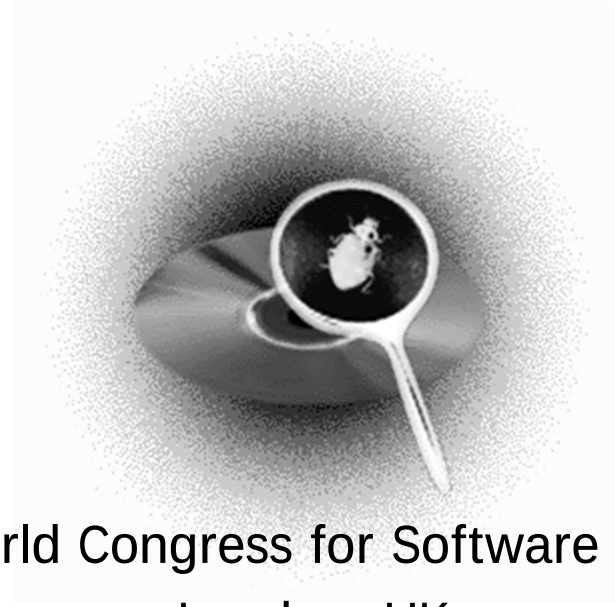
Viewpoint-based Test Requirement Analysis Modeling and Test Architectural Design



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Profile – Dr. NISHI, Yasuharu

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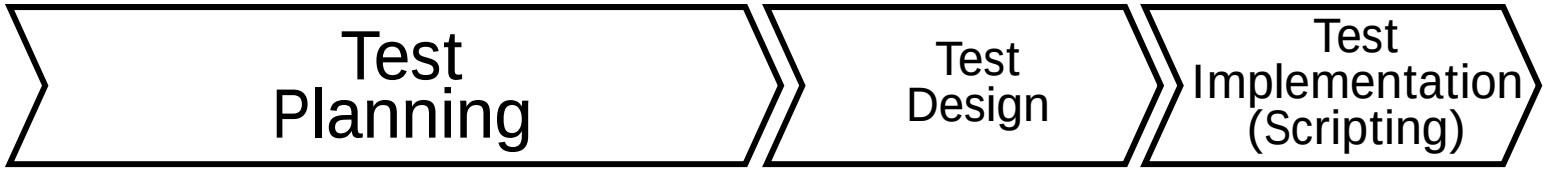
Software testing, software quality/TQM , embedded software engineering, software process improvement, software project management, system safety

Software Test Engineering Process

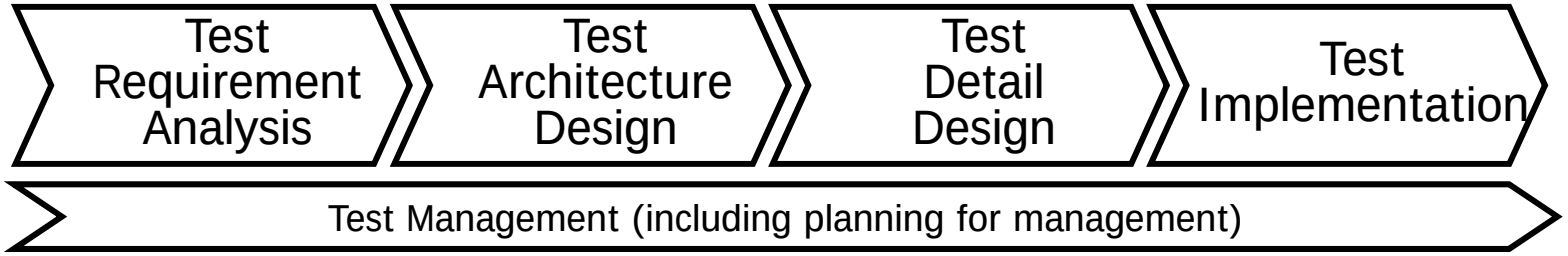
- As software has got huge and complicated, test cases (= test suite) also get huge and complicated
  - such as
    - » a test project with over 100,000 test cases
    - » over 10 test levels
    - » various test types such as load, configuration and security
  - You have to develop huge and complicated test suite systematically
- But technologies on test planning or test strategy are just immature
  - Engineering work and management work for test development are confused
- It is necessary to define software test engineering process to develop huge and complicated test suite systematically

Independent RA is necessary for testing

- Independent requirement analysis for testing is necessary
  - Requirement analysis for software isn't usually exact or detail enough
  - Of course test requirement analysis depends on SUT and its dev. Process
- Requirement analysis for testing should be more important
  - Test "planning" is just management word and NOT engineering word



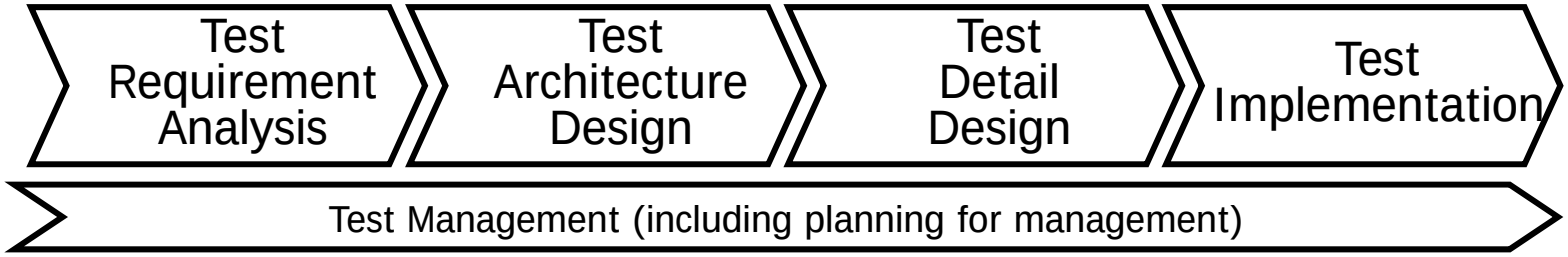
Part of typical test process



VSTeP: Viewpoint-based Test Process

VSTeP

- VSTeP(Viewpoint-based Software Test Engineering Process) is a generic test engineering process model focusing on test viewpoint
  - You can stress upper phase of test engineering process such as test requirement analysis and test architecture design which tend to be negligent
  - VSTeP drives you to good test suite, good review for test design, accumulation of knowledge and experience on testing
  - Reuse and improvement will be easy because you can do reverse-engineering of your past (unorganized) test suite
  - NGT (Notation for Generic Testing) is a made-in-Japan notation for Test Requirement Analysis and Test Architecture Design
    - » Modeling skill like object-oriented design is essentially necessary

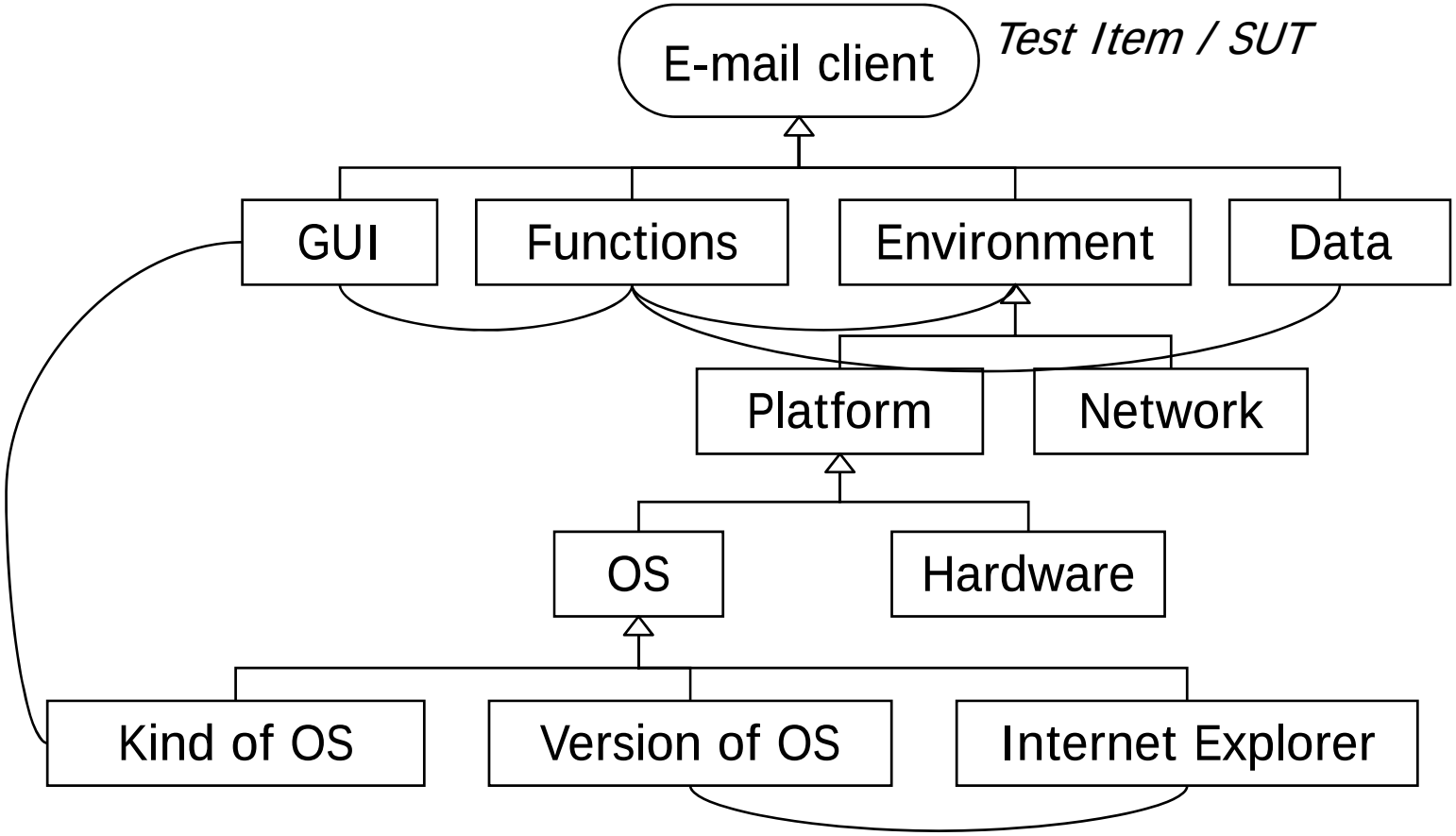


VSTeP: Viewpoint-based Test Process

Detail phase of VSTeP

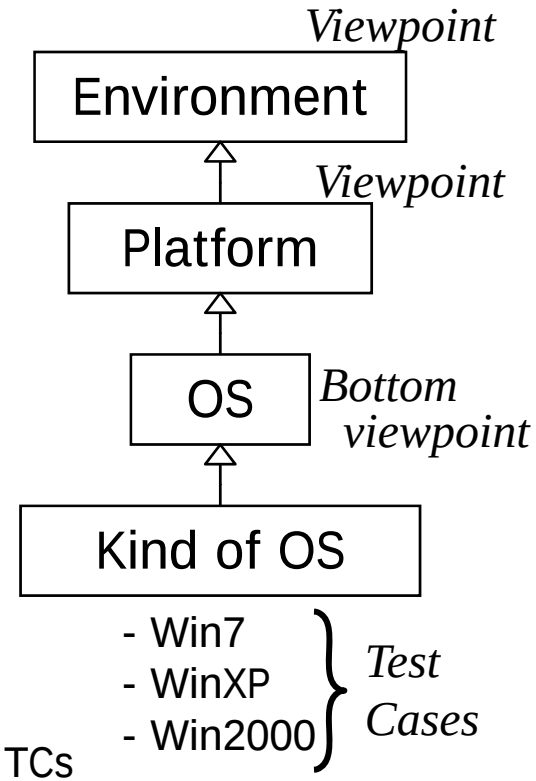
- TRA: Test Requirement Analysis
  - To make a test requirement model
    - » To extract, organize and understand test requirement
    - » To create a test requirement model which consists of test viewpoints, i.e. to create a viewpoint diagram
- TAD: Test Architecture Design
  - To make a test architecture model
    - » To re-organize test viewpoints into test containers as test types, levels and cycles for making test smooth
    - » To assemble test viewpoints into test frames which is template for TDD
- TDD: Test Detail Design
  - To make test cases
    - » To set values in detail into test frames or test viewpoints
- TI: Test Implementation
  - To make test scripts
    - » To add detail information necessary to execution to test cases
    - » To combine simple test scripts into a compound test script for making execution efficient

Example of part of viewpoint diagram drawn for TRA



What is test viewpoint: abstract test case

- Test cases has test values
  - ex) parameter: Kind of OS, values: Win7, WinXP, Win2000
  - Test parameters are also called as test conditions and test values are also called as test coverage items
  - Test cases consists of test values
- Viewpoints are abstract test cases
  - Bottom viewpoints means test parameters
  - Viewpoints don't express any test values or test cases
  - Viewpoints can have hierarchical structure like classification trees or class diagrams
  - Viewpoints can be extracted from test conditions, test items and quality characteristics such as load, configuration and performance
  - Ideally viewpoints should indicate an INTENTION of a test case
    - » Viewpoint diagram can be a repository of intentions of TCs



Various test viewpoints

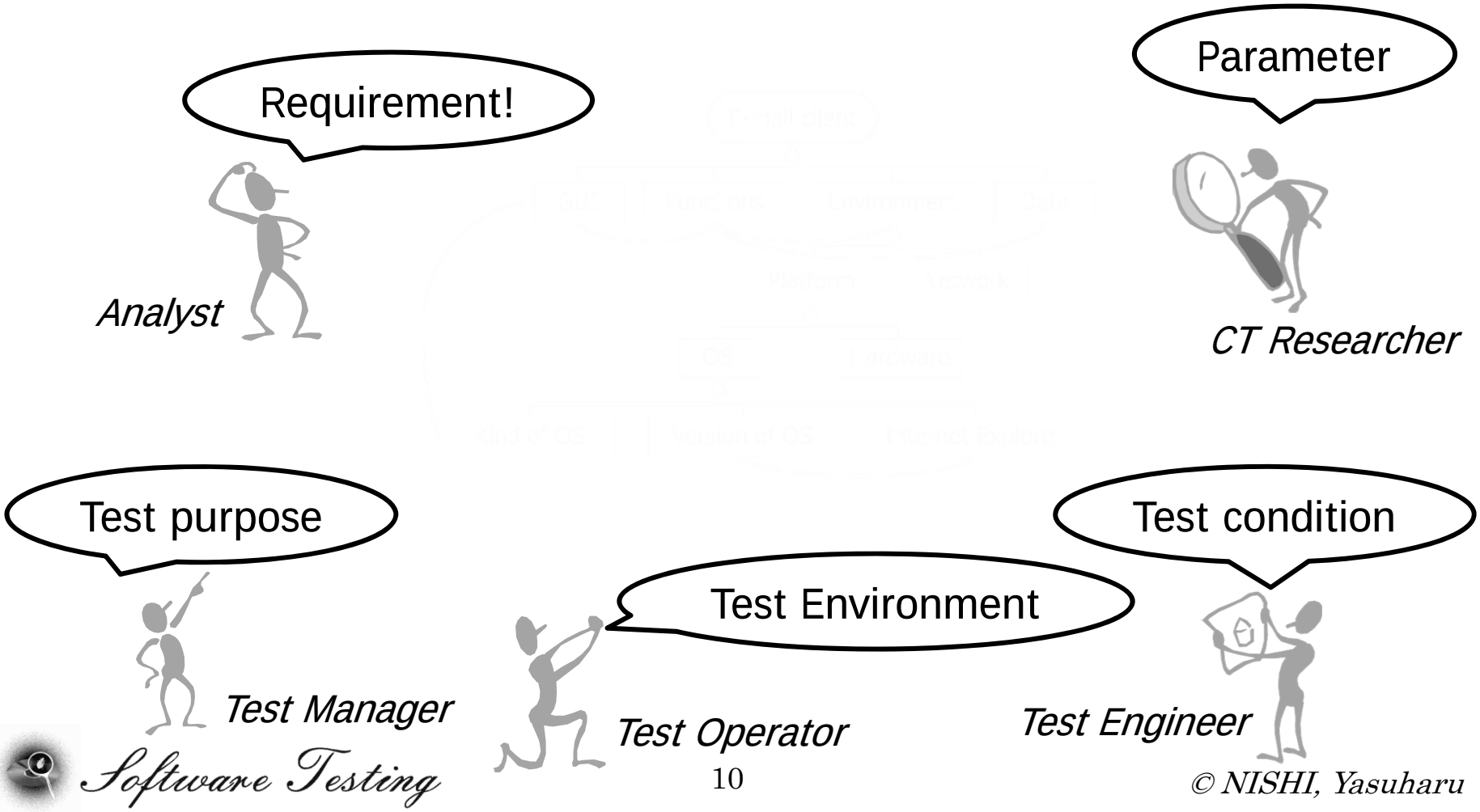
- Test viewpoint is a point where test engineers focus an attention for grasping a big picture of test design
  - Test viewpoint is abstraction and source of test cases
- Types of test viewpoints depend on organizations and/or test engineers

OS

  - What should be exhausted:
    - » Specs, functions, data etc.
    - » Test conditions
  - Characteristics which should be achieved
    - » Quality characteristics, non functional requirements etc.
  - Parts of test items
    - » Funcs, Subsystems, modules etc.
  - Bugs
    - » Errors and failures, bug patterns, weak points of test items etc.
  - Customer usage
    - » Business, lifestyle etc.
  - Other parts of systems than software
    - » Hardware units, hardware failures etc.
  - Test types
    - » Load test, configuration test etc.
  - Test levels
    - » Component test, system test etc.
  - Lists and/or diagrams developed until software testing
    - » Use cases, State transition diagrams etc.

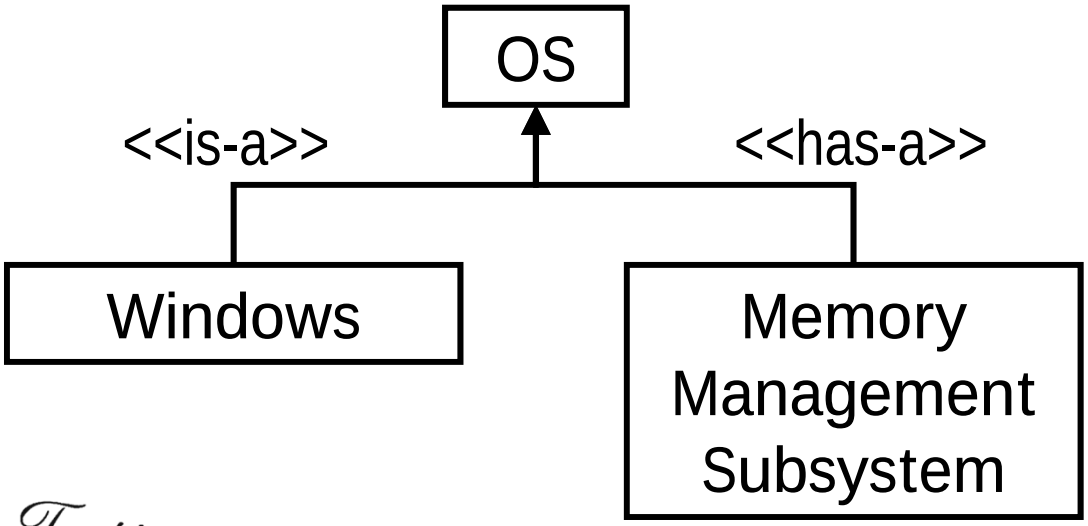
Why “viewpoint” ?

- The word “viewpoint” is independent of roles



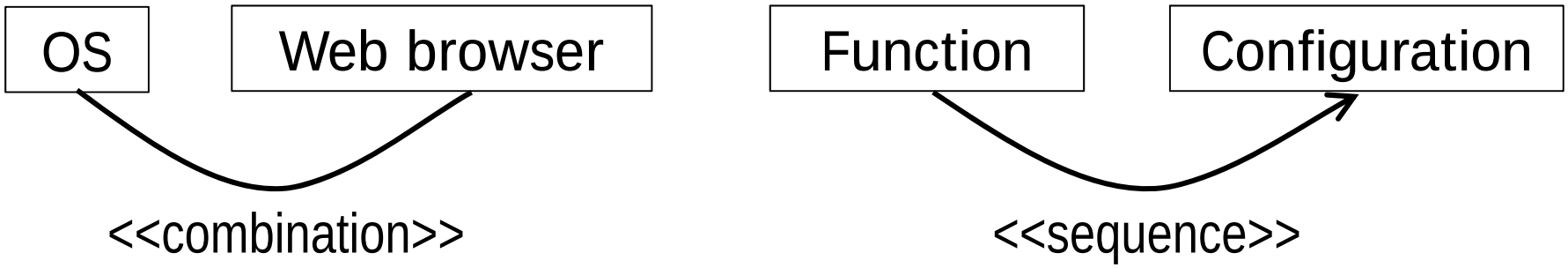
Types of Hierarchical relationship

- Test viewpoints have two fundamental relationships
  - Hierarchy relationships and Interaction relationships
  - Types of relationships can be expressed as “<<stereotype>>”
- Hierarchical relationships can bear several meanings
  - is-a relationship: inheritance
  - has-a relationship: possession
  - There may be other hierarchical relationships
    - » object-attribute and cause-effect is example



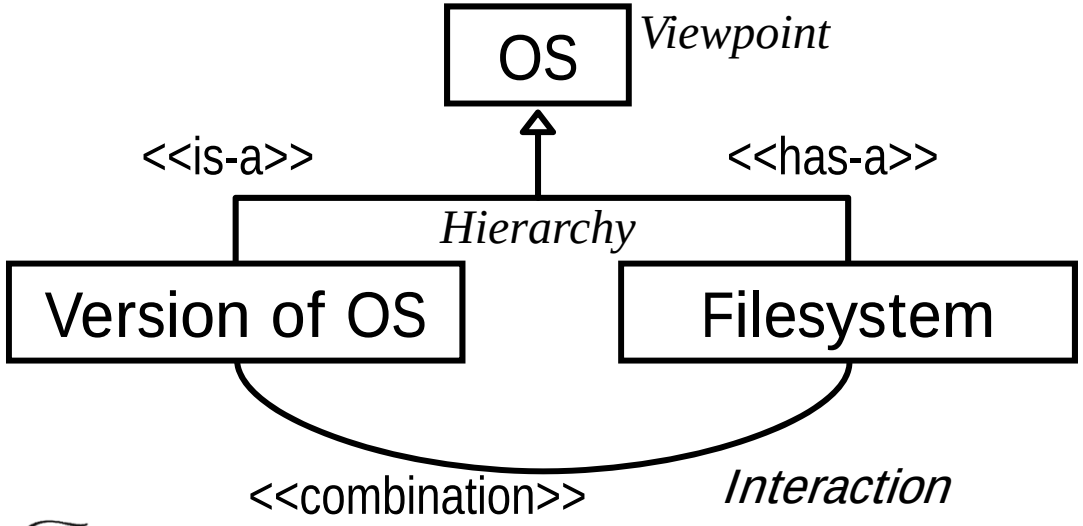
Interactive relationships of viewpoints

- Viewpoints can relate each other with interactive relationships
  - Non-hierarchical relationships are necessary: Interactive relationships
  - They can also bear several meanings: combination, sequential etc.
  - Lines without arrowhead represent “combinatorial relationships”
  - Arrows with an open head represent “sequential relationships”
  - Relationships can represent their meanings with <<stereotype>>
  - In this workshop interactive relationships without stereotypes represent combinatorial relationship



Relationships of viewpoints

- Test viewpoints have two fundamental relationships
  - Hierarchy relationships
    - » Detail a viewpoint step by step to reach test coverage item with a straight line
    - » Have several types such as is-a, has-a, cause-effect, object-attribute
  - Interaction relationships
    - » Connect test viewpoints to test combination of viewpoints with a curved line
    - » Have several types such as combination (needs combinatorial testing) etc.
- Types of relationships can be expressed as “<<stereotype>>”



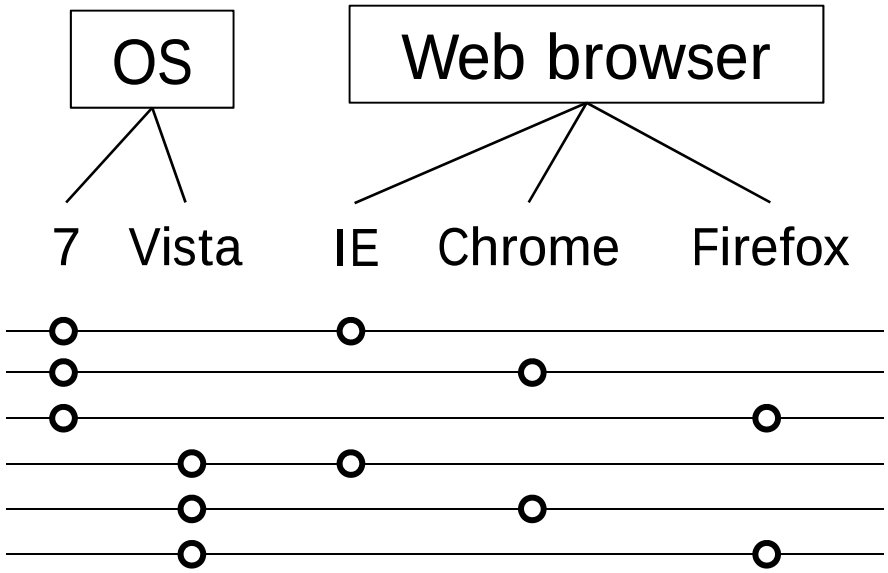
Notation of viewpoint diagram in NGT

Viewpoint	...	*Viewpoint*
↑	...	*Hierarchical Relationship*
⌣	...	*Interactive Relationship*
<<stereotype>>	...	*Stereotype*
⌣ <<combination>>	...	*Combinatorial Relationship*
→ <<sequence>>	...	*Sequential Relationship*
🗀	...	*Test Container*

Drawing tools for mindmaps are useful

Viewpoint diagram is simple enough

- Viewpoint diagram is simple enough to make a TRA/TAD model
  - More simple than classification tree

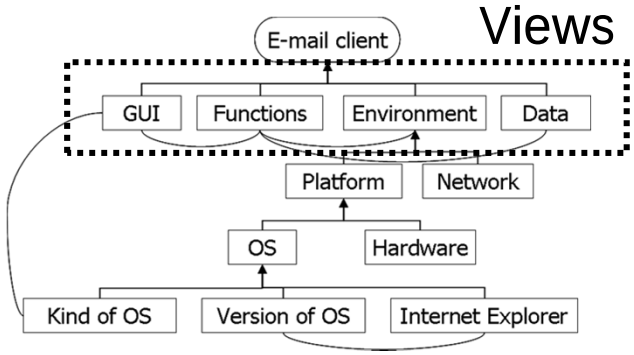


Classification Tree

Viewpoint diagram

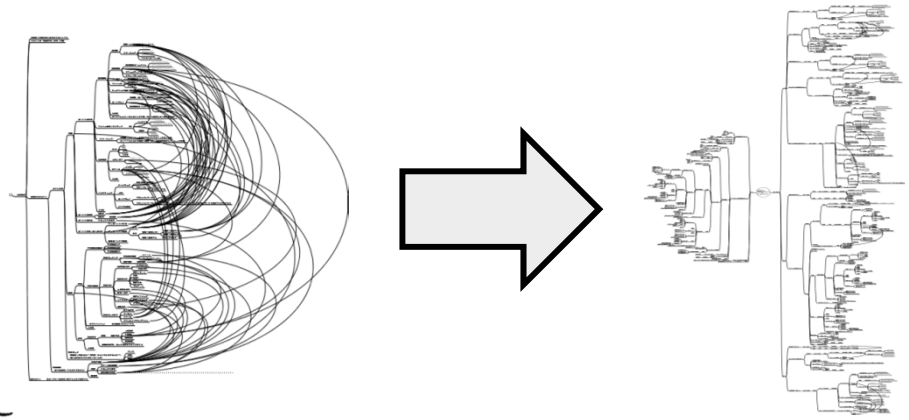
TRA: Test requirement analysis

- To extract, organize and understand test requirements
  - Requirements from customers to achieve
    - » Functional requirement, non-functional requirement, business goals etc.
  - Constraints to achieve requirement from customers
    - » Requirement of test project management such as efforts, costs etc.
    - » Test tools and/or methods directly requested by customer especially
  - Information of current quality of the test item
    - » Ex) bugs which were detected in prior reviews
- To create a test requirement model on viewpoint diagram
  - Extract test viewpoints from test requirements
  - Detail test viewpoints and connect parent viewpoint and child viewpoints
  - Extract interaction relationships and connect viewpoints
  - Top-level viewpoints are most important for grasping a big picture, called “View”



Refinement of a test requirement model

- You can refine a test requirement model to make it clear and easy to understand
  - To detail viewpoints step by step to exhaust / list all test conditions
  - To move, divide or rename viewpoints if necessary
  - To check non MECE viewpoints in each layer and re-organize them as MECE
    - » MECE: Mutually Exclusive and Collectively Exhaustive
  - To check whether brotherhood viewpoints have the same stereotypes of hierarchy connections
  - To check whether interactions would be better to change viewpoints



VSTeP

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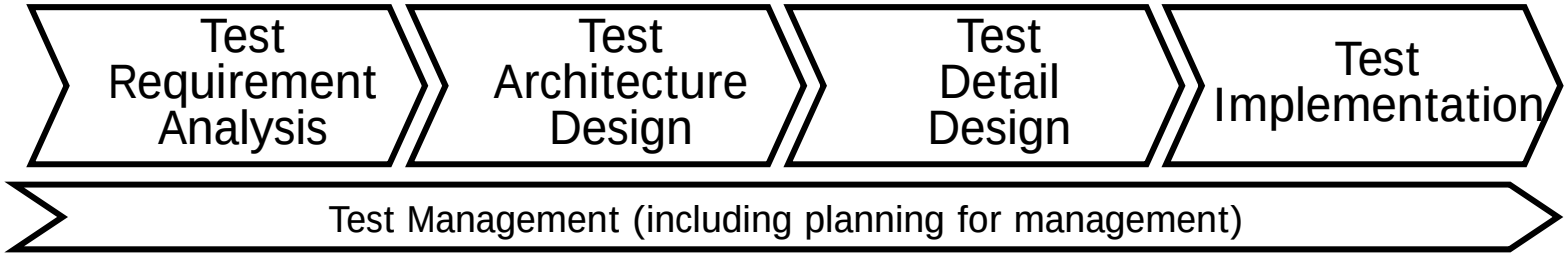
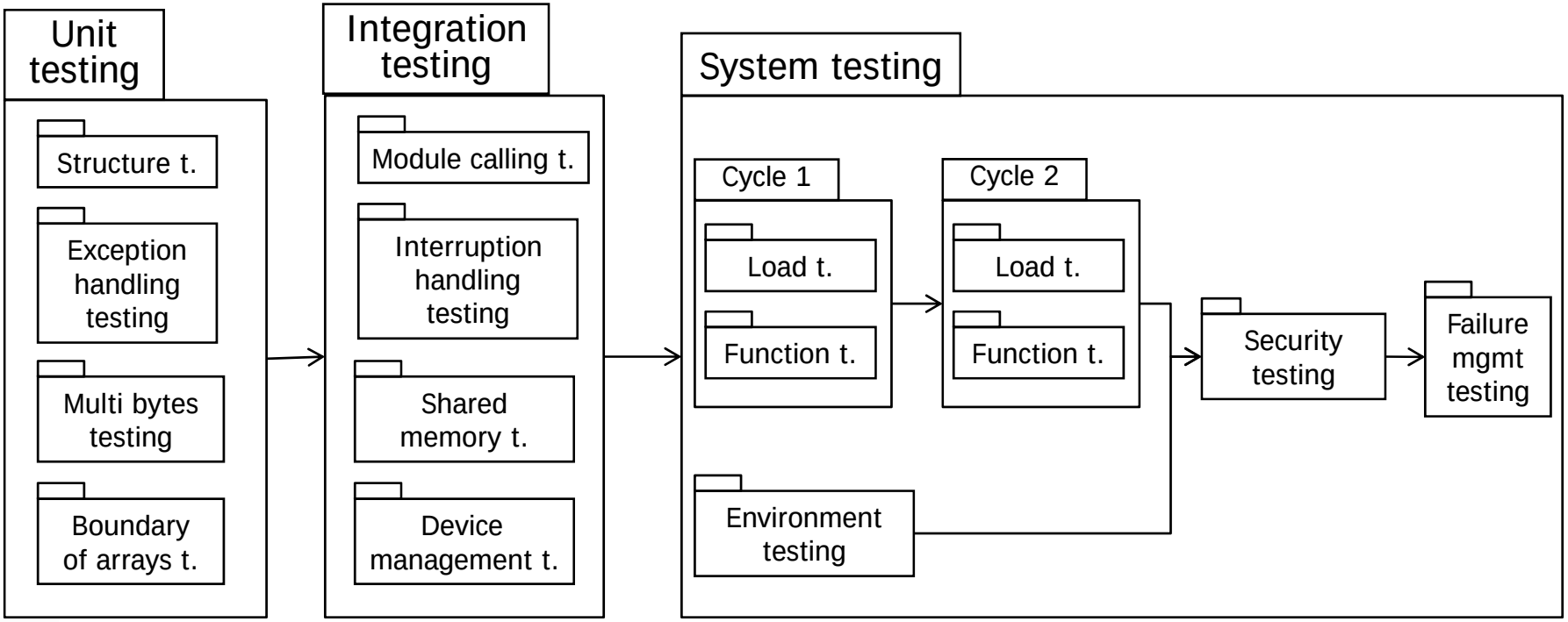


VSTeP: Viewpoint-based Test Process

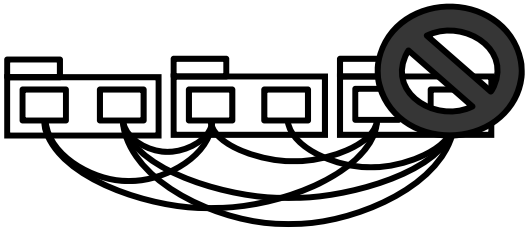
TAD: Test Architectural Design

- Test architecture is a big picture of test suite
  - It is easy to grasp a big picture in test container level for large and complicated testing
  - Several viewpoints can be packed into a “test container”
  - Test containers can be test levels, test types and test cycles



Guides for good TAD

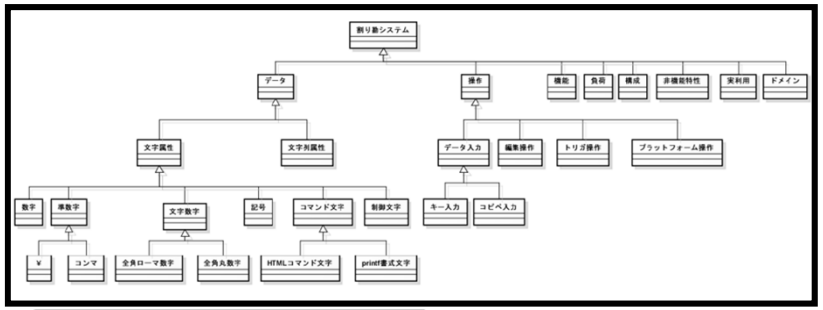
- Some characteristics, attributes and patterns for software can be applied as guides for good TAD
  - "Quality Characteristics" for software are already available such as ISO/IEC 25000s
    - » Functional Suitability / Performance efficiency / Compatibility / Usability / Reliability / Security / Maintainability / Portability
  - Other characteristics and design patterns for software design are also major
    - » Coupling / Cohesion / Encapsulation / Responsibility
    - » Design patterns such as MVC, singleton
- Characteristics for TAD is important for good TAD
  - Cohesion and coupling
    - » A test container should be packed with viewpoints with similar meanings
    - » Test containers should have so few combinatorial relationships as possible



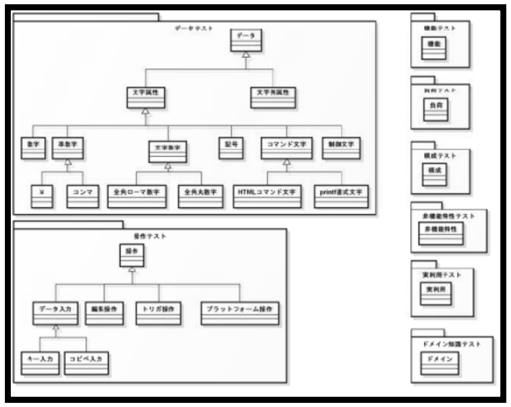
  - Maintainability / Internationaliziblity / Portability
    - » Test containers which needs modifications should be easily identified in maintenance, internationalization and porting
  - Design patterns on viewpoint level could be another guide for TAD

Quality attributes of test suite

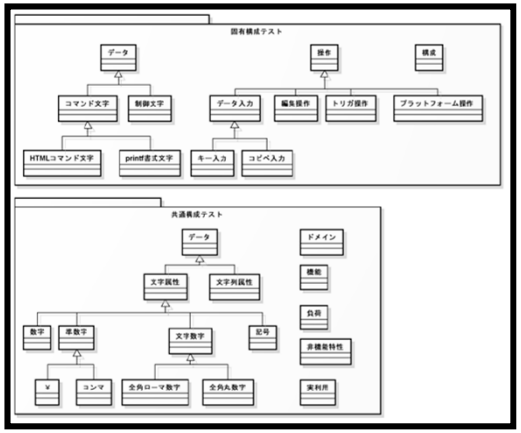
- Test architecture depends on required quality attributes of test suite
  - Test suite can have its own quality attribute if test suite is artifact
  - Ex) Maintainability of test suite
  - It doesn't mean testing of quality attribute such as ISO/IEC 25000s/9126s



Test architecture of small calculator



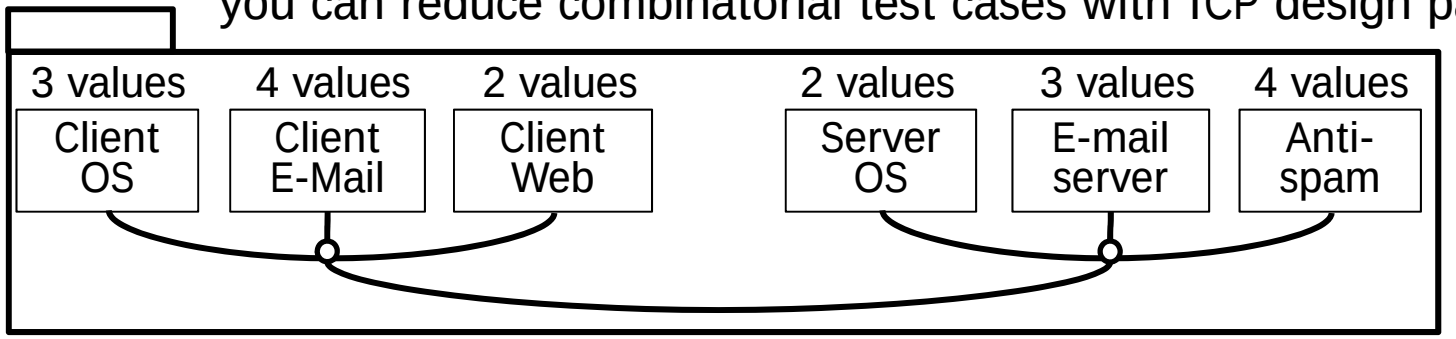
Simply divided



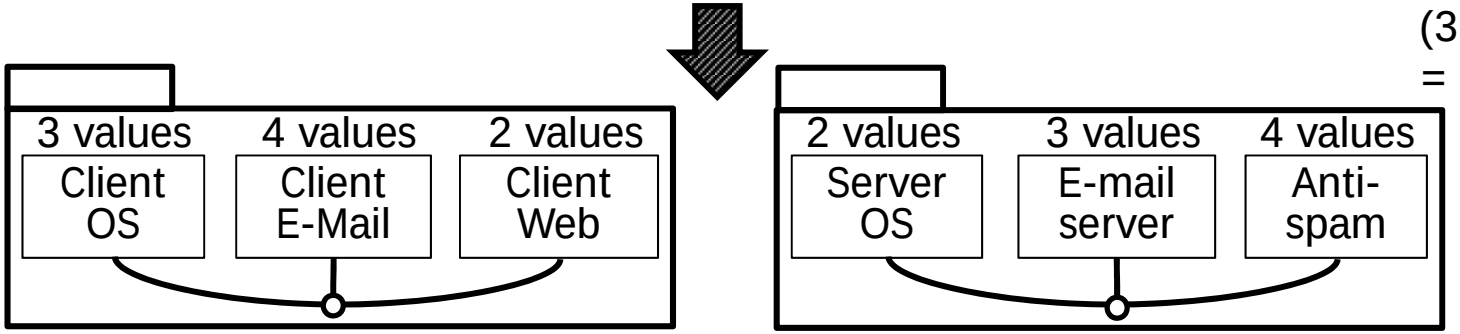
Maintainability considered

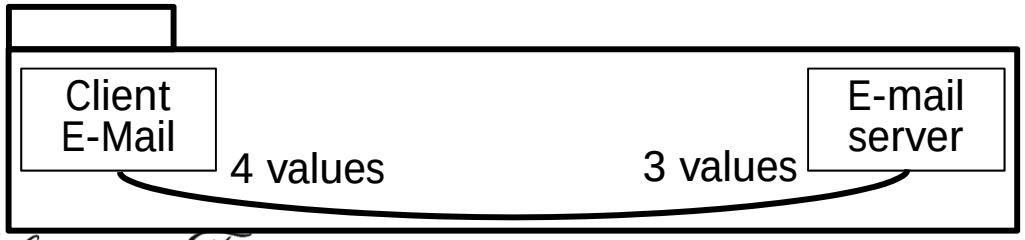
Example of design pattern for TRA/TAD

- Interaction Cluster Partitioning Pattern
  - if you can specify the source of combinatorial bugs is e-mail protocols and accept risks of bugs from other sources, you can reduce combinatorial test cases with ICP design pattern



(3 x 4 x 2) x (2 x 3 x 4)
= 576 cases





(3 x 4 x 2) + (2 x 3 x 4)
+ (4 x 3)
= 64 cases

Research Question

- Can Test Viewpoint Diagram reduce omission of test conditions?
  - Can test requirement modeling activity based on test viewpoints reduce omission of test conditions more than based on test conditions?
  - Is independent requirement “modeling” for testing is better than “deriving test conditions”?
    - » Does “Deriving test conditions” mean just reading test base and writing them?
- We conducted an experiment to compare “deriving test conditions” and “modeling test viewpoints”
  - Lecture from academia and experiment by industry

Experiment for reducing omissions of test conditions

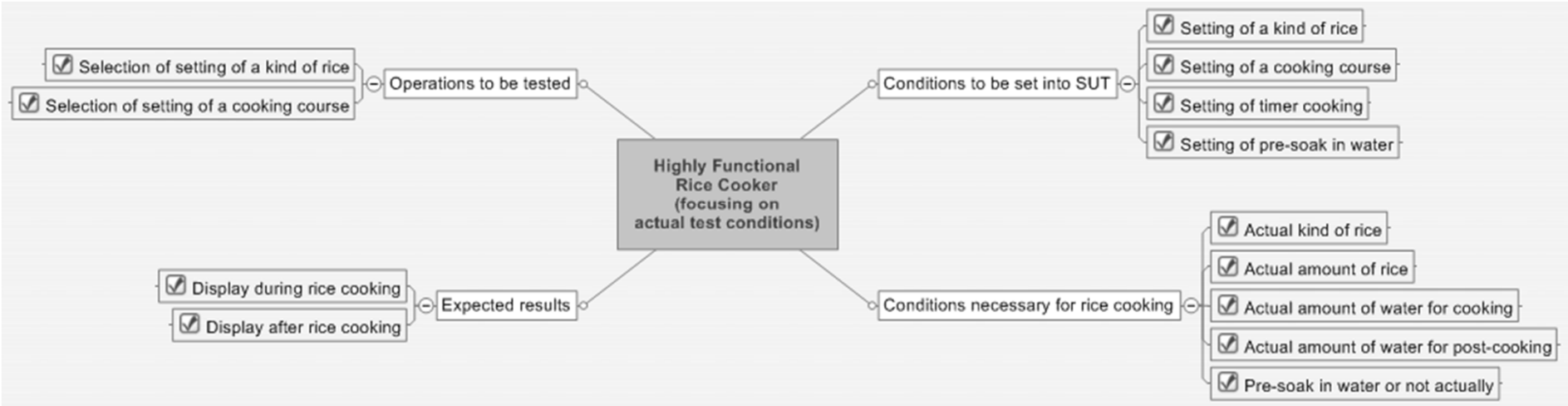
- Overview of Experiment
  - Experiment for reducing omissions of test conditions in test requirement analysis phase by 2 teams using test conditions and test viewpoints
    - » Team C: Selected test conditions using test conditions
      - · Team C selected test cases by the same way as actual test design using spreadsheet
      - · To compare easily, we redrew Team C's test cases into Test Viewpoint Diagram
    - » Team V: Selected test conditions using test viewpoint model
      - · We made lectures on NGT/VSTeP and instructed them to model with Hierarchical relationships
      - · They drew Test Viewpoint Diagram using a mindmap tool (freemind)
  - Both teams had 3-4 engineers and all engineers had 5-10 years experiences in software testing company mainly for embedded software
- Test Base / SUT
  - User manual of a highly functional rice cooker
  - Manual mainly has 2 parts:
    - » Operational instructions / functional descriptions
    - » Recommendations of cooking rice, e.g. for Sushi

※ 写真はSR-SX182です

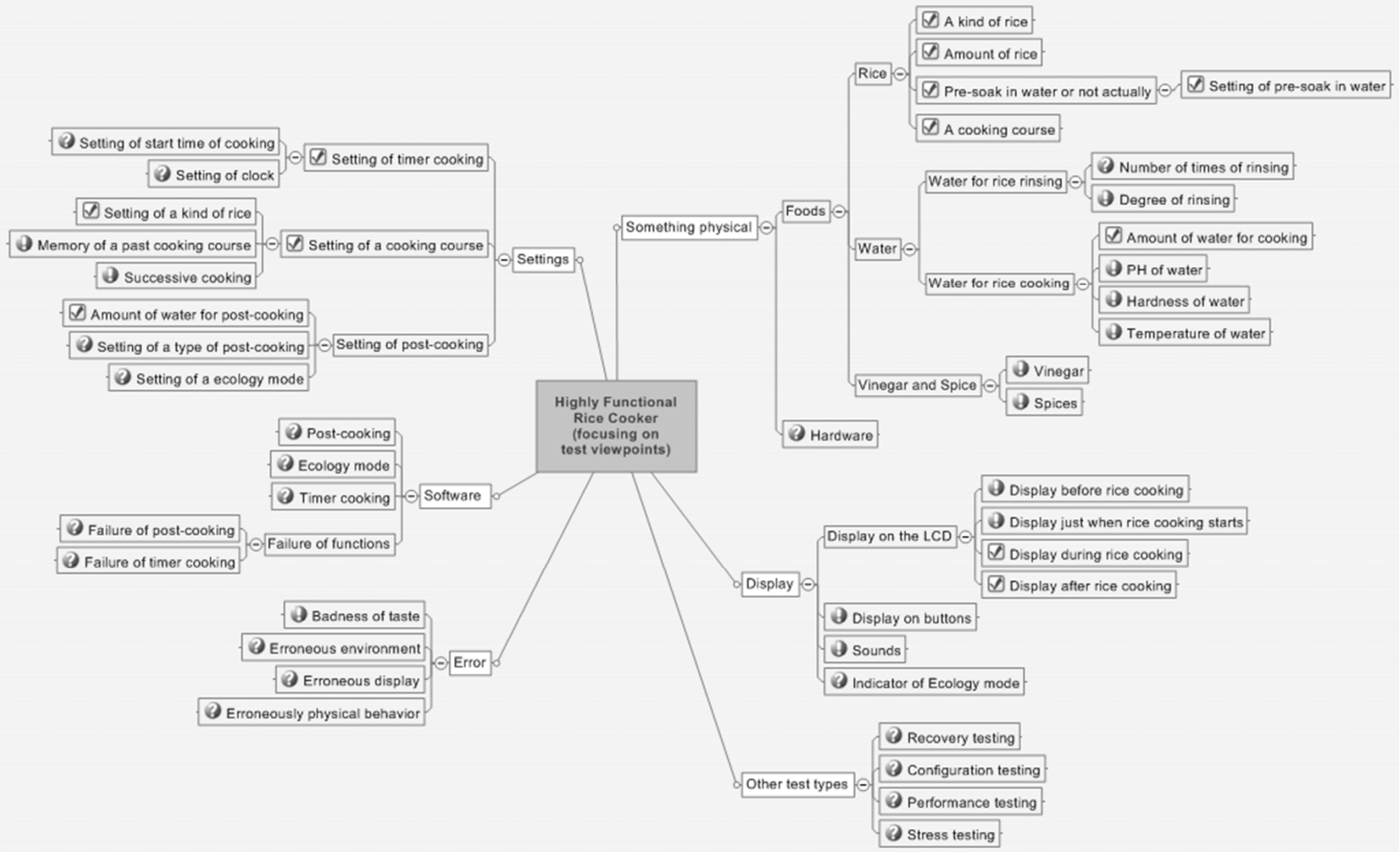
Condition-based test requirement model

Condition-Value list No.		1									
Policy for listing		**To derive necessary test conditions and values for the rice cooking functions referring to operational steps of rice cooking**									
Precondition		-		-		-		-		If post-cooking is started	
Test Conditons	No.	1		2		3		4		5	
		Kind of rice	Note	**Amount of rice**	Note	**Amount of water for cooking**	Note	**Pre-soak in water**	Note	**Amount of water for post-cooing**	Note
Test Values	1	Polished rice		1 cup		Same as gauge		Not to be soaked		45ml	
	2	Pre-washed rice		2 cups		More than gauge		To be soaked		Maximum	
	3	Sticky rice		3 cups		Less than gauge					
	4	Raw rice		4 cups							
	5	Sprouted raw rice		5 cups							
	6	Partly milled rice	Level of milling isn't categolized								
	7	Sprouted rice									
	8	Cereals rice									

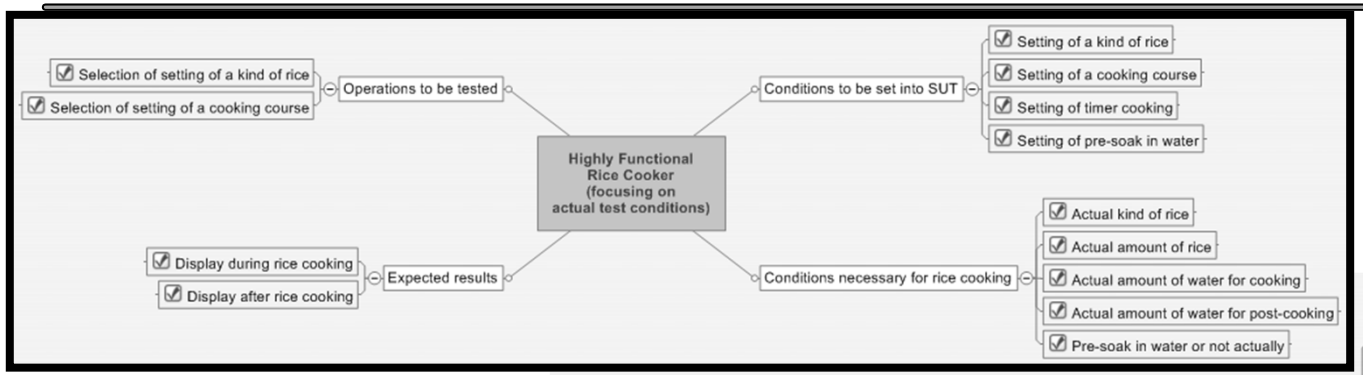
To compare easily,
we redrew the list into
Test Viewpoint Diagram



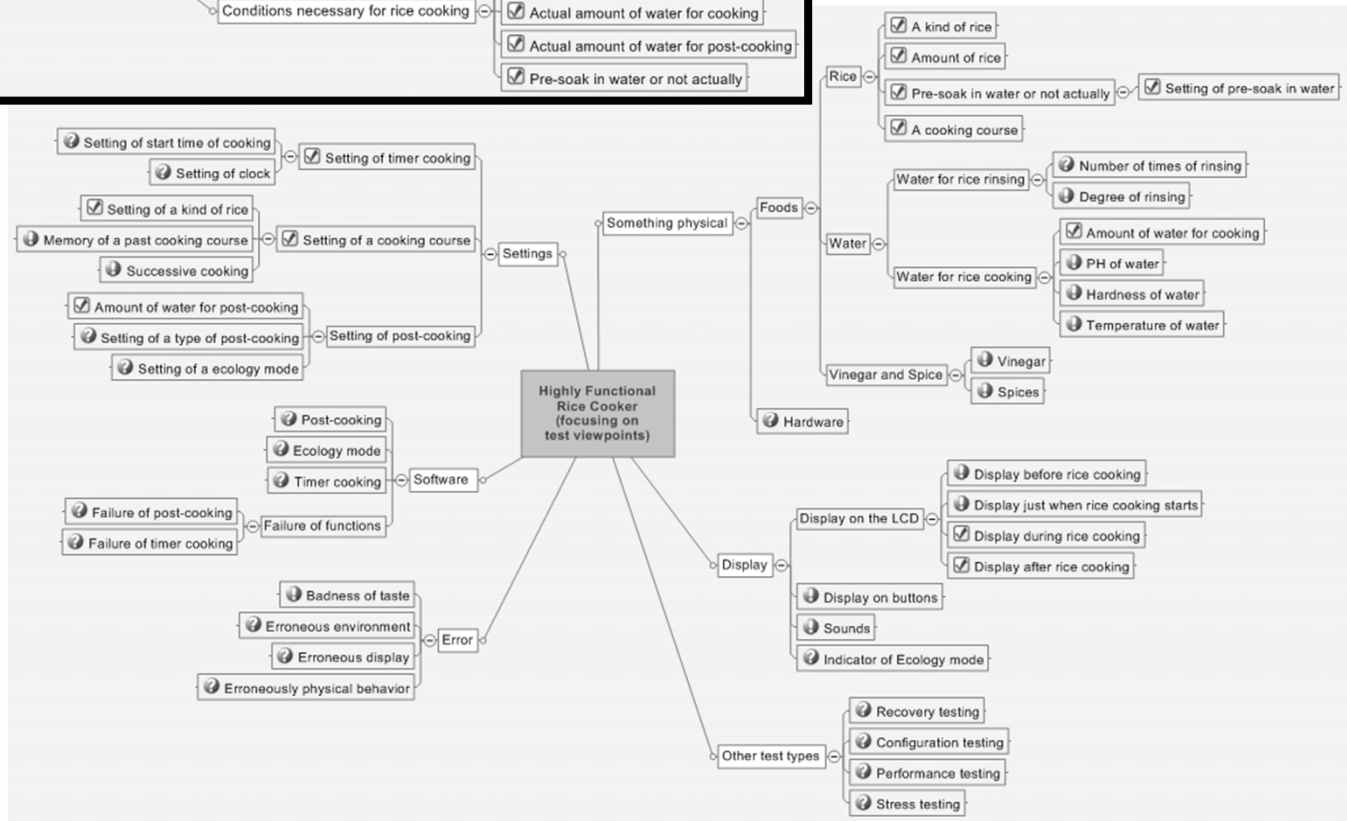
Viewpoint-based test requirement model



Comparison of Condition-based and Viewpoint-based model



Condition-based model



Viewpoint-based model

Result: no. of omissions of test conditions

- Condition-based model omitted 13 more test conditions than Viewpoint-based model
  - Team C selected test conditions only which are explicitly written and easily identified as test conditions
    - » Model is constructed in spreadsheet style
  - Team V modeled the SUT itself whether viewpoints are test conditions or not
    - » Model is constructed in NGT/mindmap style

	Conditions explicitly written	Omissions of Conditions	Out-of-scope
Condition-based Model	All	+13	0
Viewpoint-based Model	All	+0 (baseline)	18

Detail of omitted test conditions out of Condition-based model

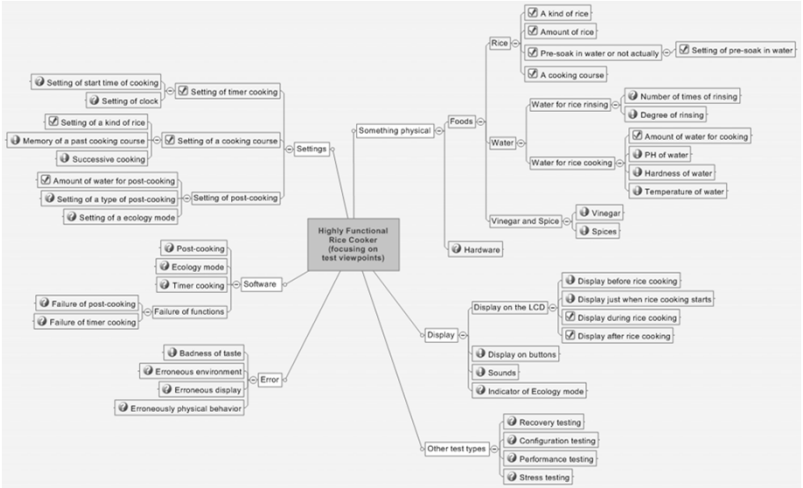
- Ambiguously written input parameter: *1 condition*
  - "Memory of a past cooking course"
- Ambiguously written usecase: *1 condition*
  - "Successive cooking"
- Attributes of physical object explicitly written in Recommendation part of the manual: *6 conditions*
  - "Degree of rinsing", "pH of Water", "Hardness of water", "Temperature of water", "Vinegar", "Spices"
- Ambiguously written expected results (behavior): *4 conditions*
  - "Display before rice cooking", "Display just when rice cooking starts", "Display on buttons", "Sounds"
- expected result of physical object explicitly written in Recommendation part of the manual: *1 condition*
  - "Badness of taste"

Consideration on threats to validity

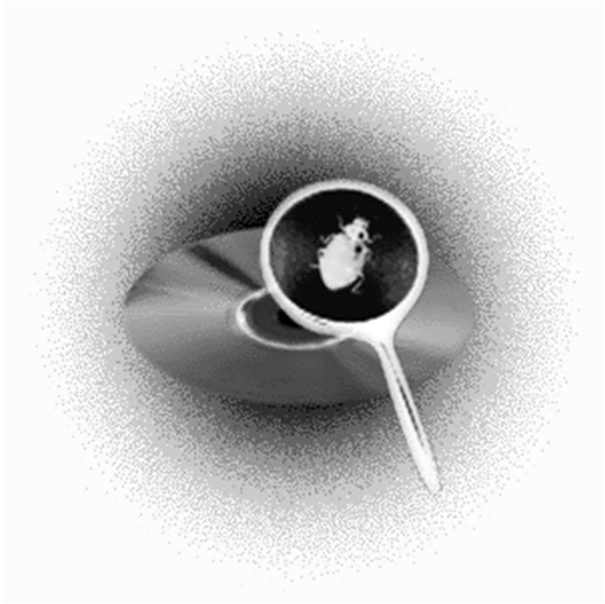
- Lack of empirical study?
  - Single experiment can be biased and consistently extract wrong information
  - We gathered multiple engineers who have almost the same experience into each team
- Lack of assessing the validity of cost and time measures?
  - Team V spend more time (but practically acceptable) on TRA than team C
  - Cost and time for TRA and TAD is often made more ignorable than TDD, TI and Test Execution
- Lack of assessing the validity of domain skills of engineers?
  - All the engineers have almost the same domain skills as rice is the most popular food in Japan
- Lack of evaluations for instances of growing size and scope?
  - Omissions are mainly about domain objects, i.e. physical objects, and ambiguous specifications
  - As size and scope of test grow, domain objects and ambiguous specifications will grow, VP model will be more effective
- Lack of evaluations for integrity and testability of the test base
  - Integrity and testability of the test base grow, description on domain object will get richer and ambiguous specification will decrease
  - Although C model can reduce omissions, integrity and testability of test basis is limited actually. We can estimate VP model will be yet more effective
- Lack of evaluations for refinement of model
  - We didn't measure or limit the number of refinement of model exactly
  - VP model was more refined than the C model
  - As good model written in good notation will be more refined, VP model can be estimated to be more effective.

Conclusion

- Independent test requirement analysis(TRA) is necessary
- It is important to construct a test requirement model in TRA
- In our experiment, test viewpoint model can reduce omission of test conditions more than test condition model
- Scientific measurement of merit of “modeling” is rather difficult or not?
  - Empirical study is necessary



Thank you for your kind attention



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