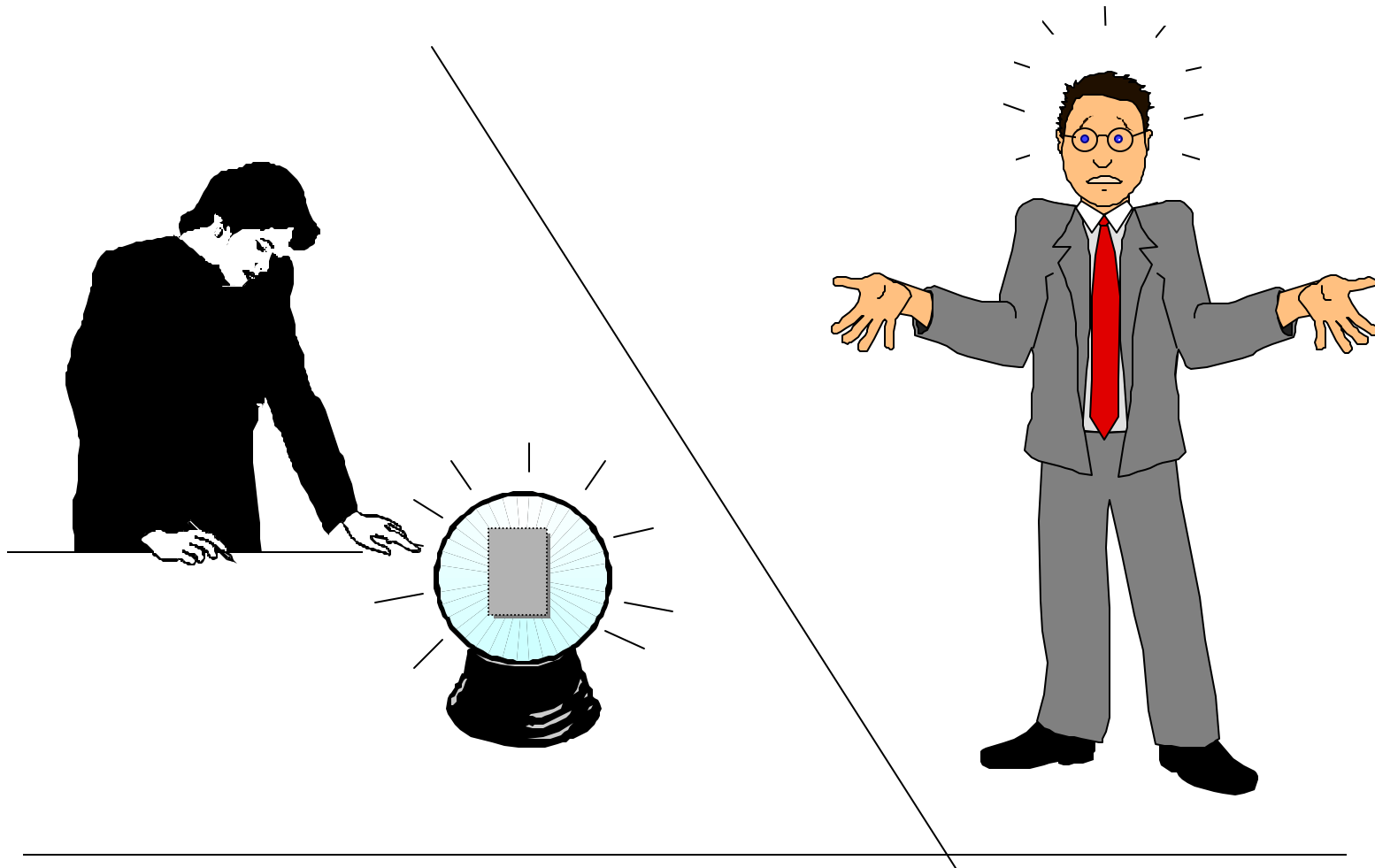

A Taxonomy for Test Oracles

Quality Week '98

Douglas Hoffman
Software Quality Methods, LLC.
24646 Heather Heights Place
Saratoga, California 95070-9710
Phone 408-741-4830
Fax 408-867-4550

Copyright © 1998, Software Quality Methods, LLC. No part of these graphic overhead slides may be reproduced, or used in any form by any electronic or mechanical duplication, or stored in a computer system, without written permission of the author.

Test Oracles

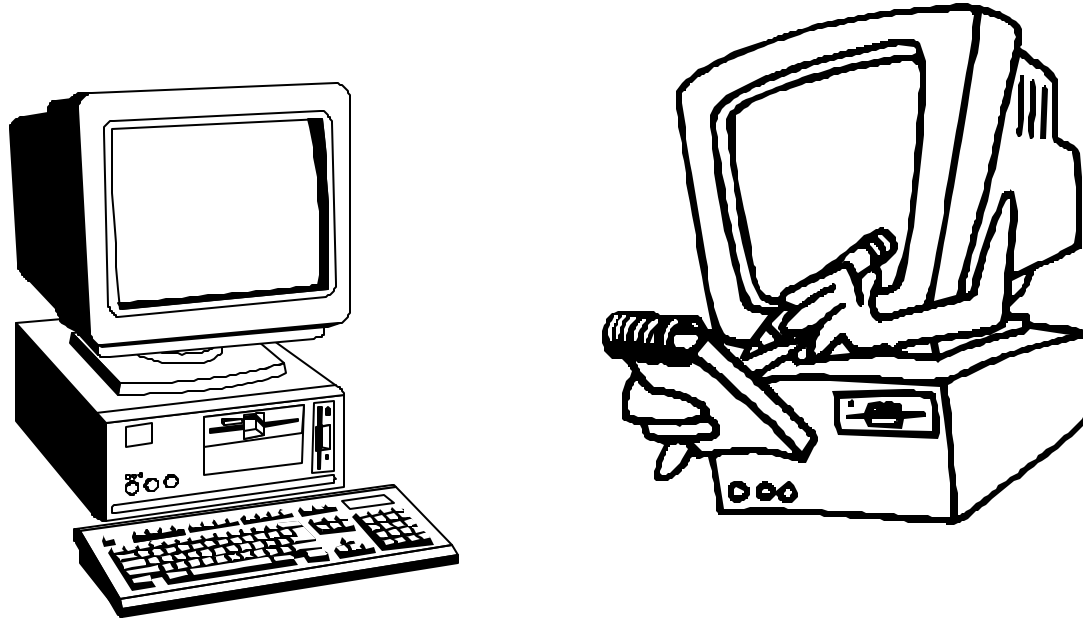


Generating Expected Results

- Manual verification of results (human oracle)
- Separate program implementing the same algorithm
- Software system simulator to produce parallel results
- Hardware simulator to emulate operations
- Earlier version of the software
- Same version of software on a different hardware platform
- Check of specific values for selected known responses
- Verification of consistency of generated values and end points
- Sampling of values against independently generated expected results

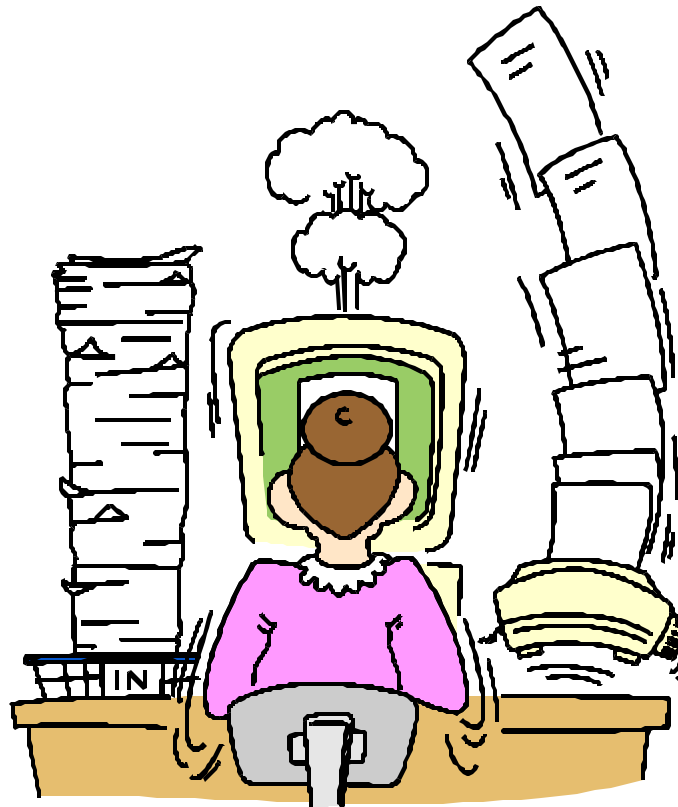
Test Automation

is not just machines running tests!



Test Automation

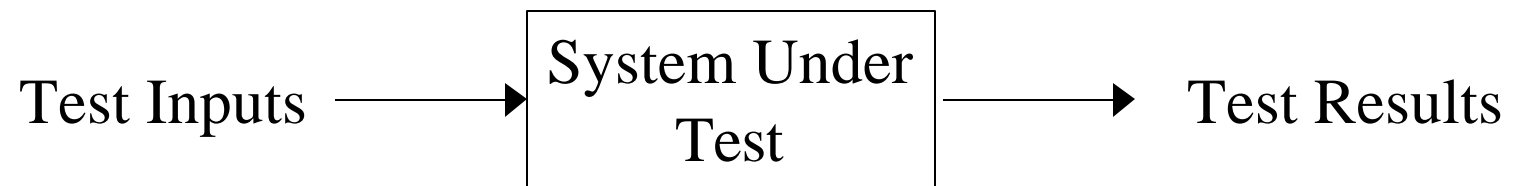
includes interpreting results!



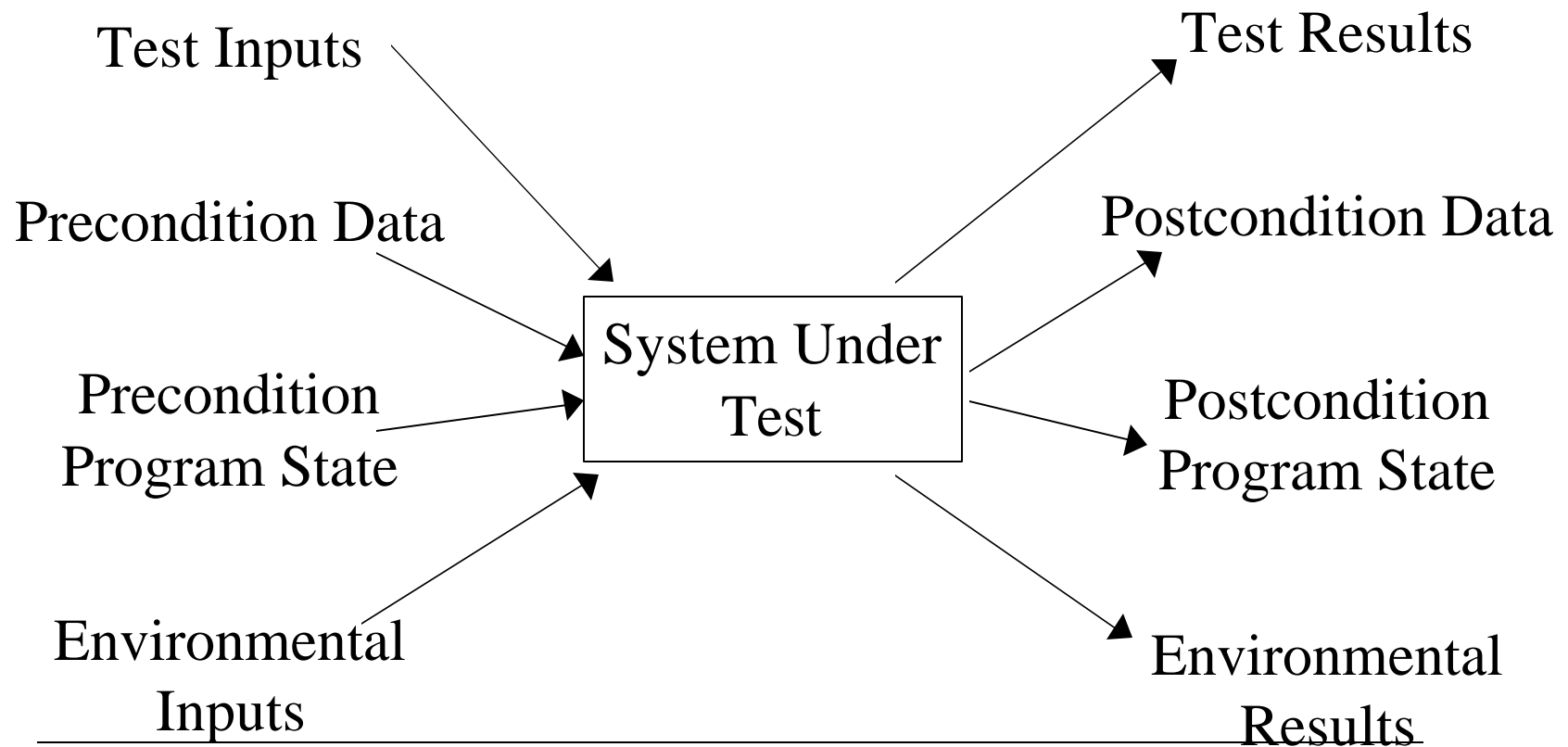
Human Oracles

- Norm for manual testing
- Sometimes slower than computers
- Can't observe system internals
- Loses concentration
- Easily “trained” to overlook errors

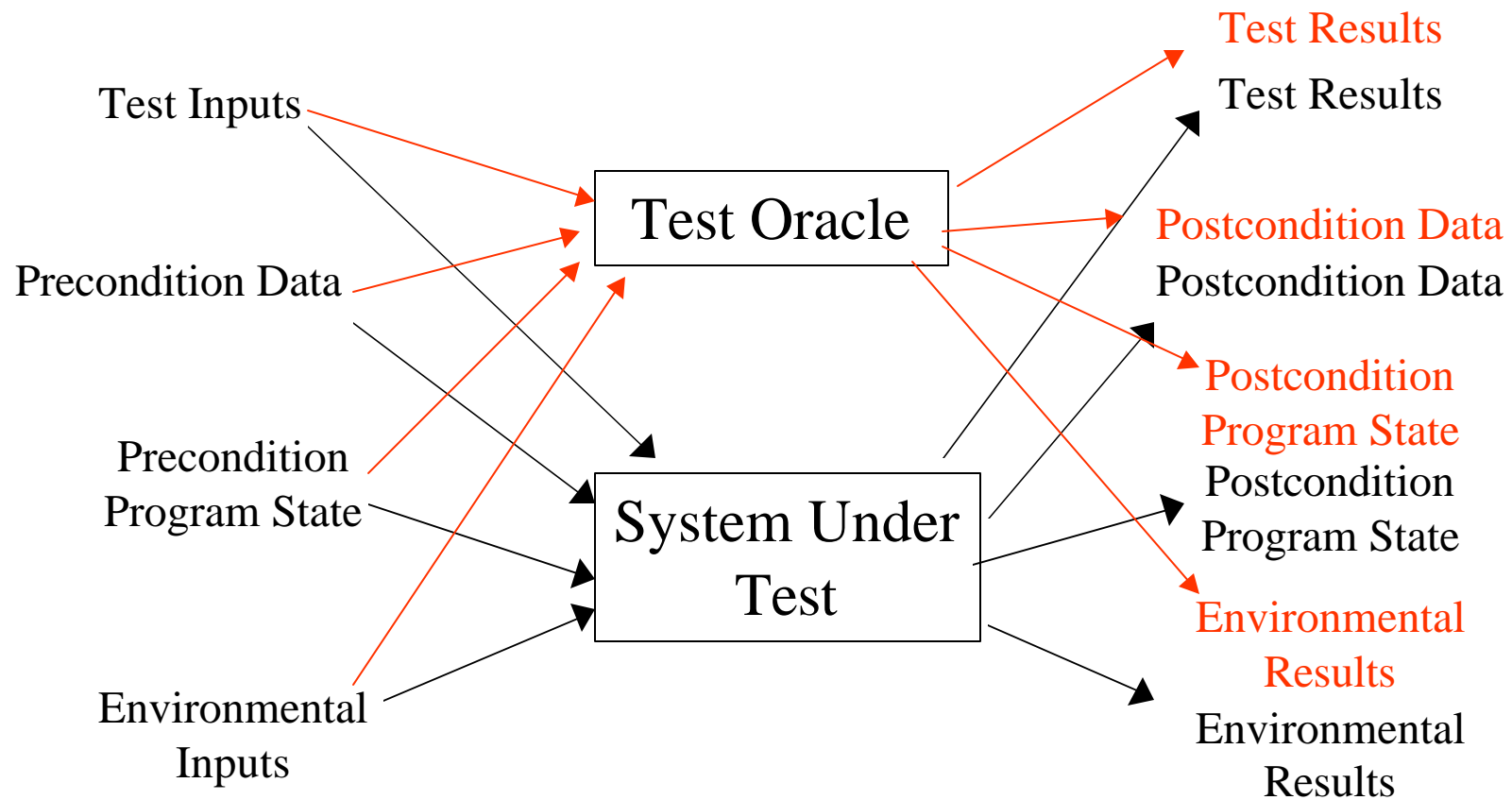
I-P-O Testing Model (Black Box)



Expanded Testing Model (Black Box)



Testing Model With Oracle



Oracles Modeled in Testing

- Differ based on SUT
- May be more than one for SUT
- Inputs may effect more than one oracle
- Oracle only produces some results

Oracle Characteristics

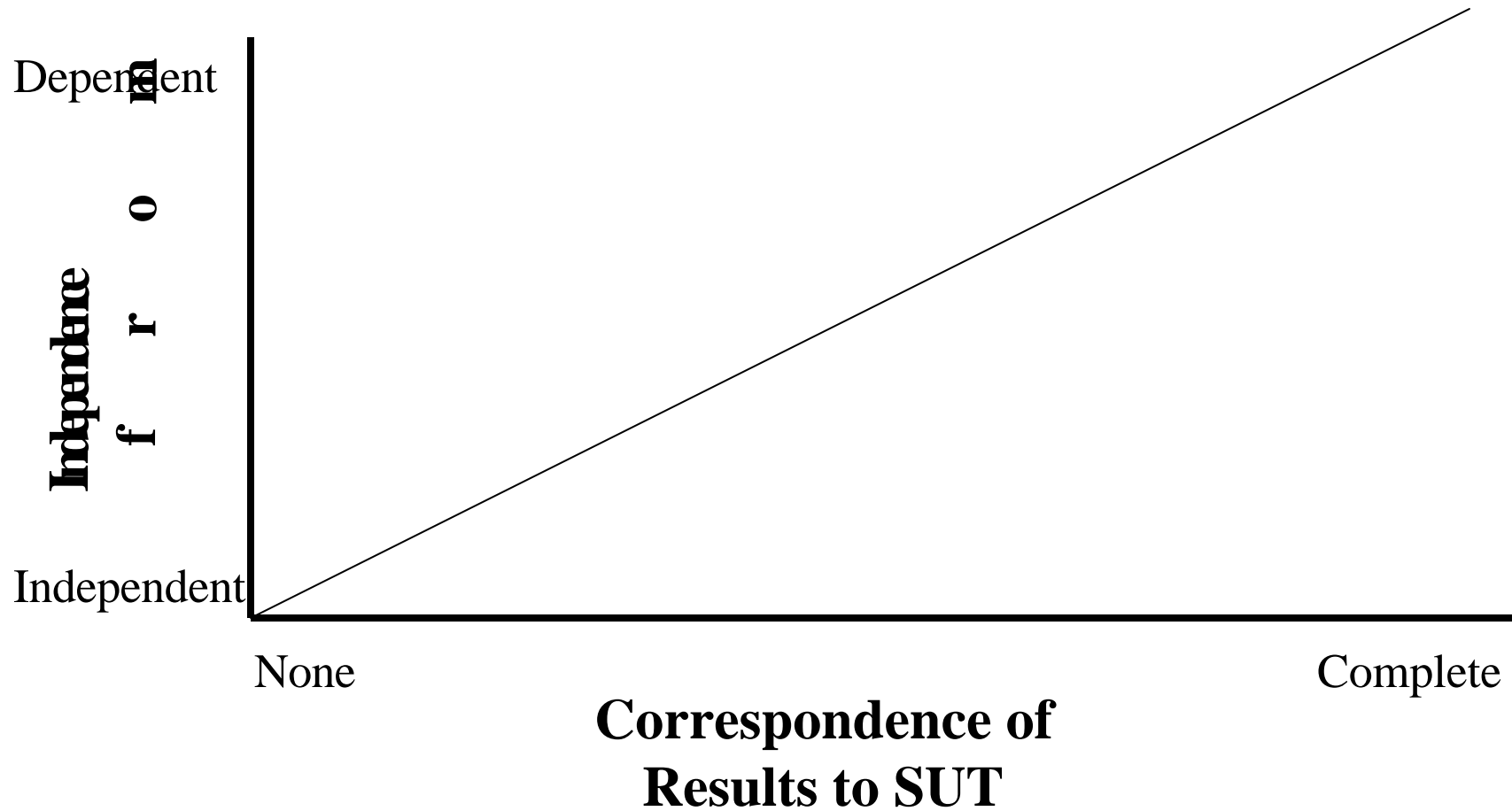
- Completeness of information from oracle
- Accuracy of information from oracle
- Independence of oracle from SUT
 - Algorithms
 - Sub-programs and libraries
 - System platform
 - Operating environment

Oracle Characteristics

(continued)

- Speed of predictions
- Time of execution of oracle
- Usability of results
- Correspondence (currency) of oracle through changes in the SUT

Scale of Oracle Characteristics



Oracle Measures

- Oracle may become as complex as SUT
- More complex oracles make more errors
- Close correspondence reduces maintainability
- Close correspondence makes common mode faults likely

Types of Oracles

- True
- Stochastic
- Heuristic
- Sampling
- Consistent

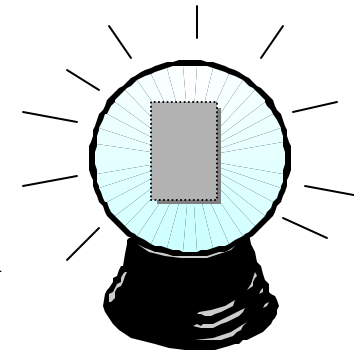
True Oracle

Pro:

- Independent of SUT
- Faithful results
- May exhaustively test
- Good for any test case

Con:

- Costly
- Complex
- Slow
- Hard to maintain



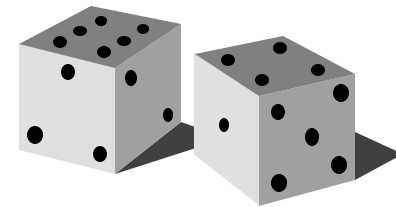
Stochastic Oracle

Pro:

- Random sampling
- Fewer values
- Uniform SUT coverage
- Can select desired coverage level
- Less Costly
- May be simple

Con:

- Can miss systematic faults
- Uniform SUT coverage
- May be slow to verify
- Cannot focus



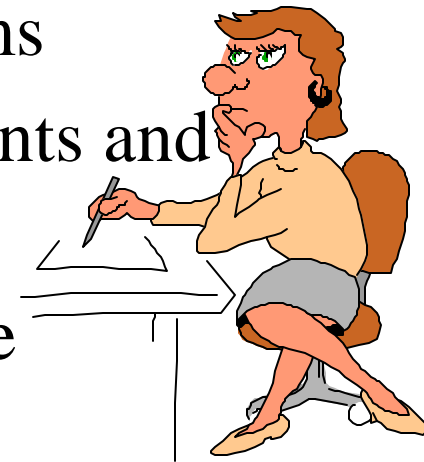
Heuristic Oracle

Pro:

- Check selected points
- Interpolate between using heuristic
- Fast for regular algorithms
- Can 'check' large volumes of data

Con:

- Can miss systematic faults
- Can miss incorrect algorithms
- Need points and heuristic
- Inflexible



Sampling Oracle

Pro:

- Can select easy values
- Quick
- Inexpensive
- Can focus

Con:

- Can miss systematic faults
- Can miss incorrect algorithms
- Likely to miss specific faults
- Easily biased

Consistent Oracle

Pro:

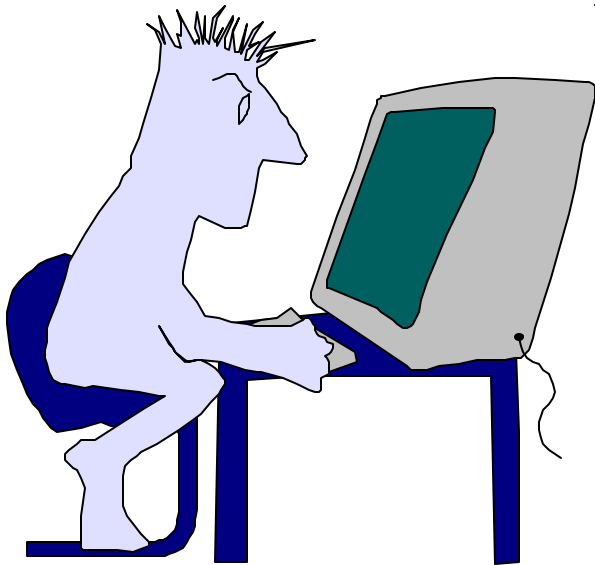
- Good for monitoring changes
- Good for checking for side-effects
- Good for regression testing
- Quick for some environments
- Can check huge volumes of raw data

Con:

- Legacy errors not found
- May be slow to verify
- May be difficult to identify fault
- Requires maintenance

Running An Oracle

- Type of results
- Time of running
- Method of verification
 - Manual
 - Automated
 - With test case
 - With automated test environment



Conclusions

- Different types of oracles possible
- Some kind of oracle needed
- Oracle not constrained like SUT
- Solutions differ with SUT
- Oracles are part of automation

