Equivalence Class Testing

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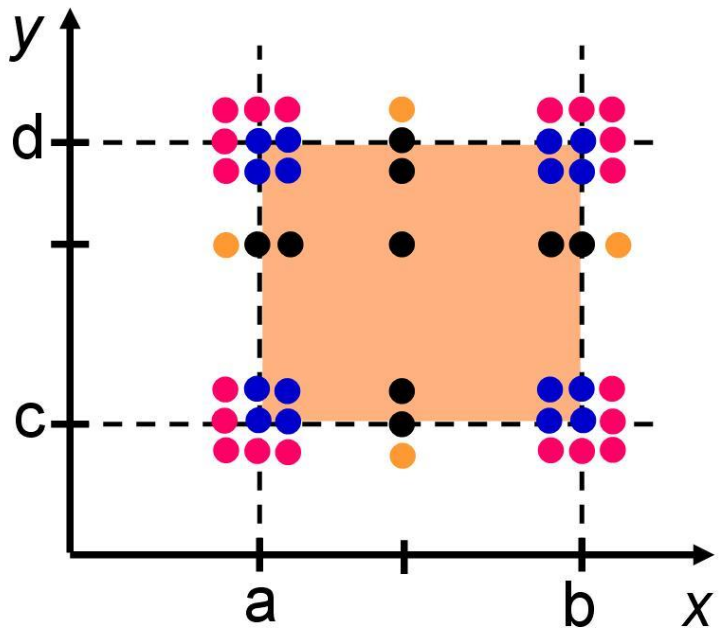
Outline

Functional Testing (recap)

- functional testing:
  program is an input from a certain domain to a certain range
- impossible to check all input/output combinations:
  need to choose some

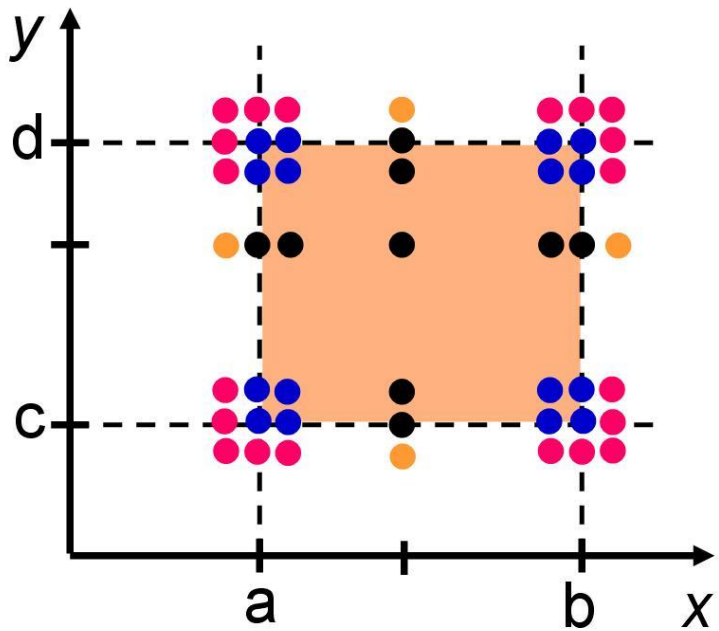
Boundary Value Testing (recap)

- boundary value testing: choose extreme values.
- variants:
  - worst-case
  - robust
  - robust worst-case
- other (non-standard) variants:
  - special value
  - random



Boundary Value Testing: Pros and Cons (recap)

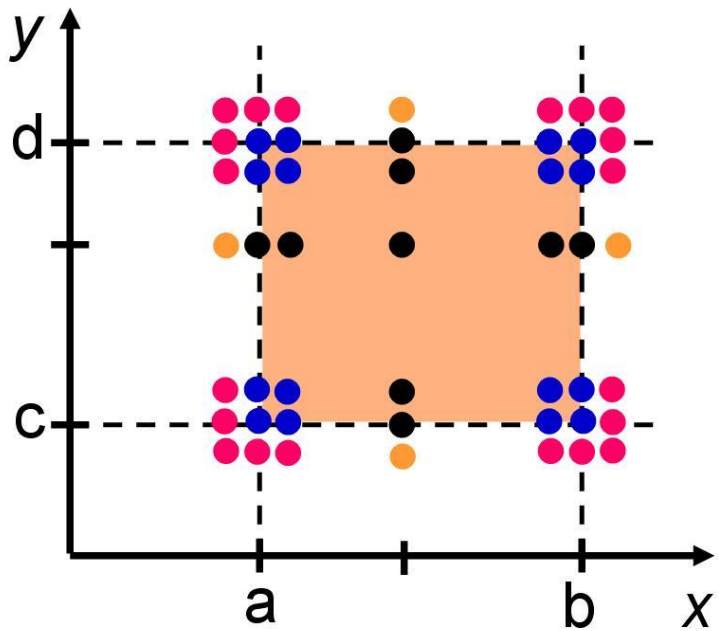
+ straightforward test-case generation
- no sense of covering the input domain
- awkward for logical vars.
- only independent input domains
- not using white-box information



Boundary Value Testing: Pros and Cons (recap)

+ straightforward test-case generation
- no sense of covering the input domain *
- awkward for logical vars. *
- only independent input domains *
- not using white-box information

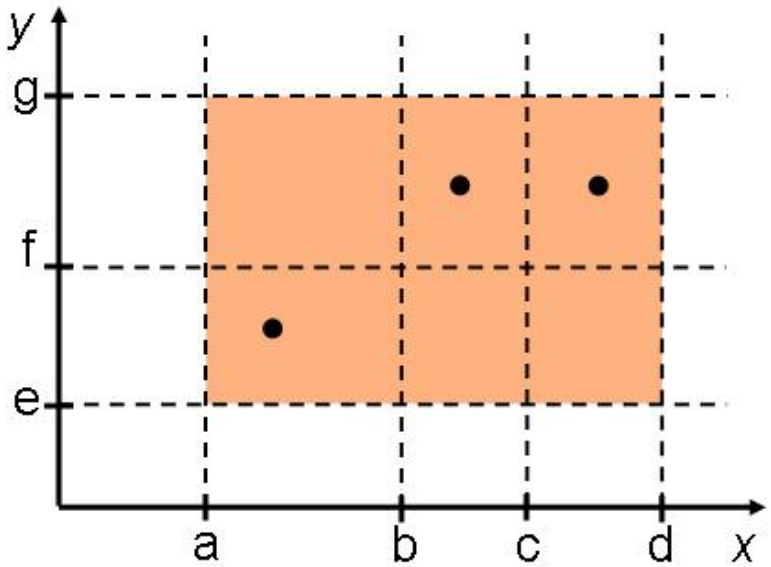
*: Today's order of business.



Outline

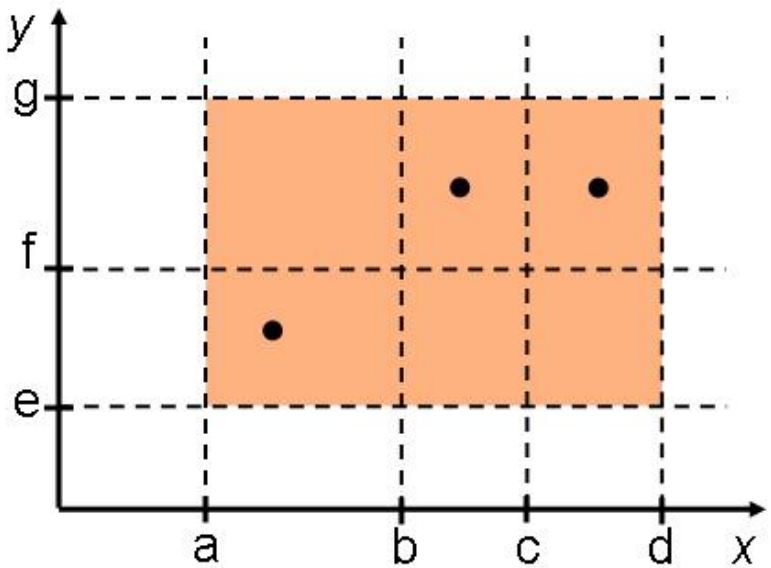
Weak Normal EC: Idea

- Define equivalence classes on the domain (range) of input (output) for each variable: (independent input)
- cover equivalence classes for the domain of each variable: single fault assumption
- how many test-cases are needed?
- also called: (equivalence, category) partition method



Little Puzzle

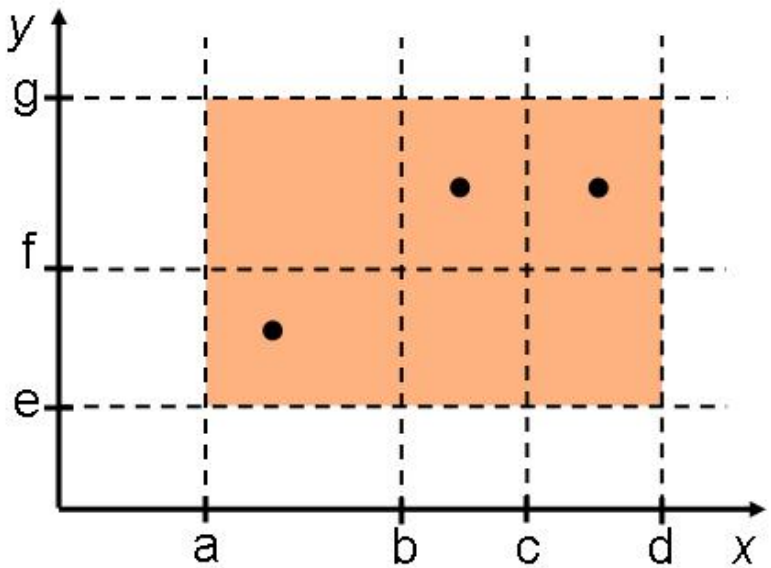
What is the minimal number of tokens that are needed to be put in an $m \times n$ grid such that each row and column contains at leats one token?



Little Puzzle

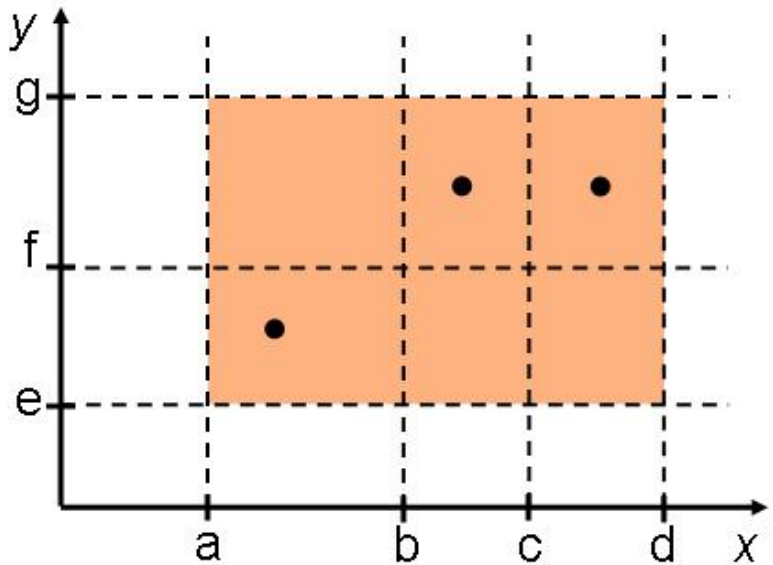
What is the minimal number of tokens that are needed to be put in an $m \times n$ grid such that each row and column contains at leats one token?

max(m,n):
Put token number i at $(max(i, m), max(i, n))$.



Weak Normal EC: Idea

- Define equivalence classes on the domain (range) of input (output) for each variable: (independent input)
- cover equivalence classes for the domain of each variable: single fault assumption
- how many test-cases are needed? $\max_x \mid S_x \mid$.



Mortgage Example (recap)

Spec. Write a program that takes
three inputs: gender (boolean), age([18-55]), salary ([0-10000])
and output the total mortgage for one person

Mortgage = salary * factor,
where factor is given by the following table.

Category	**Male**	**Female**
Young	(18-35 years) 75	(18-30 years) 70
Middle	(36-45 years) 55	(31-40 years) 50
Old	(46-55 years) 30	(41-50 years) 35

Weak Normal EC Testing

Category	**Male**	**Female**
Young	(18-35 years) 75	(18-30 years) 70
Middle	(36-45 years) 55	(31-40 years) 50
Old	(46-55 years) 30	(41-50 years) 35

- age: difficult!
- salary: [0-10000]
- male: as strange as boundary value!

Weak Normal EC Testing

Category	**Male**	**Female**
Young	(18-35 years) 75	(18-30 years) 70
Middle	(36-45 years) 55	(31-40 years) 50
Old	(46-55 years) 30	(41-50 years) 35

- age: difficult! [18-30], [31-35], [36-40], [41,45], [46-50], [51-55]
- salary: [0-10000]
- male: as strange as boundary value! true, false

Weak Normal EC Testing

if (male) **then return**

$((18 \leq age < 35)?(75 * salary) : (31 \leq age < 40)?(55 * salary) : (30 * salary))$

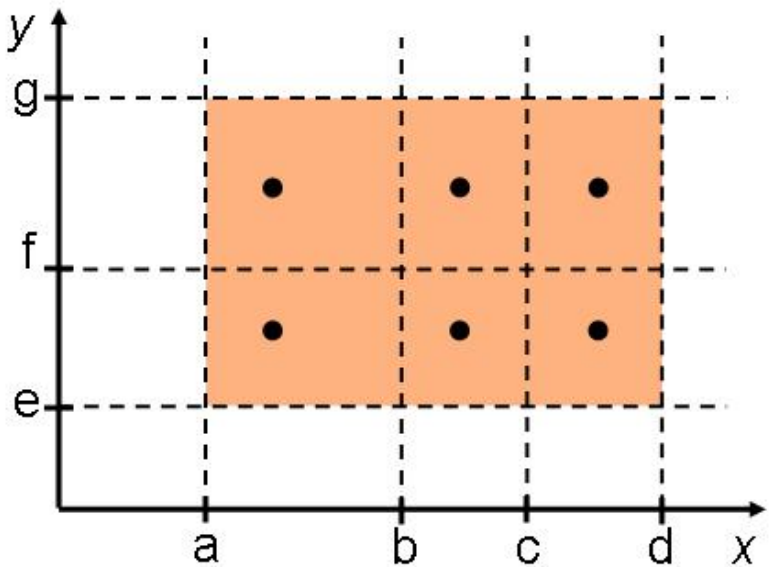
else return $((18 \leq age < 30)?(75 * salary) : (31 \leq age < 40)?(50 * salary) : (35 * salary))$

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	20	1000	75*1000	75*1000	P
female	32	1000	50*1000	50*1000	P
male	38	1000	55*1000	50*1000	P
female	42	1000	35*1000	35*1000	P
male	48	1000	30*1000	30*1000	P
female	52	1000	35*5000	too late!	F

Outline

Strong Normal EC Testing

- cover the all combinations of equivalence classes for the domain of all variables:
  multiple fault assumption
- number of test-cases? $\prod_x \mid S_x \mid$



Strong Normal EC Testing

Category	**Male**	**Female**
Young	(18-35 years) 75	(18-30 years) 70
Middle	(36-45 years) 55	(31-40 years) 50
Old	(46-55 years) 30	(41-50 years) 35

- age: [18-30], [31-35], [36-40], [41,45], [46-50], [51-55]
- salary: [0-10000]
- male: true, false

Strong Normal EC Testing

if (male) **then return**

$((18 \leq age < 35)?(75 * salary) : (31 \leq age < 40)?(55 * salary) : (30 * salary))$

else return $((18 \leq age < 30)?(75 * salary) : (31 \leq age < 40)?(50 * salary) : (35 * salary))$

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
female	20	1000	75*1000	70*1000	F
female	32	1000	50*1000	50*1000	P
female	38	1000	50*1000	50*1000	P
female	42	1000	35*1000	35*1000	P
female	48	1000	35*1000	35*1000	P
female	52	1000	35*5000	too late!	F

Strong Normal EC Testing

if (male) **then return**

$((18 \leq age < 35)?(75 * salary) : (31 \leq age < 40)?(55 * salary) : (30 * salary))$

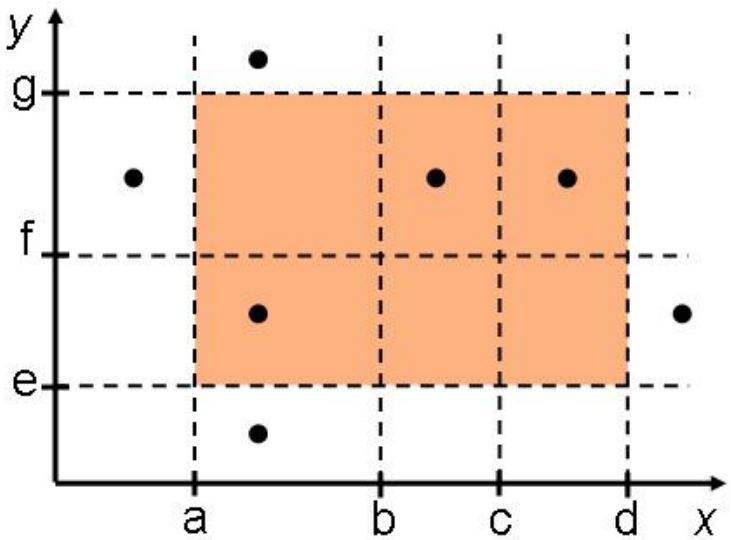
else return $((18 \leq age < 30)?(75 * salary) : (31 \leq age < 40)?(50 * salary) : (35 * salary))$

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	20	1000	75*1000	75*1000	P
male	32	1000	50*1000	75*1000	F
male	38	1000	55*1000	50*1000	P
male	42	1000	30*1000	55*1000	F
male	48	1000	30*1000	30*1000	P
male	52	1000	30*1000	30*1000	P

Outline

Weak Robust EC

- includes weak normal; adds out of range test-cases for each variable
- number of test-cases?
  $(\max_x \mid S_x \mid) + 2 * n$



Weak Robust EC Testing

if (male) **then return**

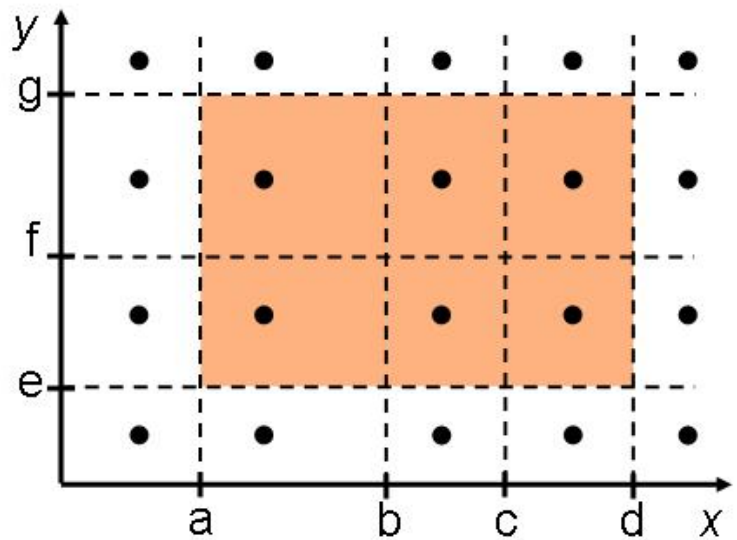
$((18 \leq age < 35)?(75 * salary) : (31 \leq age < 40)?(55 * salary) : (30 * salary))$

else return $((18 \leq age < 30)?(75 * salary) : (31 \leq age < 40)?(50 * salary) : (35 * salary))$

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	17	1000	30*1000	too young!	F
female	56	1000	35*1000	too late	F
male	36	-1	55*-1	0	F
female	36	10001	50*10001	50*10000	F

Strong Robust EC

- Same as strong normal but also checks for all out of range combinations
- number of test-cases?
  $\prod_x(\mid S_x \mid +2)$



Strong Robust EC

if (male) **then return**

$((18 \leq age < 35)?(75 * salary) : (31 \leq age < 40)?(55 * salary) : (30 * salary))$

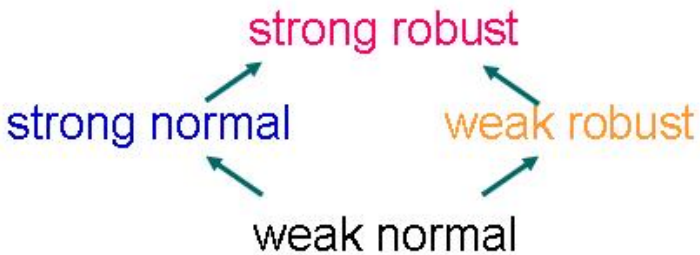
else return $((18 \leq age < 30)?(75 * salary) : (31 \leq age < 40)?(50 * salary) : (35 * salary))$

Mostly similar faults to Weak Robust EC:

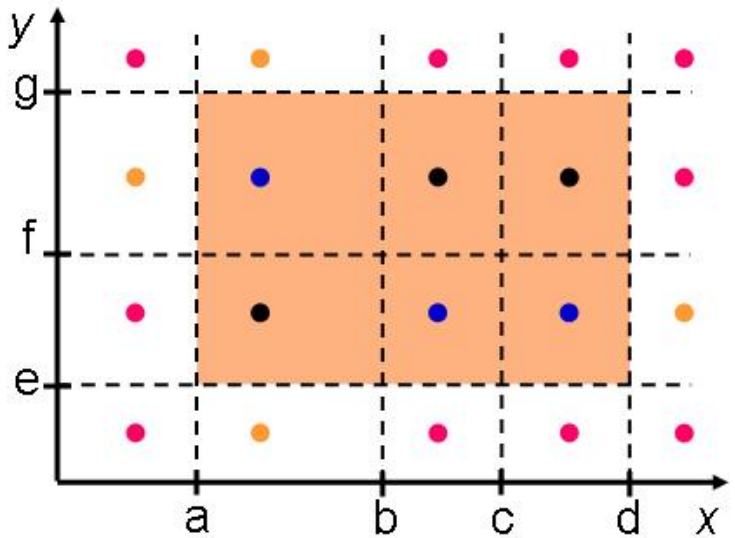
Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	17	1000	30*1000	too young!	F
female	56	1000	35*1000	too late	F
female	17	1000	35*1000	too young!	F
male	56	1000	30*1000	too late	F
male	36	-1	55*-1	0	F
female	36	10001	50*10001	50*10000	F

...

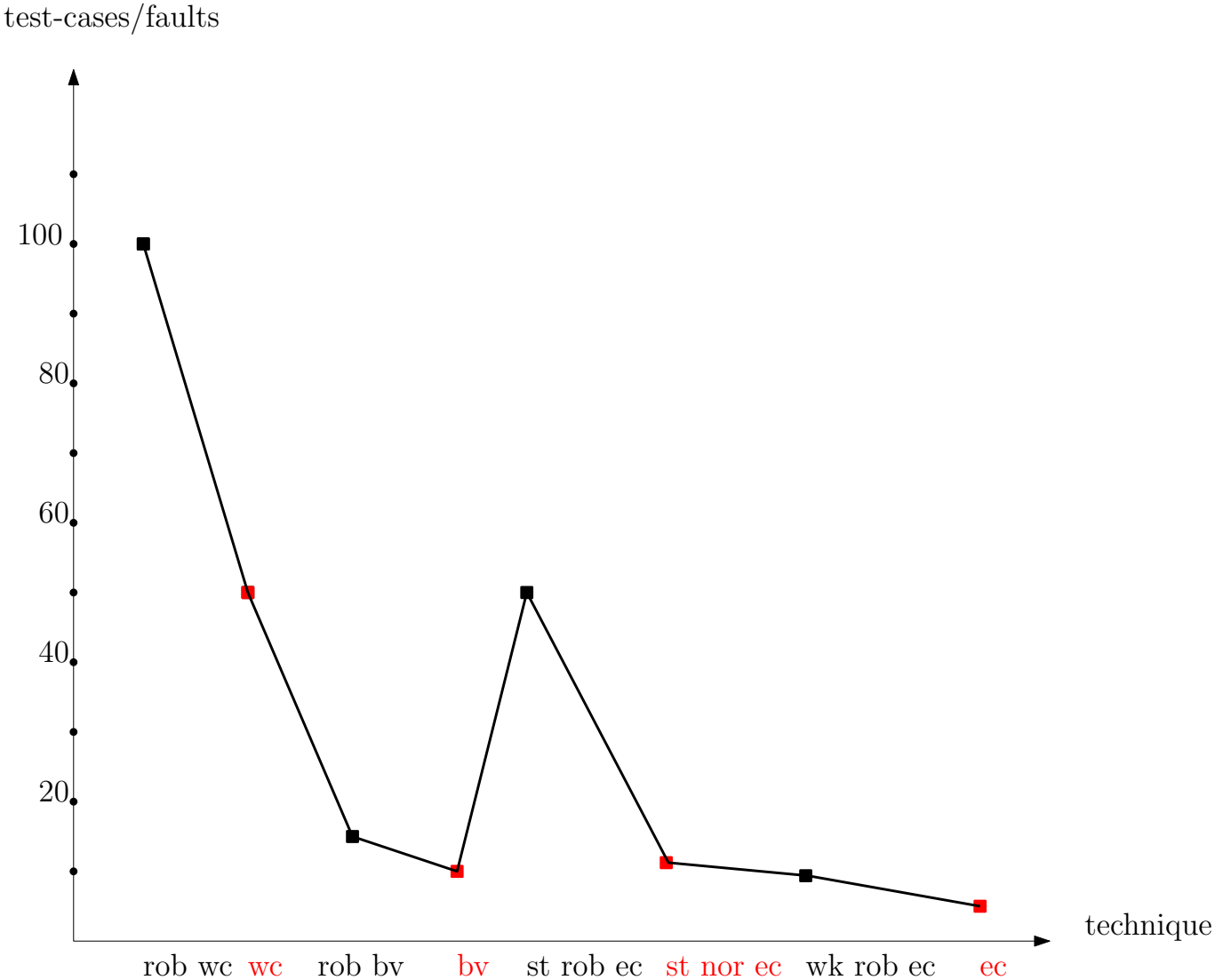
A Brief Comparison



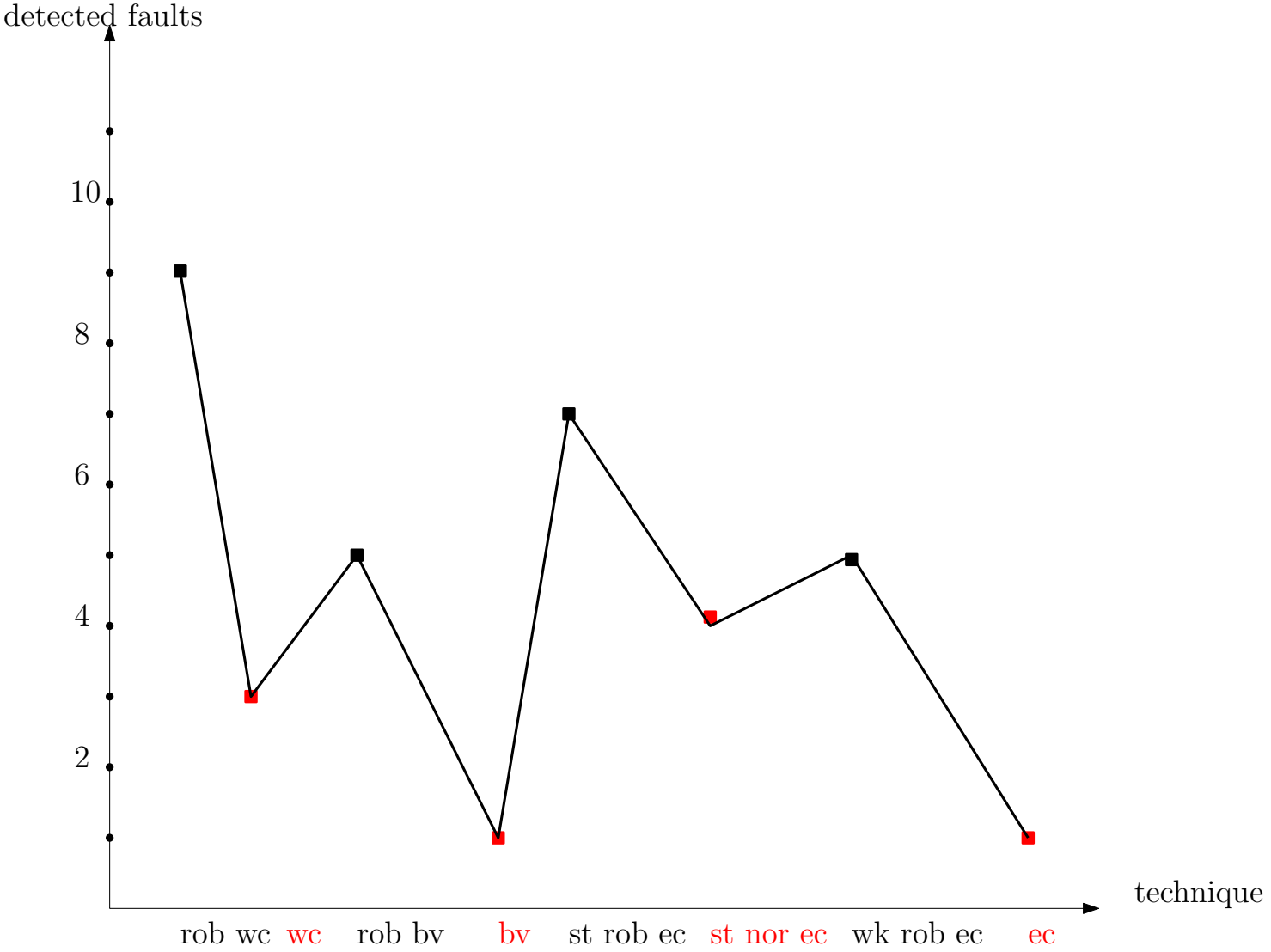
$A \rightarrow B$: Test-cases of A (faults detected by A) is a subset of those of B.



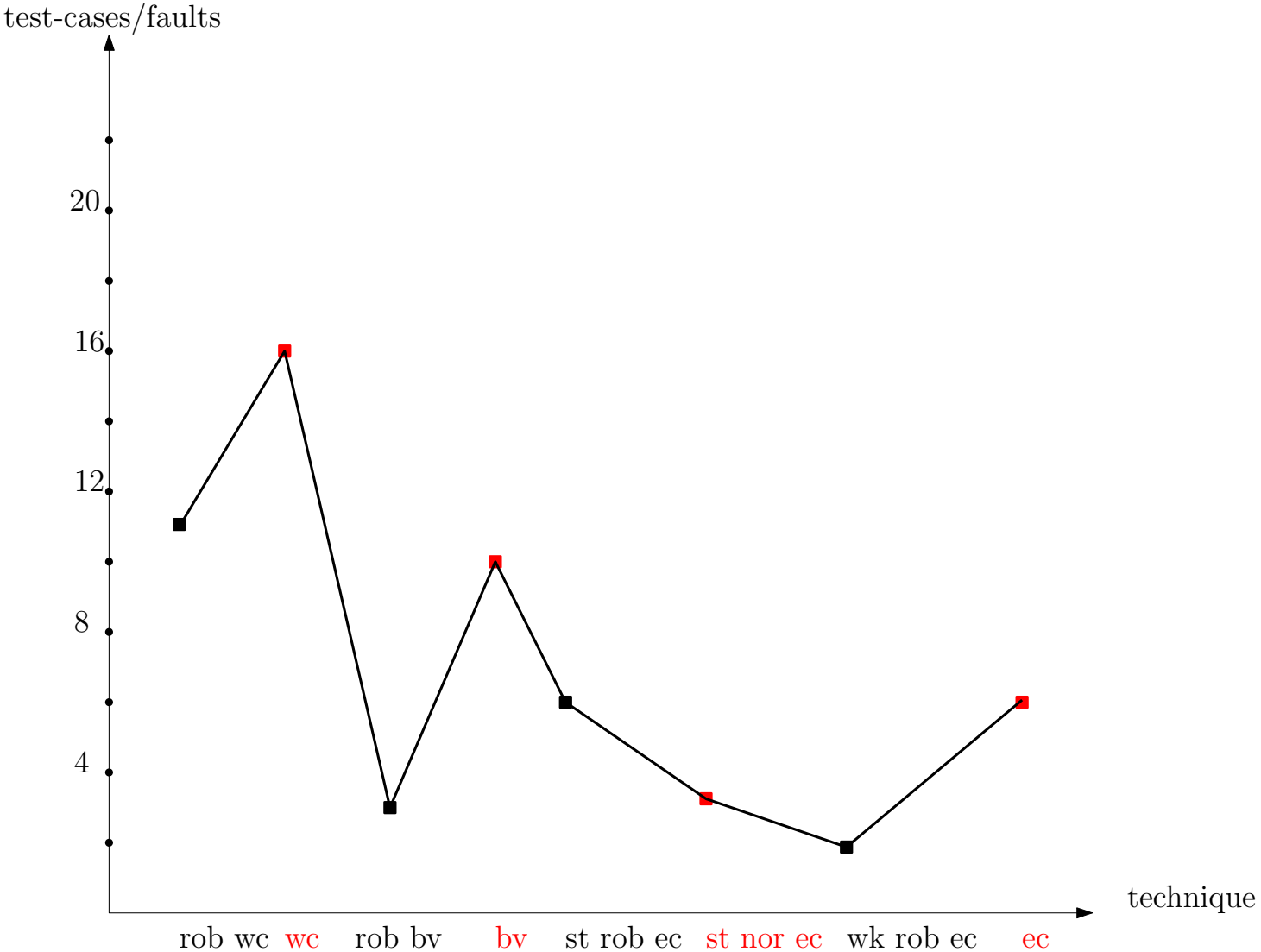
Mortgage Case: #Test-Cases



Mortgage Case: Detected Fault



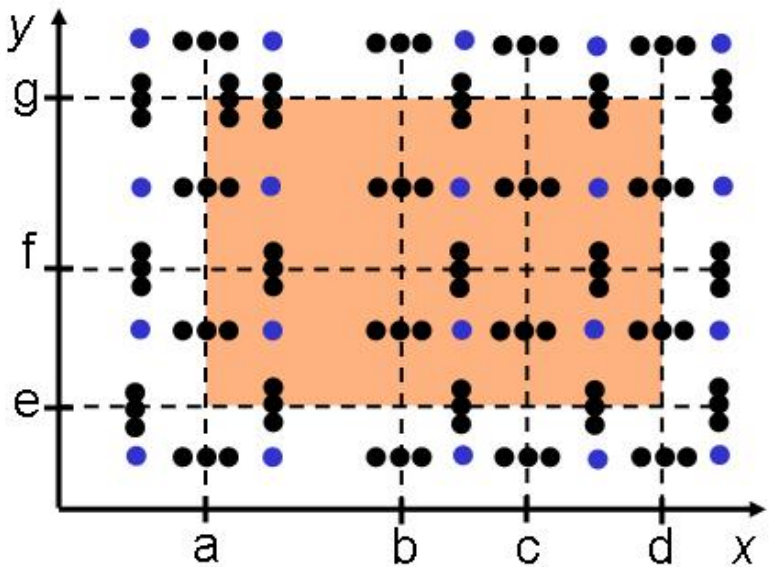
Mortgage Case: #Test-Cases/Fault



Outline

Idea

- Functional techniques need to be combined...
- Example:
  Robust WCT + Robust BV



Strong Robust EC + Robust BV

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	17	-1	30*-1	too young!	F 1
male	17	1000	30*1000	too young!	F 1
male	17	10001	30*10001	too young!	F 1
male	56 ‘	-1	30*-1	too late	F 2
male	56	1000	30*1000	too late	F 2
male	56	10001	30*10001	too late	F 2
female	17	-1	30*-1	too young!	F 3
female	17	1000	30*1000	too young!	F 3
female	17	10001	30*10001	too young!	F 3
female	56	-1	30*-1	too late	F 4
female	56	1000	30*1000	too late	F 4
female	56	10001	30*10001	too late	F 4

Strong Robust EC + Robust BV (Cont'd)

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
female	18	1000	75*1000	70*1000	F 5
female	19	1000	75*1000	70*1000	F 5
female	20	1000	75*1000	70*1000	F 5
female	29	1000	75*1000	70*1000	F 5
female	30	1000	35*1000	70*1000	F 6
female	31	1000	50*1000	50*1000	P
female	32	1000	50*1000	50*1000	P
female	34	1000	50*1000	50*1000	P
female	35	1000	50*1000	50*1000	P
female	36	1000	50*1000	50*1000	P
female	38	1000	50*1000	50*1000	P
female	39	1000	50*1000	50*1000	P
female	40	1000	35*1000	50*1000	F 7

Strong Robust EC + Robust BV (Cont'd)

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
female	41	1000	35*1000	35*1000	P
female	42	1000	35*1000	35*1000	P
female	44	1000	35*1000	35*1000	P
female	45	1000	35*1000	35*1000	P
female	46	1000	35*1000	35*1000	P
female	49	1000	35*1000	35*1000	P
female	50	1000	35*1000	35*1000	P
female	51	1000	35*1000	too late!	F 7
female	52	1000	35*1000	too late!	F 7
female	53	1000	35*1000	too late!	F 7
female	54	1000	35*1000	too late!	F 7
female	55	1000	35*1000	too late!	F 7

Strong Robust EC + Robust BV (Cont'd)

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	18	1000	75*1000	75*1000	P
male	19	1000	75*1000	75*1000	P
male	20	1000	75*1000	75*1000	P
male	29	1000	75*1000	75*1000	P
male	30	1000	75*1000	75*1000	P
male	31	1000	55*1000	75*1000	F 8
male	32	1000	55*1000	75*1000	F 8
male	34	1000	55*1000	75*1000	F 8
male	35	1000	55*1000	75*1000	F 9
male	36	1000	55*1000	55*1000	P
male	38	1000	55*1000	55*1000	P
male	39	1000	55*1000	55*1000	P
male	40	1000	55*1000	20*1000	F 10

Strong Robust EC + Robust BV (Cont'd)

Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	41	1000	30*1000	30*1000	P
male	42	1000	30*1000	30*1000	P
male	44	1000	30*1000	30*1000	P
male	45	1000	30*1000	30*1000	P
male	46	1000	30*1000	30*1000	P
male	49	1000	30*1000	30*1000	P
male	50	1000	30*1000	30*1000	P
male	51	1000	30*1000	30*1000	P
male	52	1000	30*1000	30*1000	P
male	53	1000	30*1000	30*1000	P
male	54	1000	30*1000	30*1000	P
male	55	1000	30*1000	30*1000	P

Strong Robust EC + Robust BV (Cont'd)

Gender	**Age**	**Salary**	**Output**	**Correct Out.**	**Pass/Fail**
female	17	-1	35*-1	0	F 11
female	18	-1	75*-1	0	F 11
.....					

Strong Robust EC + Robust BV (Cont'd)

Gender	**Age**	**Salary**	**Output**	**Correct Out.**	**Pass/Fail**
female	17	10001	35*10001	too young!	F 11
female	18	10001	75*10001	75*10000	F 12
...					

Strong Robust EC + Robust BV (Cont'd)

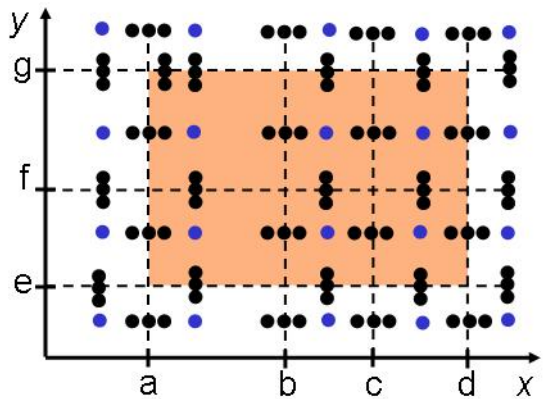
Gender	Age	Salary	Output	Correct Out.	Pass/Fail
male	17	-1	30*-1	0	F 12
male	18	-1	70*-1	0	F 12
...					

Strong Robust EC + Robust BV (Cont'd)

Gender	**Age**	**Salary**	**Output**	**Correct Out.**	**Pass/Fail**
male	17	10001	30*10001	too young!	F 12
male	18	10001	70*10001	75*10000	F 12
...					

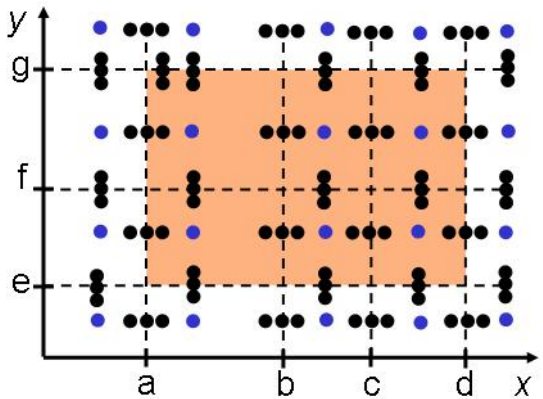
Problems

- Example:
  Strong EC + Robust BV
  number of test-cases:
  $\sim \prod_x 4(\mid S_x \mid +1)$, whopping!



Problems

- >100 test-cases for the mortgage example
- too many for any real-life program
  e.g., 5 vars., each 5 partitions:
  $\sim$ 8 million test-cases
  1 sec. for each test-case:
  3 months testing!



Problems

- Problems:
  1. No constraints on the equivalence classes
  2. Dependencies among different variables not taken into account
  3. No choice among relevant classes (e.g., apply worst-case testing on some and boundary values on others)
- Solutions: Attend the coming lecture!