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(a) Describe by using a simple diagram the concept of formal method

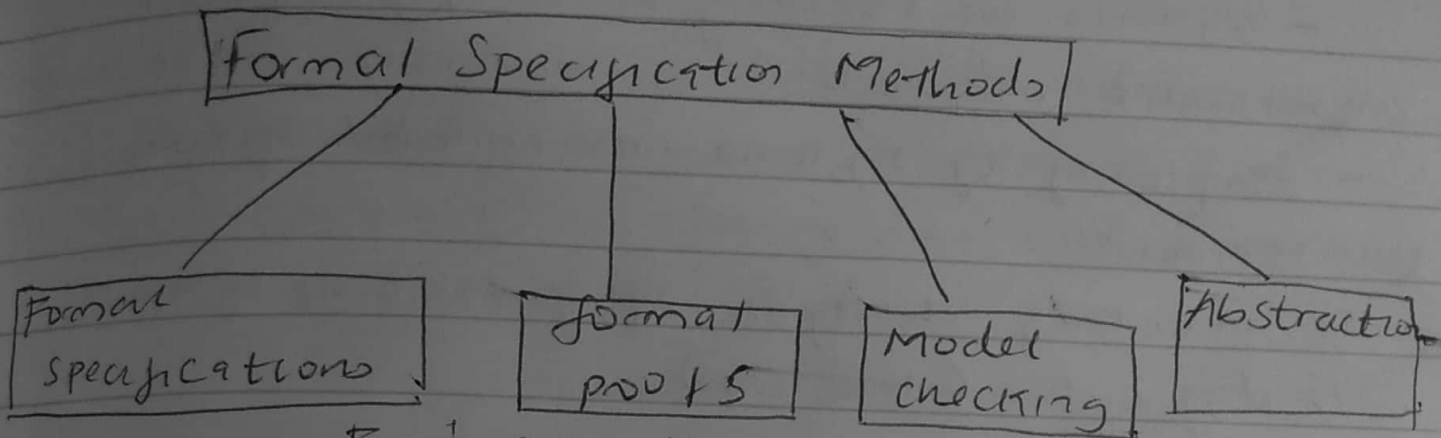


Fig 1: concept of formal methods

Formal methods are techniques and tools based on mathematics and formal logic which can be used for describing complex systems, reasoning about systems and providing support for program development

- Formal specification is the translation of non-mathematical description in a formal specification language

- Formal proofs are complete and convincing argument for validity of some property of system description
- Model checking involves determining if the finite state machine model satisfies requirements

- Abstraction involves the simplification by removing unnecessary complex details

1a(ii) What are the major reasons for considering formal methods

- systems are becoming increasingly dependent on software components

- complexity of systems with embedded software has increased

- maintaining reliability in software-intensive systems is difficult (Femi, 2020)

1b) Differentiate between functional and non-functional requirements in formal methods

functional requirement will describe a particular behaviour of function of the system when certain conditions are met while non-functional requirements specifies how a system should behave and its limit or its functionality (regtest, 2020)

2a List and discuss briefly the recommended development process of software engineering methodoly

- Analysis: involves observing the problem and gathering data

- Specification: a model of system that describes the way the system should behave

- Design: involves ^{generating} gathering an algorithm or solution to the problem in order to solve the

Coding: Writing in a programming language the system according to requirements defined in the specification and system design

Unit testing: Investigating the system and running it according to different components of a system to make sure they achieve unit requirements

Integration: Joining the different components that have gone through unit testing together

System testing: Running the entire system in a controlled manner to make sure the entire system achieves the specification

Maintenance: Involves constantly keeping the system working properly and updating system in the event of any changing specifications

b)

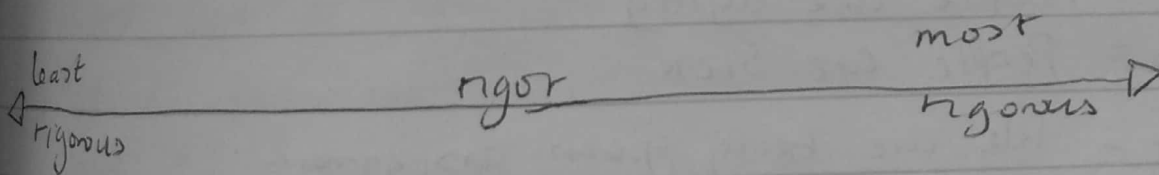


Fig: Spectrum of rigor

least rigorous: occasional mathematical notations embedded in english specifications

most rigorous: fully formal specification languages with precise semantics

3 (a). Differentiate between Propositional logic and first order predicate logic

Propositional logic converts a complete sentence into a symbol and makes it logical whereas in first-order predicate logic relation of a particular sentence will be made (involving relations, constants, functions, constants).

Propositional logic cannot use quantifiers but first order predicate logic can use quantifiers because it expresses generalization, specification and pattern unlike propositional logic
(NITISH KUMAR, 2019).

3a (ii) using propositions A, B, and C, discuss any three basic logical operations in propositional logic.

Let: A = People are dying

B = People are Sick

C = We are being given assignments

Operation 1: Negation (\neg)

$\neg B$ = People are not Sick

$\neg A$ = People are not dying

Operation 2: Disjunction (\vee)

$(A \vee C)$ = People are dying and we are being given assignments

$(B \vee C)$ = People are sick and we are being given assignments

Operation 3: Conjunction (\wedge)

$(B \wedge A) =$ People are sick or people are dying

3b) Represent the text "Every man is mortal. Smith is a man. Therefore Smith is mortal" in first order predicate calculus expression.

P_0 : Every man is mortal

P_1 : Smith is a man

P_2 : Smith is mortal

$\therefore \{P_0, P_1\} \neq P_2$.

4a) Using the principles of first order predicate calculus, represent the statement

"There exists an object that is either a curious monkey or not a monkey at all"

~~$P(x)$~~ Let $x =$ object

Let C be the domain of curious monkeys

and M be domain monkeys

$$= \exists x \Rightarrow (x \in C) \wedge (x \notin M)$$

or

Let $M(x) = x$ is a monkey

$C(x) = x$ is a curious monkey

$$\exists x \in M(x) \Rightarrow C(x)$$

4b) List and discuss any three types of formal specifications.

Property oriented:

- algebraic

- axiomatic

model oriented

- abstract model

algebraic: Data type viewed as an algebra and axioms state properties of data types operators.

It has two parts: syntax and axiom.

axiomatic: it uses first order predicate logic and it describes the desired behaviour by providing model of system.

abstract model: builds an abstract model of the system specifications using mathematical types.

5(a) Define the following

- (i) A well formed formula is a formula that is correct (syntactically) according to the rules of the current calculus
- (ii) A ^{Quantifier} predicate : These are phrases that indicate the number of objects that a statement pertains to (study.com, 2017)
- (iii) Predicate : a predicate is a statement that contains variables which may be true or false depending on the value of the variables
- (iv) A term : is a part of speech representing something but which is not true or false in its own right (wikipedia, 2020)

5(b) (i) $\text{GREATER}(a, b) = T$, if $a < b = F$

a is greater than b is true, if a less than b is false

(ii) $(\forall y) \text{LIKE}(\text{mother}(y), y)$

for all y ; the mother of y is like y

6(a) discuss with examples any three (3) software development strategies

- Waterfall model is a linear sequential flow through the phases of software implementation meaning a phase begins only if a previous phase has terminated. It is used on projects which do not require changing in the requirements because it does not allow the process to go back to a previous phase e.g. projects initiated from a request for proposal,

- Spiral model! - this combines the linear and iterative flows together. It is favored for large, expensive and complicated projects. It uses many of the same phases as waterfall but is separated by planning, risk assessment, building of prototypes and simulation e.g. an e-banking online application, a payment portal, a weather forecasting project. (misnamed), 2018

- Rapid application development models: This model involves building a software while managing resources to the bare minimum and saving time. It is used for time-critical systems which need to fulfil requirements but be up and running as soon as possible e.g. medical devices, personal projects with little deadlines

(b) a requirement document is a ~~prod~~ document containing all the requirements (objectives) that a particular system is aimed to achieve

7a) The requirement document includes

(1) The introduction: this involves the whole purpose of the particular system, the targeted customer, the scope or domain that the system's problem area is in

(2) Overall description: it includes all the underlying information from how the system should look like and the original features, characteristics.

i.e. System perspective, ^{Product} ~~system~~ identifier, user classes and characteristics, operating environment, design and implementation constraints, assumptions and dependencies

(3) Product features: This involves all the functional requirements of the system

(4) External interface requirement specifies all the hardware needs of the system such as the user interface, hardware interfaces, software interfaces, communication interfaces

(5) Non-functional requirements: contains all non-functional requirements i.e. performance requirement, Safety and security requirements etc.
(Krautzsch, 2020)

- 7b)
1. Make an outline
 2. Define the purpose of your product
 3. Describe what you are building
 4. write the requirements

(Perforce - Nico Kruger, 2018)