

**SE 2AA4, CS 2ME3 (Introduction to Software
Development)**

Winter 2018

22 Intro to Specification Continued (Ch. 5)

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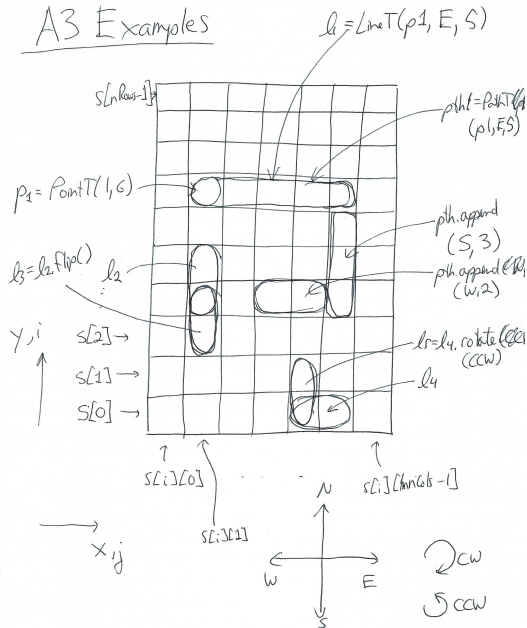
22 Intro to Specification Continued (Ch. 5)

- Administrative details
- Assignment 3
- Uses of specification
- Qualities of a good specification
- Classification of specification styles
- Examples
- How to verify a specification

Administrative Details

- Some of today's slides adapted from Dr. Wassying's slides
- A3
 - ▶ Part 1 - Specification: due 11:59 pm Mar 12
 - ▶ Part 2 - Code: due 11:59 pm Mar 26
- A4
 - ▶ Your own design and specification
 - ▶ Due April 9 at 11:59 pm
- Tutorial this week: Continuing with C++

A3 Examples



Uses of Specification

- Statement of user requirements
 - ▶ Major failures occur because of misunderstandings between the producer and the user
 - ▶ “The hardest single part of building a software system is deciding precisely what to build” ([Brooks1987](#))
 - ▶ Precise description of the borderline b/w the machine and the [environment](#) (end user and other systems)
- Statement of interface between the machine and the controlled environment
 - ▶ Serious undesirable effects can result due to misunderstandings between software engineers and domain experts about the phenomena affecting the control function to be implemented by software
 - ▶ Precise description of the borderline b/w the machine and the [environment](#) (devices controlled by machines)

Uses of Specification Continued

- Requirements for implementation
 - ▶ design process is a chain of specification (i.e., definition → implementation → verification steps)
 - ▶ **requirements specification** refers to definition of external behavior - design specification must be verified against it
 - ▶ **design specification** refers to definition of the software architecture -code must be verified against it
- A reference point during maintenance
 - ▶ Corrective maintenance only changes the implementation
 - ▶ Adaptive and perfective maintenance occur because of requirements changes
 - ▶ The requirements specification must change accordingly
 - ▶ Specification clarifies whether the change involves a modification to the interface or the implementation - if just the implementation then client modules will be unaffected

Specification Qualities

- What are the important qualities for a specification?

Specification Qualities

- The qualities we previously discussed (usability, maintainability, reusability, verifiability etc.)
- Clear, unambiguous, understandable
- Consistent
- Complete
 - ▶ Internal completeness
 - ▶ External completeness
- Incremental
- Validatable
- Abstract

Clear, Unambiguous, Understandable

- Specification fragment for a word-processor
 - ▶ Selecting is the process of designating areas of the document that you want to work on. Most editing and formatting actions require two steps: first you select what you want to work on, such as text or graphics; then you initiate the appropriate action.
- What are the potential problems with this specification?

Clear, Unambiguous, Understandable

- Specification fragment for a word-processor
 - ▶ Selecting is the process of designating areas of the document that you want to work on. Most editing and formatting actions require two steps: first you select what you want to work on, such as text or graphics; then you initiate the appropriate action.
- What are the potential problems with this specification?
 - ▶ Can an area be scattered?
 - ▶ Can both text and graphics be selected?

Clear, Unambiguous, Understandable

- Specification fragment from a real safety-critical system
 - ▶ The message must be triplicated. The three copies must be forwarded through three different physical channels. The receiver accepts the message on the basis of a two-out-of-three voting policy.
- What is a potential problems with this specification?

Clear, Unambiguous, Understandable

- Specification fragment from a real safety-critical system
 - ▶ The message must be triplicated. The three copies must be forwarded through three different physical channels. The receiver accepts the message on the basis of a two-out-of-three voting policy.
- What is a potential problems with this specification?
 - ▶ Can a message be accepted as soon as we receive 2 out of 3 identical copies, or do we need to wait for receipt of the 3rd

Unambiguous, Validatable

- Specification fragment for an end-user program
 - ▶ The program shall be user friendly.
- What is a potential problems with this specification?

Unambiguous, Validatable

- Specification fragment for an end-user program
 - ▶ The program shall be user friendly.
- What is a potential problems with this specification?
 - ▶ What does it mean to be user friendly?
 - ▶ Who is a typical user?
 - ▶ How would you measure success or failure in meeting this requirement?

Unambiguous, Validatable

- Specification fragment for a linear solver
 - ▶ Given A and b , solve the linear system $Ax = b$ for x , such that the error in any entry of x is less than 5 %.
- What is a potential problems with this specification?

Unambiguous, Validatable

- Specification fragment for a linear solver
 - ▶ Given A and b , solve the linear system $Ax = b$ for x , such that the error in any entry of x is less than 5 %.
- What is a potential problems with this specification?
 - ▶ Is A constrained to be square?
 - ▶ Can A be singular?
 - ▶ Even if the problem is made completely unambiguous, the requirement cannot be validated.

Consistent

- Specification fragment for a word-processor
 - ▶ The whole text should be kept in lines of equal length. The length is specified by the user. Unless the user gives an explicit hyphenation command, a carriage return should occur only at the end of a word.
- What is a potential problems with this specification?

Consistent

- Specification fragment for a word-processor
 - ▶ The whole text should be kept in lines of equal length. The length is specified by the user. Unless the user gives an explicit hyphenation command, a carriage return should occur only at the end of a word.
- What is a potential problems with this specification?
 - ▶ What if the length of a word exceeds the length of the line?

Same Symbol/Term Different Meaning

- Can you think of some symbols/terms that have different meanings depending on the context?

Consistent

- Language and terminology must be consistent within the specification
- Potential problem with homonyms, for instance consider the symbol σ
 - ▶ Represents standard deviation
 - ▶ Represents stress
 - ▶ Represents the Stefan-Boltzmann constant (for radiative heat transfer)
- Changing the symbol may be necessary for consistency, but it could adversely effect understandability
- Potential problem with synonyms
 - ▶ Externally funded graduate students, versus eligible graduate students, versus non-VISA students
 - ▶ Material behaviour model versus constitutive equation

Complete

- Internal completeness
 - ▶ The specification must define any new concept or terminology that it uses
 - ▶ A glossary is helpful for this purpose
- External completeness
 - ▶ The specification must document all the needed requirements
 - ▶ Difficulty: when should one stop?

Incremental

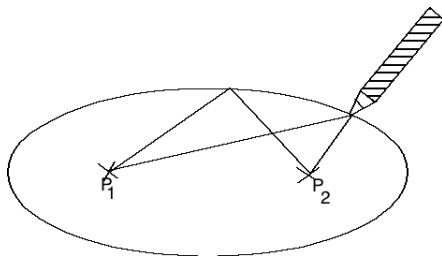
- Referring to the specification process
 - ▶ Start from a sketchy document and progressively add details
 - ▶ A document template can help with this
- Referring to the specification document
 - ▶ Document is structured and can be understood in increments
 - ▶ Again a document template can help with this

Classification of Specification Styles

- Informal, semi-formal, formal
- Operational
 - ▶ Behaviour specification in terms of some abstract machine
- Descriptive
 - ▶ Behaviour described in terms of properties
- The module state machine specification that we use is a mix of operational and descriptive specification - Why?

Example Operational Specification

- Specification of a geometric figure E
- E can be drawn as follows
 1. Select two points P_1 and P_2 on a plane
 2. Get a string of a certain length and fix its ends to P_1 and P_2
 3. Position a pencil as shown in the next figure
 4. Move the pen clockwise, keeping the string tightly stretched, until you reach the point where you started drawing



Example Descriptive Specification

Geometric figure E is described by the following equation

$$ax^2 + by^2 + c = 0$$

where a , b and c are suitable constants

Another Example

- Operational specification
 - ▶ “Let a be an array of n elements. The result of its sorting is an array b of n elements such that the first element of b is the minimum of a (if several elements of a have the same value, any one of them is acceptable); the second element of b is the minimum of the array of $n - 1$ elements obtained from a by removing its minimum element; and so on until all n elements of a have been removed.”
- Descriptive specification
 - ▶ “The result of sorting array a is an array b which is a permutation of a and is sorted.”
 - ▶ How can we further specify (formalize) the notion of sorted?

Another Example

- Operational specification
 - ▶ “Let a be an array of n elements. The result of its sorting is an array b of n elements such that the first element of b is the minimum of a (if several elements of a have the same value, any one of them is acceptable); the second element of b is the minimum of the array of $n - 1$ elements obtained from a by removing its minimum element; and so on until all n elements of a have been removed.”
- Descriptive specification
 - ▶ “The result of sorting array a is an array b which is a permutation of a and is sorted.”
 - ▶ How can we further specify (formalize) the notion of sorted?
 - ▶ $\text{sorted}(A) \equiv \forall(i : \mathbb{N} | 0 \leq i \leq (|A| - 2) : A[i] \leq A[i + 1])$

Homework Exercise

- Consider the **line formatter** specification and
 1. How well does the specification do with respect to the following qualities: abstract, correct, unambiguous, complete, consistent and verifiable?
 2. For a requirement specification like that given, what are the advantages and disadvantages of maintaining both a formal specification and a natural language specification?
- Even spending 5 minutes thinking about will help when we discuss in a future lecture
- In repo
 - ▶ The [line formatter specification](#)
 - ▶ [Meyer \(1985\)](#) “On Formalism in Specification”