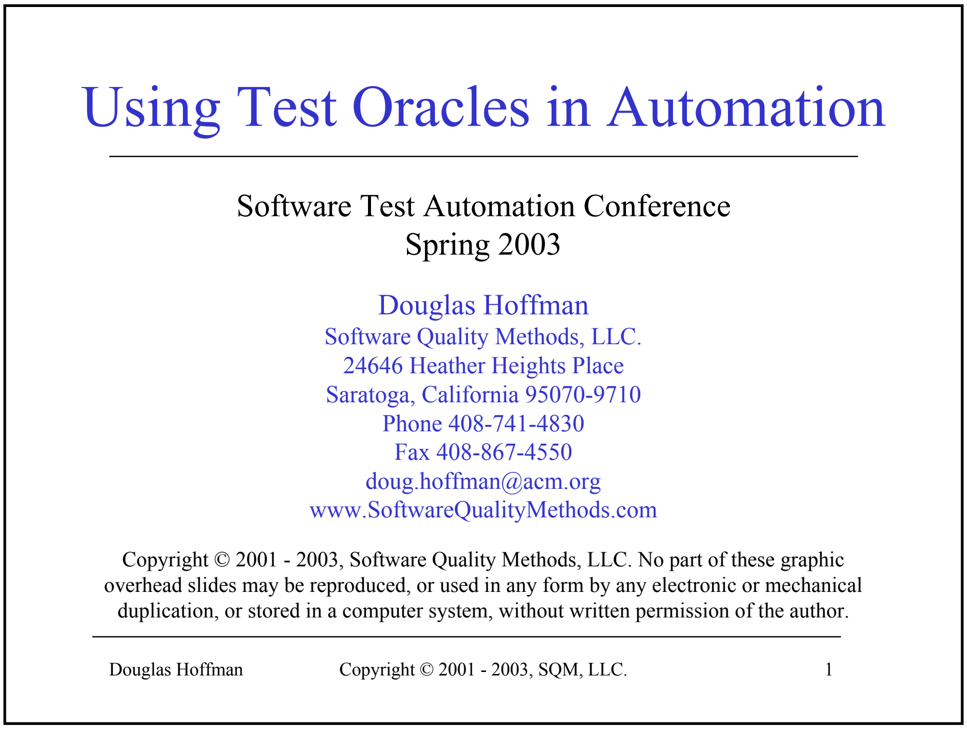

Using Test Oracles in Automation

Software Test Automation Conference
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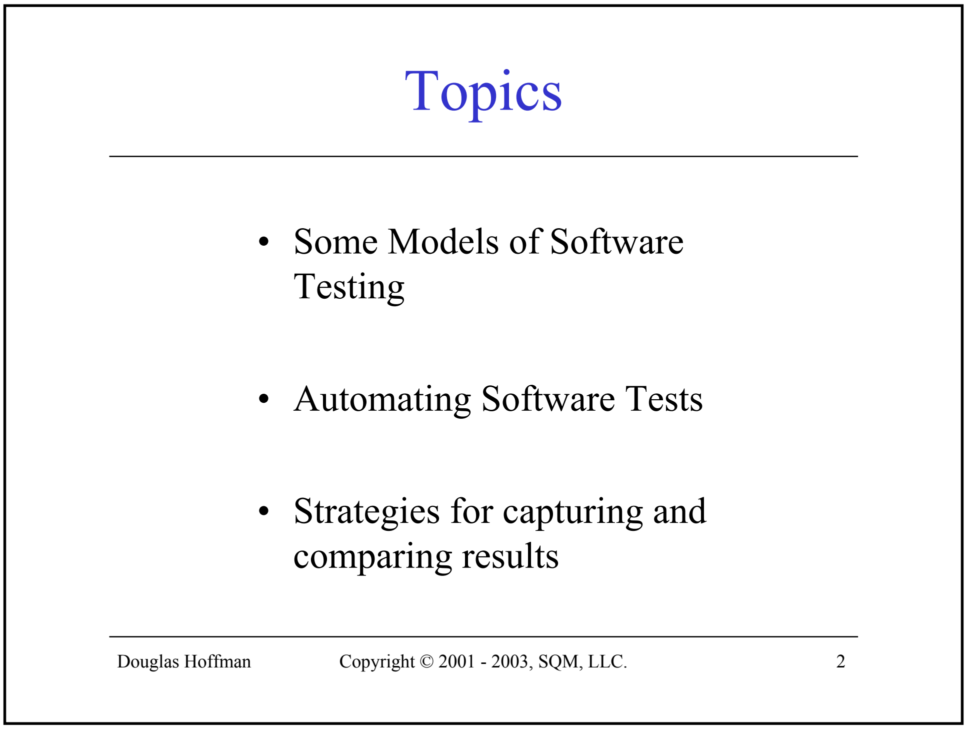
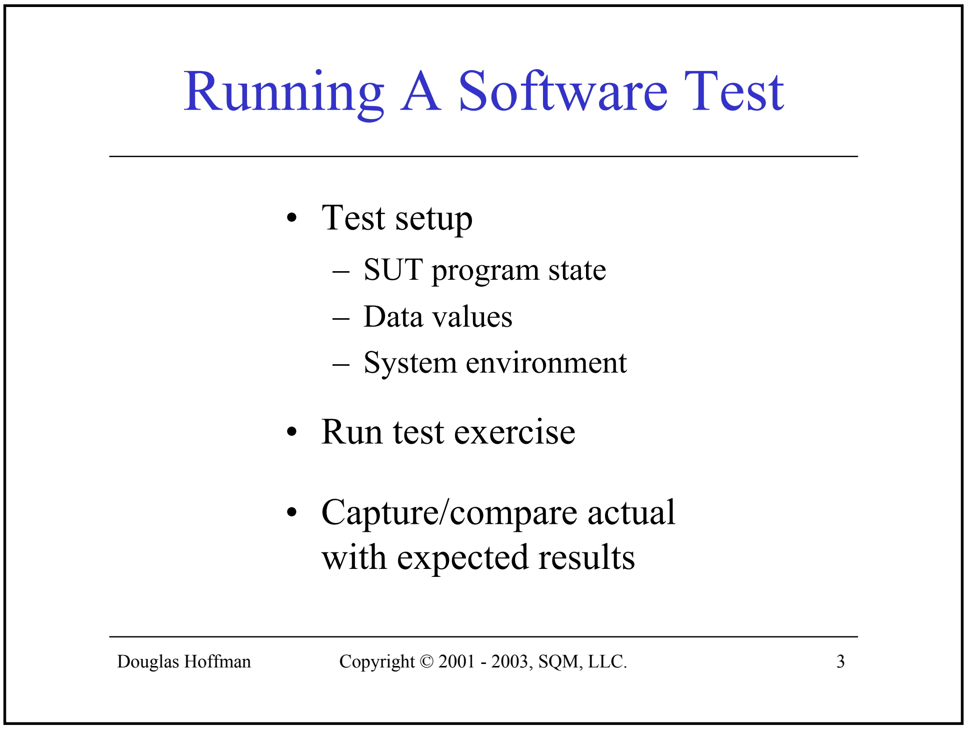


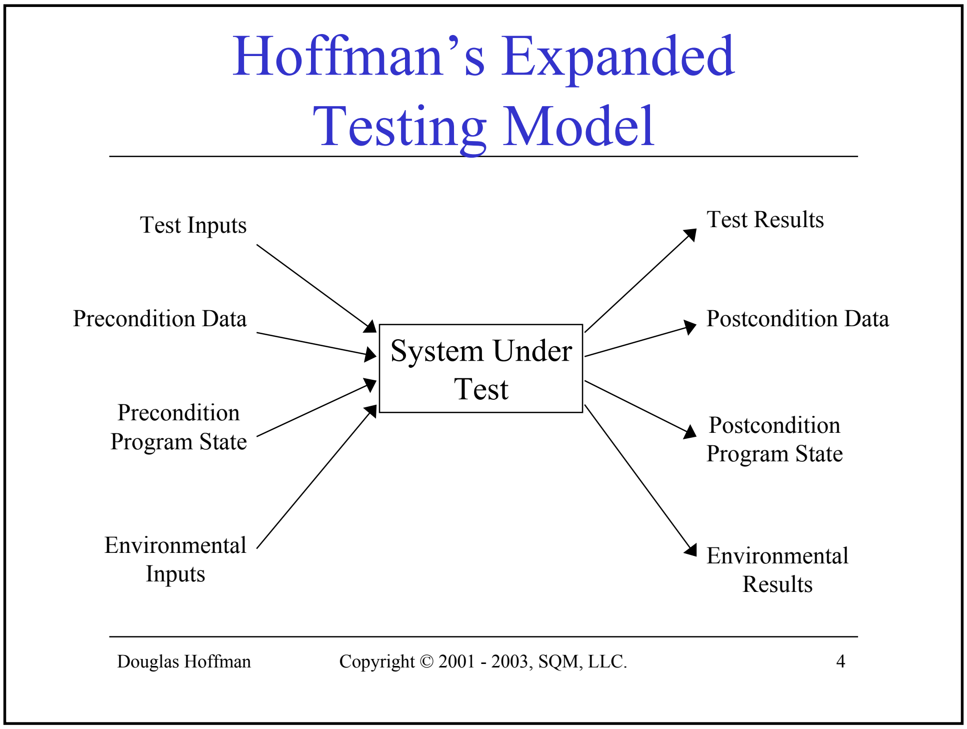
Topics

- Some Models of Software Testing
- Automating Software Tests
- Strategies for capturing and comparing results



Running A Software Test

- Test setup
  - SUT program state
  - Data values
  - System environment
- Run test exercise
- Capture/compare actual with expected results



Hoffman's Expanded Testing Model

Test Inputs

Precondition Data

Precondition Program State

Environmental Inputs

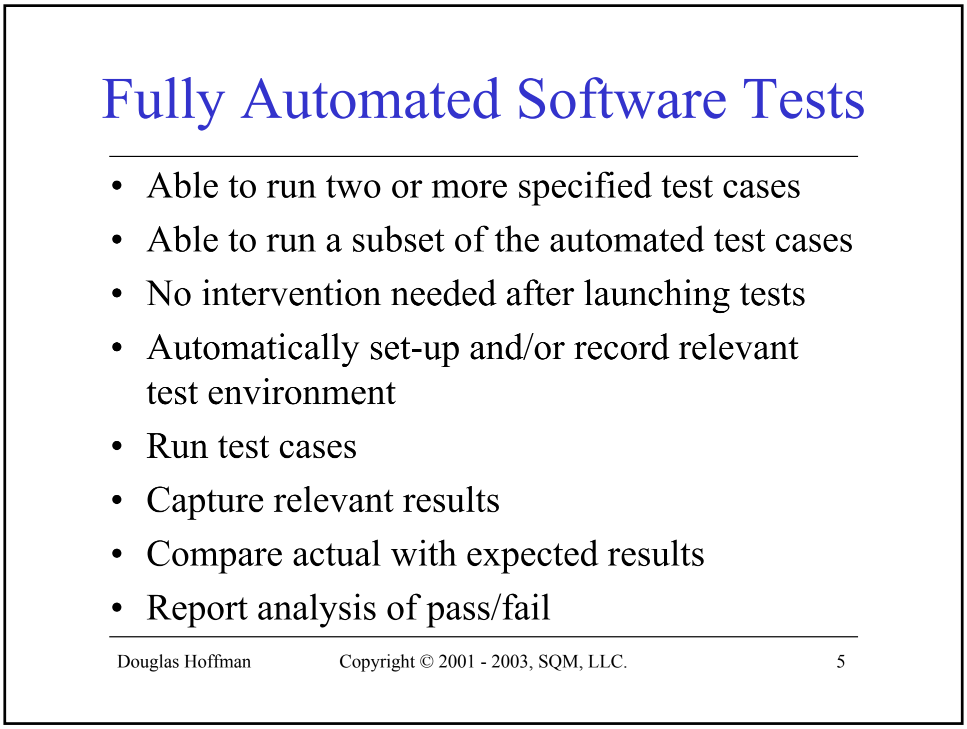
System Under Test

Test Results

Postcondition Data

Postcondition Program State

Environmental Results



Fully Automated Software Tests

- Able to run two or more specified test cases
- Able to run a subset of the automated test cases
- No intervention needed after launching tests
- Automatically set-up and/or record relevant test environment
- Run test cases
- Capture relevant results
- Compare actual with expected results
- Report analysis of pass/fail

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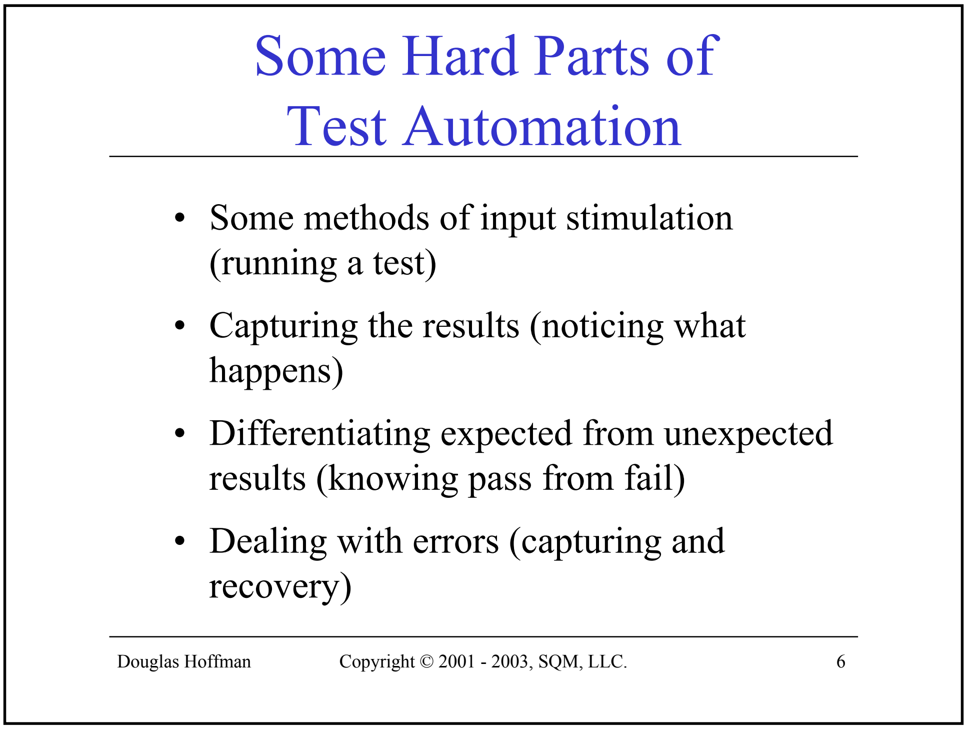

Some Hard Parts of Test Automation

- Some methods of input stimulation (running a test)
- Capturing the results (noticing what happens)
- Differentiating expected from unexpected results (knowing pass from fail)
- Dealing with errors (capturing and recovery)

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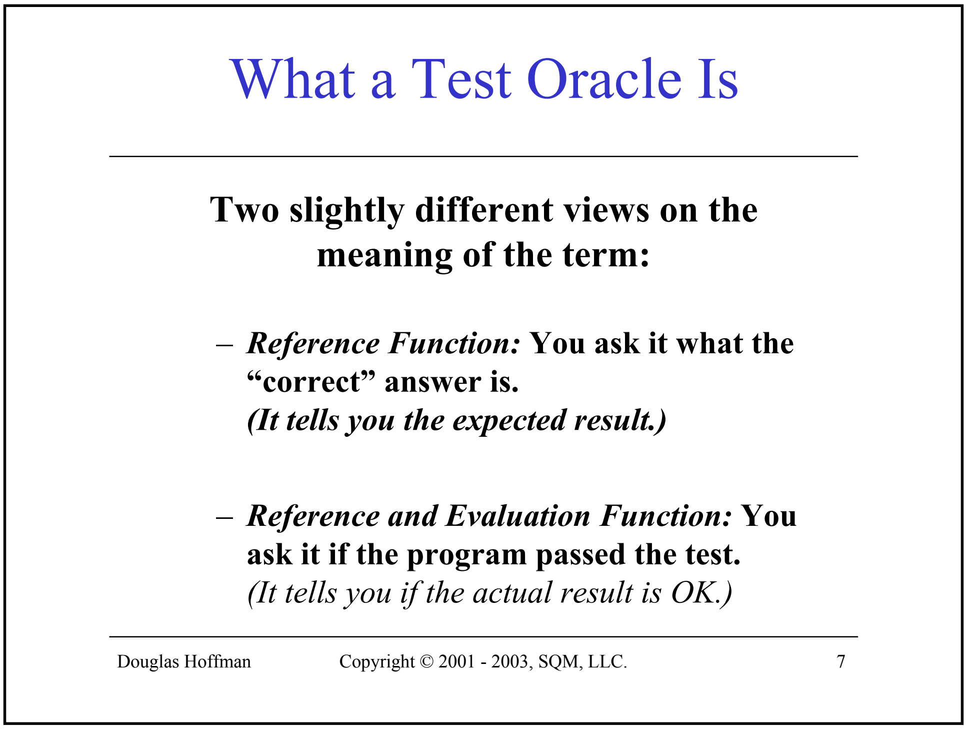
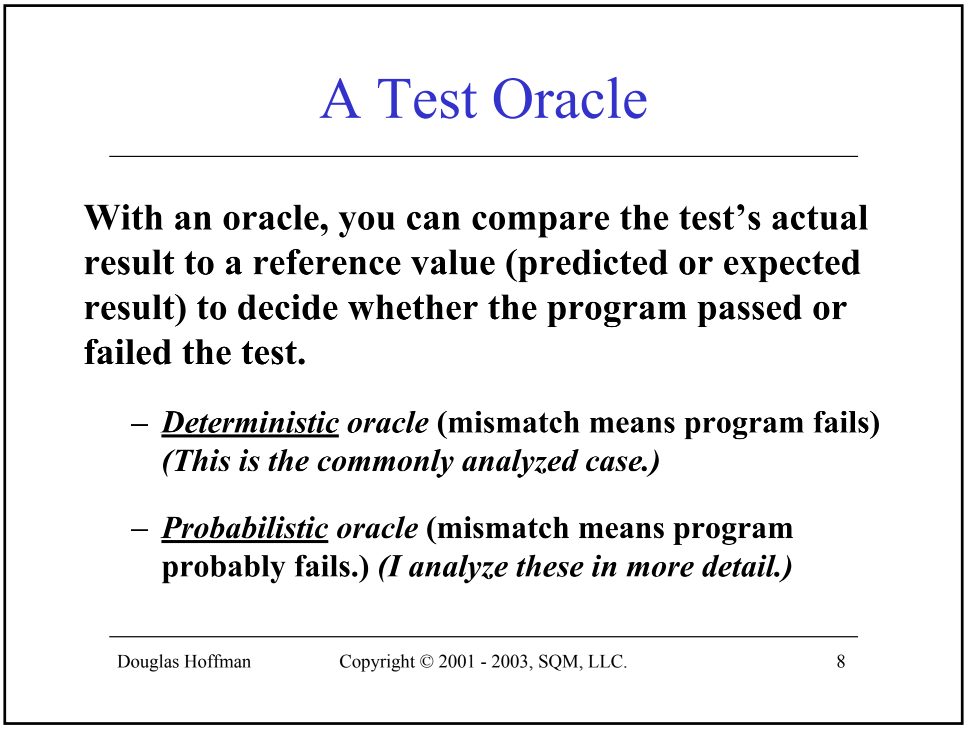


What a Test Oracle Is

Two slightly different views on the meaning of the term:

– ***Reference Function:*** **You ask it what the "correct" answer is.**
(It tells you the expected result.)

– ***Reference and Evaluation Function:*** **You ask it if the program passed the test.**
(It tells you if the actual result is OK.)

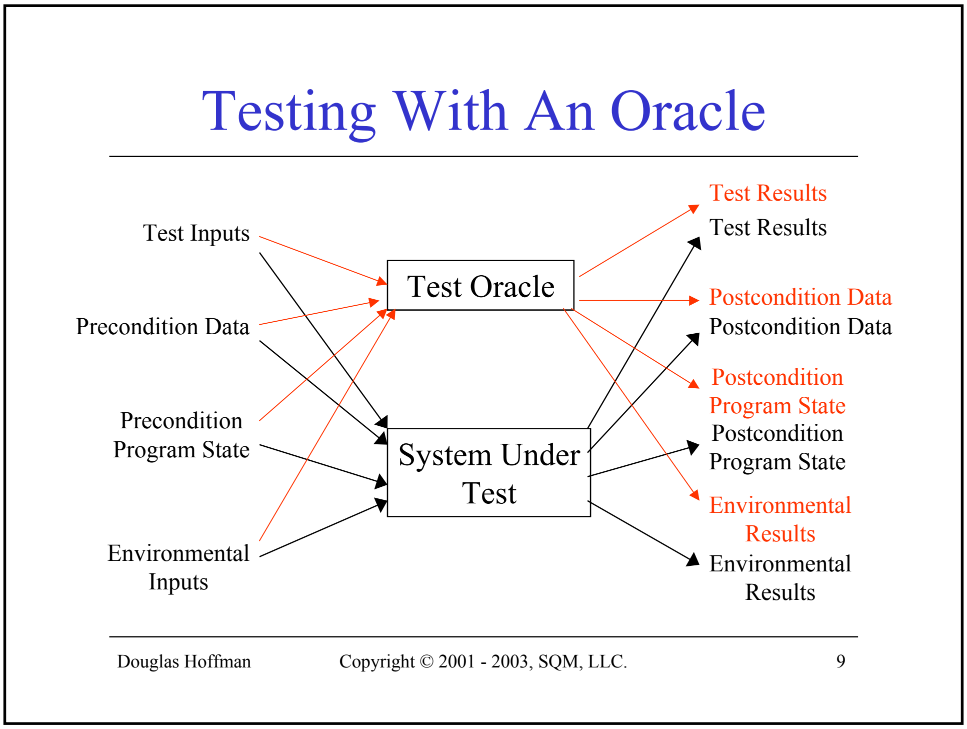


A Test Oracle

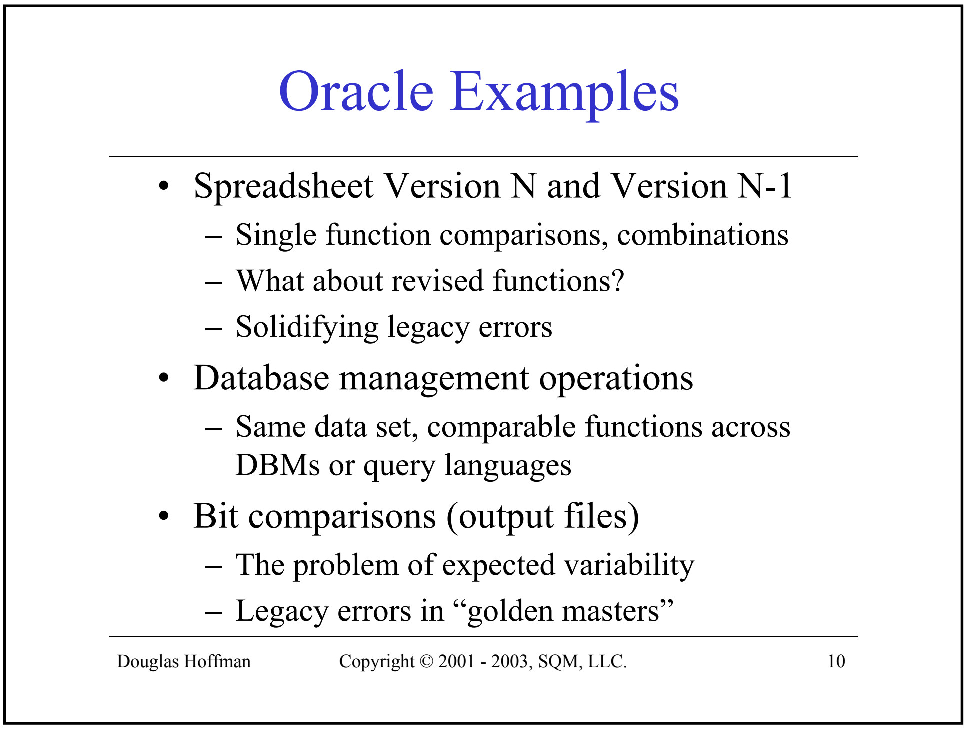
With an oracle, you can compare the test's actual result to a reference value (predicted or expected result) to decide whether the program passed or failed the test.

– ***<u>Deterministic</u> oracle*** **(mismatch means program fails)**
(This is the commonly analyzed case.)

– ***<u>Probabilistic</u> oracle*** **(mismatch means program probably fails.)** ***(I analyze these in more detail.)***

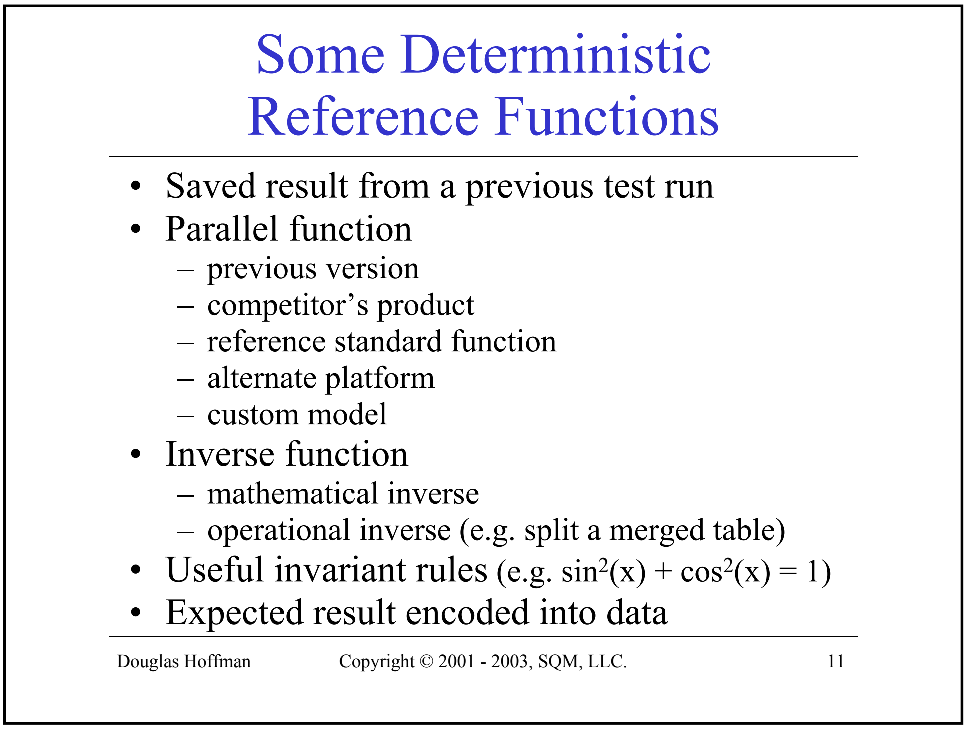


Testing With An Oracle



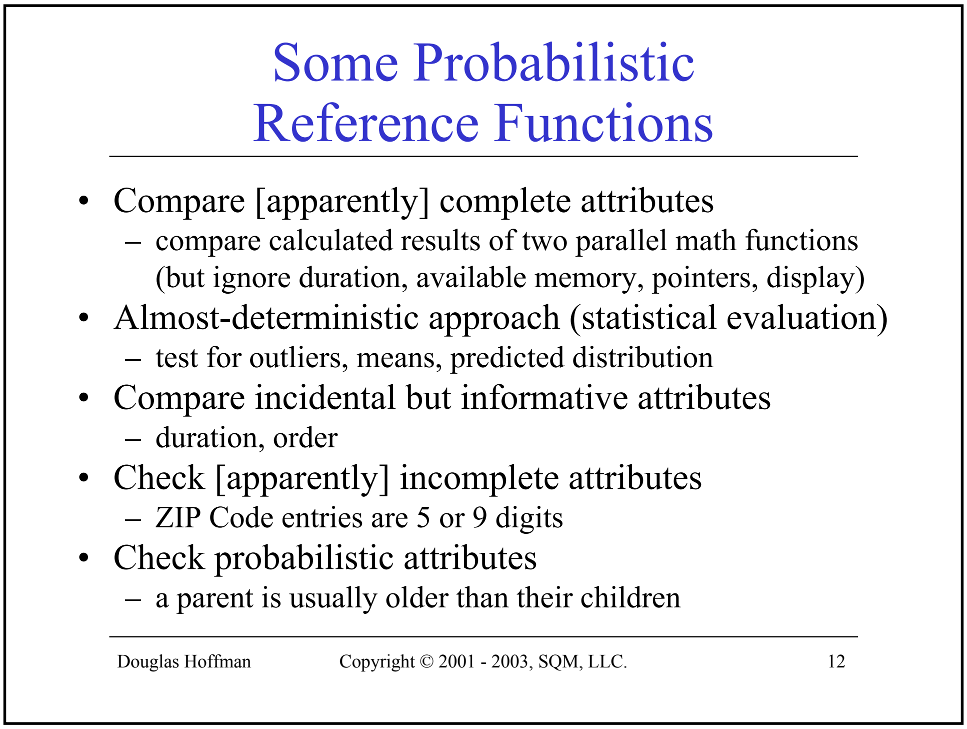
Oracle Examples

- Spreadsheet Version N and Version N-1
  - Single function comparisons, combinations
  - What about revised functions?
  - Solidifying legacy errors
- Database management operations
  - Same data set, comparable functions across DBMs or query languages
- Bit comparisons (output files)
  - The problem of expected variability
  - Legacy errors in “golden masters”



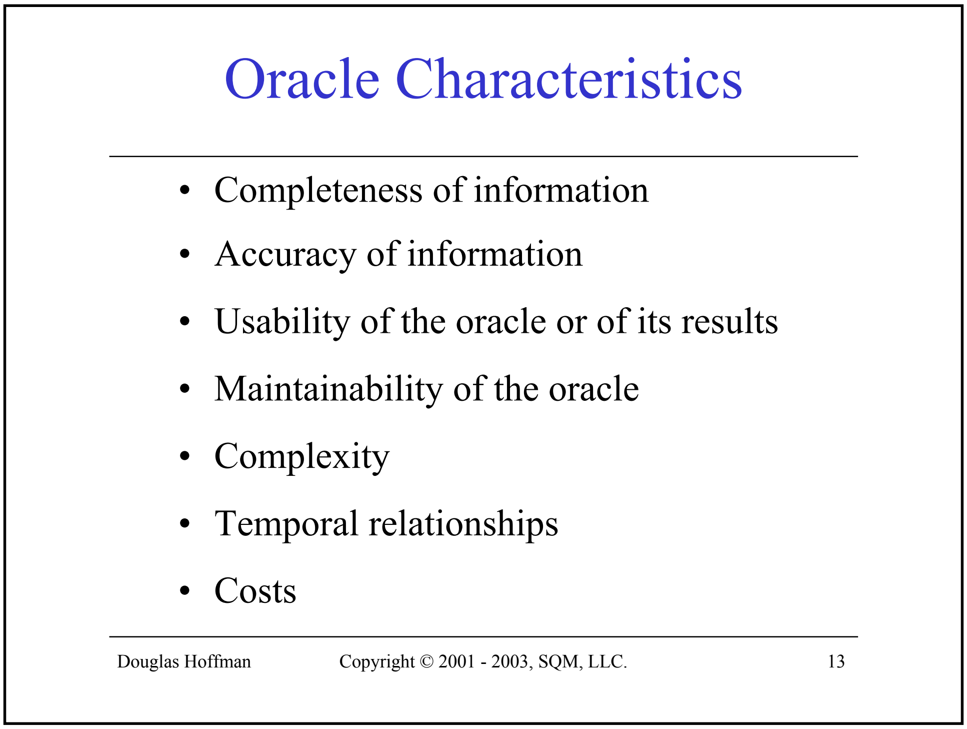
Some Deterministic Reference Functions

- Saved result from a previous test run
- Parallel function
  - previous version
  - competitor's product
  - reference standard function
  - alternate platform
  - custom model
- Inverse function
  - mathematical inverse
  - operational inverse (e.g. split a merged table)
- Useful invariant rules (e.g. $\sin^2(x) + \cos^2(x) = 1$)
- Expected result encoded into data



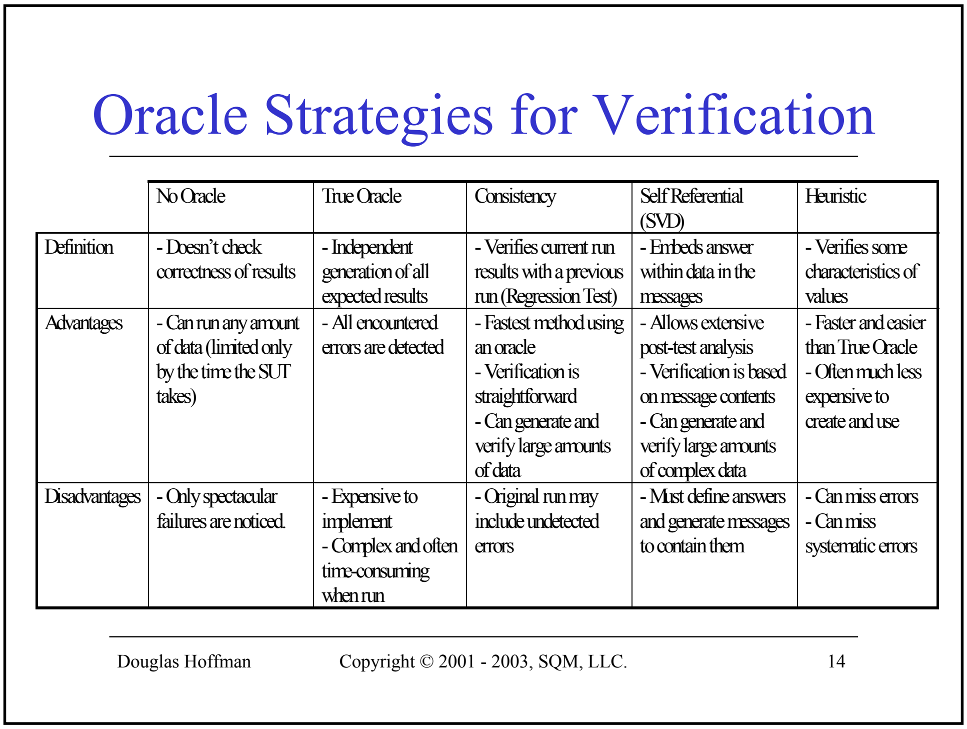
Some Probabilistic Reference Functions

- Compare [apparently] complete attributes
  - compare calculated results of two parallel math functions (but ignore duration, available memory, pointers, display)
- Almost-deterministic approach (statistical evaluation)
  - test for outliers, means, predicted distribution
- Compare incidental but informative attributes
  - duration, order
- Check [apparently] incomplete attributes
  - ZIP Code entries are 5 or 9 digits
- Check probabilistic attributes
  - a parent is usually older than their children



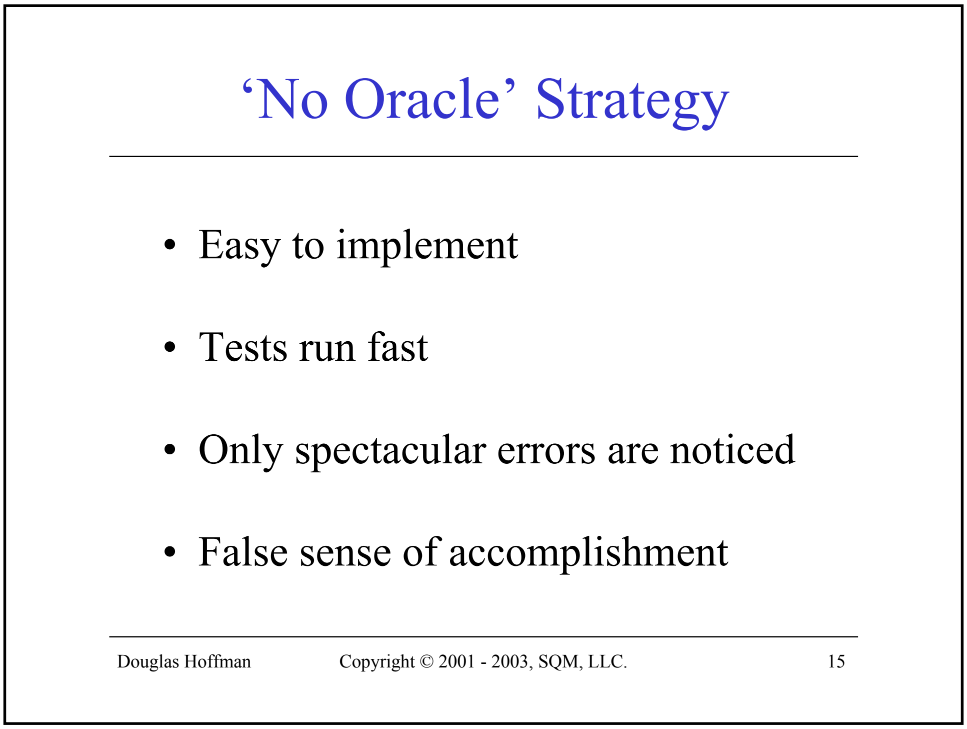
Oracle Characteristics

- Completeness of information
- Accuracy of information
- Usability of the oracle or of its results
- Maintainability of the oracle
- Complexity
- Temporal relationships
- Costs



Oracle Strategies for Verification

	No Oracle	True Oracle	Consistency	Self Referential (SVD)	Heuristic
Definition	- Doesn't check correctness of results	- Independent generation of all expected results	- Verifies current run results with a previous run (Regression Test)	- Embeds answer within data in the messages	- Verifies some characteristics of values
Advantages	- Can run any amount of data (limited only by the time the SUT takes)	- All encountered errors are detected	- Fastest method using an oracle - Verification is straightforward - Can generate and verify large amounts of data	- Allows extensive post-test analysis - Verification is based on message contents - Can generate and verify large amounts of complex data	- Faster and easier than True Oracle - Often much less expensive to create and use
Disadvantages	- Only spectacular failures are noticed.	- Expensive to implement - Complex and often time-consuming when run	- Original run may include undetected errors	- Must define answers and generate messages to contain them	- Can miss errors - Can miss systematic errors



‘No Oracle’ Strategy

- Easy to implement
- Tests run fast
- Only spectacular errors are noticed
- False sense of accomplishment

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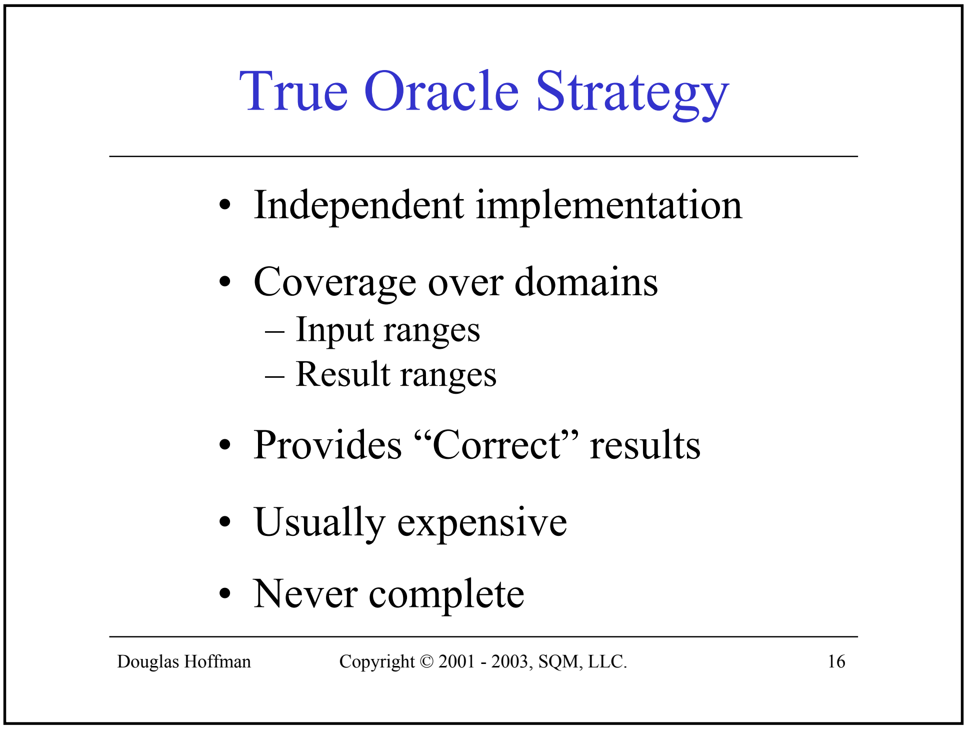

True Oracle Strategy

- Independent implementation
- Coverage over domains
  - Input ranges
  - Result ranges
- Provides “Correct” results
- Usually expensive
- Never complete

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Consistency Strategy

- A / B compare
- Check for changes
- Regression checks
  - Validated
  - Unvalidated
- Alternate versions or platforms
- Foreign implementations

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Self-Referential Strategy

- Embed results in the data
- Cyclic algorithms
- Shared keys with algorithms

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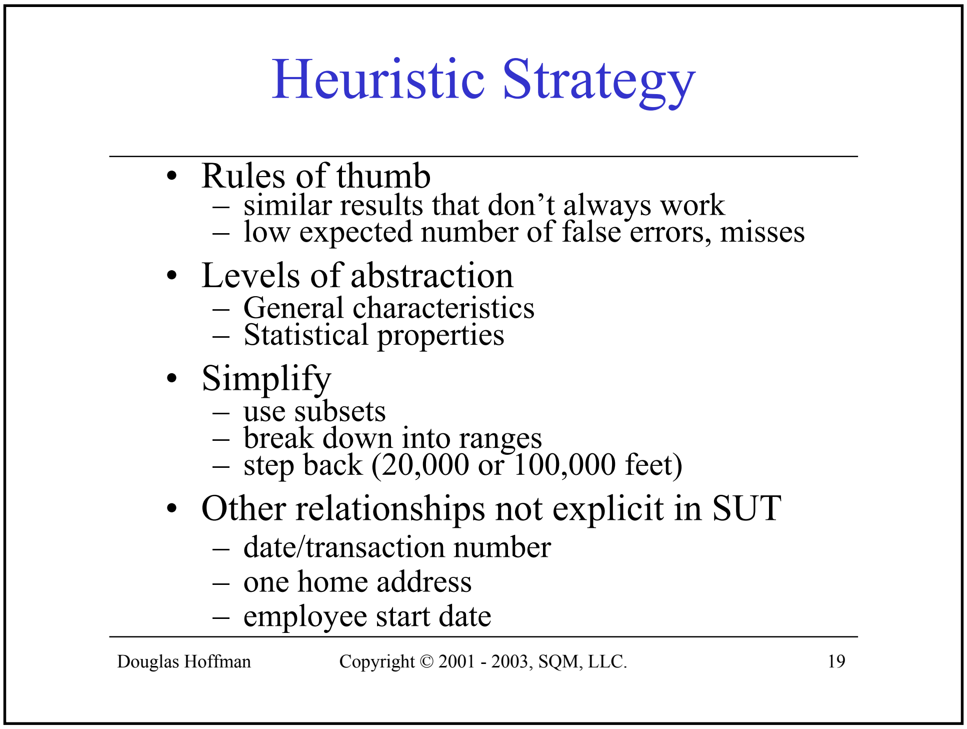

Heuristic Strategy

- Rules of thumb
  - similar results that don’t always work
  - low expected number of false errors, misses
- Levels of abstraction
  - General characteristics
  - Statistical properties
- Simplify
  - use subsets
  - break down into ranges
  - step back (20,000 or 100,000 feet)
- Other relationships not explicit in SUT
  - date/transaction number
  - one home address
  - employee start date

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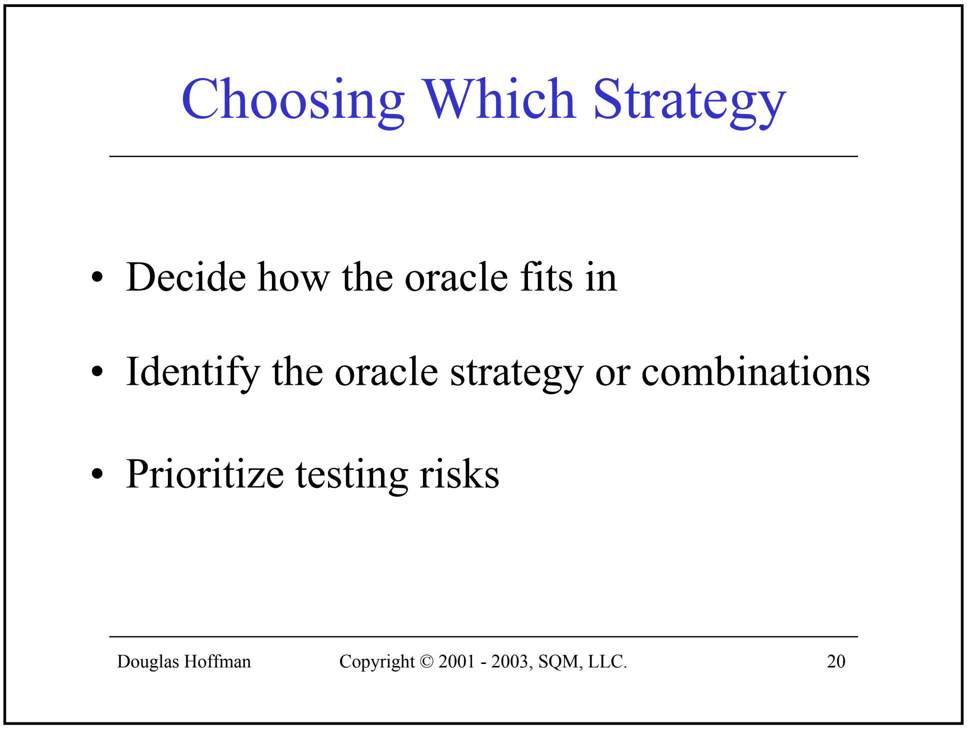

Choosing Which Strategy

- Decide how the oracle fits in
- Identify the oracle strategy or combinations
- Prioritize testing risks

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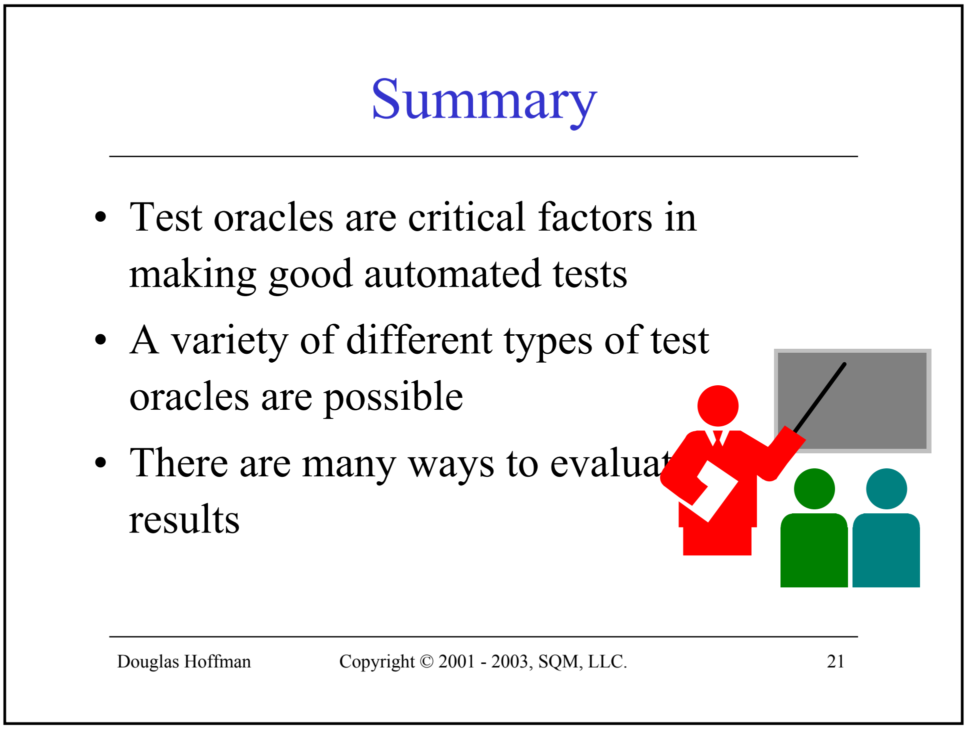

Summary

- Test oracles are critical factors in making good automated tests
- A variety of different types of test oracles are possible
- There are many ways to evaluat results

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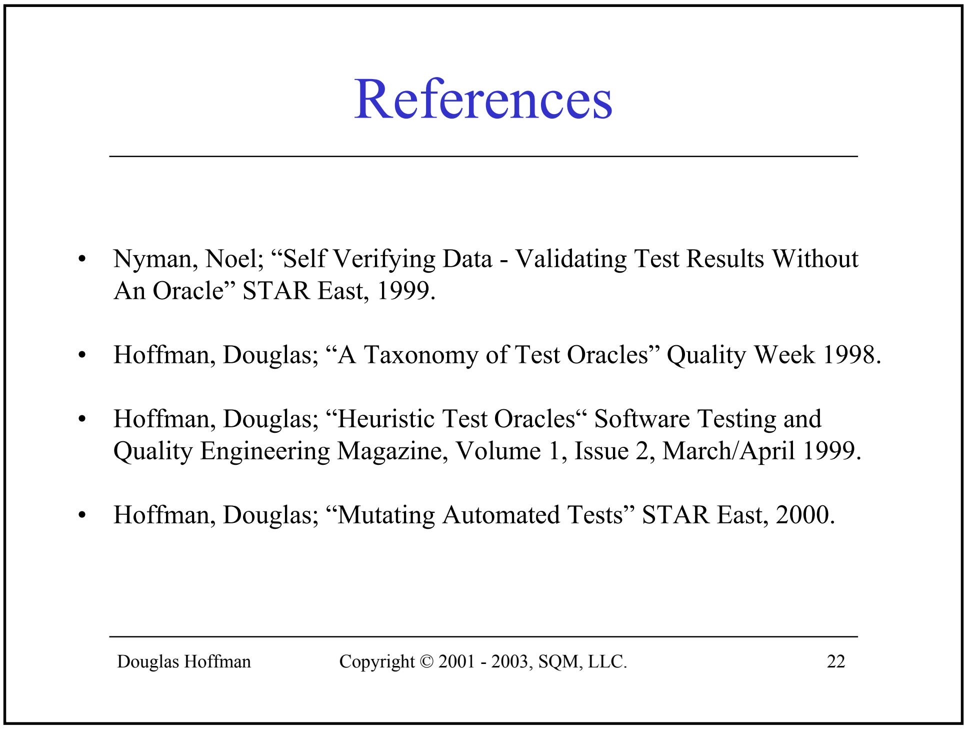

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