Software Testing

Outline

- Terminology
- Testing Activities
- Types of Testing

Famous Problems

- F-16 : crossing equator using autopilot
  - Result: plane flipped over
  - Reason?
    - Reuse of autopilot software from a rocket

- The Therac-25 accidents (1985-1987), quite possibly the most serious non-military computer-related failure ever in terms of human life (at least five died)
  - Reason: Bad event handling in the GUI
- NASA Mars Climate Orbiter destroyed due to incorrect orbit insertion (September 23, 1999)
  - Reason: Unit conversion problem

Terminology

- Failure:
  - Any deviation of the observed behavior from the specified behavior
- Erroneous state ("error"):
  - The system is in a state such that further processing by the system can lead to a failure
- Fault ("bug" or "defect") :
  - The mechanical or algorithmic cause of an error
- Validation:
  - Activity of checking for deviations between the observed behavior of a system and its specification

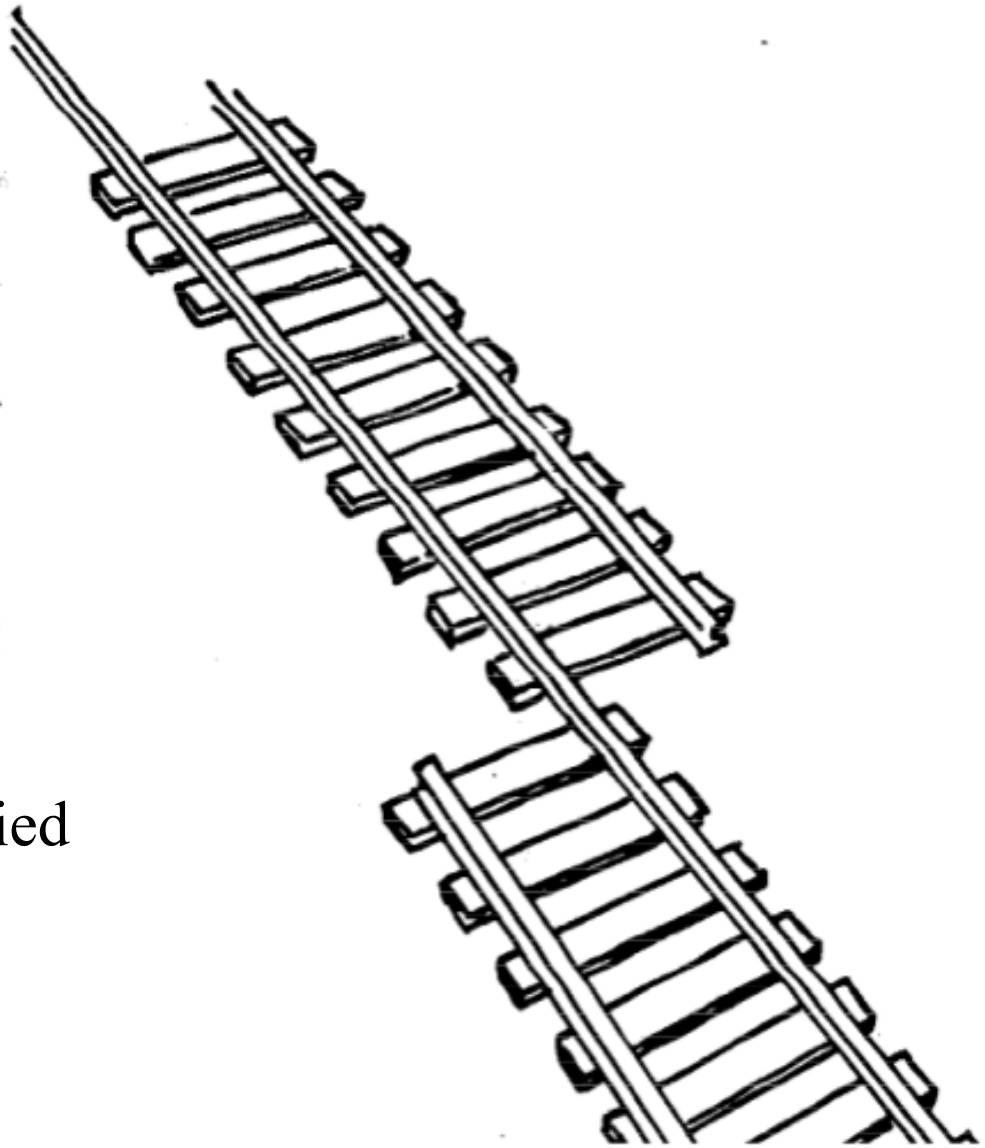
What is this?

A failure?

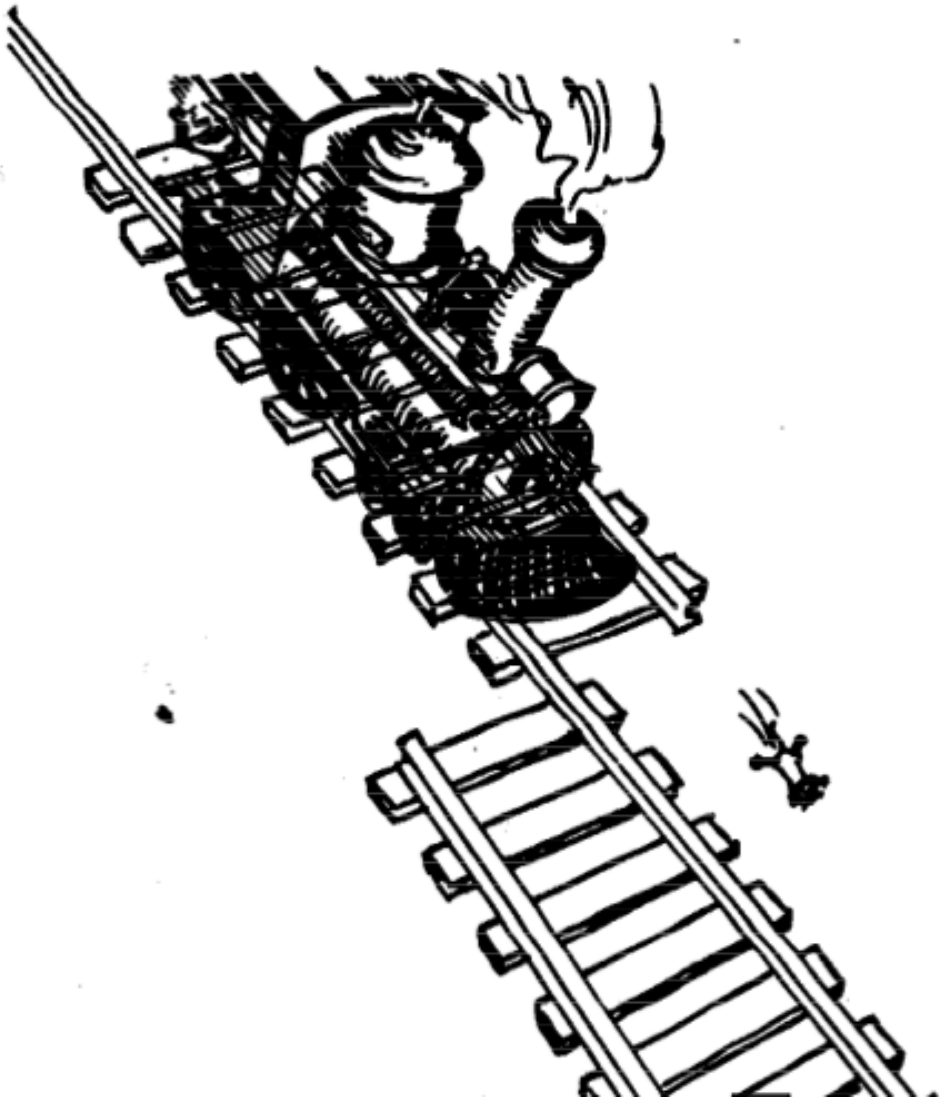
An error?

A fault?

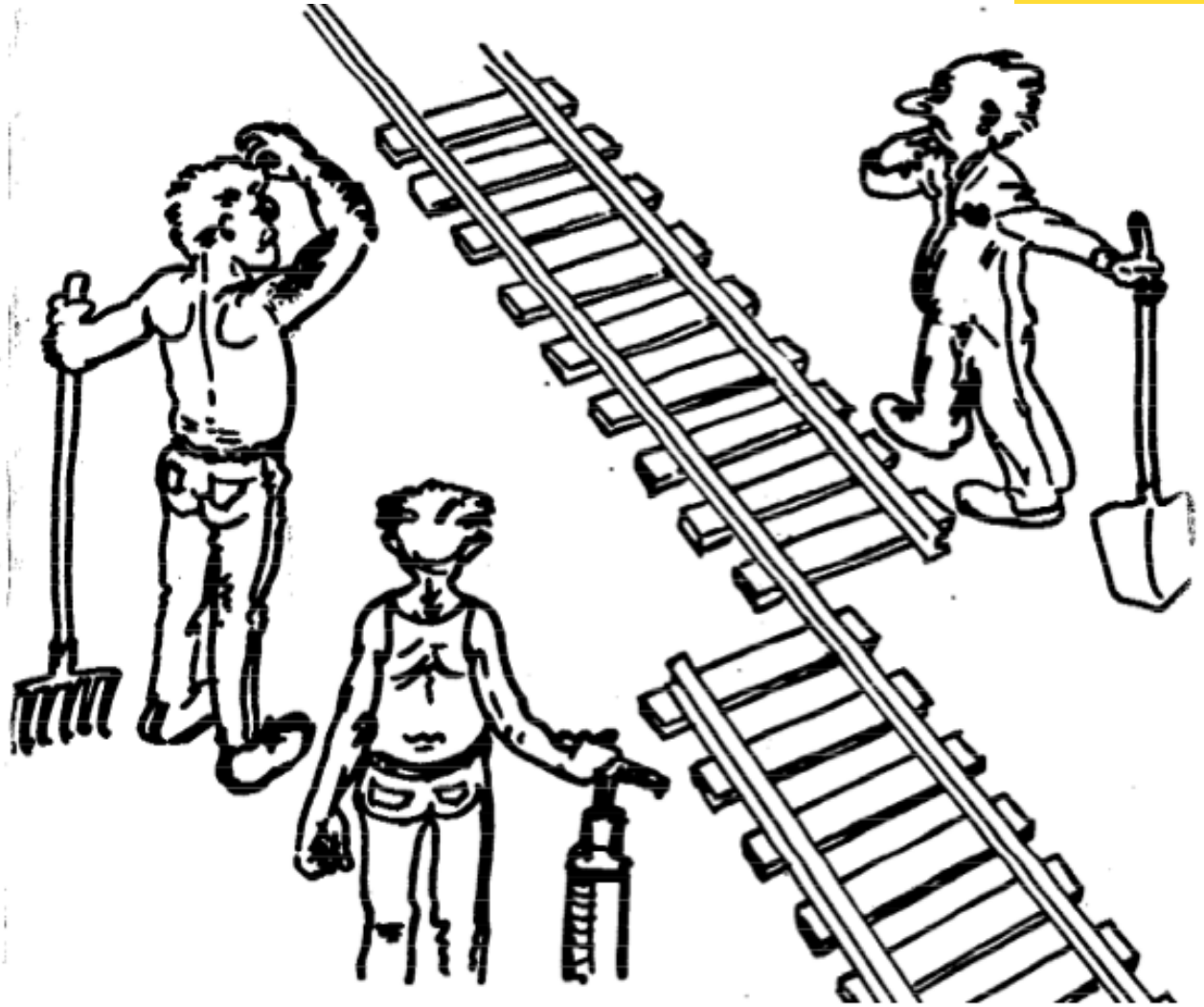
We need to describe specified and desired behavior first!



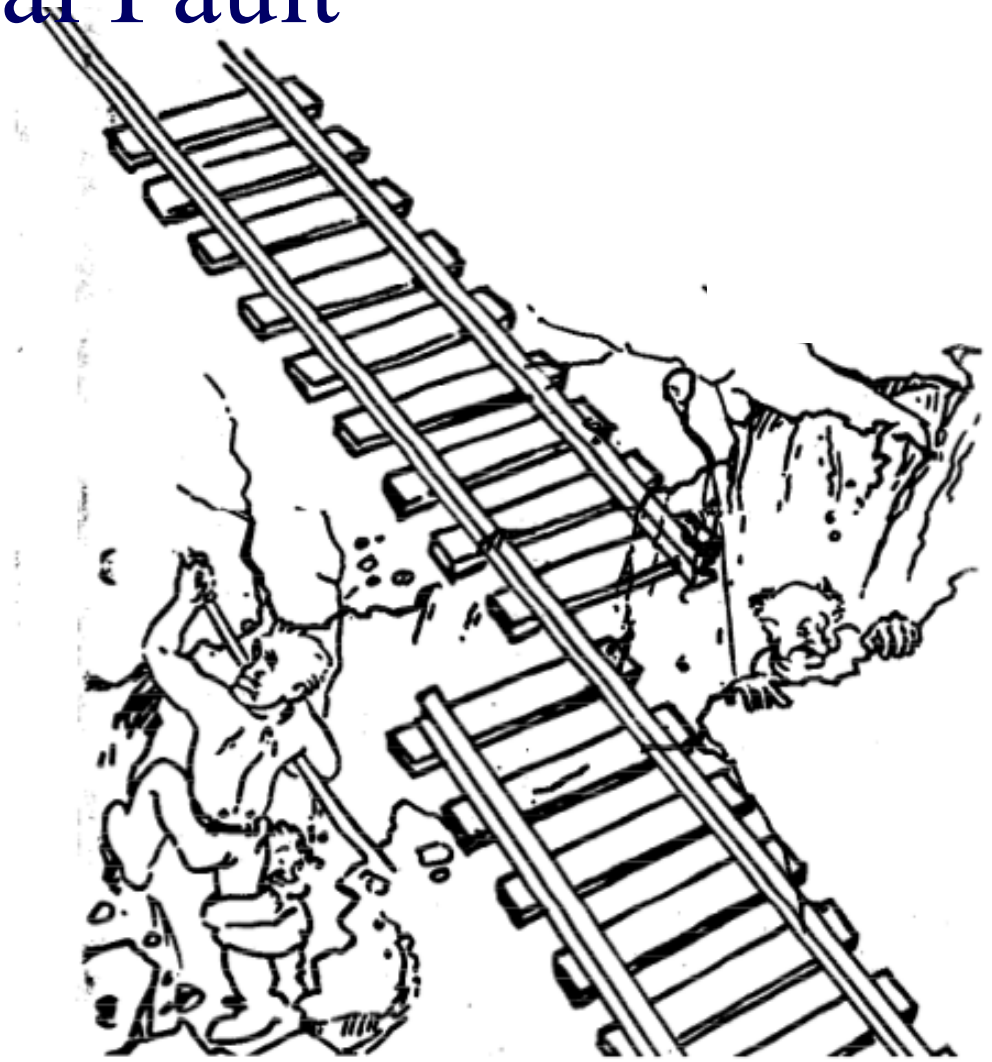
Erroneous State (“Error”)



Algorithmic Fault



Mechanical Fault

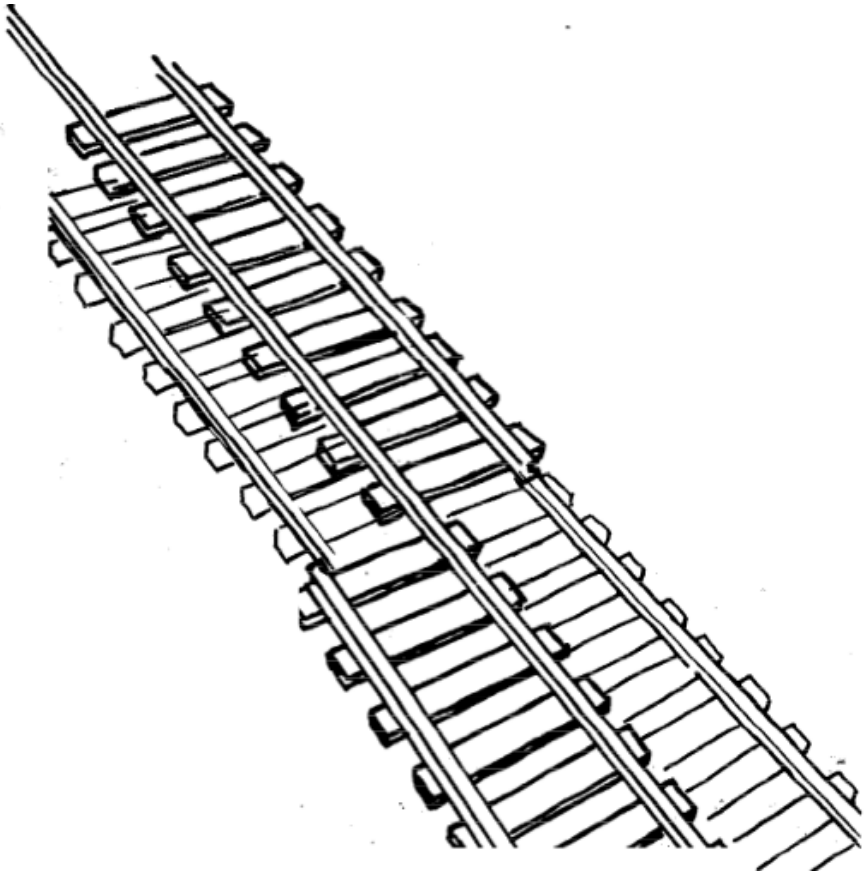


Examples of Faults and Errors

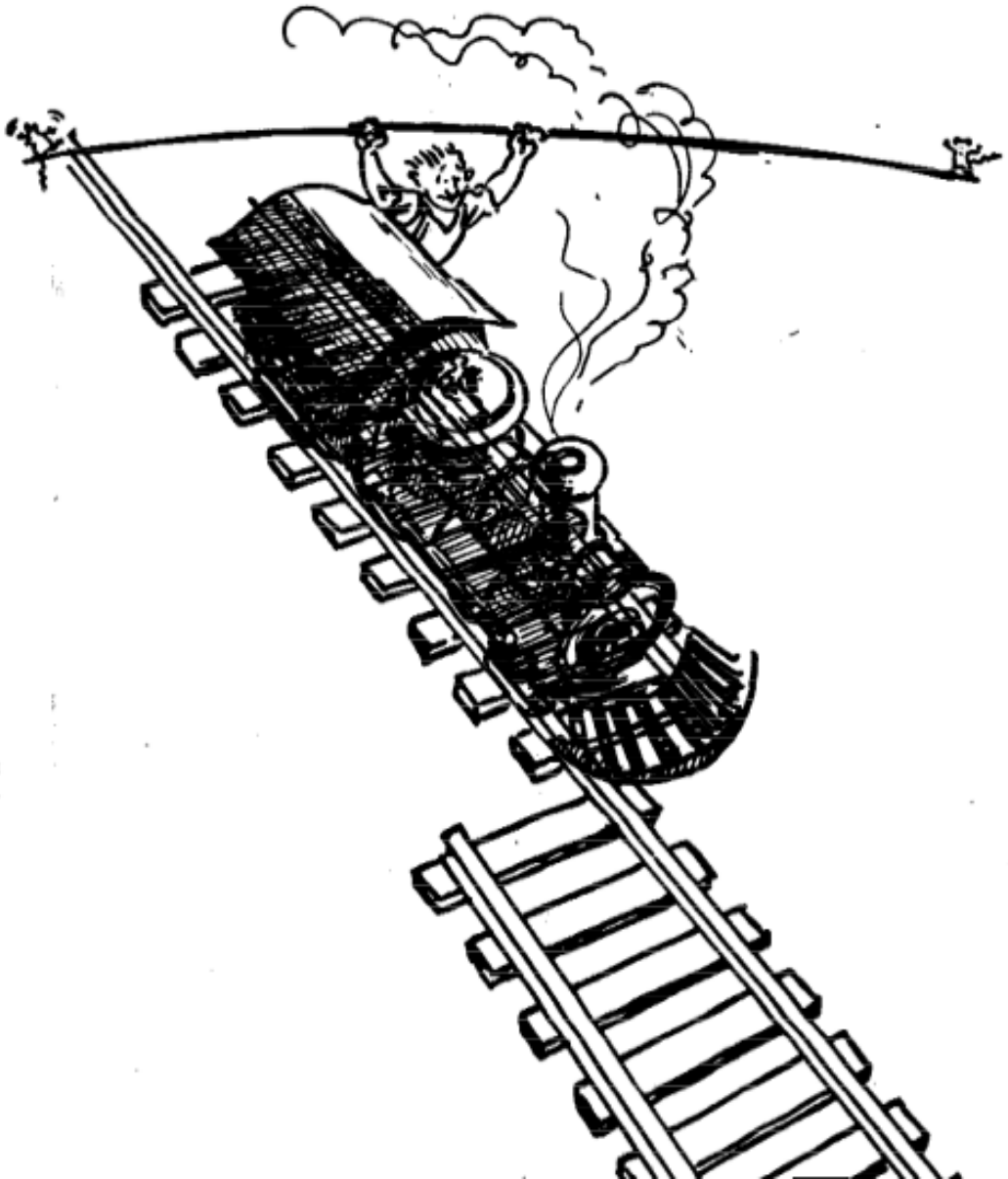
- Faults in the Interface specification
  - Mismatch between what the client needs and what the server offers
  - Mismatch between requirements and implementation
- Algorithmic Faults
  - Missing initialization
  - Incorrect branching condition
  - Missing test for null
- Mechanical Faults (very hard to find)
  - Operating temperature outside of equipment specification
- Errors
  - Null reference errors
  - Concurrency errors
  - Exceptions

How do we deal with Errors, Failures and Faults?

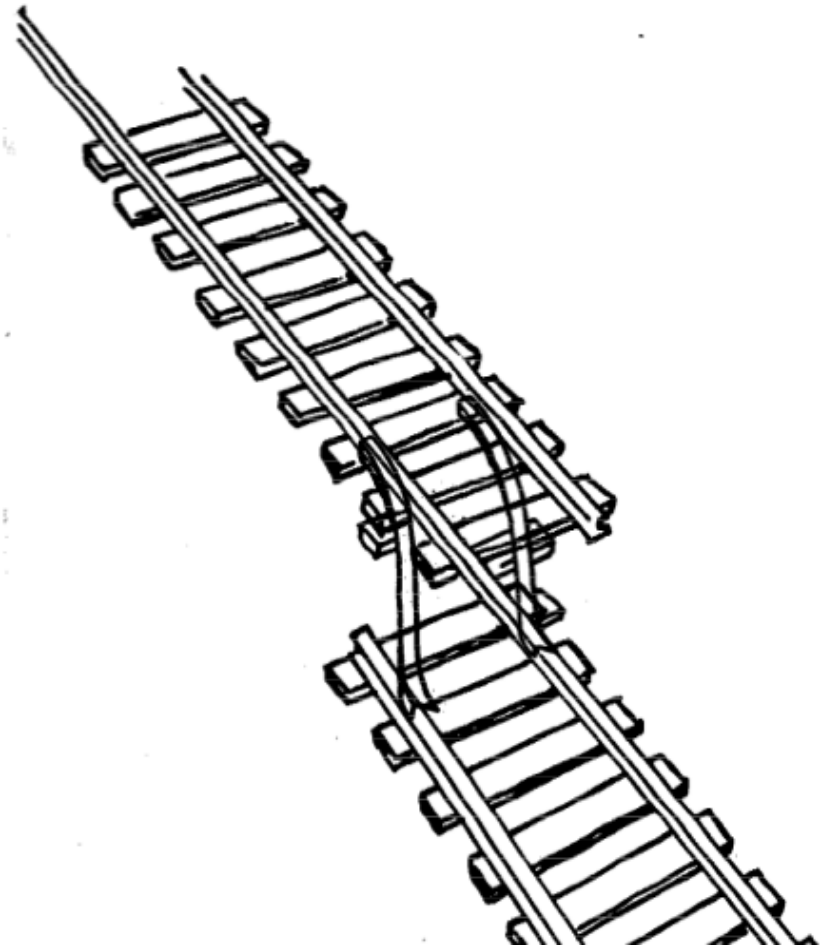
Modular Redundancy



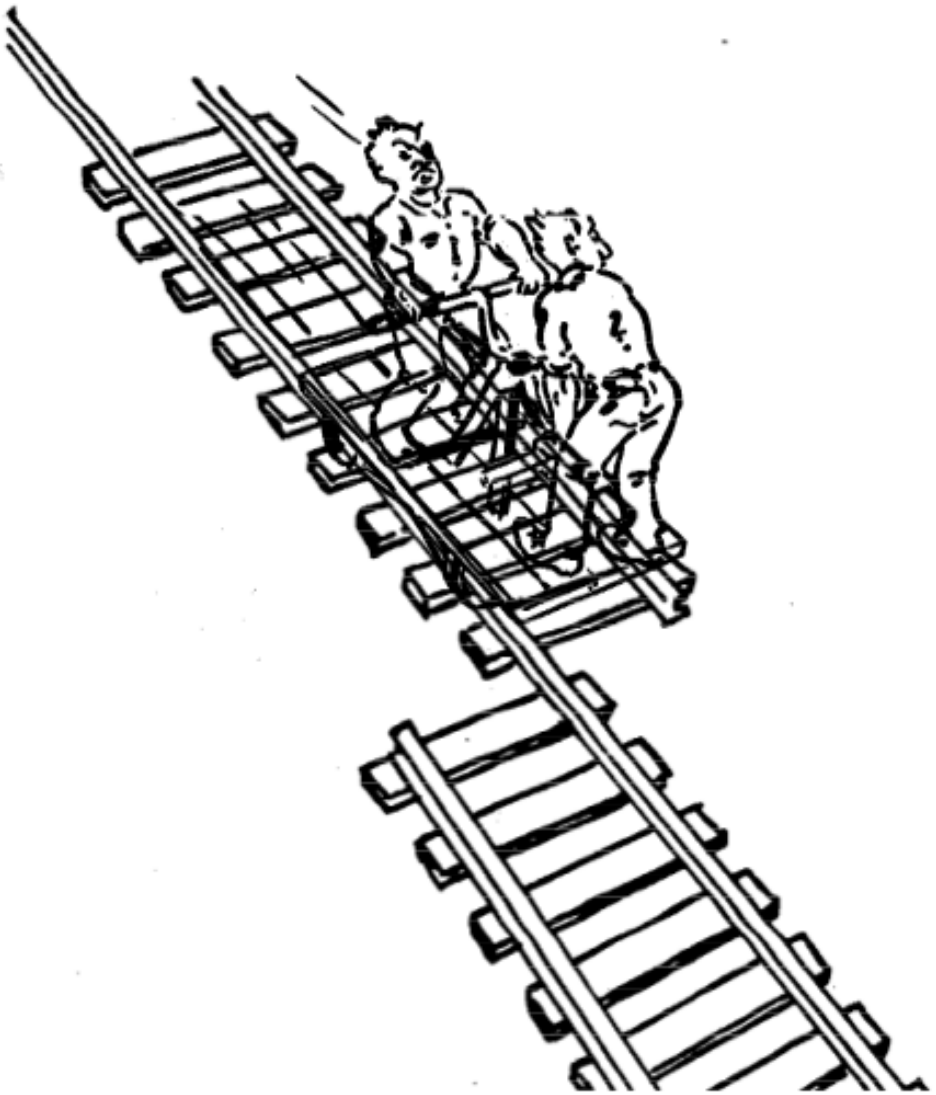
Declaring the Bug as a Feature



Patching



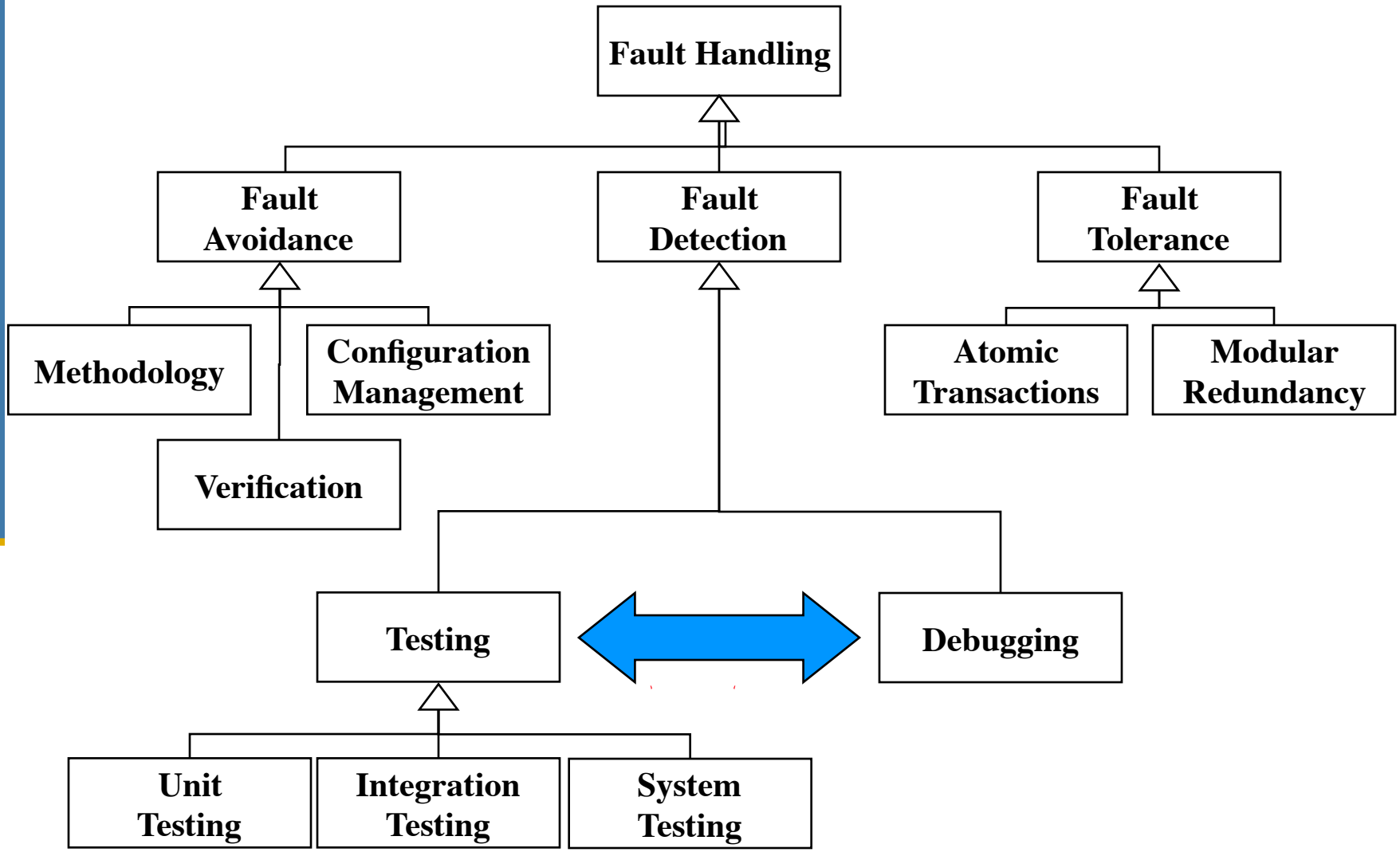
Testing



Another View on How to Deal with Faults

- Fault avoidance (before system is released)
  - Use methodology to reduce complexity
  - Use configuration management to prevent inconsistency
  - Apply verification to prevent algorithmic faults
  - Use Reviews
- Fault detection (while system is running)
  - *Testing*: Activity to provoke failures in a planned way
  - *Debugging*: Find and remove faults
  - *Monitoring*: Deliver information about state (used during debugging
- Fault tolerance (recover from failure once the system is released)
  - Exception handling
  - Modular redundancy

Taxonomy for Fault Handling Techniques



Observations

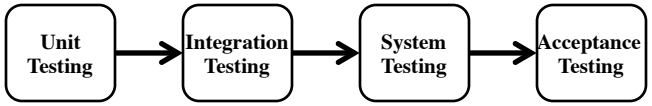
- It is impossible to completely test any nontrivial module or system
  - Practical limitations: Complete testing is prohibitive in time and cost
  - Theoretical limitations: e.g. Halting problem
- “Testing can only show the presence of bugs, not their absence” (Dijkstra).
- Testing is not for free

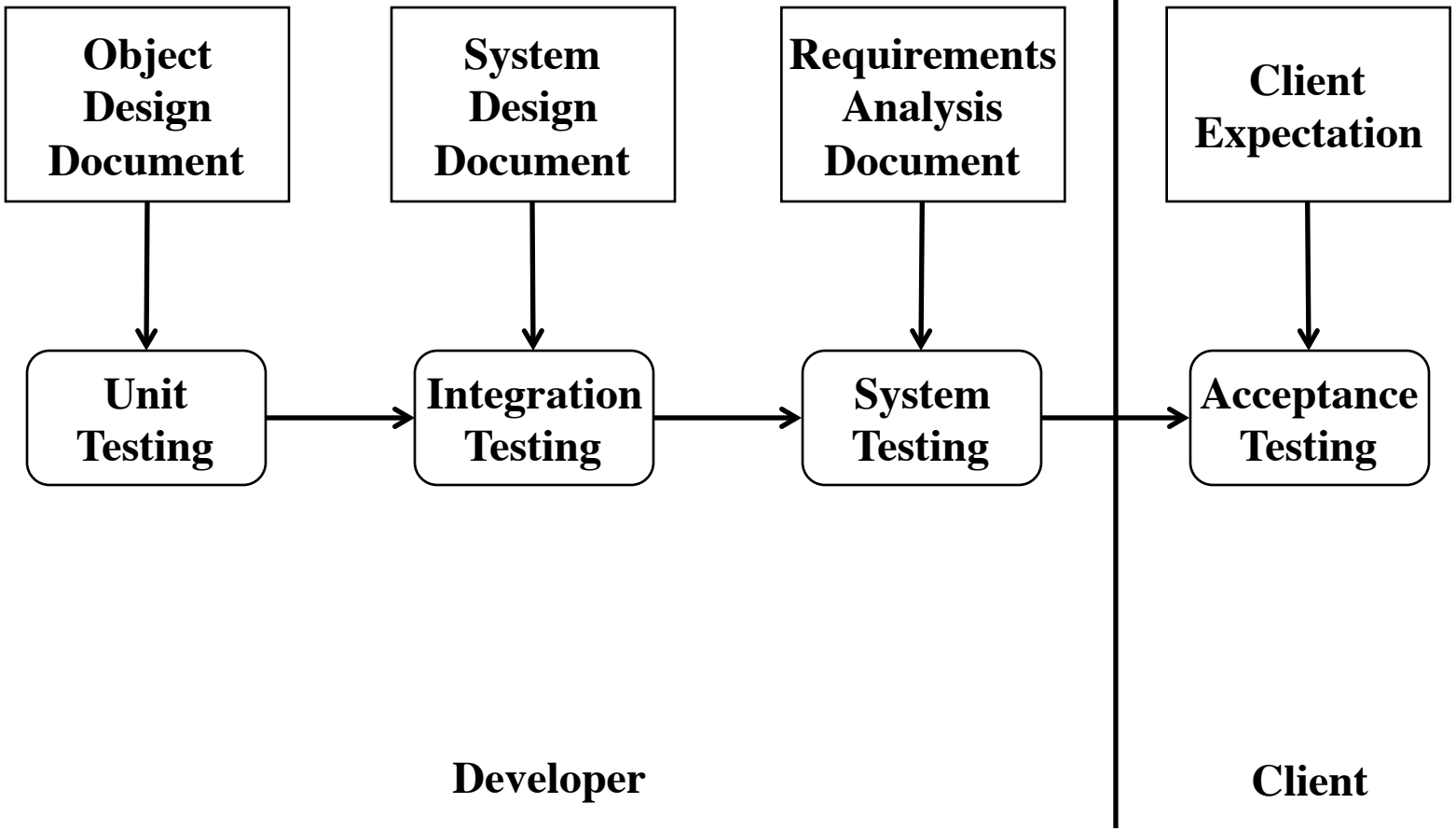
=> Define your goals and priorities

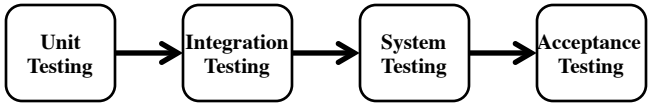
Testing takes creativity

- To develop an effective test, one must have:
  - Detailed understanding of the system
  - Application and solution domain knowledge
  - Knowledge of the testing techniques
  - Skill to apply these techniques
- Testing is done best by independent testers
  - We often develop a certain mental attitude that the program should behave in a certain way when in fact it does not
  - Programmers often stick to the data set that makes the program work
  - A program often does not work when tried by somebody else.

Testing Activities

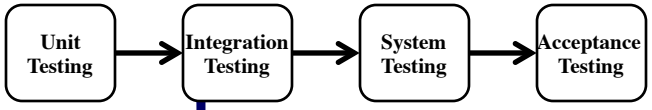






Types of Testing

- Unit Testing
  - Individual component (class or subsystem)
  - Carried out by developers
  - Goal: Confirm that the component or subsystem is correctly coded and carries out the intended functionality
- Integration Testing
  - Groups of subsystems (collection of subsystems) and eventually the entire system
  - Carried out by developers
  - Goal: Test the interfaces among the subsystems.



Types of Testing continued...

- System Testing
  - The entire system
  - Carried out by developers
  - Goal: Determine if the system meets the requirements (functional and nonfunctional)
- Acceptance Testing
  - Evaluates the system delivered by developers
  - Carried out by the client. May involve executing typical transactions on site on a trial basis
  - Goal: Demonstrate that the system meets the requirements and is ready to use.