A Framework for Testing and Analysis

Learning objectives

- Introduce dimensions and tradeoff between test and analysis activities
- Distinguish validation from verification activities
- Understand limitations and possibilities of test and analysis

Verification and validation

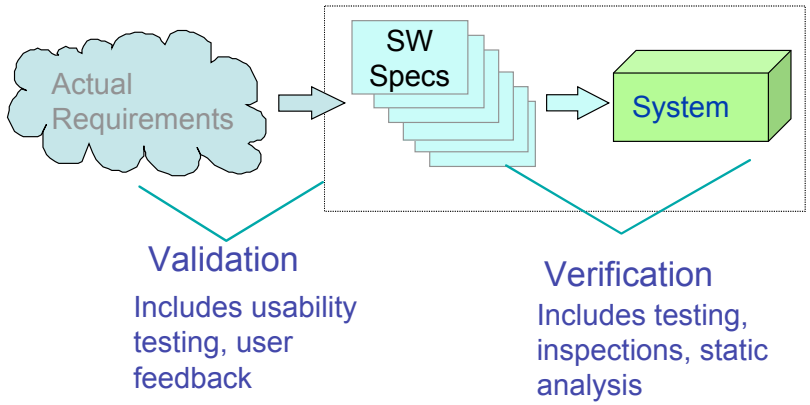
- Validation:
  does the software system meets the user's real needs?

  are we building the right software?

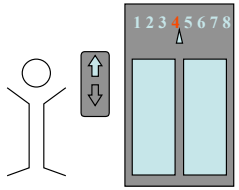
- Verification:
  does the software system meets the requirements specifications?

  are we building the software right?

Validation and Verification



Verification or validation depends on the specification

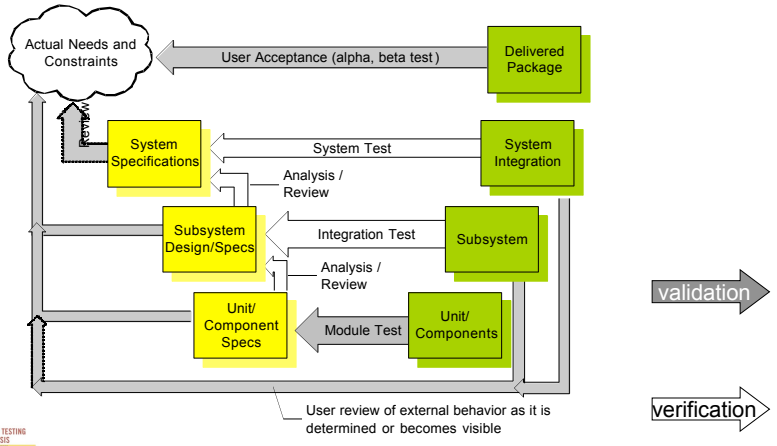


Example: elevator response

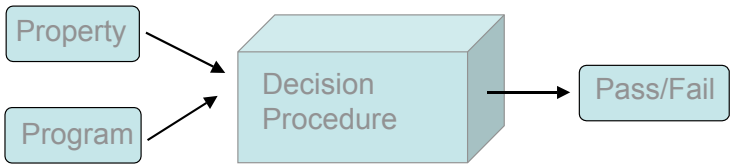
Unverifiable (but validatable) spec: ... if a user presses a request button at floor i, an available elevator must arrive at floor i soon...

Verifiable spec: ... if a user presses a request button at floor i, an available elevator must arrive at floor i within 30 seconds...

Validation and Verification Activities



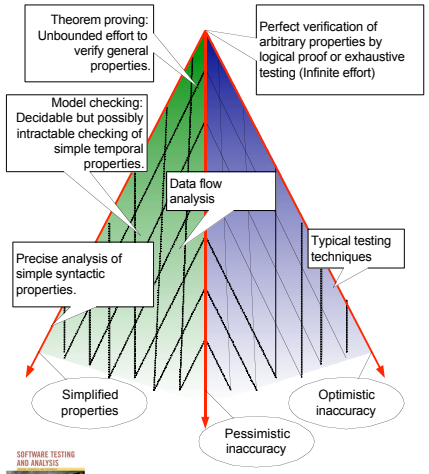
You can't ~~always~~ *ever* get what you want



Correctness properties are undecidable

the halting problem can be embedded in almost every property of interest

Getting what you need ...



- optimistic inaccuracy: we may accept some programs that do not possess the property (i.e., it may not detect all violations).
  - testing
- pessimistic inaccuracy: it is not guaranteed to accept a program even if the program does possess the property being analyzed
  - automated program analysis techniques
- simplified properties: reduce the degree of freedom for simplifying the property to check

Example of simplified property: Unmatched Semaphore Operations

original problem

```
if ( .... ) {
    ...
    lock(S);
}
...
if ( ... ) {
    ...
    unlock(S);
}
```

Static checking for match is necessarily inaccurate ...

simplified property

Java prescribes a more restrictive, but statically checkable construct.

```
synchronized(S) {
        ...
        ...
}
```

Some Terminology

- **Safe**: A safe analysis has no optimistic inaccuracy, i.e., it accepts only correct programs.
- **Sound**: An analysis of a program P with respect to a formula F is sound if the analysis returns true only when the program does satisfy the formula.
- **Complete**: An analysis of a program P with respect to a formula F is complete if the analysis always returns true when the program actually does satisfy the formula.

Summary

- Most interesting properties are undecidable, thus in general we cannot count on tools that work without human intevention
- Assessing program qualities comprises two complementary sets of activities: validation (daes the software do what it is supposed to do?) and verification (does the system behave as specificed?)
- There is no single technique for all purposes: test designers need to select a suitable combination of techniques