Test Oracles

- Discussion
  - Automation of oracle necessary
  - Expected behavior given
  - Necessary parts of an oracle
  - Name spaces

Test Oracle

- A test oracle determines whether a system behaves correctly for test execution
- Webster Dictionary - Oracle
  - a person giving wise or authoritative decisions or opinions
  - an authoritative or wise expression or answer

Purpose of Test Oracle

- Sequential Systems
  - Check functionality
- Reactive (event-driven) Systems
  - Check functionality
  - Timing
  - Safety

Reactive Systems

- Complete specification requires use of multiple computational paradigms
- Oracles must judge all behavioral aspects in comparison with all system specifications and requirements
- Hence oracles may be developed directly from formal specifications

Parts of an Oracle

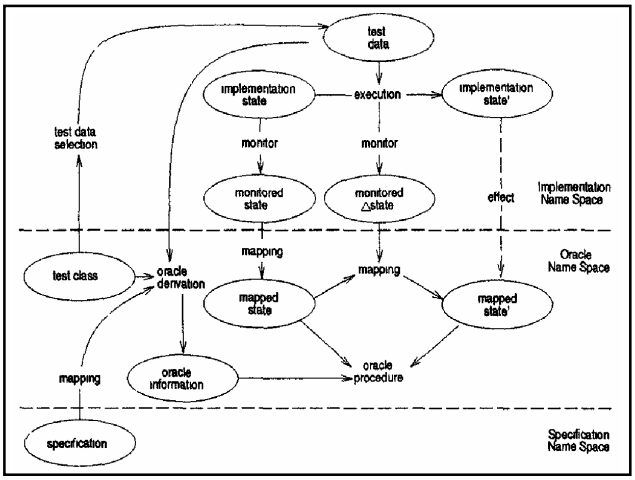
- Oracle information
  - Specifies what constitutes correct behavior
    - Examples: input/output pairs, embedded assertions
- Oracle procedure
  - Verifies the test execution results with respect to the oracle information
    - Examples: equality
- Test monitor
  - Captures the execution information from the run-time environment
    - Examples
      - Simple systems: directly from output
      - Reactive systems: events, timing information, stimuli, and responses

Approach

- Test class
  - Set of test data described by a condition that constrains input data and the initial system state
- Every test class will have an explicitly represented test oracle
- Results are monitored and verified against the oracle corresponding to all test classes satisfied for the test data

Phases of the Approach

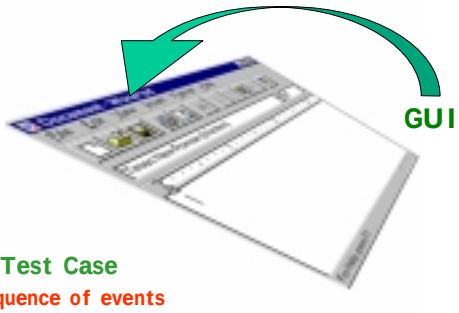
- Oracle derivation
  - From specifications for each test class
- Monitoring test execution
- Mapping and applying the oracle procedure to the execution results



Automated Test Oracles for GUIs

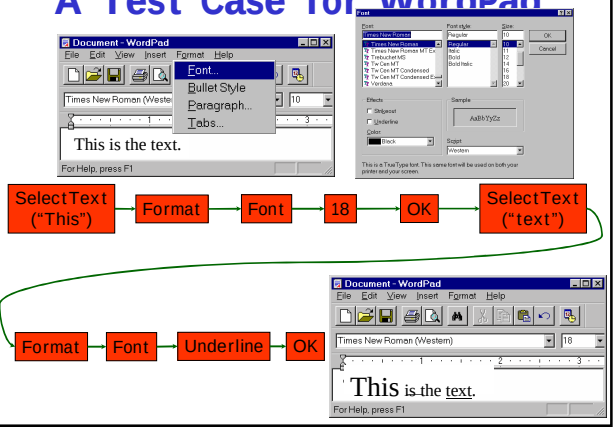
Foundations of Software Engineering, 2000

GUI Test Cases

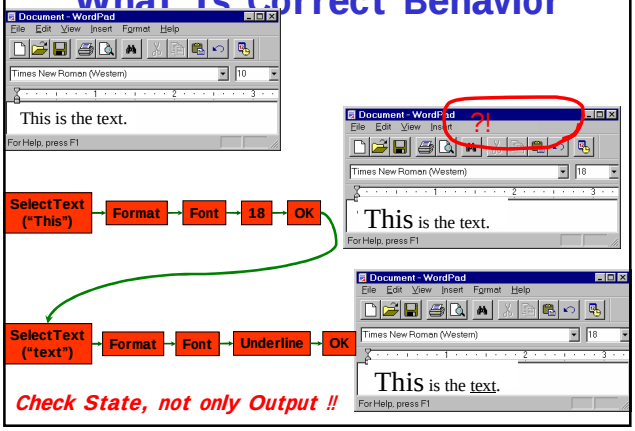


- GUI Test Case
  - Sequence of events

A Test Case for WordPad

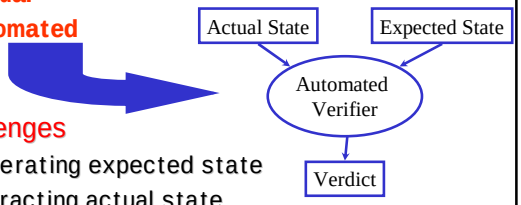


What Is Correct Behavior



Research Focus

- Goal
  - To check the GUI's state after each event
- Approaches
  - Manual
  - Automated

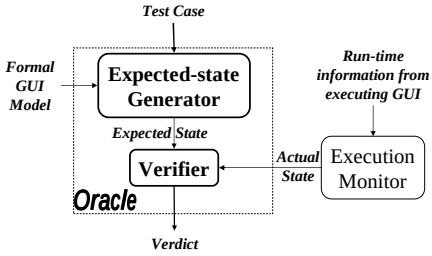


- Challenges
  - Generating expected state
  - Extracting actual state
  - Comparing expected & actual states

Outline

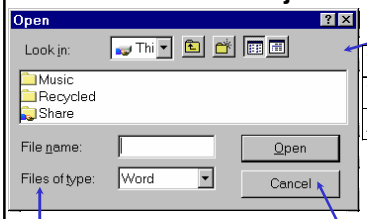
- Overview of GUI Oracle
- Generating Expected State
  - Modeling the GUI's State
    - Objects
    - Properties
  - Modeling the Events
- Obtaining Actual GUI's State
- Comparing Actual & Expected States

Overview of GUI Oracle



Modeling the GUI

A GUI consists of Objects



Form

Window State	wsNormal
Width	1088
AutoScroll	TRUE

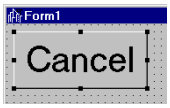
Label

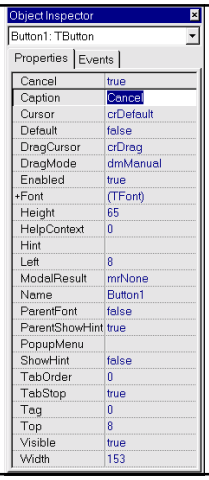
Align	alNone
Caption	Files of type:
Color	clBtnFace
Font	(tFont)

Button

Caption	Cancel
Enabled	TRUE
Visible	TRUE
Height	65

All Properties of Cancel





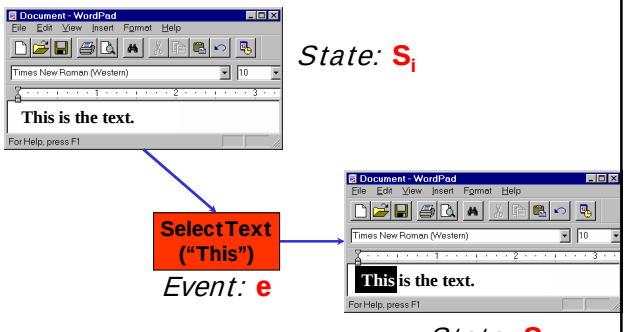
Determining Properties

- Manual Examination of GUI
- Specifications (Reduced Set)
  - GUI being tested
- Toolkit/Language (Complete Set)
  - All available properties

Now we know how to represent the GUI's state

Modeling Events

- Events are State Transducers



Notation: $S_j = [S_i, e]$

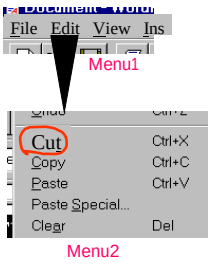
Representing Events

- We define an event as:

  $State_j = [State_i, event]$
- For example:

  $State_j = [State_i, cut]$
- Need a compact representation

Operators



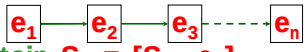
Operator :: *CUT*
Preconditions:
isCurrent(Menu2).

Effects:
FORALL Obj in Objects
Selected(Obj) ⇒
ADD inClipboard(Obj)
DEL onScreen(Obj)
DEL Selected(Obj)
ADD isCurrent(Menu1)
DEL isCurrent(Menu2).

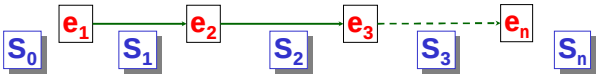
Obtaining next state

Deriving Expected State

- Given S_0, the initial state,
- A sequence of events



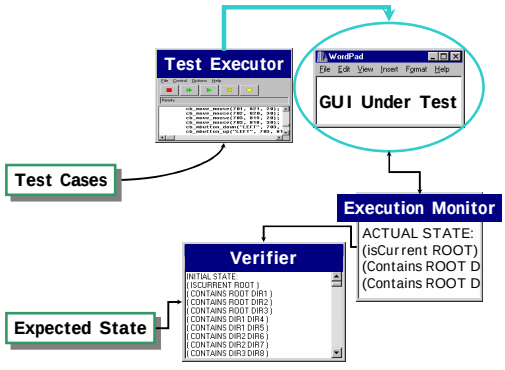
- Obtain $S_1 = [S_0, e_1]$
- And $S_i = [S_{i-1}, e_i]$



Obtaining Actual GUI's State

- Execution Monitor
  - Screen Scraping
  - Queries
  - Compatible with Expected State
  - Returns <Object, Property, Value>
    <Button1, "Caption", "Cancel">

Automated Execution



Comparing Actual and Expected States

- **Verifier**
- **Three Levels of Testing**
  - **Changed Property Set** *(Operators)*
  - **GUI Relevant Property Set** *(Specifications)*
  - **Complete Property Set** *(Toolkit/Language)*
- **Hybrid Approach**
  - **Use all 3**