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

Winter 2018

26 Specification Quality DRAFT

Dr. Spencer Smith

Faculty of Engineering, McMaster University

December 15, 2017

26 Specification Quality DRAFT

- Administrative details
- Abstract class versus interface
- Use cases with UML
- Sequence diagrams in UML
- Line Formatter Example

Administrative Details

TBD

A3 Hints

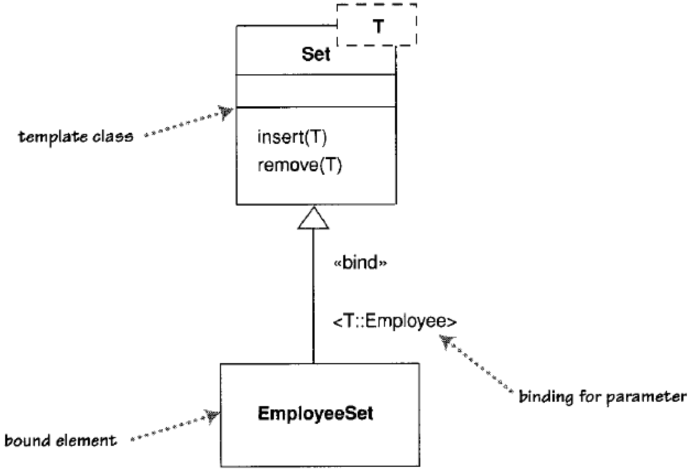
TBD

A3 Hints Continued

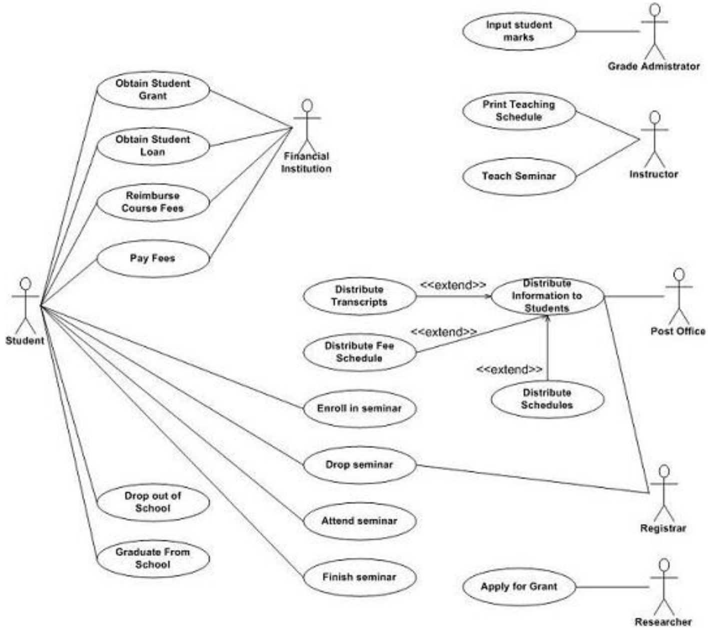
TBD

- Interface
  - Methods are implicitly abstract and public
  - Methods can have default implementation (JDK 8)
  - Cannot have constructors
  - Variables are final
  - Can only extend interfaces
  - Classes can extend multiple instances
  - Appropriate for unrelated classes
- Abstract class
  - At least one method is declared as abstract
  - Some methods can implement a default behaviour
  - Cannot instantiate them, but can have constructors
  - Variables are not necessarily final
  - Can extend other class
  - Can implement multiple interfaces
  - Classes can extend only one abstract class
  - Sharing code between closely related classes

UML Diagram for Generic Classes



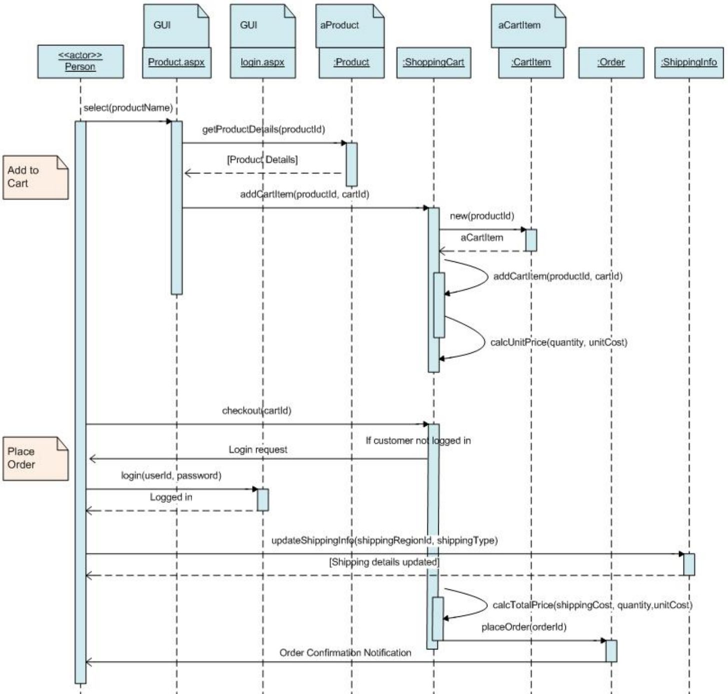
UML Class Diagram Template



UML 2 Use Case Diagrams: An Agile Introduction

Use Cases

- Often used for capturing requirements
- From user's (actor's) viewpoint
  - Person
  - Other system
  - Hardware
  - etc. (anything external)
- Each circle is a use case
- Lines represent possible interactions
- An actor represents a role, individuals can take on different roles



GUI
GUI
aProduct
aCartItem
<<actor>>
Person
Product.aspx
login.aspx
:Product
:ShoppingCart
:CartItem
:Order
:ShippingInfo
select(productName)
getProductDetails(productId)
Add to Cart
[Product Details]
addCartItem(productId, cartId)
new(productId)
aCartItem
addCartItem(productId, cartId)
calcUnitPrice(quantity, unitCost)
checkout(cartId)
If customer not logged in
Place Order
Login request
login(userId, password)
Logged in
updateShippingInfo(shippingRegionId, shippingType)
[Shipping details updated]
calcTotalPrice(shippingCost, quantity,unitCost)
placeOrder(orderId)
Order Confirmation Notification

Sequence Diagrams

- Represents a specific use case scenario
- How objects interact by exchanging messages
- Time progresses in the vertical direction
- The vertically oriented boxes show the object's lifeline

Sequence Diagram Question

- Is a sequence diagram an operational or a descriptive specification?
- If objects exchange a message, should there be an association between their classes?

Line Formatter

- Input stream signalled with ET
- Exactly one ET character in each input stream
- Character classifications:
  - Break character - BL (blank) and NL (new line)
  - Non Break Character - all others except ET
  - End of text indicator ET
- Word is a non-empty sequence of non break characters
- Break is a sequence of one or more break characters
- Output same sequence of words, except if there is an oversize word
  - Oversize means more than MAXPOS characters, where MAXPOS is a positive integer
  - If there is an oversize word
    - Set Alarm to TRUE
    - Exit the program

Line Formatter

- Up to the point of an error, the program's output should have the following properties
  - A new line should start only between words and at the beginning of the output text, if any
  - A break in the input is reduced to a single break character in the output
  - As many words as possible should be placed on each line (i.e. between successive NL characters)
  - No line may contain more than MAXPOS characters (words and BLs)

Abstract?

Abstract?

- Not abstract!
- Specifies an implementation for error handling (variable named Alarm)
- Do not have to name the variable Alarm
- Could use exception handling (or another approach) instead
- ET is a machine dependent (program domain) concept

Correct?

Correct?

- The definition of line is incorrect!
- A line is defined as being between NLs, which ignores text before the first NL and after the last NL
- The output file does not contain ET, which is either a bug in the spec or a significant non-uniformity

Unambiguous?

Unambiguous?

- Ambiguous!
- “point of error” is not defined
- Output matches input to the last acceptable word, or the last acceptable character?
- “trailing blanks ending with ET” is ambiguous
- The program’s output should be the same sequence of words as in the input
  - But the input is not a sequence of words
  - If the input were a sequence of words, what about leading or trailing breaks?
  - “As many words as possible should be placed on each line”
    - WHO WHAT “NL” WHEN
    - WHO “NL” WHAT WHEN

Complete?

Complete?

- Not complete!
- Meaning of NL and its relation to the concept of line is left implicit
- Alarm is not specified if MAXPOS is never exceeded

Consistent?

Consistent?

- Not consistent!
- "non-empty" and "one or more" (synonyms)
- "stream" and "sequence" (synonyms)
- Is the input a "stream of characters" or a "sequence of words separated by breaks"? – sequence of T is not the same as sequence of sequence of T

Verifiable?

Verifiable?

- The specification cannot be verified, since it is ambiguous and incorrect

Advantages and Disadvantages?

- Advantages and disadvantages of maintaining both formal and a natural language spec?

Advantages and Disadvantages?

- Advantages and disadvantages of maintaining both formal and a natural language spec?

- Advantage of natural language - understandability
- Advantage of formal spec
  - Unambiguous
  - Highlights difficult to informally detect cases
  - Checking for completeness and consistency
  - Amenable to tool support
- Advantage of both - all of the above advantages
- Disadvantages - have to maintain two specs
- Automatic translation
  - Formal spec to natural language has been researched
  - Natural language to formal spec has received more attention

English and Mathematics as Languages

- English is a language
- So is Mathematics
- Both have
  - Rules of grammar (syntax)
  - Semantics
- When writing in any language, pay attention to grammar and semantics. Get both right.

English and Mathematics: A Difference

- In English and other natural languages
  - Ambiguity desired, intentionally possible
  - Unambiguous statements almost impossible
- In Mathematics
  - Ambiguity not desired, intentionally prevented
  - Ambiguous statements almost impossible (even in probability theory, fuzzy logic)

Mathematics and Engineering

- Therefore, mathematics is the language of engineering

Correct Syntax for Mathematics

- Make sure the syntax of your mathematical expressions is correct
- Correct syntax does not guarantee correct semantics
- Incorrect syntax makes the mathematics ambiguous
- Example problems to watch for
  - Mismatch of types
    - $(\text{p.xcoord}() + \mathit{width}) \wedge \text{p.xcoord}()$
    - $\neg(\text{integer})$
    - Set of sequences accessed by $[i]$
    - $\forall(i : \mathbb{N} \wedge j : \mathbb{N} \ldots)$
  - Use of programming language notation in mathematics
    - Integer values instead of boolean
    - length $==$ MAX_SIZE
  - $(x > 7) = \mathit{true}$ instead of $(x > 7)$ (bad form)

Different World Views

- English and other natural languages
  - Express both static and dynamic views
  - States and actions (verbs of being and action)
- Imperative programming languages
  - Primarily dynamic world view (changes)
- Functional programming languages
  - Static world view
- Mathematics
  - Static world view only
- Fundamental conceptual differences

Static Versus Dynamic Views

- These very different world views pose a conceptual hurdle for the translator
- The translator must bridge the gap between
  - Dynamic and static view of problem statement
  - Dynamic world view of programming and
  - Purely static world view of mathematics
- Not hard, but requires conscious attention

Translating Between Languages

- Translating a statement from one language to another is a multistep (not single) process
    1. Statement in source language to a mental understanding of the meaning of the statement
    2. Reformulate mental understanding into target language view, concepts, culture
    3. Mental understanding of the meaning of the statement to a statement in the target language
- The first and last statement must mean the same

Translators

- Knowing two languages: not enough to translate
- A good translator knows well
  - The two languages
  - AND the subject being translated
  - AND how to translate
- These three things are different

Organization and Style

- When writing in English or any other natural language, one pays careful attention to
  - Organization of the essay, report, etc.
  - Style of expression
- When writing in Mathematics, to do the same:
  - Clear, complete, conscise
  - KISSS (Keep it Simple Sharp and Straightforward)
  - Understandable
  - Interesting

Strategies

- Understand the meaning of the original
- Obtain all needed information
- Close the gap between the English text and mathematics
- Divide and conquer (complexity)

Strategy: Understand the Original

- Describe specific instance of general problem
- Distinguish essentials from background
- Draw a diagram
- Express in intermediate or mixed language
- Identify object referred to
- Identify implicit (but false) “information”
- Identify missing information
- Identify relationships between essential objects
- Identify special cases

Strategy: Obtain all Needed Information

- Ask the author of the task description
- Identify gaps in the description of the task
- Identify implicit “information”
- Ask if implicit “information” may be assumed
- Identify data present and ask about related details
- Ask if missing information is really needed
- Read carefully, thoroughly, precisely

Strategy: Close Gap English – Mathematics

- Express implicit information explicitly
- Reduce vagueness and ambiguity
- Reword English text to be closer to mathematics (express in an intermediate, mixed language)

Strategy: Divide and Conquer

- Construct a table
- Distinguish between specific cases
- Introduce an auxiliary mathematics function
- Modularize

Strategy: Draw Diagrams, Describe Specific Instances of the Given Problem

- Graphical representations help understand the meaning of the message
- For specific instances, think of extreme cases first to simplify
  - $n = 0$
  - $n = 1$
  - $n = \inf$
- Think of a normal sized problem, usually something like $n \geq 3$
- You might want to write down truth tables

A Small Translator's Glossary

English	Mathematics
and, but	$\wedge$
or	$\vee$
for all, each, every, any	$\forall$, $\wedge$ series, universal quantification
for no, none	$\forall$, $\wedge$ series, universal quantification, with a negated assertion
there is (are), there exist(s), for some, at least one	$\exists$, $\vee$ series, existential quantification

A Small Translator's Glossary Continued

English	Mathematics
integer	... $\in \mathbb{Z}$
sorted	$\wedge_{i=0}^{n-2} A[i] \leq A[i+1]$, $\forall(i : \mathbb{N} \mid 0 \leq i < n-1 : A[i] \leq A[i+1])$
if (when, whenever) ... then ...	... $\rightarrow$ ..., sometimes $\wedge$
search, find, equal, present	$=$
exchange, rearrange, different order, different sequence, merge, copy, sort	permutation

Your Translator's Glossary

- A professional translator compiles his/her own translation glossary
  - Over time
  - Based on own accumulated experience
- You should too!

Exercise

Consider an array D with index values ranging from 1 to n. The subject of this example is part of a specification for a subprogram that will count how many times a particular given value occurs in the array D.

The goal of this exercise is to write a postcondition for the subprogram, relating the various relevant variables values when the search is complete.

Exercise Continued

Understand the task in the original language

- Identify objects referred to (look for nouns in the original English text)

- Identify missing information

Exercise Continued

Understand the task in the original language

- Identify objects referred to (look for nouns in the original English text)
- Array D, index value, times (count), particular given value, relevant variables's value
- Identify missing information

Exercise Continued

Understand the task in the original language

- Identify objects referred to (look for nouns in the original English text)
- Array D, index value, times (count), particular given value, relevant variables's value
- Identify missing information
- Names of variable for: index, times (count), particular given value

Exercise Continued

Understand the task in the original language

- Identify objects referred to (look for nouns in the original English text)
- Array D, index value, times (count), particular given value, relevant variables's value
- Identify missing information
- Names of variable for: index, times (count), particular given value
- Are there any other relevant variables?

Exercise

- Identify missing information
- Names of variable for
    - Index: assume i
    - Times (count): ask the author of the task, assume *count*
    - Particular given value: Ask the author of the task, assume *key*
    - Are there any other relevant variables? (no?)

Reference

- Baber, Robert L., *Translating English to Mathematics*, 2002