headings on all reports that the data is sensitive, and access is limited by their system privileges.

Good

4.1 The system shall notify users attempting to access the ABC database that

- The ABC data is classified “sensitive”
- Access to the ABC data is limited according to the user’s system privileges
- Page headings on all reports generated using the ABC database must state that the report contains sensitive information

4.1.1 The system shall require the user to acknowledge the notification before being allowed to access the ABC database.

Textual Requirements Specification

Guidelines – Style Guide

- Use words like ‘must’, ‘can’, ‘ought’, ‘should’, ‘is’, etc. carefully
  - *Either:* precise definition: ‘must’, ‘ought’ show that the requirement is mandatory, etc.
  - *Or:* separate mandatory from optional requirements through a definition of a respective attribute or through a chapter heading
- Use active instead of passive
  - *Wrong:* a result is displayed
  - *Right:* the system displays the result
(thus the actor is obvious!)
- Illustrate complex dependencies with graphics
- Use precise references
- Use automatic spellchecker

Textual Requirements Specification

Guidelines – Style Guide

- Express requirements so they are testable. Thus it is possible to check whether or not the system meets the requirements
  - Is it possible to create a test case for requirement X?
- State rationale for each requirement
  - The rationale is important as a basis for deciding upon changes or omissions of requirements during development
- Explanations in requirements are confusing
  - <u>*Negative example:*</u> “To enable an experienced user to work efficiently, the access authorization is also checked on double-clicking a list item and if this authorization is valid, the customer-specific data will be displayed in ‘Access’ field. In case the SQL-query returns an error code (-1), …“
  - <u>*Better solution:*</u> *M*ake explanations explicit

Textual Requirements Specification

Guidelines – Style Guide

- Avoid generalities
  - Leads to ambiguities → Example Tamagotchi: “On clicking the R-button the selected function is canceled.“ Is this also true for the time function?
  - Seems boring if it has platitude characteristics → Example: “Input masks should be displayed entirely on screen. Scrolling should be avoided if possible. That is a principle of graphical user-interface design!“
- Document the sources (persons) of all requirements
  - For a large number of requirements or after a certain period of time, it is difficult to remember a source, if a requirement must be changed.

Textual Requirements Specification

Guidelines – Technical Terms

- Why should technical terms be defined?
- The advantage is to avoid misunderstandings caused by the following phenomena:
  - Unclear terms. Meaning is unclear to the requirement engineer (e.g., “butterfly valve”)
  - Ordinary terms may have special meanings to clients/users (“article”, “call”)
  - Different terms for the same „thing“ (synonyms) used by different sources or because the vocabulary of concepts of the client is not yet defined
  - Same term for related, but still different „things“ (polysemy) e.g. “school” = the institution *or* specific school (e.g., Werner v. Siemens Schule in Hildesheim)

Textual Requirements Specification

Guidelines – Technical Terms

Choose terms appropriate for the readers

Example → ISDN phone

- *For the hardware engineer:* key codes and activation of the LCD display
- *For the interface designer:* key sequences and masks on the LCD display
- *For the user of the telephone:* functions like call forwarding
- The correct description level is the one, that suits the expectations of the requirements-document reader

Lecture 4: Requirements Documentation

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    3. **Syntactic Requirements Patterns**

Textual Requirements Specification

Syntactic Requirements Patterns

- Technique that aims at avoiding mistakes
- Also known as *requirement templates*

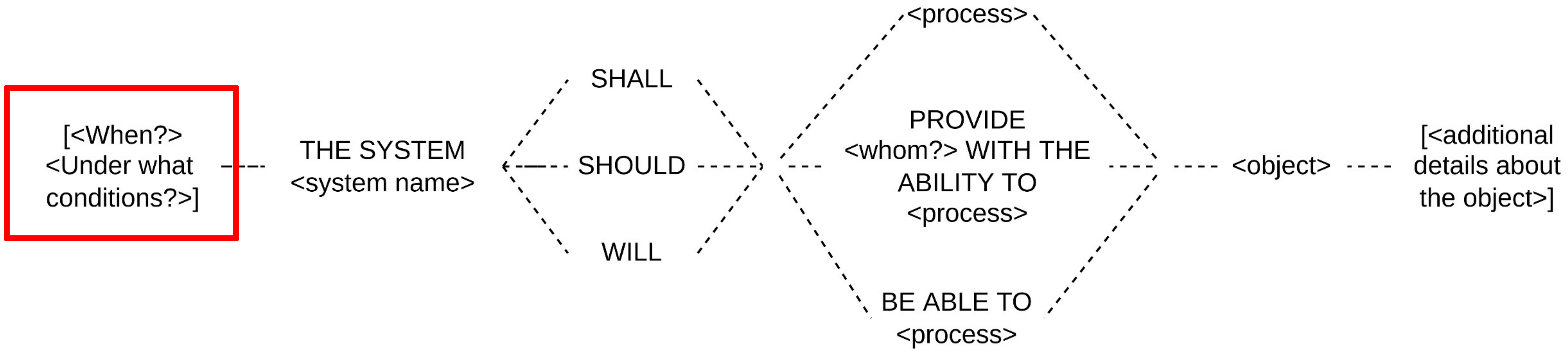
> *“A syntactic requirement pattern defines a syntactic structure for documenting requirements in natural language and defines meaning of each part of the syntactic structure.”*

- A good pattern contains:
  - Condition, subject, “legal obligation”, verb, object

K. Pohl (2010) – Requirements Engineering – Fundamentals, Principles and Techniques

Textual Requirements Specification

Syntactic Requirements Patterns – Example

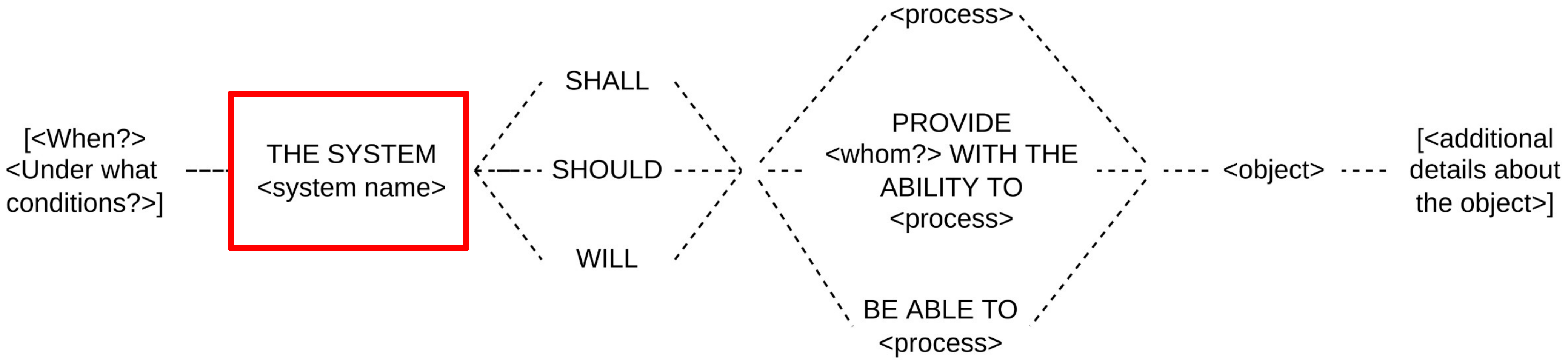


- *<when?> / <under what conditions>*
  - Conditions under which the function documented in the requirement is performed
  - Temporal or logical
  - One or more

C. Rupp (2009) – Requirements Engineering and Management

Textual Requirements Specification

Syntactic Requirements Patterns – Example

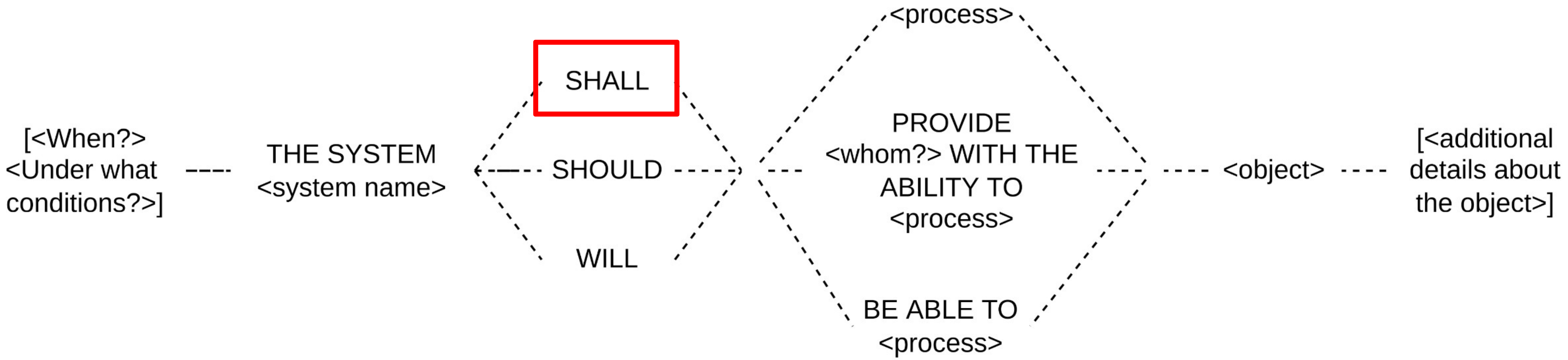

[<When?> <Under what conditions?>]
THE SYSTEM <system name>
SHALL
SHOULD
WILL
<process>
PROVIDE <whom?> WITH THE ABILITY TO <process>
BE ABLE TO <process>
<object>
[<additional details about the object>]

- *THE SYSTEM / <system name>*
  - Name of the system that shall provide the functionality
  - Subject of the sentence

C. Rupp (2009) – Requirements Engineering and Management

Textual Requirements Specification

Syntactic Requirements Patterns – Example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- *SHALL*
  - Legally binding requirement
  - If a statement does not contain "shall", it is not a requirement

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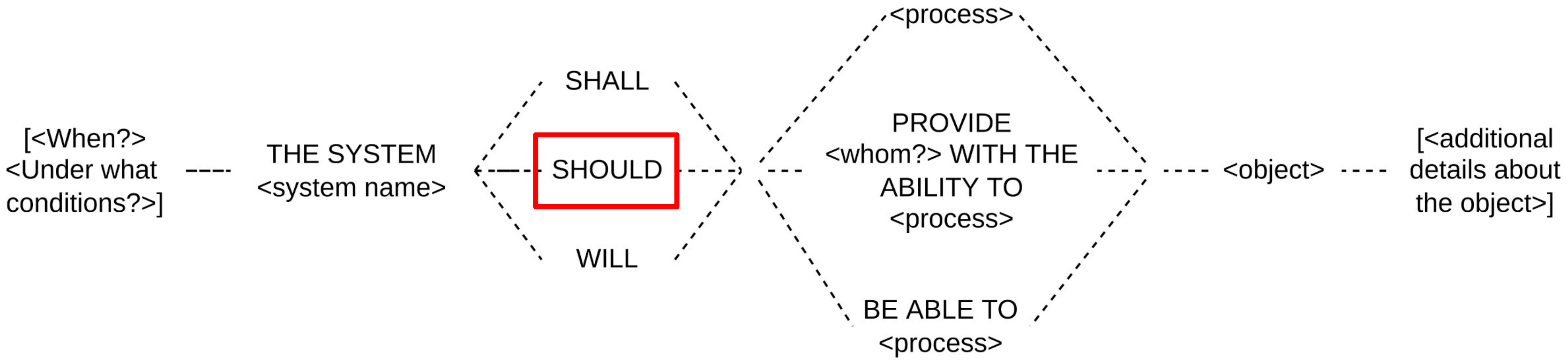
Textual Requirements Specification

Syntactic Requirements Patterns – Example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- *SHOULD*
  - Highly recommended feature
  - Optional, not contractually required
  - More like goals instead of requirements

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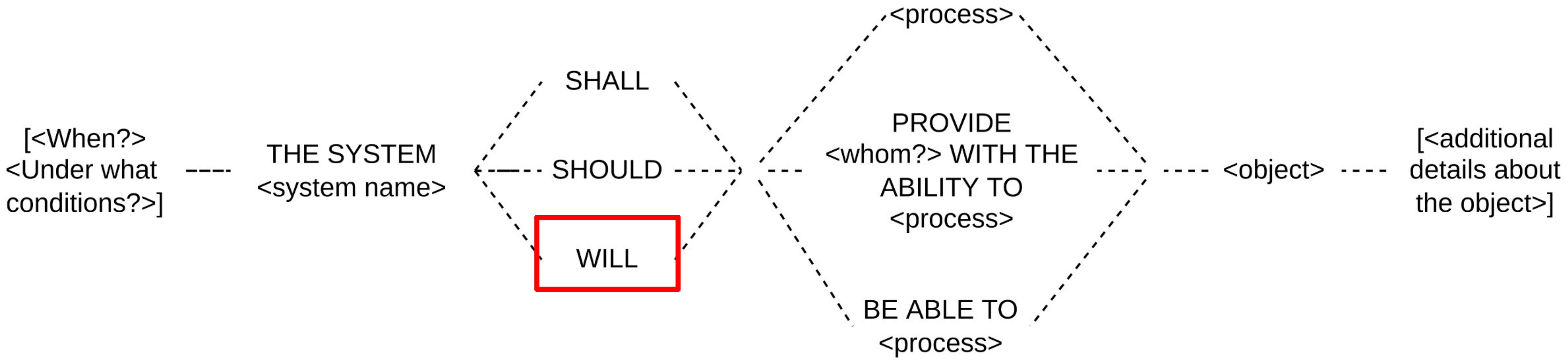
Textual Requirements Specification

Syntactic Requirements Patterns – Example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<object>
[<additional details about the object>]

- *WILL*
  - Statements of fact
  - Example: If I want to tell you something about another system I will use “will”.

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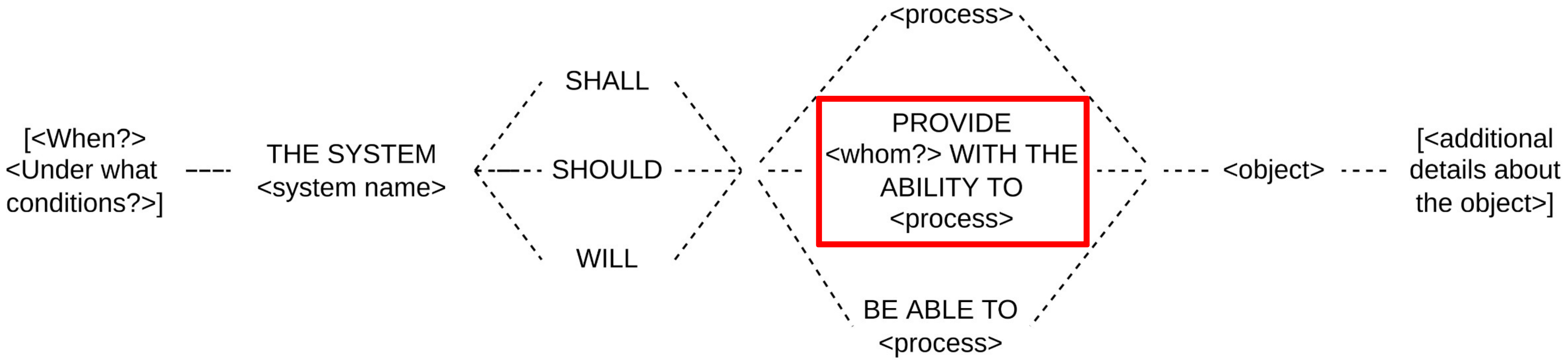
Textual Requirements Specification

Syntactic Requirements Patterns – Example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BE ABLE TO <process>
<object>
[<additional details about the object>]

- *PROVIDE <whom?> WITH THE ABILITY TO <process>*
  - Same as <process>, except: Applies to requirements offered to specific users → <whom?>

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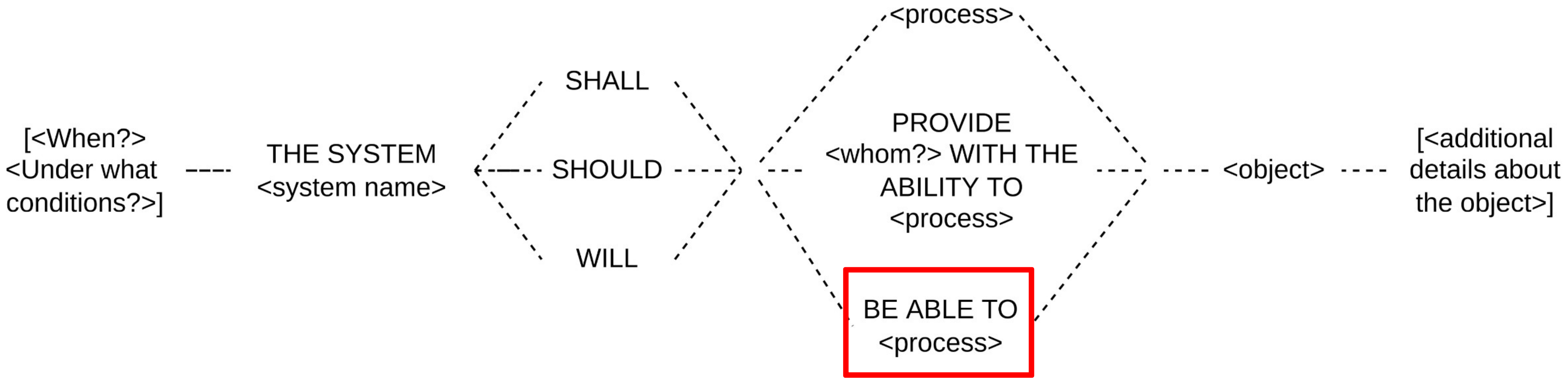
Textual Requirements Specification

Syntactic Requirements Patterns – Example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PROVIDE <whom?> WITH THE ABILITY TO <process>
BE ABLE TO <process>
<object>
[<additional details about the object>]

- *BE ABLE TO <process>*
  - Same as <process>, except: Applies to requirements that are performed as reactions to trigger events from other systems

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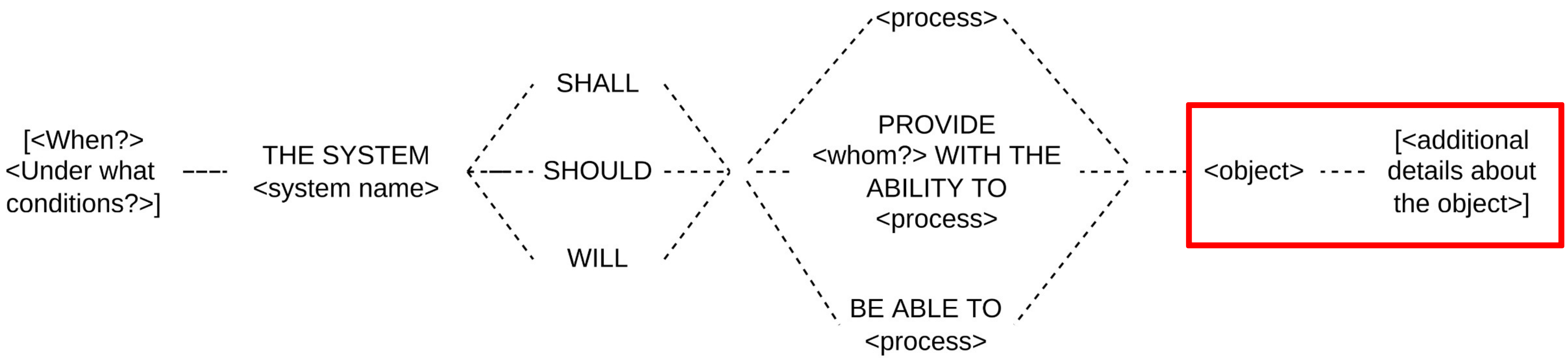
Textual Requirements Specification

Syntactic Requirements Patterns – Example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BE ABLE TO <process>
<object>
[<additional details about the object>]

- *<object> and <additional details about the object>*
  - Object for which the functionality is required, e.g., which document shall be printed

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Textual Requirements Specification

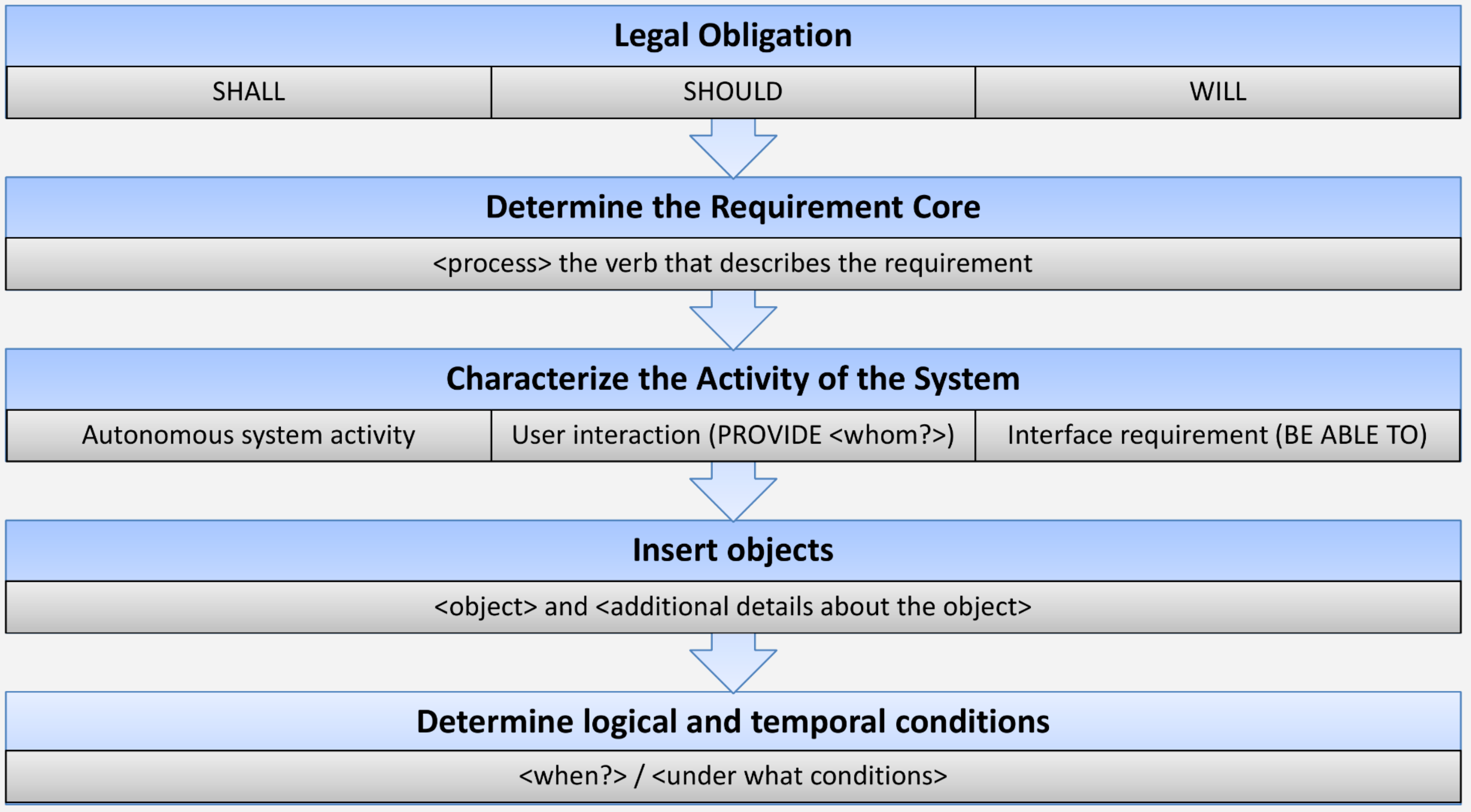
Syntactic Requirements Patterns – Example

- “If the glass break detector detects the damaging of a window, the Burglar3000 shall inform the head office of the security service.”
  - <when>: if the glass break detector detects the damaging of a window
  - <system name>: the Burglar3000
  - SHALL
  - <process>: inform
  - <object>: the head office of the security service

K. Pohl (2010) – Requirements Engineering – Fundamentals, Principles and Techniques

Textual Requirements Specification

Syntactic Requirements Patterns – Fitting a Requirement into the Pattern



Legal Obligation

SHALL | SHOULD | WILL

Determine the Requirement Core

<process> the verb that describes the requirement

Characterize the Activity of the System

Autonomous system activity | User interaction (PROVIDE <whom?>) | Interface requirement (BE ABLE TO)

Insert objects

<object> and <additional details about the object>

Determine logical and temporal conditions

<when?> / <under what conditions>

K. Pohl (2010) – Requirements Engineering – Fundamentals, Principles and Techniques

SUMMARY

Summary

- Requirements Documentation is a key artifact
  - Required amount of requirements documentation depends on context
- Natural language is a versatile means for requirements documentation
  - Versatility allows ambiguities and problems with the perspective
  - Ambiguity (multiple forms)
  - Guidelines for writing requirements documents
- Syntactic Requirements Patterns define a fixed structure for the requirements documentation
  - Condition, subject, legal obligation, verb, object

Questions?