Software Development Cycle

A SW Development Framework for SW with High Assurance
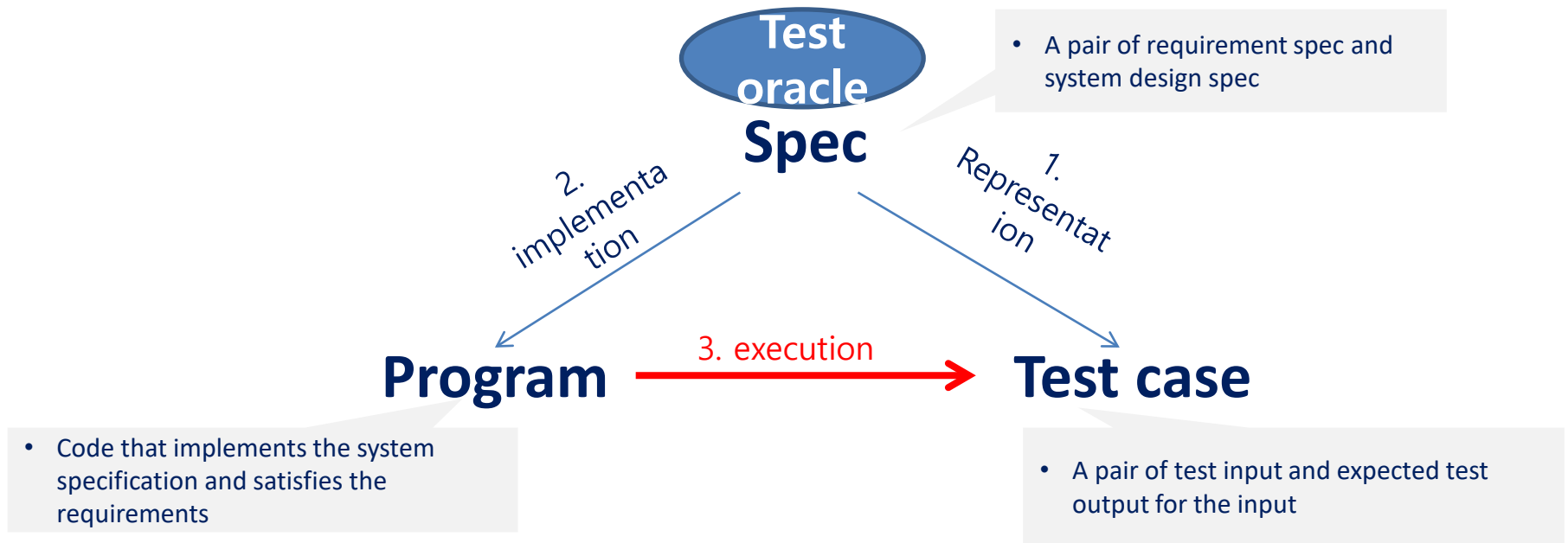

Requirement analysis	System design	Design analysis	Implement-ation	Testing	Monitoring
Formal require-ment Spec.	Formal system modeling	Model analysis/ verification	Model-assisted code generation	Model-based testing	Runtime monitoring and checking
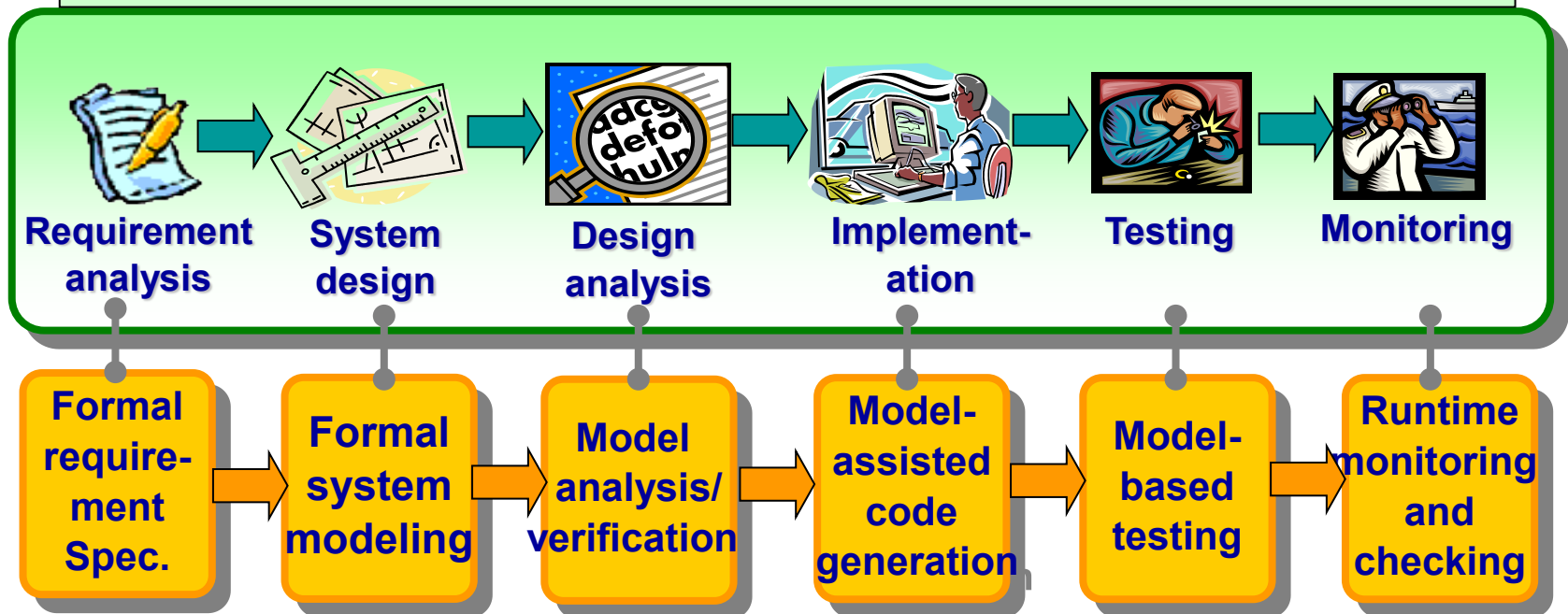
SW Development and Testing Model (a.k.a. V model)

Manual Labor

Requirements Specification

Architectural Design

Detailed Design

Source Code

Acceptance Test

System Test

Integration Test

Unit Test

Abstraction

Moonzoo Kim
Provable SW Lab

KAIST
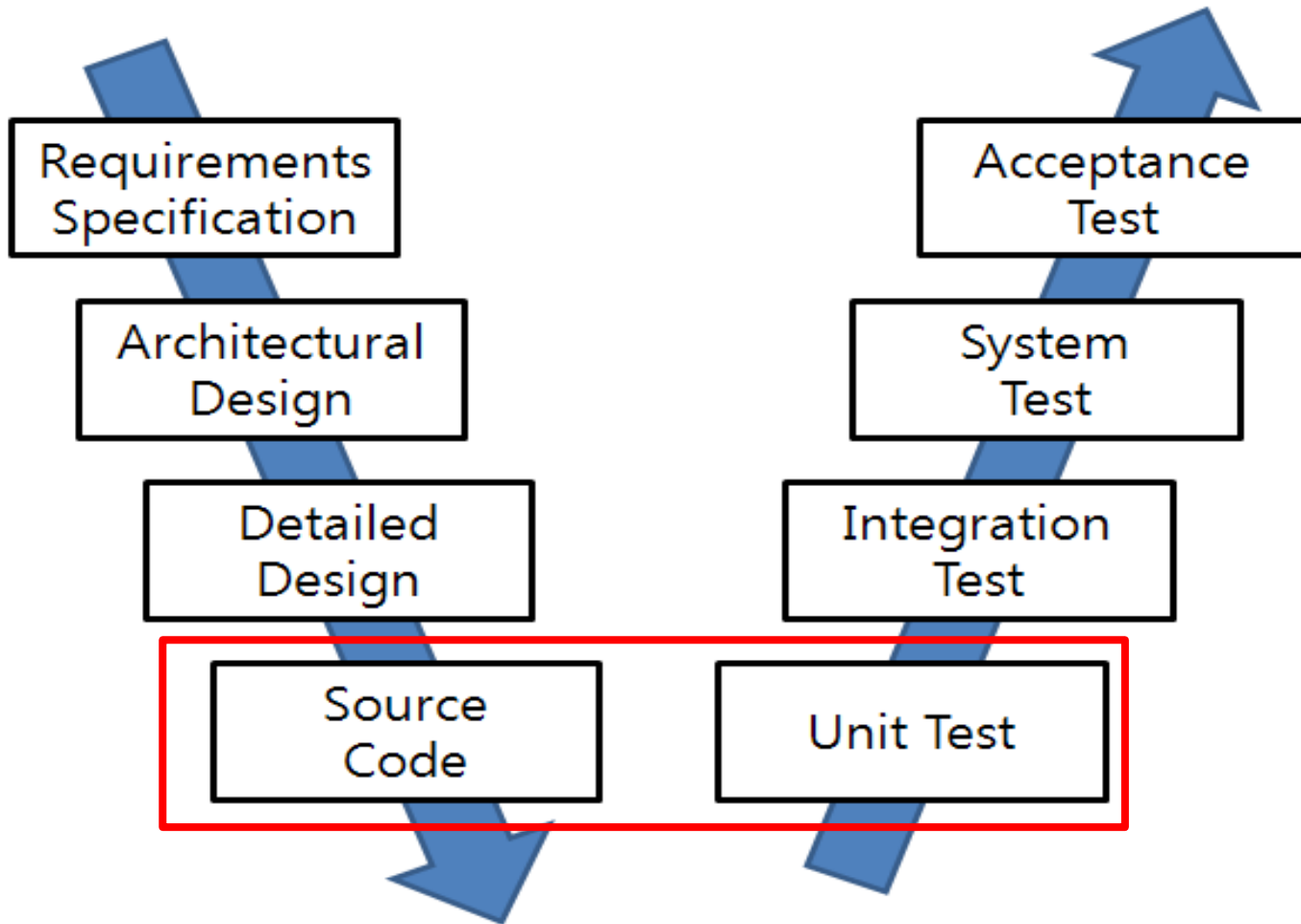
Foundation of Software Testing

Test oracle

Spec

- A pair of requirement spec and system design spec

2. implementation

1. Representation

Program → **3. execution** → **Test case**

- Code that implements the system specification and satisfies the requirements

- A pair of test input and expected test output for the input
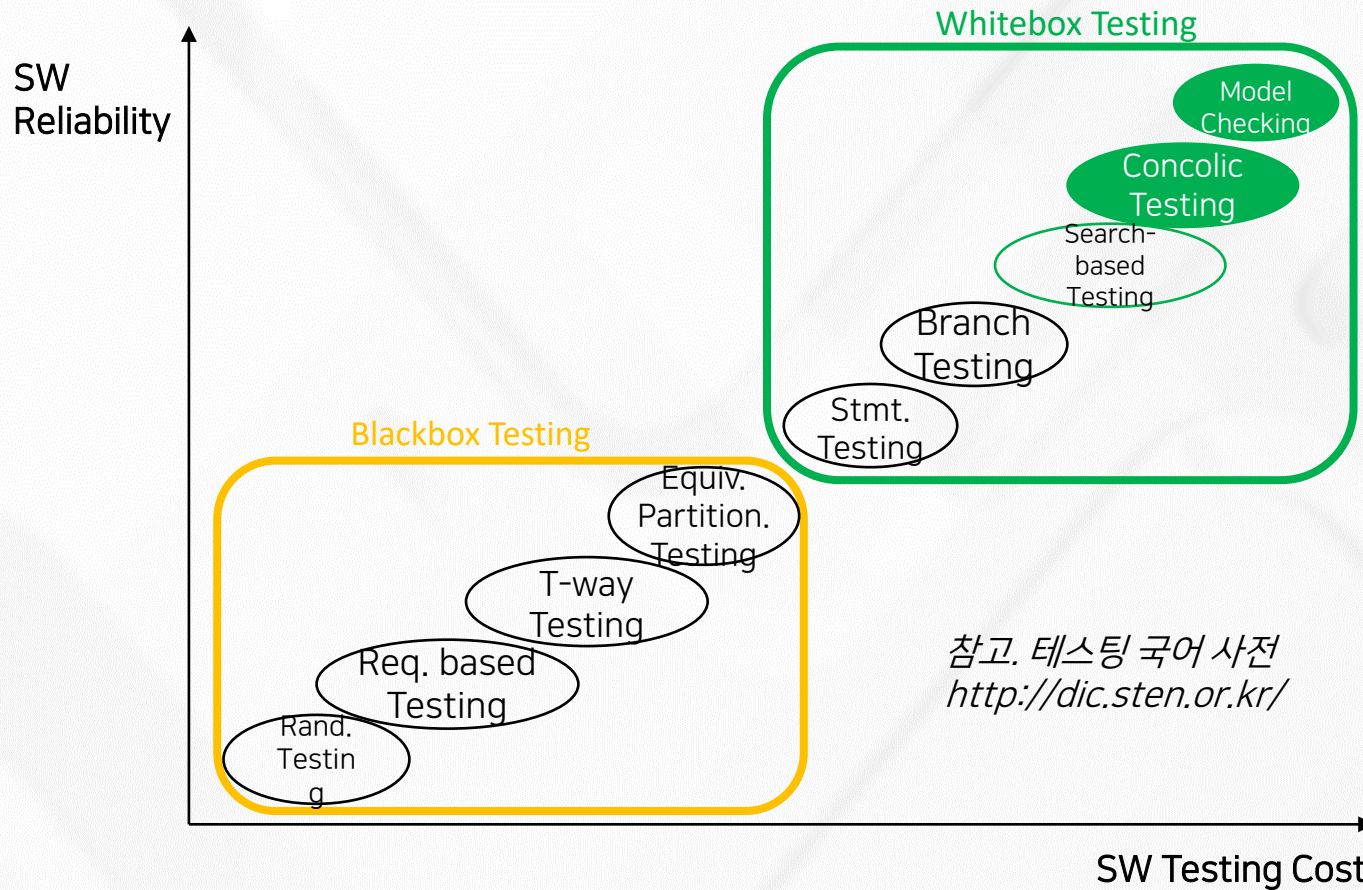
Multiple targets for software testing

1. Does the test cases represent the requirement spec correctly?
   → Scenario based testing (black-box testing)

2. Is the design spec implemented as program correctly?
   → Model-based testing (grey-box testing)

3. Does the program satisfy test cases correctly?
   → Code-based testing (white-box testing)

Black Box Testing

- A main goal of testing is <u>to generate multiple test cases,</u> one of which may reveal a bug.
- Black box testing concerns only input/output of a target program (i.e., ignore program code)
  - Ex1. Requirement specification based testing
  - Ex2. Random (input generation) testing
  - Ex3. Category partitioning method
  - Ex4. T-way testing
- Advantage of black box testing
  - Intuitive and simple
  - Requires little expertise on program/code analysis techniques
  - Requires less effort compared to white-box testing
    - cheaper but less effective

Moonzoo Kim **KAIST**

Various SW Testing Techniques w/ Different Cost and Effectiveness

SW Reliability

Whitebox Testing

Model Checking

Concolic Testing

Search-based Testing

Branch Testing

Stmt. Testing

Blackbox Testing

Equiv. Partition. Testing

T-way Testing

Req. based Testing

Rand. Testing

참고. 테스팅 국어 사전
http://dic.sten.or.kr/

SW Testing Cost

Requirement based Blackbox Testing VS Logic based Whitebox Testing

	Black Box Test	White Box Test
Def.	Functional test based on the requirement specification	Logical analysis based on target source code
View point	User	Developer
Bug detection criteria	Interface and/or performance problem	Logical problems
Verification & Validation level	High (user)	Low (testing)
Target bugs	Observable external errors	Internal errors due to logic problem, uncovered stmt.
Technique	Category partition, boundary value analysis, etc.	Loop, control structure test
Bug detection ability	Low	High
# of TC	Small	Large
Application	Beta test	Alpha test

If a requirement is specified as an `assert` statement requirement can be tested through whitebox texting

Example of Blackbox Testing Technique:

The Category-Partition Method for Specifying and Generating Functional Tests
(Thomas J. Ostrand and Marc J.Balcer [CACM,1988])

The original slides from Prof. Shmuel Sagiv's lecture notes
msagiv@post.tau.ac.il

Content:

- Introduction.
- The category-partition method:

    - characteristics.

    - the method.

    - examples.

- Other methods.

The goal of functional testing

- To find discrepancies between the **actual behavior** of the implemented system's function and the **desired behavior** as described in the system's functional specification.

How to achieve this goal ?

- Tests have to be execute for all the system functions.

- Tests have to be designed to maximize the chances of finding errors in the software.

Functional test can be derived <u>from 3 sources:</u>

1. The software specification.

2. Design information.

3. The code itself.

Partition - The standard approach

- The main idea is to **partition the input domain** of function being tested, and then **select test data for each class** of the partition.

- The problem of all the existing techniques is the **lack of systematic**.

Input domain

p1	p2
a	2 16
y	4
i	
p3	**p4**
1 3	z p
7	q

A strategy for test case generation

1. Transform the system's specification to be more concise and structured.

2. Decompose the specification into functional unit - to be tested independently.

3. Identify the parameters and environment conditions.

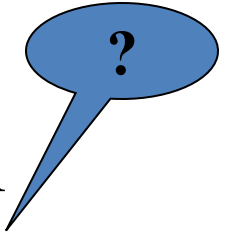# A strategy for test case generation (cont)

4. Find categories that characterize each paramet er and environment condition.

5. Every category should be partitioned into distin ct choices .

⇓

formal test specification

A strategy for test case generation (cont)

6. test frames - set of choices, one from **?**

$$\Downarrow$$ each category.

test cases - test frame with specific

values for each choices.

$$\Downarrow$$

test scripts - sequence of test cases.

Example

Command: find

Syntax: find <pattern> <file>

Function: The find command is used to locate one or
more instance of a given pattern in a text file. All lines in the file that contain the pattern are written to standard output. A line containing the pattern is written only once, regardless of the number of times the pattern occurs in it.

The pattern is any sequence of characters whose length does not exceed the maximum length of a line in the file .To include a blank in the pattern, the entire pattern must be enclosed in quotes (").To include quotation mark in the pattern , two quotes in a row (" ") must be used.

Example:

find john myfile

    display lines in the file **myfile** which contain **john**

find "john smith" in myfile

    display lines in the file **myfile** which contain **john smith**

find "john"" smith" in myfile

    display lines in the file **myfile** which contain **john" smith**

Categories

Parameters:

Pattern size:

empty
single character
many character
longer than any line in the file

4

Quoting:

pattern is quoted
pattern is not quoted
pattern is improperly quoted

3

Embedded blanks:

no embedded blank
one embedded blank
several embedded blanks

3

Embedded quotes:

no embedded quotes
one embedded quotes
several embedded quotes

3

File name:

good file name
no file with this name
omitted

3

Total Tests frames:
1944 (=4*3*3*3*3*3*2)

Environments:

Number of occurrence of pattern in file:

none
exactly one
more than one

3

Pattern occurrences on target line:

one
more than one

2

Adding Constraints between Categories to Reduce #of TC'S

Parameters:

Pattern size:

empty	[property Empty]
single character	[property NonEmpty]
many character	[property NonEmpty]
longer than any line in the file	[property NonEmpty]

Quoting:

pattern is quoted	[property Quoted]
pattern is not quoted	[if NonEmpty]
pattern is improperly quoted	[if NonEmpty]

Embedded blanks:

no embedded blank	[if NonEmpty]
one embedded blank	[if NonEmpty and Quoted]
several embedded blanks	[if NonEmpty and Quoted]

Embedded quotes:
   no embedded quotes   [if NonEmpty]
   one embedded quotes   [if NonEmpty]
   several embedded quotes   [if NonEmpty]

File name:
   good file name
   no file with this name
   omitted

Environments:
  Number of occurrence of pattern in file:
   none   [if NonEmpty]
   exactly one   [if NonEmpty] [property Match]
   more than one   [if NonEmpty] [property Match]

  Pattern occurrences on target line:
   one   [if Match]
   more than one   [if Match]

Total Tests frames:
678

Parameters:

Pattern size:

empty	[property Empty]
single character	[property NonEmpty]
many character	[property NonEmpty]
longer than any line in the file	[error]

Quoting:

pattern is quoted	[property quoted]
pattern is not quoted	[if NonEmpty]
pattern is improperly quoted	[error]

Embedded blanks:

no embedded blank	[if NonEmpty]
one embedded blank	[if NonEmpty and Quoted]
several embedded blanks	[if NonEmpty and Quoted]

Embedded quotes:

    no embedded quotes   [if NonEmpty]

    one embedded quotes   [if NonEmpty]

    several embedded quotes   [if NonEmpty]

File name:

    good file name

    no file with this name   [error]

    omitted

Total Tests frames: 125

Environments:

  Number of occurrence of pattern in file:

    none   [if NonEmpty]

    exactly one   [if NonEmpty] [property Match]

    more than one   [if NonEmpty] [property Match]

  Pattern occurrences on target line:

   one   [if Match]

    more than one   [if Match]

White Box Testing (1/2)

- White box testing concerns program code itself
- Many different viewpoints on "program code"
  - program code as a graph (i.e., structural coverage)
  - program code as a set of logic formulas (i.e., logical coverage)
  - program code as a set of execution paths (i.e., behavioral/dynamic coverage)
- Advantages:
  - More effective than blackbox testing in general
  - Can measure the testing progress quantitatively based on coverage achieved
- Should be used with blackbox testing together for maximal bug detection capability
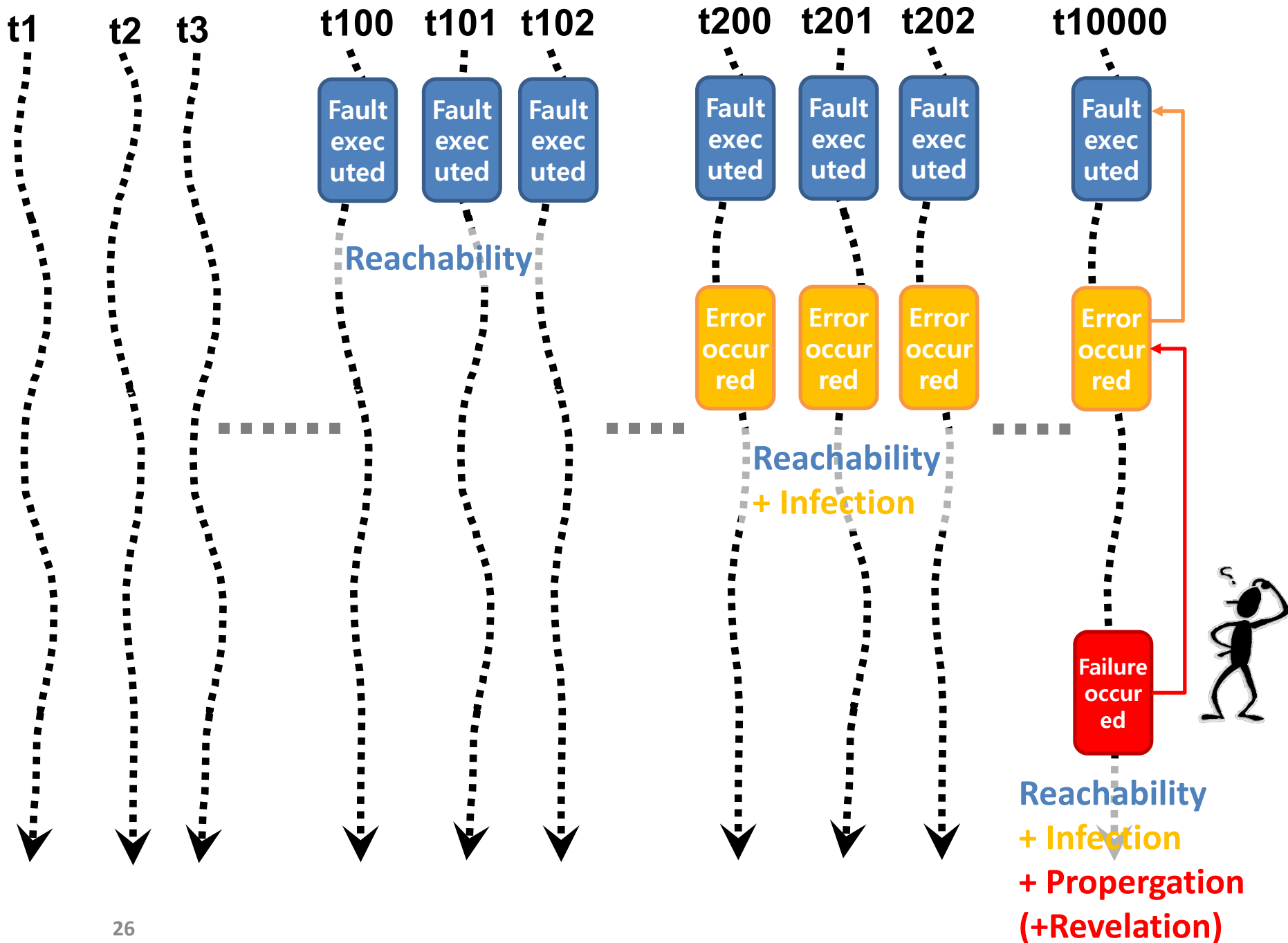 - Blackbox testing and whitebox testing often explore different segments of target program space

Moonzoo Kim

White Box Testing (2/2)

- Coverage is a good predictor/indicator of testing effectiveness
  - Utilizing correlation between structural coverage and fault detection ability
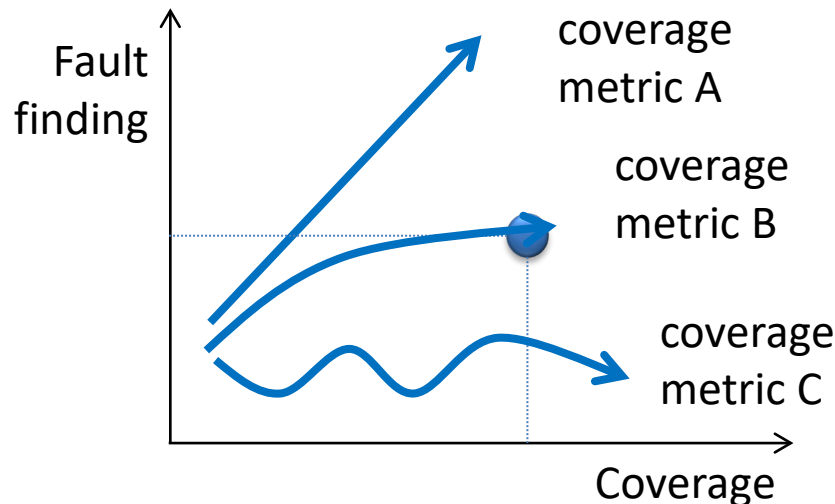
Bug Observability/Detection Model: **R**eachability, **I**nfection, **P**ropagation, and **R**evelation (RIPR)

- Terminology
  - Fault: static defect in a program text (a.k.a a bug)
  - Error: dynamic (intermediate) behavior that deviates from its (internal) intended goal
    - A fault causes an error (i.e. error is a symptom of fault)
  - Failiure: dynamic behavior which violates a ultimate goal of a target program
    - Not every error leads to failure due to error masking or fault tolerance

- Graph coverage
  - Test requirement satisfaction == Reachability
    - the fault in the code has to be reached
- Logic coverage
  - Test requirement satisfaction
    == Reachability +Infection
    - the fault has to put the program into an error state.
      - Note that a program is in an error state does not mean that it will always produce the failure
- Mutation coverage
  - Test requirement satisfaction
    == Reachability +Infection + Propagation
    - the program needs to exhibit incorrect outputs
- Furthermore, test oracle plays critical role to reveal failure of a target program (Revelation)

t1 t2 t3 t100 t101 t102 t200 t201 t202 t10000

Fault executed

Reachability

Error occurred

Reachability
+ Infection

Failure occured

Reachability
+ Infection
+ Propergation
(+Revelation)

26

사용자 관점의 테스트 방법, Black Box Test

기법	설명
동등 분할 기법 (Equivalence Partitioning)	프로그램의 입력 도메인을 테스트 케이스가 산출될 수 있는 데이터 클래스로 분류하는 방법
경계값분석기법 (Boundary Value Analysis)	입력 조건의 중간 값보다 경계 값에서 에러가 발생 될 확률이 높다는 점을 이용하여 테스트 케이스를 생성
오류 예측 기법 (Error Guessing)	각 시험 기법들이 놓치기 쉬운 오류들을 감각 및 경험으로 찾아보는 방법
원인 결과 그래프 기법 (Cause Effect Graph)	입력 데이터 간 관계가 출력에 미치는 영향을 그래프로 표현하여 오류를 발견하도록 함
의사결정 테이블 테스팅	논리적 조건이나 상황에서 입력 조건과 결과를 참, 거짓으로 표현하여 조합을 만들고 테스트케이스를 작성
상태전이 테스팅	시스템에 반영되는 이전의 상태가 무엇인지, 상태간 전이, 상태를 변화시키는 이벤트와 입력값을 파악

Parameters:

Pattern size:

  empty   [property Empty]

  single character   [property NonEmpty]

  many character   [property NonEmpty]

  longer than any line in the file   [error]

Quoting:

  pattern is quoted   [property quoted]

  pattern is not quoted   [if NonEmpty]

  pattern is improperly quoted   [error]

Embedded blanks:

  no embedded blank   [if NonEmpty]

  one embedded blank   [if NonEmpty and Quoted]

  several embedded blanks   [if NonEmpty and Quoted]

Embedded quotes:

  no embedded quotes   [if NonEmpty]

  one embedded quotes   [if NonEmpty]

  several embedded quotes   [if NonEmpty]   [single]

File name:

  good file name

  no file with this name   [error]

  omitted

Environments:

  Number of occurrence of pattern in file:

  none   [if NonEmpty]   [single]

  exactly one   [if NonEmpty] [property Match]

  more than one   [if NonEmpty] [property Match]

  Pattern occurrences on target line:

  one   [if Match]

  more than one   [if Match]   [single]

Total Tests frames: 40