Restricted Use Case Modeling (RUCM) Approach

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Overview – Use Case Modeling

- *A use case model, including a use case diagram and a set of use case specifications, is commonly applied in practice to structure and document requirements.*
- Use Case Specifications (UCS) are usually textual documents complying with a use case template that, though helping read and review use cases, inevitably contains ambiguities.

Overview - RUCM

- *Restricted Use Case Modeling (RUCM) is a use case modeling approach, which is composed of a set of well-defined restriction rules and a new template.*
- *The goal of RUCM is to reduce ambiguity, improve understandability of use case models, and facilitate automated generation of analysis models.*
- *The approach has been experimentally evaluated to be applicable, and easier to understand. It yields better models when used by humans.*

RUCM – Use Case Template

- *A use case template is used to structure use case specifications.*

RUCM – Use Case Template

- RUCM template has eleven first-level fields (first column of Table 1). The last four fields are decomposed into second-level fields (second column of the last four rows).

Use Case Name	The name of the use case. It usually starts with a verb.	
Brief Description	Summarizes the use case in a short paragraph.	
Precondition	What should be true before the use case is executed.	
Primary Actor	The actor which initiates the use case.	
Secondary Actors	Other actors the system relies on to accomplish the services of the use case.	
Dependency	Include and extend relationships to other use cases.	
Generalization	Generalization relationships to other use cases.	
Basic Flow	Specifies the main successful path, also called "happy path".	
	Steps (numbered)	Flow of events.
	Postcondition	What should be true after the basic flow executes.
Specific Alternative Flows	Applies to one specific step of the basic flow.	
	RFS	A reference flow step number where flow branches from.
	Steps (numbered)	Flow of events.
	Postcondition	What should be true after the alternative flow executes.
Global Alternative Flows	Applies to all the steps of the basic flow.	
	Steps (numbered)	Flow of events.
	Postcondition	What should be true after the alternative flow executes.
Bounded Alternative Flows	Applies to more than one step of the basic flow, but not all of them.	
	RFS	A list of reference flow steps where flow branches from.
	Steps (numbered)	Flow of events.
	Postcondition	What should be true after the alternative flow executes.

RUCM – Use Case Template

- Use Case Name
  - This field gives the name of the use case.
  - It usually starts with a verb (e.g., *Withdraw Fund*) and should be consistent with the name of the same use case in the use case diagram.

RUCM – Use Case Template

- Brief Description
  - This field summarizes the use case in a short paragraph.
  - It captures the essence of the use case.

RUCM – Use Case Template

- Precondition
  - The precondition of a use case specifies what must be always true before the use case begins.

RUCM – Use Case Template

- Primary Actor
  - The primary actor of a use case is the principle actor which initiates the use case.

RUCM – Use Case Template

- Secondary Actor
  - The secondary actors of a use case are the actors that the system relies on to accomplish the use case.

RUCM – Use Case Template

- Dependency
  - This field specifies <<include>> and <<extend>> relationships of a use case to other use cases.

RUCM – Use Case Template

- Generalization
  - This field specifies generalization relationships a use case to other use cases.

RUCM – Use Case Template

- Basic Flow
  - The basic flow of a use case describes a main successful path that satisfies the interests of the stakeholders.
  - It often does not include any condition or branching.
  - It is recommended to describe separately the conditions and branching in alternative flows.
  - A basic flow is composed of a sequence of steps and a postcondition.
  - Each UCS can only have one basic flow.

RUCM – Use Case Template

- Basic Flow
  - The action steps can be one of the following five interactions:
    - Primary actor → syste§m
      - the primary actor sends a request and data to the system;
    - System → system
      - the system validates a request and data;
    - System → system
      - the system alters its internal state (e.g., recording or modifying something);
    - System → primary actor
      - the system replies to the primary actor with a result;
    - System → secondary actor
      - the system sends requests to a secondary actor.

RUCM – Use Case Template

- Basic Flow
  - All steps are numbered sequentially. This implies that each step is completed before the next one is started.
  - If there is a need to express conditions, iterations, or concurrency, then specific keywords, specified as restriction rules should be applied.

RUCM – Use Case Template

- Alternative Flows
  - Alternative flows describe all the other scenarios or branches, both success and failure.
  - An alternative flow always depends on a condition occurring in a specific step in a flow of reference, referred to as *reference flow*, and that reference flow is either the basic flow or an alternative flow itself.
  - Similarly to the basic flow, an alternative flow is composed of a sequence of numbered steps.

RUCM – Use Case Template

- Alternative Flows
  - A *specific alternative flow* is an alternative flow that refers to a specific step in the reference flow.
  - A *bounded alternative flow* is a flow that refers to more than one step in the reference flow– consecutive steps or not.
  - A *global alternative flow* is an alternative flow that refers to any step in the reference flow.

RUCM – Use Case Template

- Alternative Flows
  - For specific and bounded alternative flows, a RFS (Reference Flow Step) section, specified as rule R19, is used to specify one or more (reference flow) step numbers.
  - Each alternative flow must have a postcondition.
  - Our template enforces that each flow of events (both basic flow and alternative flows) of a UCS contains its own postcondition.

An Example

- ATM System
  - Withdraw Fund
  - Transfer Fund
  - Query Account
  - Validate PIN

Use Case Name	Withdraw Fund	
Brief Description	ATM customer withdraws a specific amount of funds from a valid bank account.	
Precondition	The system is idle. The system is displaying a Welcome message.	
Primary Actor	ATM customer	
Secondary Actors	None	
Dependency	INCLUDE USE CASE Validate PIN.	
Generalization	None	
Basic Flow	**Steps**	
	1	INCLUDE USE CASE Validate PIN.
	2	ATM customer selects Withdrawal.
	3	ATM customer enters the withdrawal amount.
	4	ATM customer selects the account number.
	5	The system VALIDATES THAT the account number is valid.
	6	The system VALIDATES THAT ATM customer has enough funds in the account.
	7	The system VALIDATES THAT the withdrawal amount does not exceed the daily limit of the account.
	8	The system VALIDATES THAT the ATM has enough funds.
	9	The system dispenses the cash amount.
	10	The system prints a receipt showing transaction number, transaction type, amount withdrawn, and account balance.
	11	The system ejects the ATM card.
	12	The system displays Welcome message.
	Postcondition	ATM customer funds have been withdrawn.

Specific Alternative Flows	**BFS 5-7**	
	1	The system displays an apology message MEANWHILE the system ejects the ATM card.
	2	The system shuts down.
	3	ABORT.
	Postcondition	ATM customer funds have not been withdrawn. The system is shut down.
Global Alternative Flows	IF ATM customer enters Cancel THEN	
	1	The system cancels the transaction MEANWHILE the system ejects the ATM card.
	2	ABORT.
	ENDIF	
	Postcondition	ATM customer funds have not been withdrawn. The system is idle. The system is displaying a Welcome message.
Bounded Alternative Flows	**BFS 8**	
	1	The system displays an apology message MEANWHILE the system ejects the ATM card.
	2	ABORT.
	Postcondition	ATM customer funds have not been withdrawn. The system is idle. The system is displaying a Welcome message.

RUCM – Restriction Rules

- *RUCM contains 26 restriction rules to restrict the way that users write use case specifications.*
- *They are based on a thorough literature review and have been experimentally evaluated to be understandable, easy to apply, and not restrictive.*
- *Together with the RUCM template, we can expect more precise and comprehensible use case models.*

RUCM – Restriction Rules

- UCM restriction rules are classified into two groups:
  - Restrictions on the use of natural language (R1-R16)
  - Restrictions enforcing the use of specific keywords for specifying control structures (R17-R25)

RUCM – Restriction Rules (R1-R16)

- Restrictions on the use of natural language (R1-R16)
  - Restriction rules apply only to action steps (R1-R7)
  - Restriction rules apply to all sentences (R8-R16)

RUCM – Restriction Rules (R1-R3)

R1-R3 enforce describing flows of events correctly.

- R1 - The subject of a sentence in basic and alternative flows should be the system or an actor.
  - The card has been ejected.
  - *The system* ejects the ATM card.
- R2 - Describe the flow of events sequentially.

  1. The system ejects the ATM card.
  2. The system dispenses the cash amount.

  1. The system dispenses the cash amount.
  2. The system ejects the ATM card.
- R3 - Actor-to-actor interactions are not allowed.

  The customer gives the teller the ATM card.

  The customer inserts the ATM card into the card reader.

RUCM – Restriction Rules (R4-R5)

- R4
  - Describe one action per sentence. (Avoid compound predicates.)
  - Otherwise it is hard to decide the sequence of multiple actions in a sentence.

    …the system cancels the transaction and ejects the card.

    The system cancels the transaction MEANWHILE the system ejects the card.
- R5
  - Use present tense only.

    The system *ejected* the card.

    The system *ejects* the card.
  - Enforce describing what the system does, rather than what it will do or what it has done.

RUCM – Restriction Rules (R6-R7)

R6 and R7 enforce explicitly showing the subject and/or object(s) of a sentence.

- R6
  - Use active voice rather than passive voice.

    The card *is ejected*.

    The system *ejects* the card.
- R7
  - Clearly describe the interaction between the system and actors without omitting its sender and receiver.

    Customer enters PIN.

    ATM customer enters PIN number *to the system*.

RUCM – Restriction Rules (R8-R9)

- R8
  - Use declarative sentence only. “Is the system idle?” is a non-declarative sentence.

    Ejects the card.

    The system ejects the card.
- R9
  - Use words in a consistent way. Keep one term to describe one thing.

    Customer inserts the ATM card…

    ATM customer inserts the ATM card…

RUCM – Restriction Rules (R10-R11)

- R10
  - Don't use modal verbs (e.g., *might*)

    The system *might* eject the card.

    The system ejects the card.
- R11
  - Avoid adverbs (e.g., *very*)

    The system *very likely* ejects the card.

    The system ejects the card.
- Modal verbs and adverbs usually indicate uncertainty; therefore metrics should be used if possible.

RUCM – Restriction Rules (R12-R14)

- R12
  - Use simple sentences only. A simple sentence must contain only one subject and one predicate.

    System displays customer accounts *and* prompts customer for transaction type…

    1. The system displays ATM customer accounts.
    2. The system prompts ATM customer for …
- R13
  - Don't use negative adverb and adjective (e.g., *hardly*, *never*), but it is allowed to use *not* or *no*.

    The PIN number *has never been* validated.

    The PIN number *has not* been validated
- R14
  - Don't use pronouns (e.g. *he*, *this*)

    …*it* reads the card number.

    …*the system* reads the card number.

RUCM – Restriction Rules (R15-R16)

- R15
  - Don't use participle phrases as adverbial modifier.

    ATM is idle, *displaying a Welcome message.*

    The system is idle. The system is displaying a Welcome message.
- R16
  - Use "the system" to refer to the system under design consistently.

    "ATM" or "The ATM system"

    the system

RUCM – Restriction Rules (R17-R26)

#	Description
R17	INCLUDE USE CASE
R18	EXTENDED BY USE CASE
R19	RFS
R20	IF-THEN-ELSE-ELSEIF-ENDIF
R21	MEANWHILE

#	Description
R22	VALIDATE THAT
R23	DO-UNTIL
R24	ABORT
R25	RESUME STEP
R26	Each basic flow and alternative flow should have their own postconditions.

RUCM – Restriction Rules (R17)

- R17
  - Use keywords INCLUDE USE CASE to describe the include dependencies with other use cases.
  - Grammar
    - INCLUDE USE CASE <included use case name>
  - Explanation
    - The keywords can be used in basic and step alternative flows.
  - Example:

    Include Validate PIN abstract use case.

    INCLUDE USE CASE Validate PIN

RUCM – Restriction Rules (R18)

- R18
  - Use keywords EXTENDED BY USE CASE to refer to the extended use case.
  - Grammar
    - EXTENDED BY USE CASE <extending use case>
  - Explanation
    - The keywords can be used in basic and step alternative flows.
  - Example:

    Use case CreateIncident extends the current use case.

    EXTENDED BY USE CASE CreateIncident

RUCM – Restriction Rules (R19)

- R19
  - Use keyword RFS in a specific (or bounded) alternative flow to refer to a step number (or a lower bound step number and an upper bound step number) of a reference flow step that this alternative flow corresponds to.
  - Grammar
    - RFS <reference flow step #> (specific alternative flow)
    - RFS <reference flow step numbers> (bounded alternative flow)
    - Not required notation for global alternative flow.
  - Explanation
    - One specific or bounded alternative flow must correspond to exactly one or more than one reference flow steps.
  - Example:
    - RFS Basic Flow 5 …
    - RFS Basic Flow 5-7, 10, 14 …

RUCM – Restriction Rules (R20)

- R20
  - Use pairs of keywords of IF, THEN, ELSE, ELSEIF, and ENDIF to describe conditional logic sentences.
  - Grammar
    - IF <condition> THEN <steps> ENDIF
    - IF <condition> THEN <steps> – ELSE <steps> ENDIF
    - IF <condition> THEN <steps> – ELSEIF <condition> THEN <steps> ENDIF
  - Example:

    IF the system recognizes the ATM card, THEN the system reads the ATM card number, ENDIF.

RUCM – Restriction Rules (R21)

- R21
  - Use keyword MEANWHILE to describe concurrency.
  - Grammar
    - <action> MEANWHILE <action>
  - Explanation
    - It implies that the sentence before keyword MEANWHILE and the sentence after the keyword occur concurrently.
  - Example:

    …the system cancels the transaction and ejects the card.

    …the system cancels the transaction MEANWHILE the system ejects the card.

RUCM – Restriction Rules (R22)

- R22
  - Use keyword VALIDATES THAT to describe condition checking sentences. VALIDATES THAT means that the condition is evaluated and must be true to proceed to the next step.
  - Grammar
    - VALIDATES THAT <condition>
  - Explanation
    - The alternative case (the condition does not hold) must be described in its corresponding alternative flow (BFS).
  - Example:

    … the system checks whether the user-entered PIN…

    …the system VALIDATES THAT the user- entered PIN…

RUCM – Restriction Rules (R23)

- R23
  - Use keyword pair DO and UNTIL to describe iteration.
  - Grammar
    - DO <steps> UNTIL <condition >
  - Explanation
    - Following keyword DO is a sequence of steps. Following keyword UNTIL is a loop ending condition.
  - Example:

    DO

    action1

    action2

    UNTIL condition

RUCM – Restriction Rules (R24)

- R24
  - Use keyword ABORT to describe an exceptionally exit action. An alternative flow ends either with ABORT or RESUME STEP.
  - Grammar
    - ABORT
  - Explanation
    - Used in alternative flows, iterative, and conditional logic sentences. It means the ending of a use case.

RUCM – Restriction Rules (R25)

- R25
  - Use keyword pair RESUME STEP to describe the situation where an alternative flow goes back to its corresponding basic flow.
  - Grammar
    - RESUME STEP <basic flow step #>
  - Explanation
    - Used in alternative flows.

RUCM – Restriction Rules (R26)

- R26
  - Each basic flow and alternative flow should have their own postconditions.

Example 1

- **PRECONDITION:**
  - Original sentence: ATM is idle, displaying a Welcome message.
  - Rewritten sentence: The system is idle. The system is displaying a Welcome message.
  - Reason: The original sentence breaks R15, which suggests not using participle phrases as adverbial modifier. Therefore, the original sentence is split into two simple sentence.

Example 2

- **BASIC FLOW STEP 1**
  - Original sentence: Include Validate PIN abstract use case
  - Rewritten sentence: INCLUDE USE CASE Validate PIN
  - Reason: the keyword INCLUDE USE CASE specified as R17, should be used to describe the dependency relationship between use cases *Withdraw Fund* and *Validate PIN*.

Example 3

- **BASIC FLOW STEP 2-4**
- Original sentence: Customer selects Withdrawal, enters the amount, and selects the account number.
- Rewritten sentences:
  2. ATM customer selects Withdrawal through the system
  3. ATM customer enters the withdrawal amount through the system.
  4. ATM customer selects the account number through the system.
- Reason: the original sentence is not a simple sentence (violating R12 and R4); it contains three predicates, which implies three action steps. Besides, it is not clear whether these three actions occur concurrently or sequentially. Therefore, we rewrite the sentence into three sequential action steps: 2-4.
- As specified in R9, the terms should be used in a consistent way; therefore "ATM customer" should be used instead of "Customer: in the original sentence.
- R7 says that the interaction between actors and the system should be clearly described without omitting its sender and receiver. The original sentence violates R7 and we rewrite the sentence by explicitly saying "…through the system".