

# Coverage Criteria for GUI Testing

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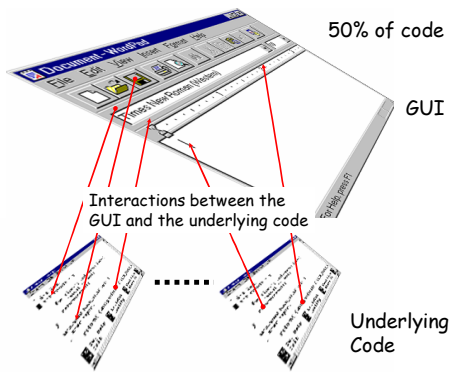
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## Research focus



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## GUI Test Case

- Sequence of Events
  - [IEEE TSE Feb '01]
- Not just individual events

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Coverage Criteria

- Two purposes
  - Test data selection criteria
    - Rules used to select test cases
  - Test data adequacy criteria
    - Rules used to determine how much testing has been done
- Common Examples for Conventional Software
 

- Statement coverage
  - Branch coverage
  - Path coverage

Structural Representation of the Code

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Coverage Criteria for GUIs

- Cannot use code-based coverage
  - Source code not always available
  - Event-based input
    - Different level of abstraction
- Our Contribution
  - Hierarchical structure of the GUI in terms of events
  - Coverage criteria based on events

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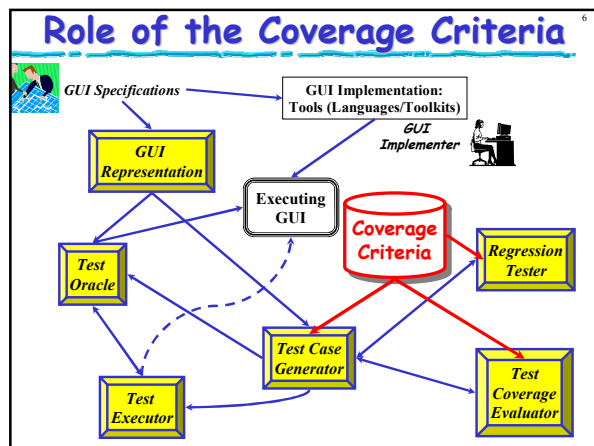
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## Outline

- GUI Definition
- Representation of GUIs
- Coverage Criteria
- Case Study
- Conclusions

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## GUI Definition

- Hierarchical
- Graphical Front-end
- Accepts User-generated and System-generated events
- Fixed sets of events
- Deterministic Output
- State of the GUI is the set of Objects and their Properties

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## GUI Representation

- Motivation
  - GUI testing needs a "Unit of Testing"
    - Manageable
    - Test the unit comprehensively
    - Test interactions among units
  - GUIs are created using library elements
    - Need to test these elements before packaging them for reuse
      - Certain level of confidence that the element has been adequately tested
    - User of these elements should be able to test the element in its context of use

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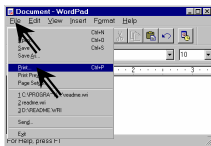
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## Model GUI Hierarchically

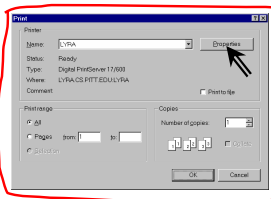
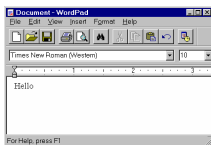
- Hierarchy
  - GUIs are decomposed into a hierarchy of components
  - Hierarchical decomposition makes testing intuitive and efficient
  - Several hierarchical views of GUIs
  - We examine **Modal Dialogs** to create the hierarchical model

## Modal Windows in GUIs



Main

## Modal Windows in GUIs

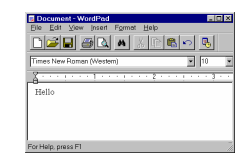
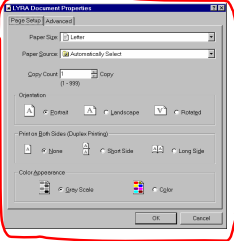


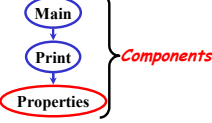
Main

Print

invokes

## Modal Windows in GUIs



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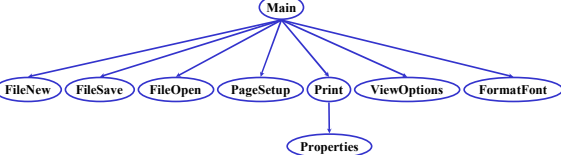
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## Integration Tree



**Definition:** Integration tree is a triple  $\langle N, R, B \rangle$

- $N$  is the set of components in the GUI
- $R \in N$  is a designated component called the **Main** component
- $B$  is the set of directed edges showing the invokes relation between components, i.e.,  $(C_x, C_y) \in B$  iff  $C_x$  invokes  $C_y$ .

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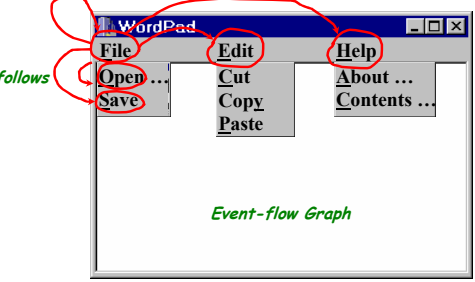
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## Representing a Component



*Event-flow Graph*

**Definition:** Event  $e_x$  follows  $e_y$  iff  $e_x$  can be performed immediately after  $e_y$ .

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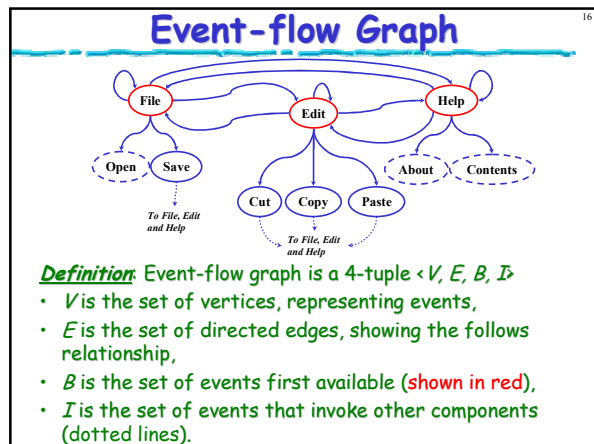
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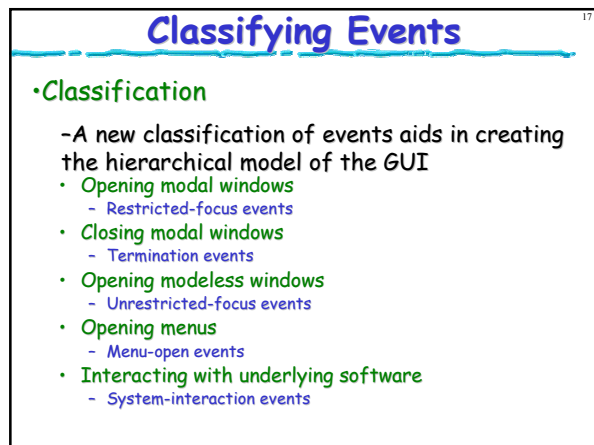
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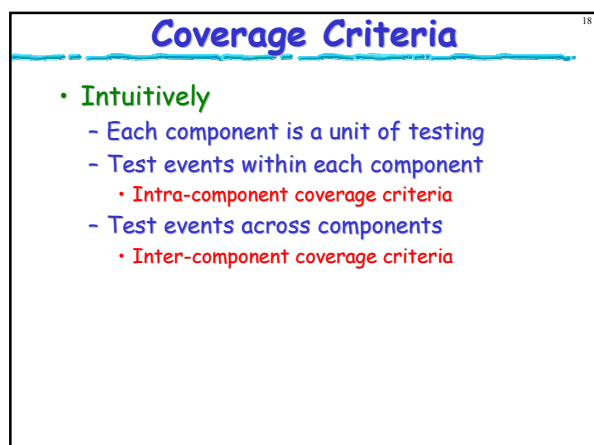
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Coverage Criteria

- Intra-component Coverage
  - Event coverage
    - Individual events
    - Each node in the event-flow graph
  - Event-interaction coverage
    - Each pair of events
    - Each edge in the event-flow graph
  - Length-n event sequence coverage
    - Sequences of events
    - Bounded by length
      - Length-1 event sequences
      - Length-2, length-6 event sequences
    - Paths in the event-flow graph

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Coverage Criteria

- Inter-component Coverage
  - Invocation coverage
    - Invoke each component
    - Each restricted-focus event
  - Invocation-termination coverage
    - Invoke each component and terminate it
    - Restricted-focus event followed by a termination event
  - Inter-component length-n coverage
    - Longer sequences from one component to another
    - Bounded by length

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Case Study

- Purpose
  - To determine:
    - How many test cases do we need to test WordPad
    - Correlation between event and code-based coverage
    - How well did our planning-based approach [ICSE '99] do
- Experimental design
  - GUI: our version of MS WordPad (36 modal windows, 362 events)
  - Hardware platform: 350 MHz Pentium based machine, 256 MB RAM

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## Test Cases for WordPad

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	Event-sequence Length							
Component Name	1'	2'	1	2	3	4	5	6
Main			56	791	14354	255720	4490626	78385288
FileOpen			10	80	640	5120	40960	327680
FileSave			10	80	640	5120	40960	327680
Print			12	108	972	8748	78732	708588
Properties			13	143	1573	17303	190333	2093663
PageSetup			11	88	704	5632	45056	360448
FormatFont			9	63	441	3087	21609	151263
Print+Properties	1	2	13	260	3913	52520	663013	
Main+FileOpen	1	2	10	100	1180	17160	278760	
Main+FileSave	1	2	10	100	1180	17160	278760	
Main+PageSetup	1	2	11	110	1298	18876	306636	
Main+FormatFont	1	2	9	81	909	13311	220509	
Main+Print+Properties			12	145	1930	28987	466578	

## Results

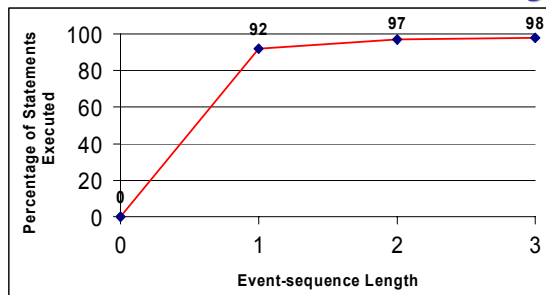
## Correlation between Event-based & Code-based Coverage

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- Code Instrumentation
- Generated all event sequences up to length 3. Total test cases: 21,659
- Executed all 21,659 cases and obtained execution traces
- Statement coverage

## Correlation between Event-based & Code-based Coverage

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## Results



## Evaluating the Planning Approach<sup>25</sup>

- Used our earlier-developed planning-based approach
- 500 test cases of different lengths

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## Evaluating the Planning Approach<sup>26</sup>

	Event-sequence Length							
Component Name	1'	2'	1	2	3	4	5	6
Main			88	41	10.92	0.36	0.03	0.00
FileOpen			90	56	17.50	0.72	0.06	0.05
FileSave			90	41	20.63	1.27	0.47	0.02
Print			92	34	32.20	9.00	3.92	0.19
Properties			92	45	27.59	1.80	0.97	0.06
PageSetup			91	49	25.43	2.56	0.66	0.06
FormatFont			89	37	39.00	13.67	0.66	0.06
Print+Properties	100	0	46	51.15	8.18	3.87	0.05	
Main+FileOpen	100	0	40	11.00	10.17	1.30	0.16	
Main+FileSave	100	0	20	13.00	8.64	1.26	0.28	
Main+PageSetup	100	0	45	60.91	4.31	1.94	0.08	
Main+FormatFont	100	0	33	28.40	5.17	0.97	0.10	
Main+Print+Properties			50	38.62	6.37	0.65	0.09	

## Results

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## Future Work<sup>27</sup>

- GUI's Structure and its Testability
- Apply Criteria to
  - Object-oriented Software
  - Component-based Software
  - Reactive Software

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