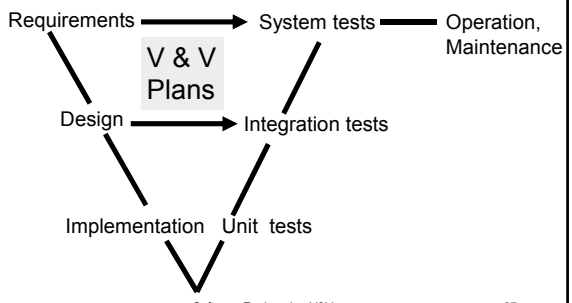
The V-model



Defect testing

Goals:

– detect as many defects as possible
– detect the most damaging defects
– detect the most likely defects - statistical test!

Black-box testing: the source code is not considered (maybe even not known).

Glass-box testing: the tests are chosen based on the source code.

What is a test?

- A *test suite* is a set of test cases run together for a single purpose.
- A *test case* consists of
  – Test data
    - Including invalid inputs
  – Expected outcome (correct answer)
  – Expected behaviour (e.g. response time)

Black-box testing [8.1.2]

No code – but requirements!

Partition testing:

- Partitions: input and output equivalences.
  – *typical values*
  – *boundary values*
  – *invalid inputs*

Example: sorting a list

- lenght of list
  – empty list: boundary value
  – list with one element: boundary value
  – list with some "typical" number of elements
  – list with extremely many elements: boundary value
- comparisons
  – no duplicates (typical?)
  – some duplicates (typical)
  – all elements are the same (boundary value)
- invalid inputs
  – not a list
  – a list with elements that cannot be compared

Glass-box testing

”All code" should be tested at least once

– testing once is rather weak
– what does "all code" mean?

Definition: *coverage* is the percentage of "all code" that is tested by a test suite.

Coverage

- Statement coverage
  - every statement must be tested
- Branch coverage
  - every choice (if, while) must be tested for both true and false.

Example (coverage)

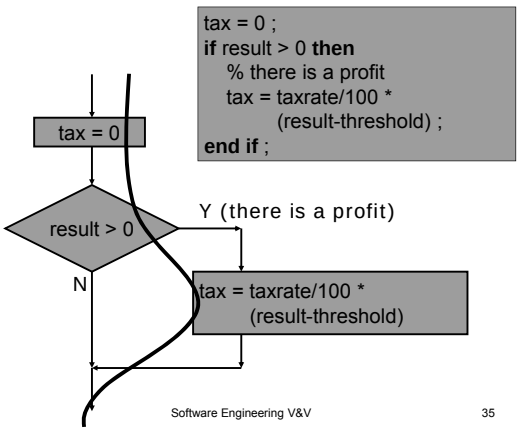
Specification

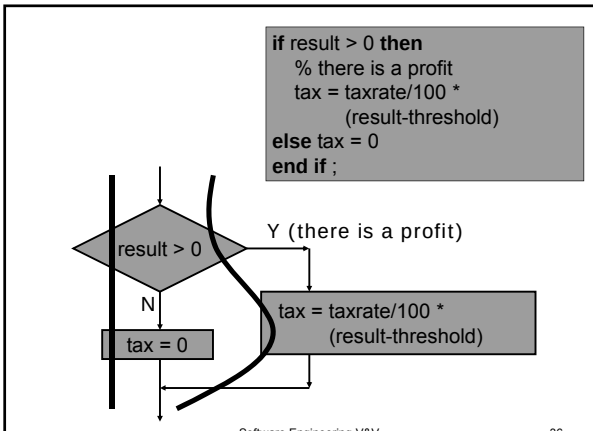
inputs: *result*, *taxrate*, *threshold*

output: *tax*

relation: *tax* is <*taxrate*> % of the profit,
but the first <*threshold*> SEK is not taxed.

glossary: *profit* - a positive result.

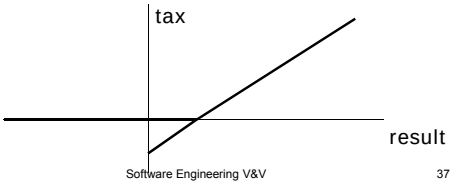




Coverage testing flaws

Coverage testing tests code that exists, but

- not under all conditions,
- not code that should exist, but doesn't.

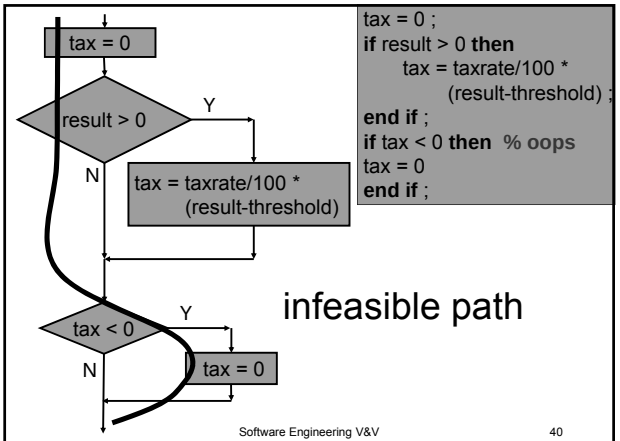


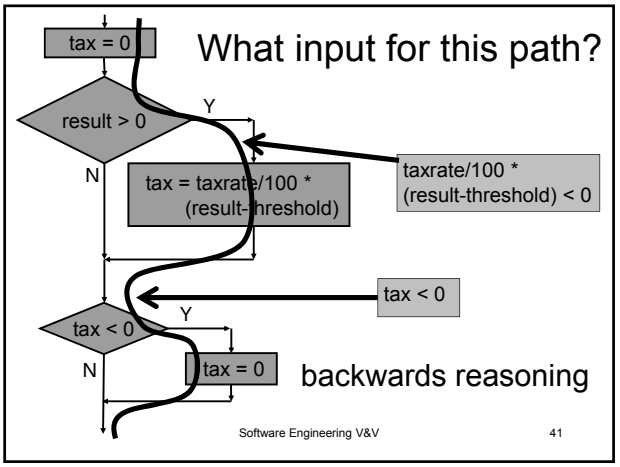
How to do coverage testing?

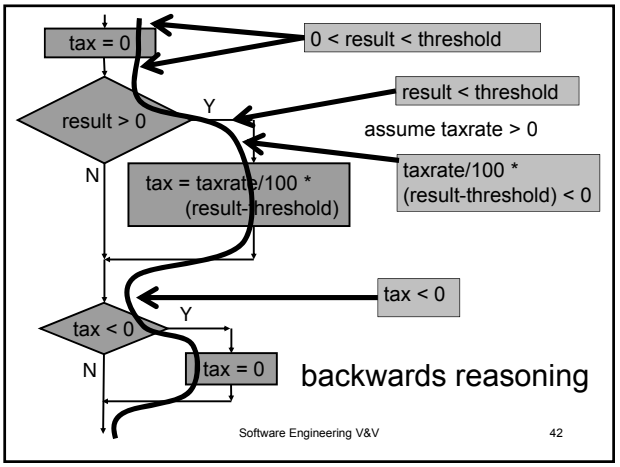
- Decide on test data
  - based on … (statistical, partitioning)
- Use a testing tool that records
  - which code is executed during the test,
  - computes coverage.
- Problem:
  - you reach 80%, 90% or 95% coverage,
  - obscure code is only reached for very specific input
  - *dead code* is not executed for any input.

How to do coverage testing? (theoretically)

- Decide on *paths* that cover the code
- For each path:
  - compute an input that will produce this path,
  - run a test with this input.
- Problems:
  - how to compute inputs for a given path,
  - there may be no such input (*infeasible path*)







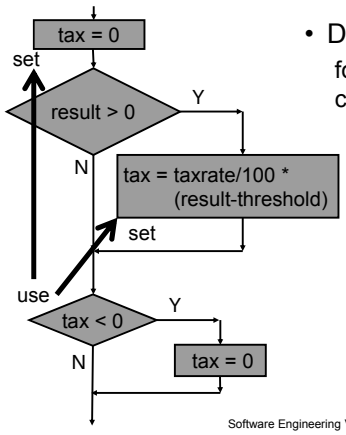
Further coverage criteria

- Condition coverage

```
% find item in array A
i = 1;
found = false;
while i ≤ A.length and not found do
    if A[i] = item then …
```

- requires tests
  - i ≤ A.length **and not** found
  - i > A.length ← obvious in partition test!
  - found is true ←

- Relational operator coverage
  for each comparison a < b,
  test boundary cases
  - a = b
  - a = b-1
- Path coverage
  - every feasible path is covered
  - for programs without loops
  - **100% path coverage**
    does not guarantee correctness!



- Data flow coverage
  for each variable,
  connect **set** – **use** pairs

- Loop coverage
  execute each loop
  – 0 times (if possible)
  – 1 time
  – several times
- Error message coverage
  – force the system to produce every error message

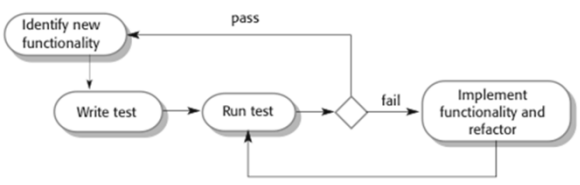
Interface coverage tests

- Function coverage
  – every *function* is called at least once (weak)
- Call coverage
  – every *function call* is executed at least once

Testing concurrent systems

- Problems:
  – What is a path? Sequence of executed statements from more than one source code.
  – A combinatorial explosion
  – Programmers make errors because of unforeseen sequences.
  – Hard to control which sequence is tested
    - errors may be hard to reproduce.
    - difference between "laboratory" and "reality".

Figure 8.9 Test-driven development



Summary

- Black box
  – Based on specification
  – ”Natural”
- Glass box
  – Coverage ... Different criteria
  – 100% coverage ≠ 100% correct
- Concurrent systems
  – Testing *may* find *some* faults