قطعه‌بندی فضای دامنه

محمد تنهایی

Input Domains

The **input domain** to a program contains all the possible inputs to that program

For even small programs, the input domain is so large that it might as well be **infinite**

Testing is fundamentally about **choosing finite sets** of values from the input domain

Input parameters define the scope of the input domain

- Parameters to a method
- Data read from a file
- Global variables
- User level inputs

Domain for each input parameter is **partitioned into regions**

At least **one value** is chosen from each region

Benefits of ISP

Can be **equally applied** at several levels of testing

- Unit
- Integration
- System

Relatively easy to apply with **no automation**

Easy to **adjust** the procedure to get more or fewer tests

No **implementation knowledge** is needed

- just the input space

Partitioning Domains

Domain $\boldsymbol{D}$

Partition scheme $\boldsymbol{q}$ of $\boldsymbol{D}$

The partition $\boldsymbol{q}$ defines a set of blocks, $\boldsymbol{Bq = b_1, b_2, \ldots b_Q}$

The partition must satisfy two **properties** :

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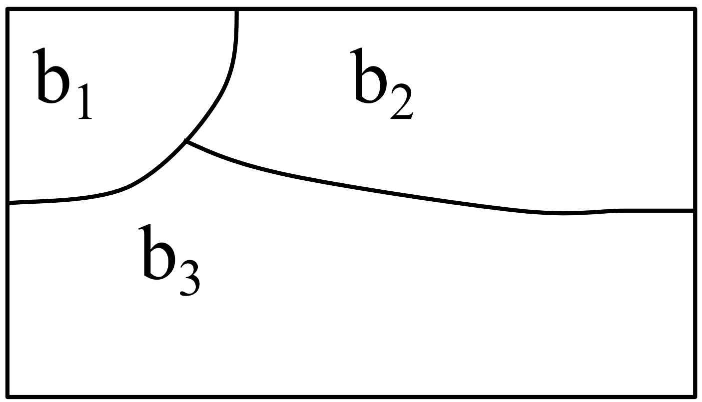

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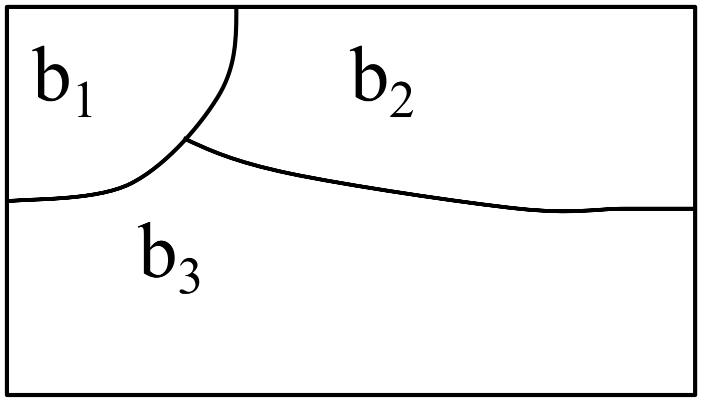

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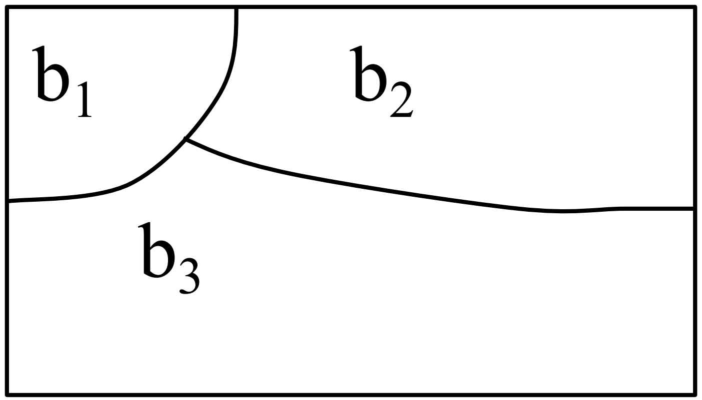

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$$\boxed{\bigcup_{b \in Bq} b = D}$$

Using Partitions – Assumptions

Choose a **value** from each partition

Each value is assumed to be **equally useful** for testing

Application to testing

- Find **characteristics** in the inputs : parameters, semantic descriptions, ...
- **Partition** each characteristics
- **Choose tests** by combining values from characteristics

Example **Characteristics**

- Input X is null
- Order of the input file F (sorted, inverse sorted, arbitrary, ...)
- Min separation of two aircraft
- Input device (DVD, CD, VCR, computer, ...)

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File F sorted ascending

- b1 = true
- b2 = false

File F sorted descending

- b1 = true
- b2 = false

Properties of Partitions

If the partitions are not **complete** or **disjoint**, that means the partitions have not been considered carefully enough

They should be reviewed carefully, like any **design** attempt

Different **alternatives** should be considered

We model the input domain in **five steps** ...

Two Approaches to Input Domain Modeling

1. **Interface-based** approach

   Develops characteristics directly from **individual input** parameters

   Simplest application

   Can be **partially automated** in some situations

2. **Functionality-based** approach

   Develops characteristics from a **behavioral view** of the program under test

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Input Domain Model (IDM)

1. Interface-Based Approach

Mechanically consider each parameter in isolation

This is an easy modeling technique and relies mostly on **syntax**

Some domain and semantic information won't be used

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Three *int* parameters

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Three *int* parameters

IDM for each parameter is identical

Reasonable characteristic : *Relation of side with zero*

2. Functionality-Based Approach

Identify characteristics that correspond to the intended functionality

Requires more **design effort** from tester

Can incorporate **domain** and **semantic** knowledge

Can use **relationships** among parameters

Modeling can be based on **requirements**, not implementation

The same parameter may appear in multiple characteristics, so it’s **harder** to translate values to test cases

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The three parameters represent a *triangle*

IDM can combine all parameters

Reasonable characteristic : *Type of triangle*

Interface-Based IDM – TriTyp

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First Characterization of TriTyp's Inputs

Characteristic	b_1	b_2	b_3
q_1 = "Relation of Side 1 to 0"	greater than 0	equal to 0	less than 0
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Possible values for partition q_1

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Test boundary conditions

12

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Correct Geometric Characterization of TriTyp's Inputs

Characteristic	b_1	b_2	b_3	b_4
q_1 = "Geometric Classification"	scalene	isosceles, not equilateral	equilateral	invalid

Functionality-Based IDM – TriTyp (*cont*)

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Possible values for geometric partition q_1

Characteristic	b_1	b_2	b_3	b_4
Triangle	(4, 5, 6)	(3, 3, 4)	(3, 3, 3)	(3, 4, 8)

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Four Characteristics for TriTyp

Characteristic	b_1	b_2
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q_2 = "Isosceles"	True	False
q_3 = "Equilateral"	True	False
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- Use **constraints** to ensure that
  - Equilateral = True implies Isosceles = True
  - Valid = False implies Scalene = Isosceles = Equilateral = False

Modeling the Input Domain

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Step 1：Identify testable **functions**

- Individual **methods** have one testable function
- In a **class**, each method has the same characteristics
- **Programs** have more complicated characteristics—modeling documents such as UML use cases can be used to design characteristics
- **Systems** of integrated hardware and software components can use devices, operating systems, hardware platforms, browsers, etc

Step 2：Find all the **parameters**

- Often fairly **straightforward**, even mechanical
- Important to be **complete**
- **Methods**：Parameters and state (non-local) variables used
- **Components**：Parameters to methods and state variables
- **System**：All inputs, including files and databases

Modeling the Input Domain (*cont*)

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Step 3 : Model the **input domain**

- The domain is scoped by the **parameters**
- The structure is defined in terms of **characteristics**
- Each characteristic is **partitioned** into sets of **blocks**
- Each block represents a set of **values**
- This is the most **creative design step** in applying ISP

Step 4 : Apply a test **criterion** to choose **combinations** of values

- A test input has a **value** for each parameter
- One **block** for each characteristic
- Choosing **all combinations** is usually infeasible
- Coverage criteria allow **subsets** to be chosen

Step 5 : Refine combinations of blocks into **test inputs**

- Choose **appropriate values** from each block

Steps 1 & 2 – Identifying Functionalities, Parameters and Characteristics

A creative engineering step

More characteristics means more tests

Interface-based : Translate parameters to characteristics

Candidates for characteristics :

- Preconditions and postconditions
- Relationships among variables
- Relationship of variables with special values (zero, null, blank, ...)

Should **not** use program source – characteristics should be based on the **input domain**

- Program source should be used with graph or *logic* criteria

Better to have **more characteristics** with **few blocks**

- Fewer mistakes and fewer tests

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Functionality-Based Approach

Two parameters : list, element

Characteristics :

- number of occurrences of element in list
  - (0, 1, >1)
- element occurs first in list
  - (true, false)
- element occurs last in list
  - (true, false)

Step 3 : Modeling the Input Domain

Partitioning characteristics into blocks and values is a very **creative engineering** step

More blocks means more tests

The partitioning often flows directly from the definition of **characteristics** and both steps are sometimes done together

- Should **evaluate** them separately – sometimes fewer characteristics can be used with more blocks and vice versa

Strategies for identifying values :

- Include valid, invalid and special values
- Sub-partition some blocks
- Explore boundaries of domains
- Include values that represent “normal use”
- Try to balance the number of blocks in each characteristic
- Check for completeness and disjointness

Using More than One IDM

Some programs may have dozens or even hundreds of parameters

Create several small IDMs

- A divide-and-conquer approach

Different parts of the software can be tested with different amounts of rigor

- For example, some IDMs may include a lot of invalid values

It is okay if the different IDMs overlap

- The same variable may appear in more than one IDM

Step 4 – Choosing Combinations of Values

Once characteristics and partitions are defined, the next step is to **choose test values**

We use **criteria** – to choose effective subsets

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For TriTyp: Base	2, 2, 2	2, 2, 1	2, 1, 2	1, 2, 2
		2, 2, 0	2, 0, 2	0, 2, 2
		2, 2, -1	2, -1, 2	-1, 2, 2

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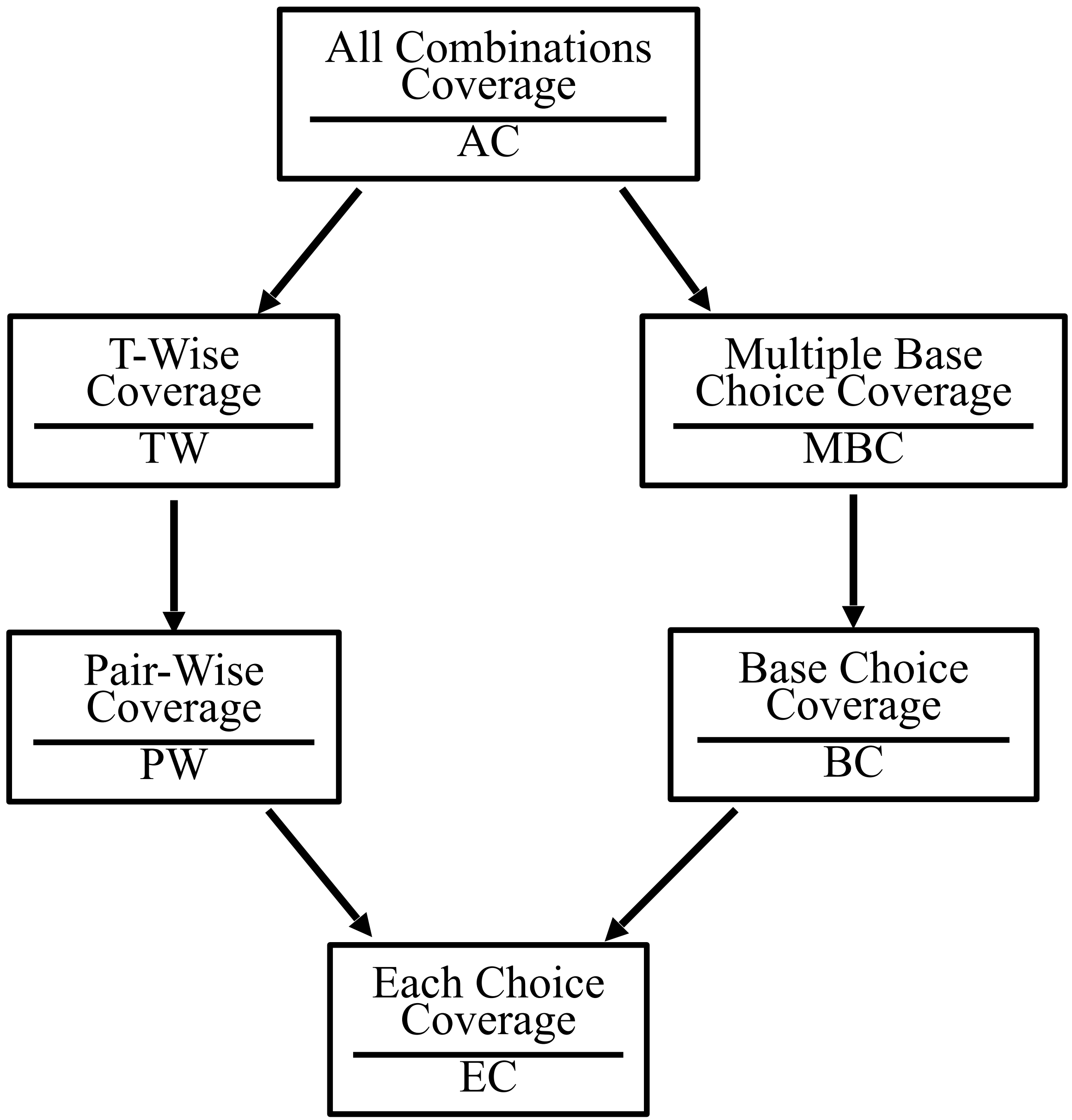
	1, 1, -1	1, -1, 1	-1, 1, 1
	1, 1, 2	1, 2, 1	2, 1, 1

ISP Coverage Criteria Subsumption



Constraints Among Characteristics

- Some combinations of blocks are **infeasible**
  - "less than zero" and "scalene" ... not possible at the same time
- These are represented as **constraints** among blocks
- Two general types of constraints
  - A block from one characteristic **cannot be** combined with a specific block from another
  - A block from one characteristic can **ONLY BE** combined with a specific block form another characteristic
- Handling constraints depends on the criterion used
  - **AC, PW, TW** : Drop the infeasible pairs
  - **BC, MBC** : Change a value to another non-base choice to find a feasible combination

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Based only on the **input space** of the program, not the implementation

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