# Input Space Partitioning

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# Outcomes

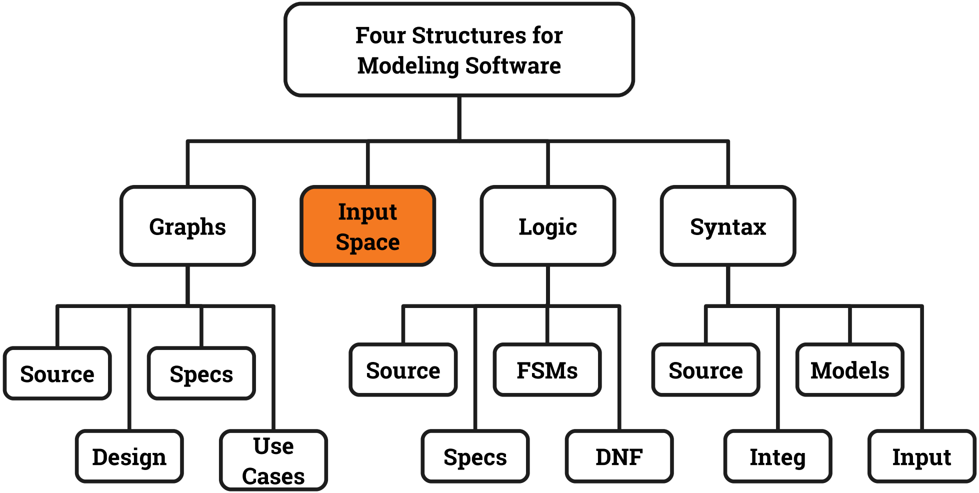
At the end of Today's Lecture you will be able to:

- Understand the basics of ISP
- To partition an input domain
- Model an input domain
- Understand parameters and their characteristics
- Understand multiple ISP based criteria

# Inspiration

“Just because you’ve counted all the trees doesn’t mean you’ve seen the forest.” – Anonymous

# Input Space Coverage



# Benefits of ISP

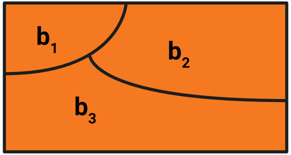
- Can be **equally applied** at several levels of testing
  - Unit
  - Integration
  - System
- Relatively easy to apply with **no automation**
- Easy to **adjust** the procedure to get more or fewer tests
- No **implementation knowledge** is needed
  - Just the input space

# Input Domains

- The **input domain** for 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
- Input domains are **partitioned into regions** (blocks)
- At least **one value** is chosen from each block

# Partitioning Domains

- Domain $D$
- Partition Scheme $q$ of $D$
- The partition $q$ defines a sets of blocks, $B_q = b_1, b_2, \ldots, b_q$
- The partition must satisfy two **properties**:
  1. **Disjoint** (no overlap): $b_i \cap b_j = \varnothing, \forall i \neq j, b_i, b_j \in B_q$
  2. **Coverage** (all blocks cover the domain $D$): $\bigcup_{b \in B_q} b = D$



# In Class Exercise

Design a partitioning for all integers. That is, partition integers into blocks such that each block seems to be equivalent in terms of testing.

Make sure your partition is valid:

1. Pairwise disjoint
2. Complete

# Using Partitions - Assumptions

- Choose a **value** from each block
- Each value is assumed to be **equally useful** for testing
- Application to testing
  - Find **characteristics** in the inputs: parameters, semantic descriptions, ...
  - **Partition** each characteristic
  - **Choose tests** by combining values from characteristics
- Example **Characteristics**
  - Whether input X is null
  - Order of the input list F (sorted, inverse sorted, arbitrary, ...)
  - Min separation of two aircraft
  - Input device (DVD, CD, VCR, computer, ...)
  - Hair color, height, major, age

# Choosing Partitions

- Choosing (or defining) **partitions** seems easy, but is easy to get wrong
- Consider the characteristic "**order of elements in list F**"

$b_1$ = sorted in ascending order
$b_2$ = sorted in descending order
$b_3$ = arbitrary order

but ... something's fishy
Length 1 : [ 14 ]
The list will be in all three blocks
That is, disjointness is not satisfied

**Solution:**
Each characteristic should address just one property

- $C_1$: List F sorted ascending
  - $c_1.b_1 = true$
  - $c_1.b_2 = false$
- $C_2$: List F sorted descending
  - $c_2.b_1 = false$
  - $c_2.b_2 = true$

# Modeling the Input Domain

- **Step 1:** Identify testable **functions**
- **Step 2:** Find all **inputs & parameters**
  - Move from implementation level to design abstraction level
- **Step 3:** Model the **input domain**
  - Entirely at the design abstraction level
- **Step 4:** Apply a test **criterion** to choose **combinations** of values
  - Entirely at the design abstraction level
- **Step 5:** Refine combinations of blocks into **test inputs**
  - Back to the implementation abstraction level

# In Class Exercise

- Pick one of the programs from Chapter 1 (findLast, numZero, etc.)
- Create an IDM for your program
- Take 10 minutes

# 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** (list is not empty)
  - **Relationships** to constants and among variables ($x > 0, x \neq y$)
  - Based on software **behavior** (element is in the set)
- 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



ROAR

# Example IDM Based on Syntax

- Consider method `triang()` form class `TriangleType` in `Triangle.java` on Moodle

```
public enum Triangle { Scalene, Isosceles, Equilateral, Invalid }
public static Triangle triang(int Side1, int Side2, int Side3)
// Side1, Side2, and Side3 represent the lengths of the sides of a triangle
//Returns the appropriate enum value
```

The IDM for each parameter is identical
Reasonable characteristic: Relation of side with zero

# Example IDM Based on Behavior

- Again, consider method `triang()` from class `TriangleType`:
  - The three parameters represent a `triangle`
  - The IDM can combine all parameters
  - Reasonable characteristic: **type of triangle**

# In Class Exercise

- **Identify functionalities, parameters, and characteristics for** `findElement()`

```
public boolean findElement(List list, Object element)
// Effects: if list or element is null throw NullPointerException
//          else return true if element is in the list, false otherwise
```

# Steps 1&2–IDM

```
public boolean findElement(List list, Object element)
// Effects: if list or element is null throw NullPointerException
//          else return true if element is in the list, false otherwise
```

## Parameters and Characteristics

Two parameters: **list, element**
Characteristics based on syntax:

- **list** is null (block1 = true, block2 = false)
- **list** is empty (block1 = true, block2 = false)

Characteristics based on behavior:

- 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
- Partitioning often flows directly from the definition of **characteristics** and both steps are done together
  - Should **evaluate** them separately – sometimes fewer characteristics can be used with more blocks and vice versa

# Step 3

## Modeling the Input Domain, cont'd

- **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**

# triang() IDM based on Syntax

- `triang()` has one testable function and three integer inputs

## First Characterization of TriType's Inputs

| Characteristic | $b_1$ | $b_2$ | $b_3$ |
|---|---|---|---|
| $q_1$ = "Relation of Side 1 to 0" | > 0 | = 0 | < 0 |
| $q_2$ = "Relation of Side 2 to 0" | > 0 | = 0 | < 0 |
| $q_3$ = "Relation of Side 3 to 0" | > 0 | = 0 | < 0 |

# Are there any questions?