CMPT 473
Software Quality Assurance

Scale & Combinatorial Testing

Nick Sumner

Recall from Last Time

- Consider our triangle classifier
  - Takes 3 integers for sides 1, 2, & 3

Characteristic	b1	b2	b3
Side 1 <?> 0	Side 1 > 0	Side 1 = 0	Side 1 < 0
Side 2 <?> 0	Side 2 > 0	Side 2 = 0	Side 2 < 0
Side 3 <?>0	Side 3 > 0	Side 3 = 0	Side 3 < 0

3 guiding questions…

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What won't this test well?

Recall from Last Time (part 2)

- We can subdivide partitions to cover more behavior

Characteristic	b1	b2	b3	b4
Value of side 1	Side 1 > 1	Side 1 = 1	Side 1 = 0	Side 1 < 0
Value of side 2	Side 2 > 1	Side 2 = 1	Side 2 = 0	Side 2 < 0
Value of side 3	Side 3 > 1	Side 3 = 1	Side 3 = 0	Side 3 < 0

How many tests now?

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Suppose inputs or characteristics I_1, I_2, I_3, …, I_n

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- Find command: 4x3x3x3x3x3x2 = 1944 tests

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Too many to reasonably even create!

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```
  Pattern Size:
    Empty                             [Property Empty]
    Single character                  [Property NonEmpty]
    Many characters                   [Property NonEmpty]
    Longer than any line in the file  [Property NonEmpty]
```

```
  Quoting:
    Pattern is quoted                 [Property Quoted]
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    Pattern is improperly quoted      [If NonEmpty]
```

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  - [error] to identify when 1 test for a block is sufficient

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- What else might we do?
  - Not test as thoroughly (sampling)

Why might this be okay?

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  - Constraints
  - [property] to identify rules for useful tests
  - [error] to identify when 1 test for a block is sufficient
- What else might we do?
  - Not test as thoroughly (sampling)
  - Identify related variables/domains & test together

Why would this lead to fewer tests?

Choosing Combinations

Several possible strategies:

- All Combinations

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But is it inherently bad?

Combinations – Each Choice

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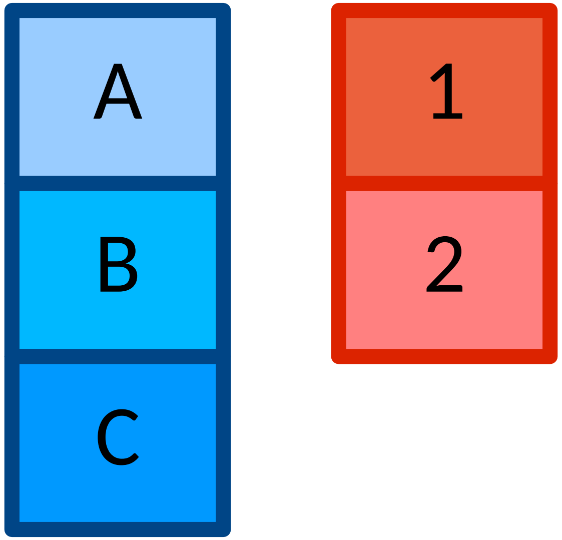


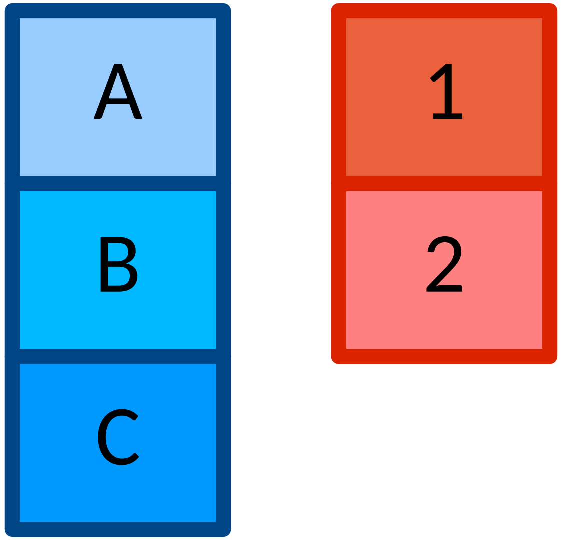
A
B
C

1
2

Adequate Tests:

Combinations – Each Choice

- How can we minimize #tests and still test each block?
- Each Choice
  - 1 value from each block used in at least one test



Adequate Tests:
(A,1), (B,2), (C,1)

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Are these tests *good*? Why?

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How many tests?

Combinations – Each Choice

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- Each Choice
  - 1 value from each block used in at least one test
  - # tests = maximum number of blocks

How many tests?

Why?

Combinations – ???

- Can we come up with a compromise?

Combinations – Pair Wise/All Pairs

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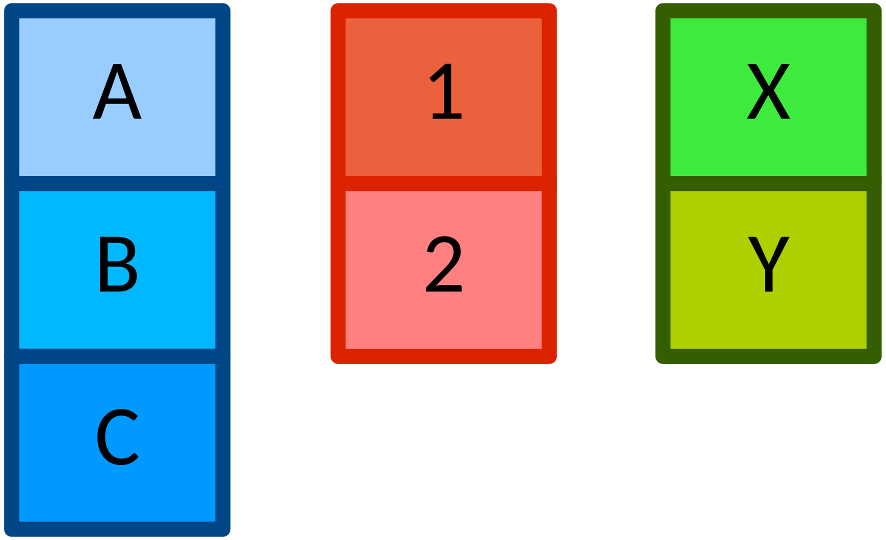
A
B
C
1
2
X
Y

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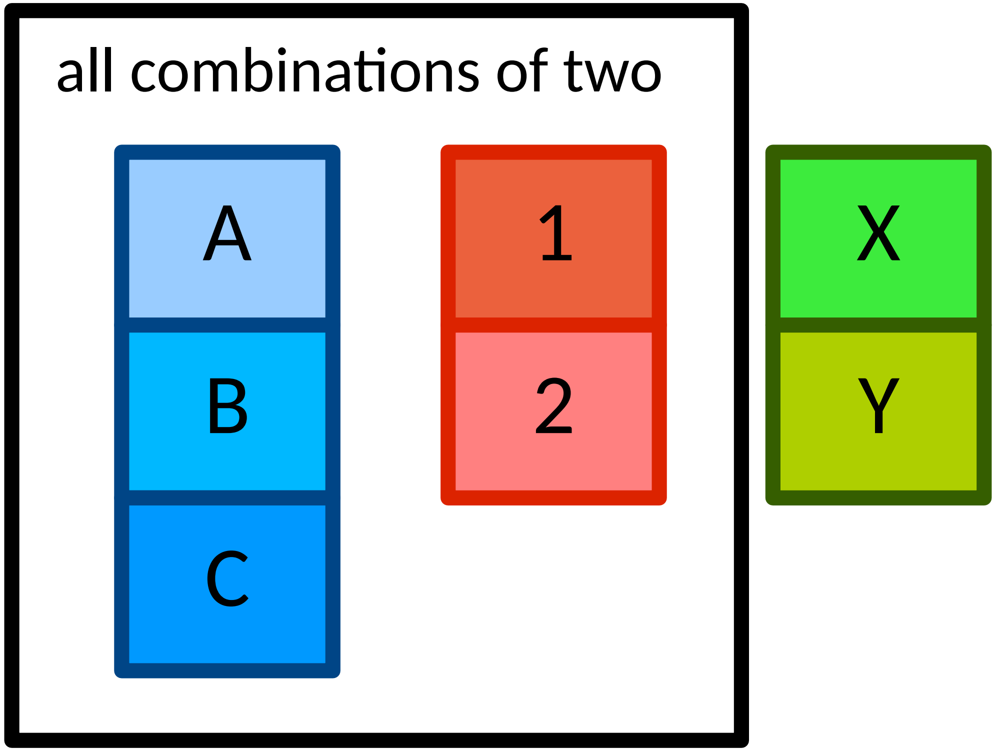

Adequate Tests:
(A,1,*), (A,2,*)
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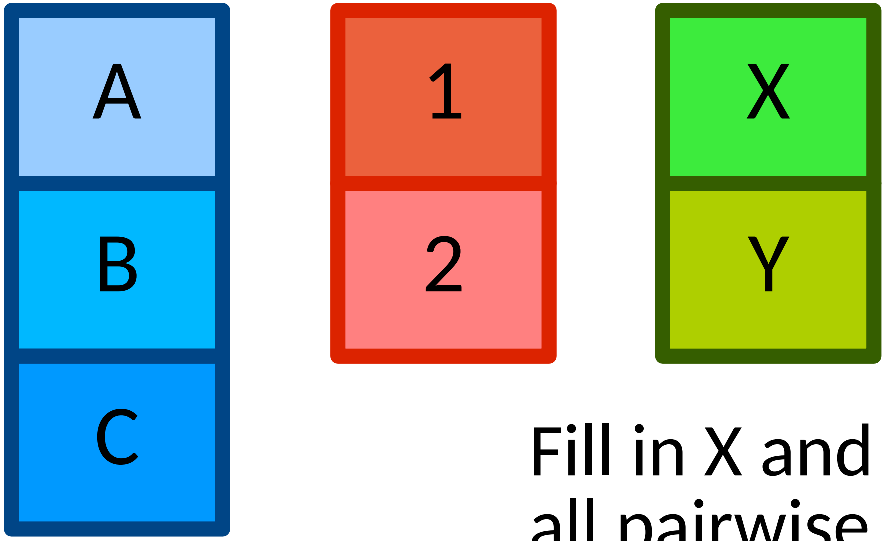

Adequate Tests:
(A,1,**X**), (A,2,**Y**)
(B,1,**Y**), (B,2,**X**)
(C,1,*), (C,2,*)

Fill in X and Y to make sure
all pairwise combos are tested!

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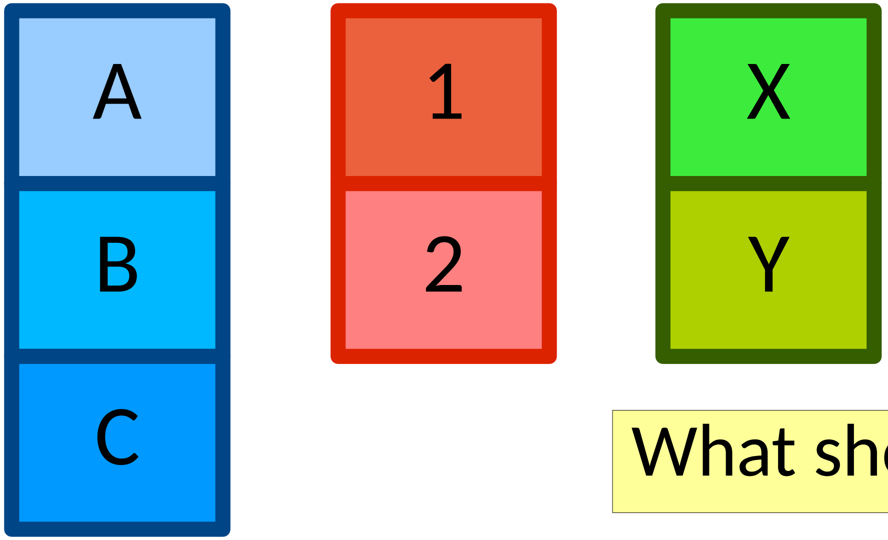

Adequate Tests:
(A,1,X), (A,2,Y)
(B,1,Y), (B,2,X)
(C,1,*), (C,2,*)

What should the last two be?

Combinations – Pair Wise/All Pairs

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How many tests?

Expected on the order of $|D_1|$ * $|D_2|$ * log(n)

Combinations - ???

- Can we extend this further?

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What happens as T increases?

Combinations – T-wise

- Can we extend this further?
- T-wise
  - 1 value from each block for each group of T characteristics
  - #tests ≥ product of T largest domain partitionings
  - Bounded by $(\text{max number of blocks})^{T}$
  - More expensive than pairs & uncertain gains

Combinations – T-wise

- Can we extend this further?
- T-wise
  - 1 value from each block for each group of T characteristics
  - #tests ≥ product of T largest domain partitionings
  - Bounded by (max number of blocks)^T
  - More expensive than pairs & uncertain gains

T is often called the *test strength*

Combinations – Base Choice

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  - What if we know that certain values are important?

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- Base Choice
  - Select a base test
  - Generate tests by changing only one block and taking other values from the base

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- Cho

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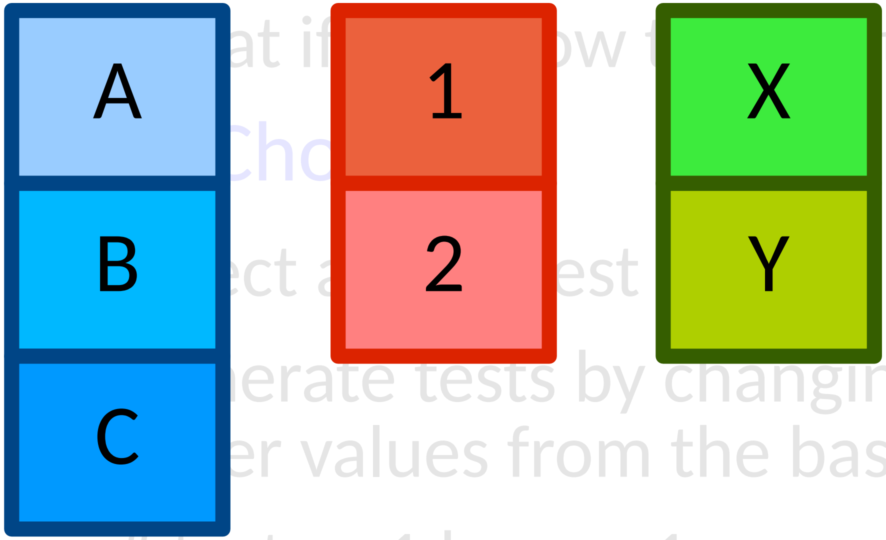
– # tests = 1 base + 1 per each other block



Base Test:

Adequate Tests:

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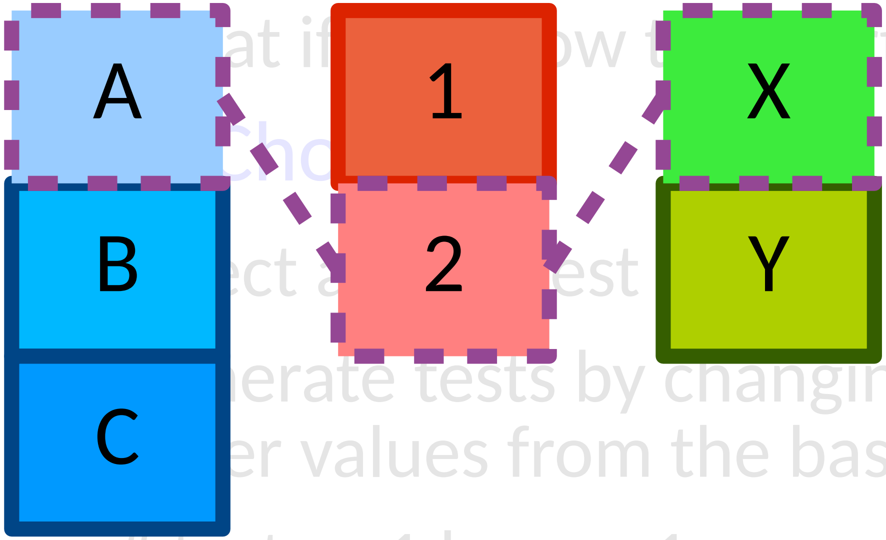

Base Test:
(A,2,X)

Adequate Tests:

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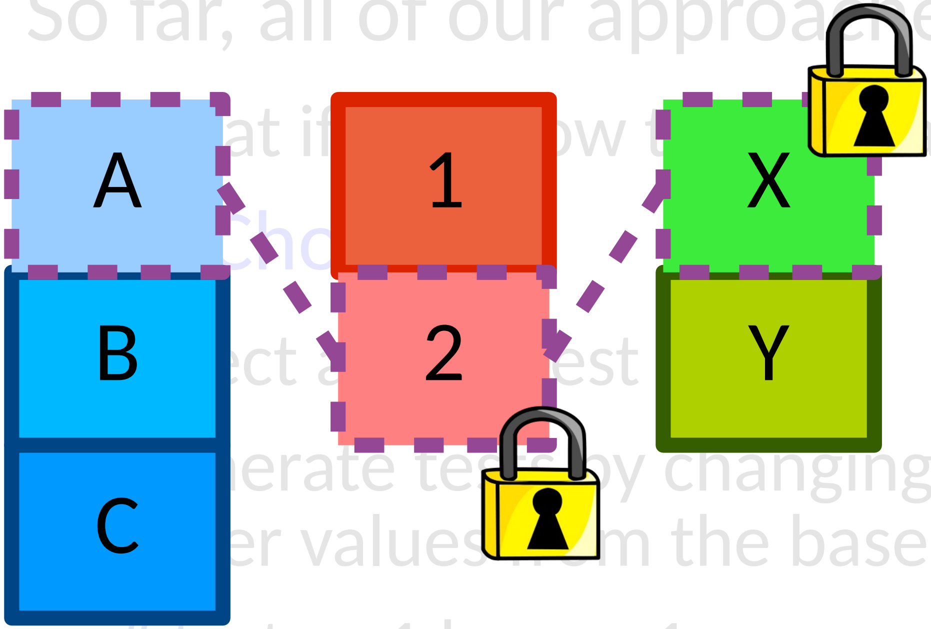

Base Test:
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Adequate Tests:
(B,2,X), (C,2,X)

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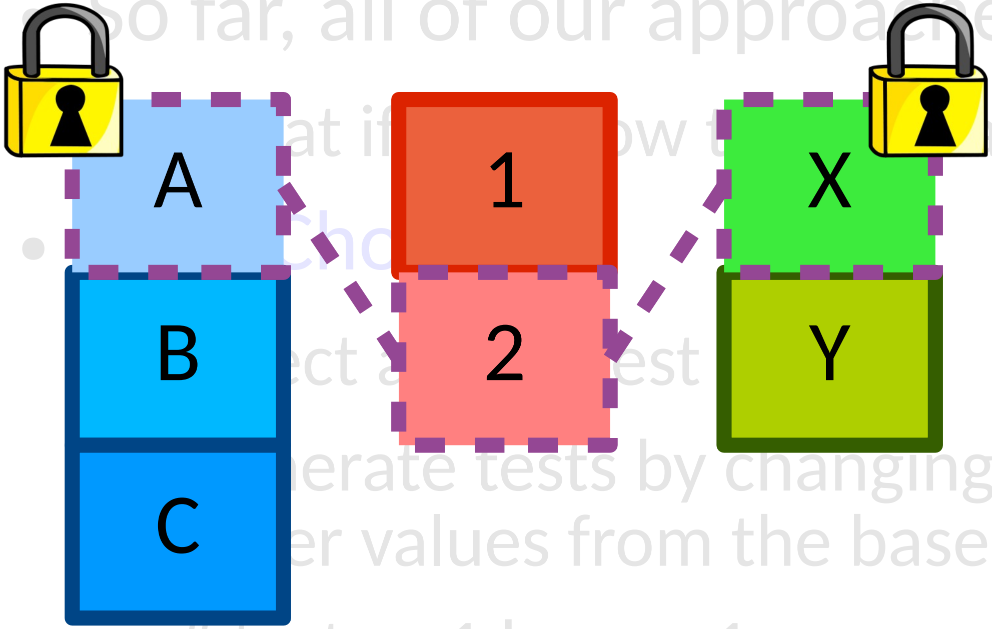

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(A,1,X)

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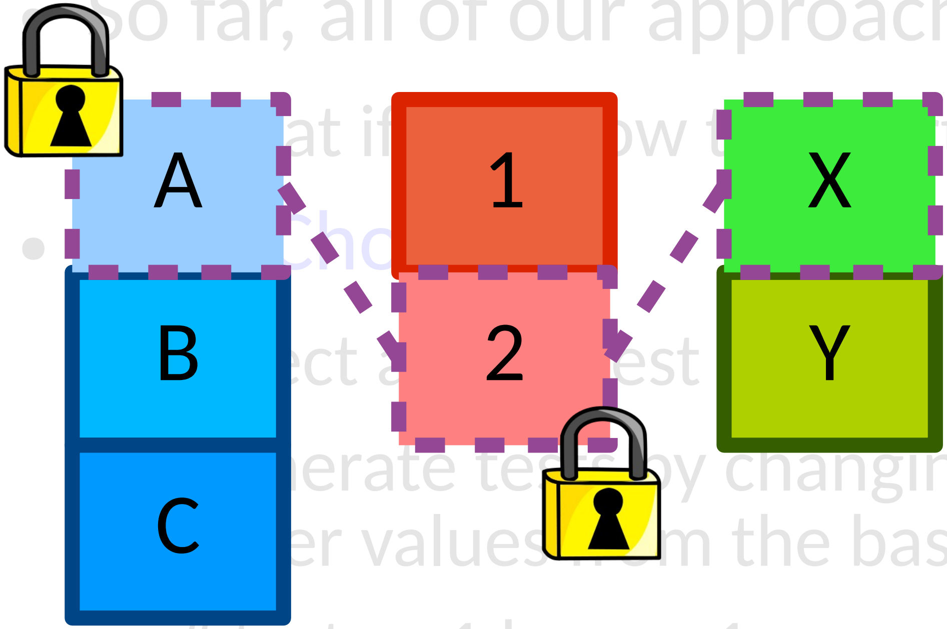

Base Test:
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Adequate Tests:
(B,2,X), (C,2,X)
(A,1,X)
(A,2,Y)

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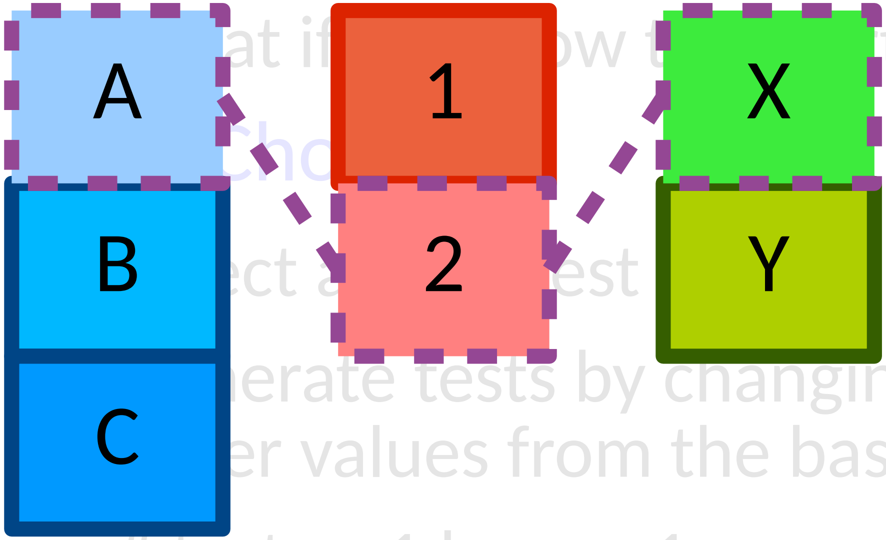

Base Test:
(A,2,X)

Adequate Tests:
(B,2,X), (C,2,X)
(A,1,X)
(A,2,Y)

Combinations – Base Choice

- So far, all of our approaches are domain agnostic
  - What if we know that certain values are important?
- Base Choice
  - Select a base test
  - Generate tests by changing only one block and taking other values from the base
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What does this look like for the triangle classifier?

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$$1 + \sum |D_i - 1|$$

Base Choices

Which test to use as a base is *crucial*

Why? What if we choose poorly?

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- Must at least be *feasible*
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How might we select a base test?

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- Guided by:
  - Most likely?
  - Simplest?
  - Smallest?
  - Etc.

Base Choices

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- Must at least be *feasible*
  - Do the combined values create a valid run?
- Guided by:
  - Most likely?
  - Simplest?
  - Smallest?
  - Etc.
- Decision must be well understood & well maintained

Combinations - ???

- ***Notice the pattern*.**
  - Can base choices be extended?

Combinations – Multiple Base Choice

- *Notice the pattern.*
  - Can base choices be extended?
- Multiple Base Choice
  - Select 1 or more base characteristics
  - Generate base tests by using each at least once
  - Change 1 block at a time to an unselected one just as before

M base tests:

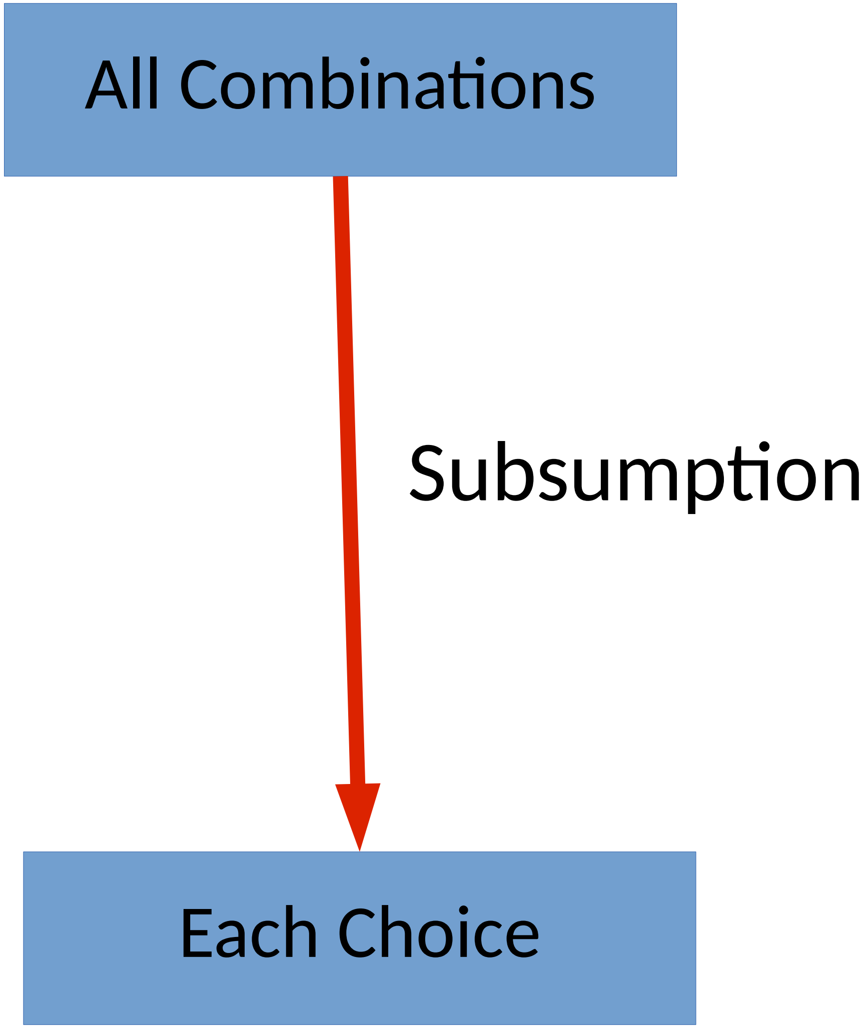
$$M * (1 + \sum |D_i\text{-}1|)$$

How Are They Related?

All Combinations

Each Choice

How Are They Related?



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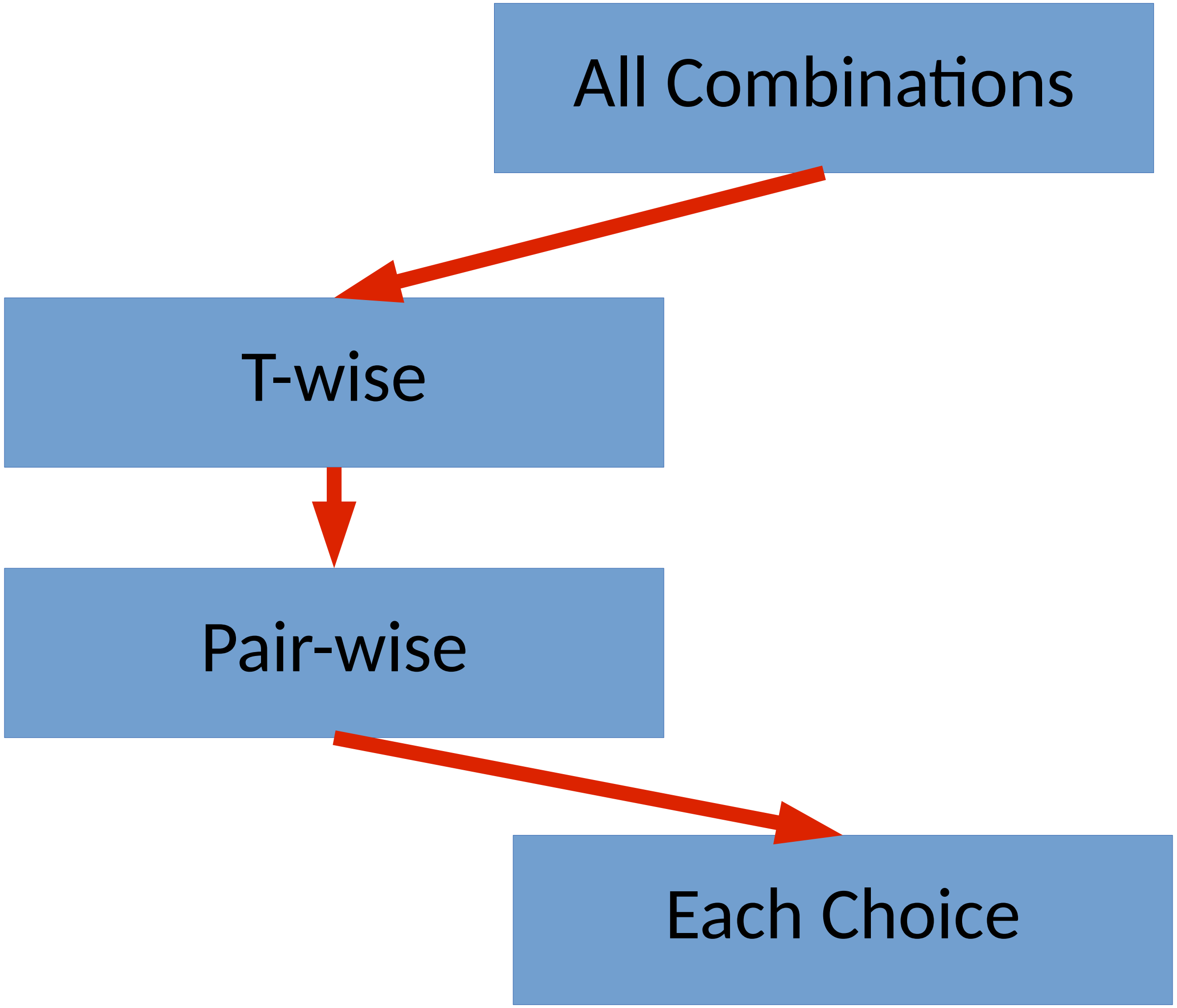

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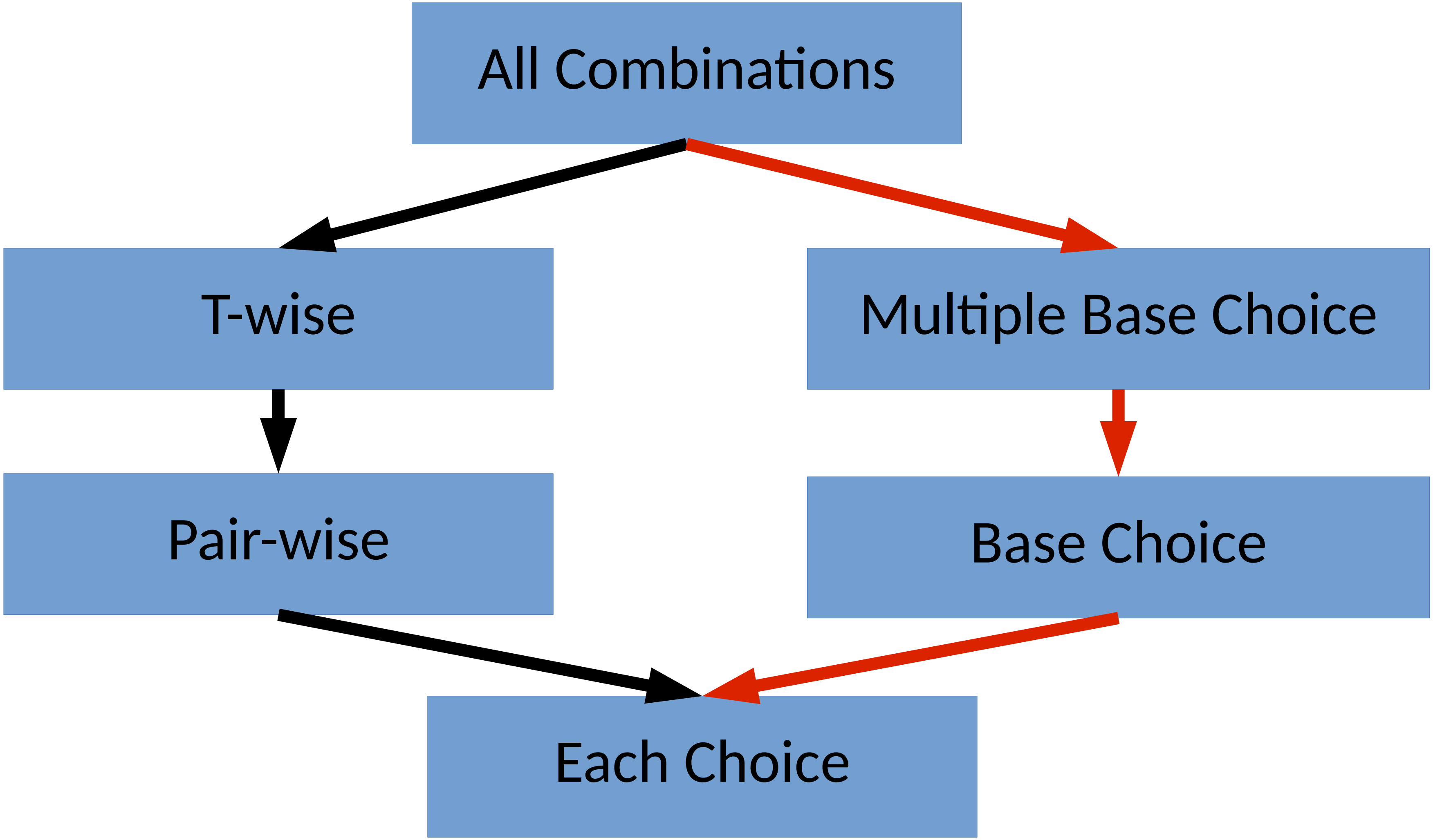


All Combinations

T-wise

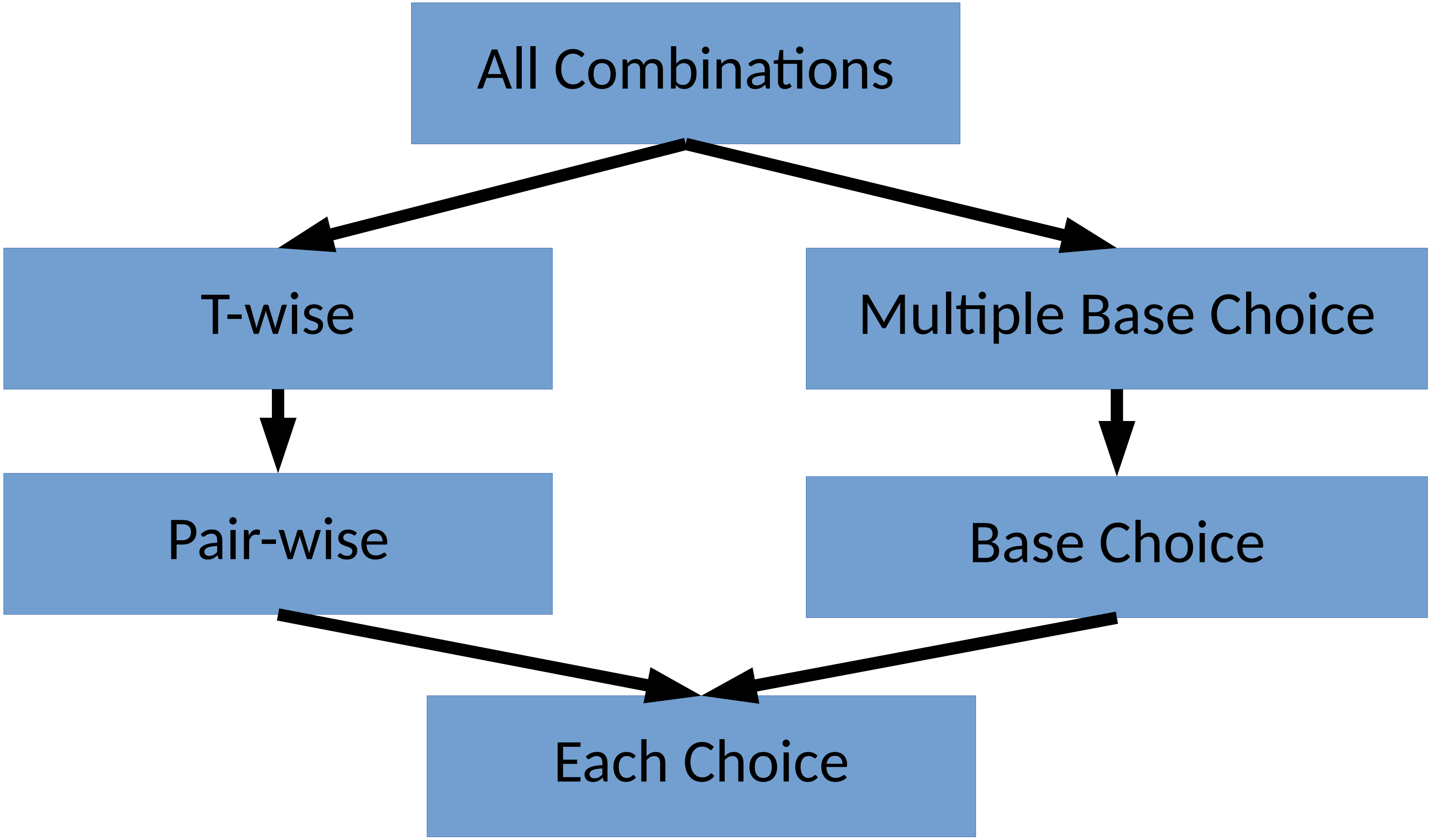
Multiple Base Choice

Pair-wise

Base Choice

Each Choice

How Are They Related?



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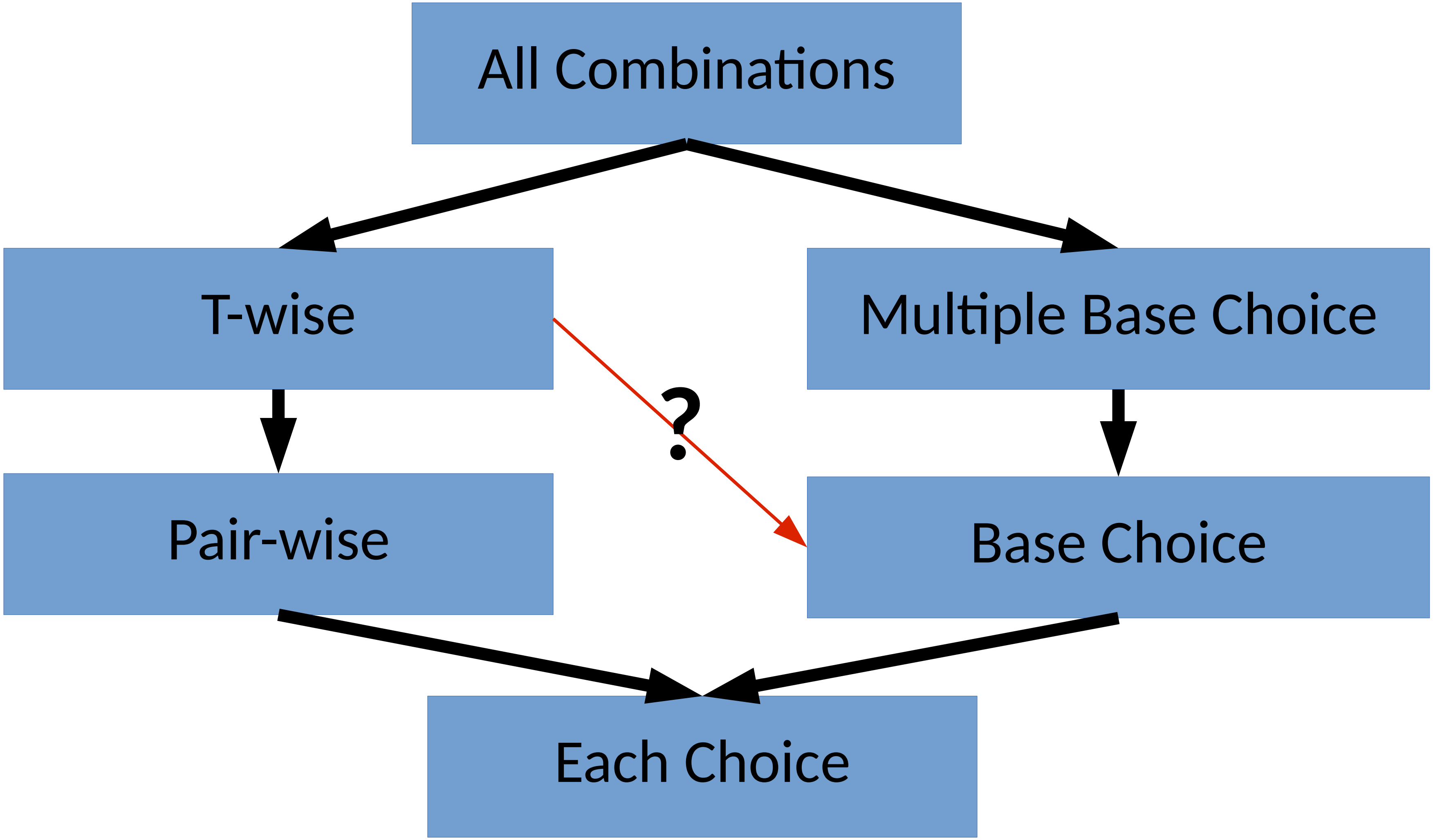

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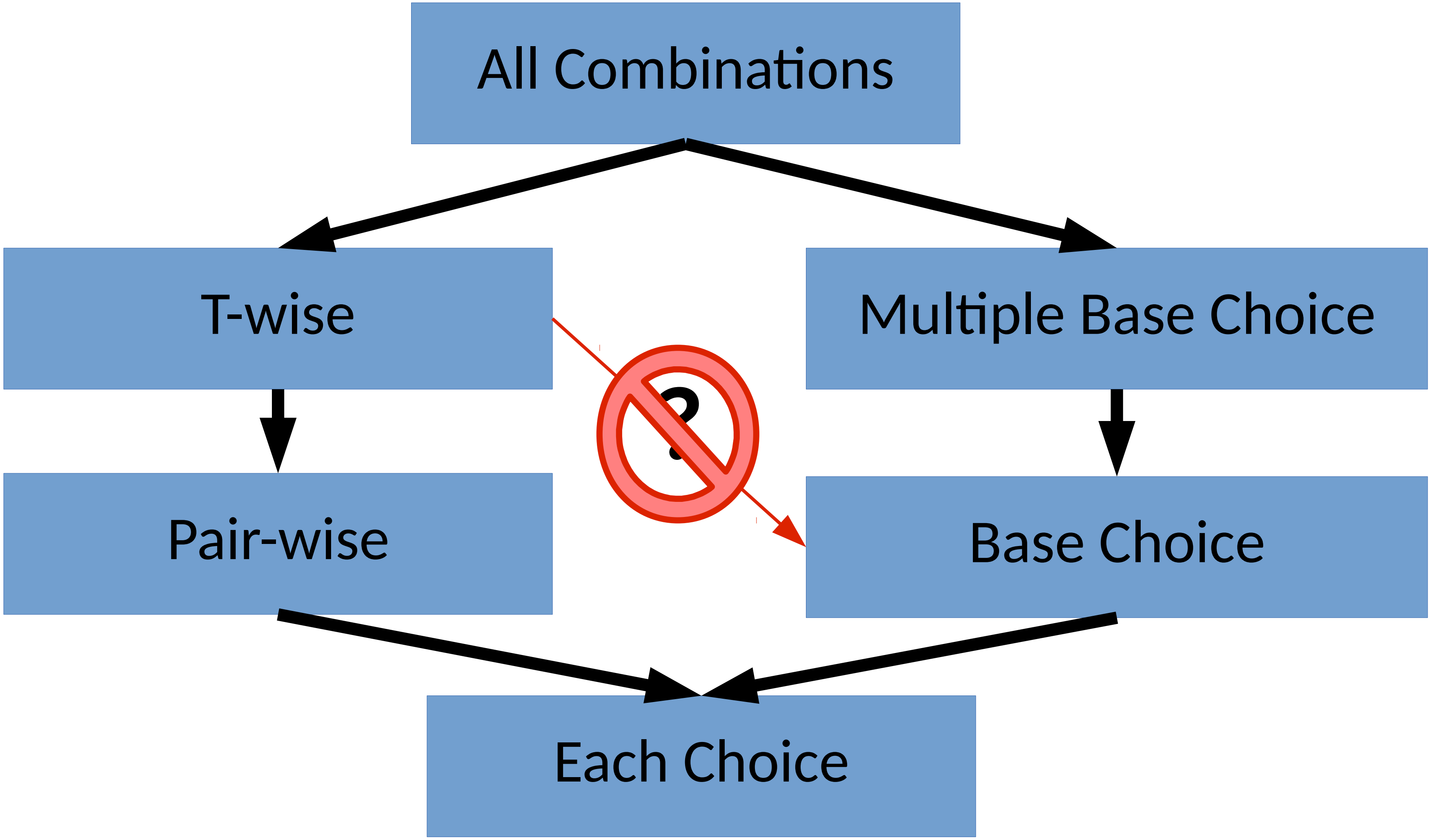

Remember the Constraints

- Constraints, and [error]s can reduce the # of tests further
  - No need to test invalid constraints
  - No need to test more than one [error]