

Composing a Framework to Automate Testing of Operational Web-Based Software

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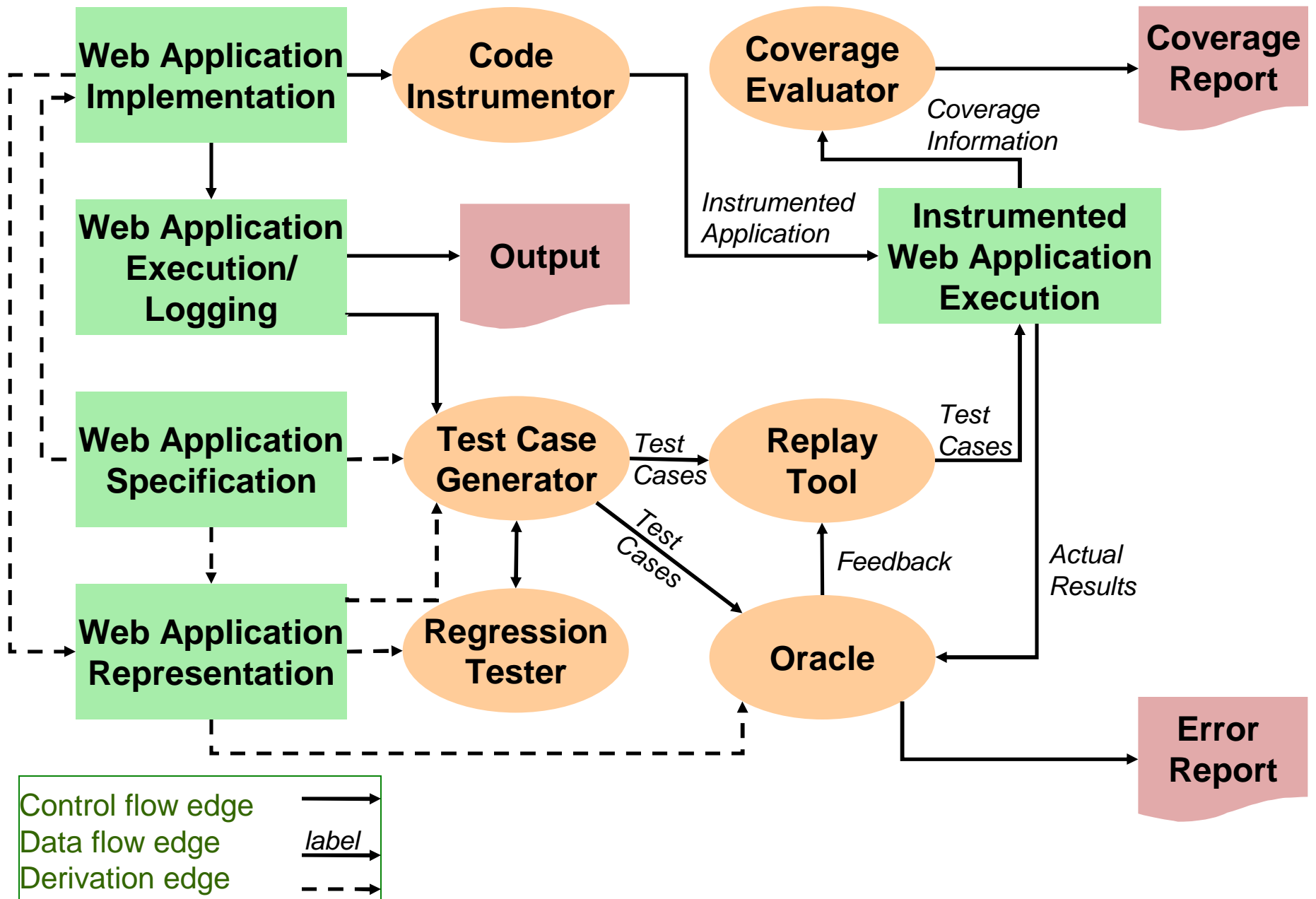
Lori Pollock (University of Delaware)

International Conference on Software Maintenance (ICSM), 2004
September 12, 2004

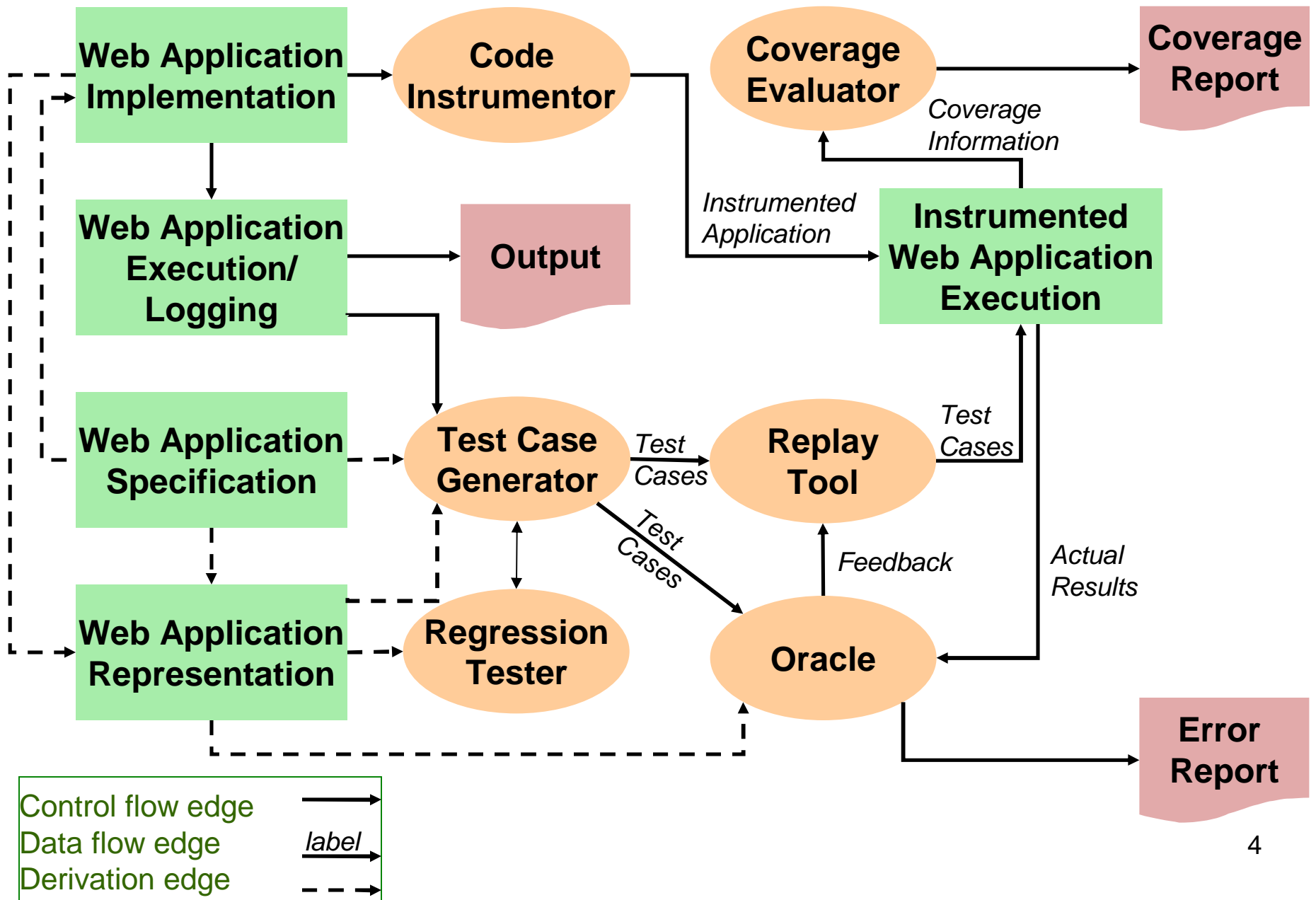
Motivation

- Web-based applications
 - Example: e-commerce applications
- Characteristics
 - Short time to market
 - Extensively used
 - High reliability expected
 - Demand for continuous availability
 - Large user community
- Goal: To address the need for an **automated** cost-effective testing strategy for web applications

Generic Framework For Web Testing



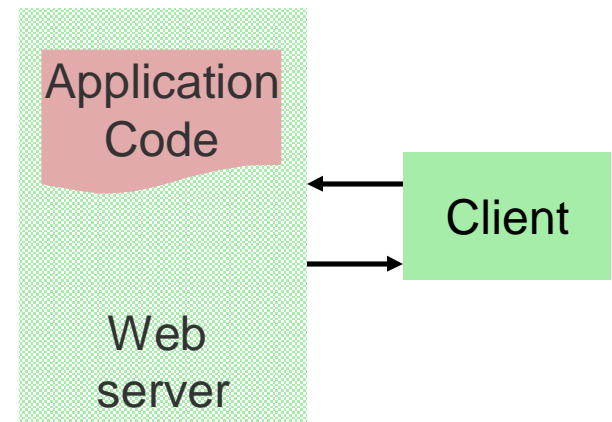
Generic Framework For Web Testing



Contributions

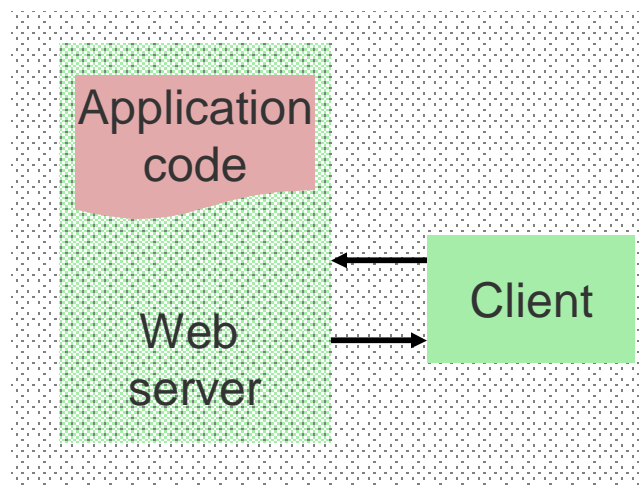
- Initial prototype of an automated testing strategy
- Applicable in beta-testing/maintenance phase
- User sessions as test cases: represent user behavior
- Incrementally update the test suite on-the-fly
- Evolve the test suite with changing operational profile
- Demonstrate how existing tools work together
- Case study to exemplify usability, costs, scalability

Web Application Execution and Logging



Web Application Execution and Logging

- Exploit web server's ability to log user sessions
- Modify server's access log to capture specific information



Access Log

```
10.197.37.159
```

```
[03/Feb/2004:16:17:22-0500]
```

```
GET /bookstore/Registration.jsp?
```

```
member_login=bobmason&password=hello
```

```
--header "Cookie:JSESSIONID=a7m89iuy9i"
```

```
10.197.37.159
```

```
[03/Feb/2004:16:20:22-0500]
```

```
POST /bookstore/Login.jsp
```

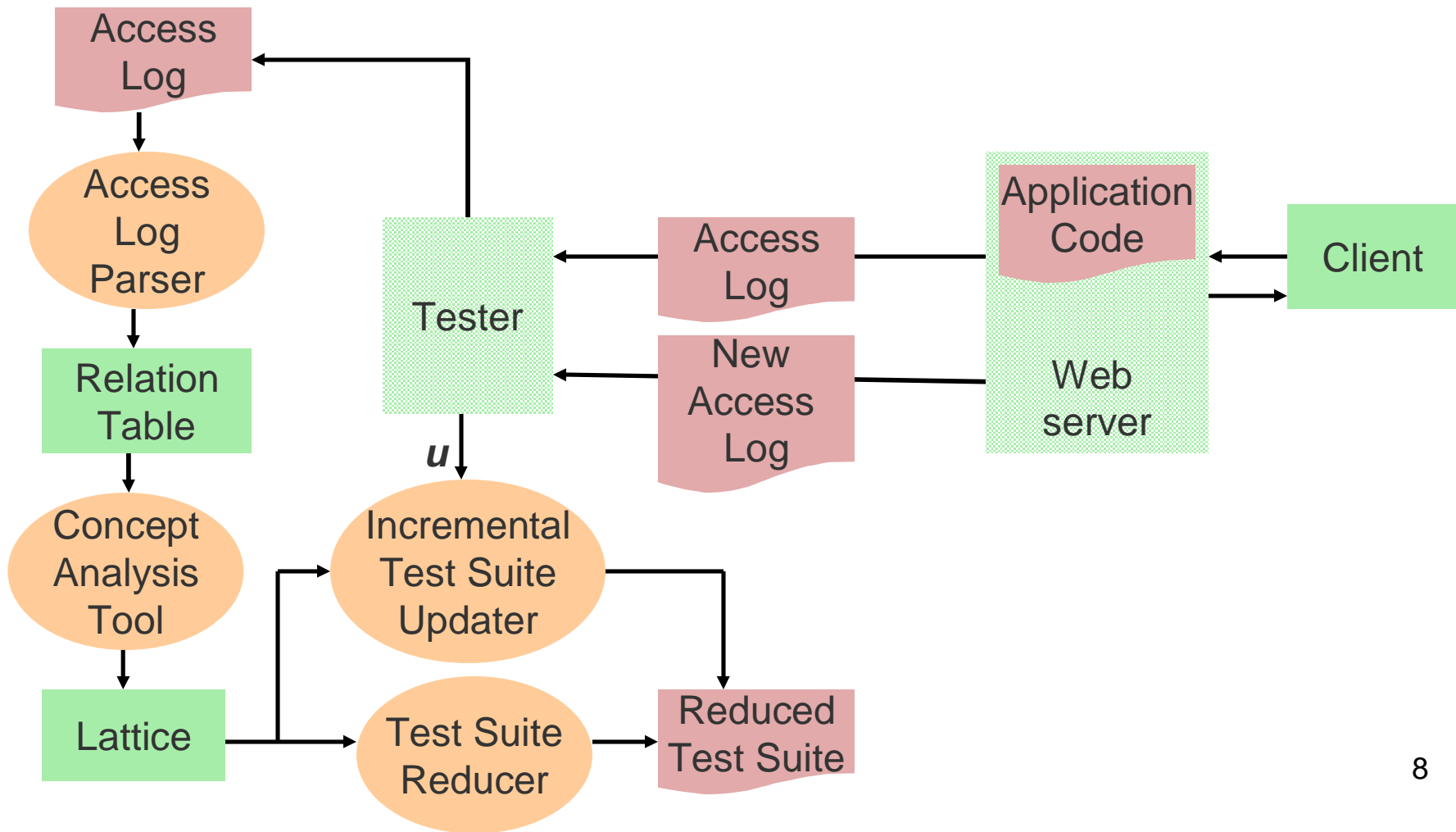
```
--post-data="&Password=hello&
```

```
FormName=Login&FormAction=login&
```

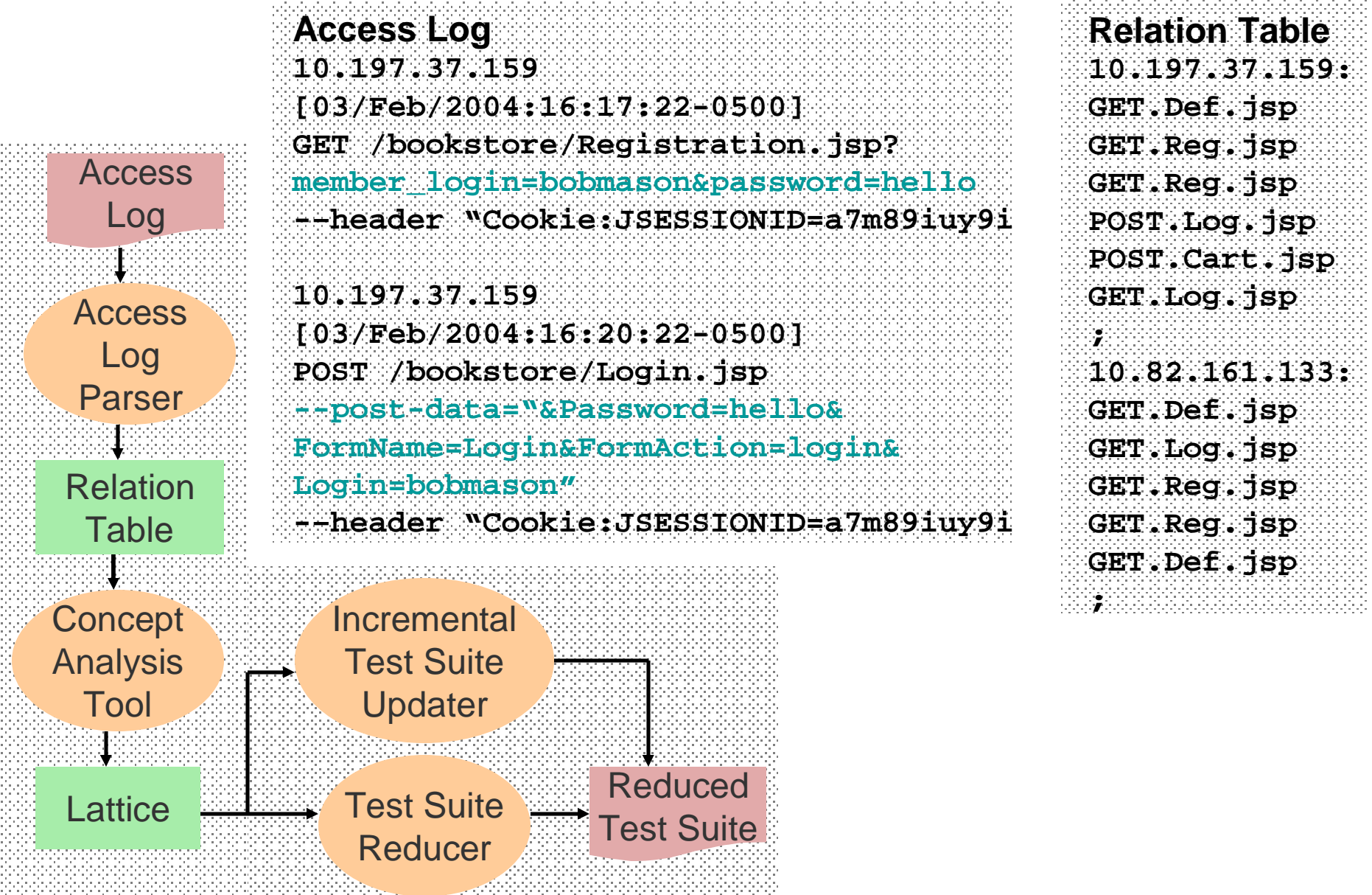
```
Login=bobmason"
```

```
--header "Cookie:JSESSIONID=a7m89iuy9i"
```

Test Case Generation and Suite Reduction



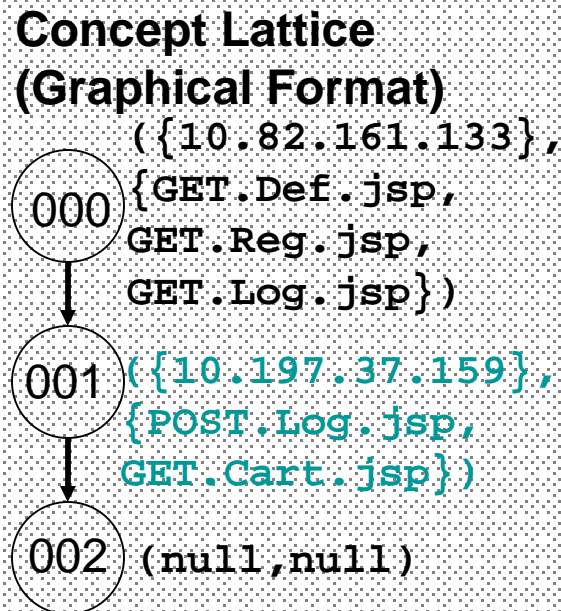
Test Case Generation and Suite Reduction



Concept Analysis

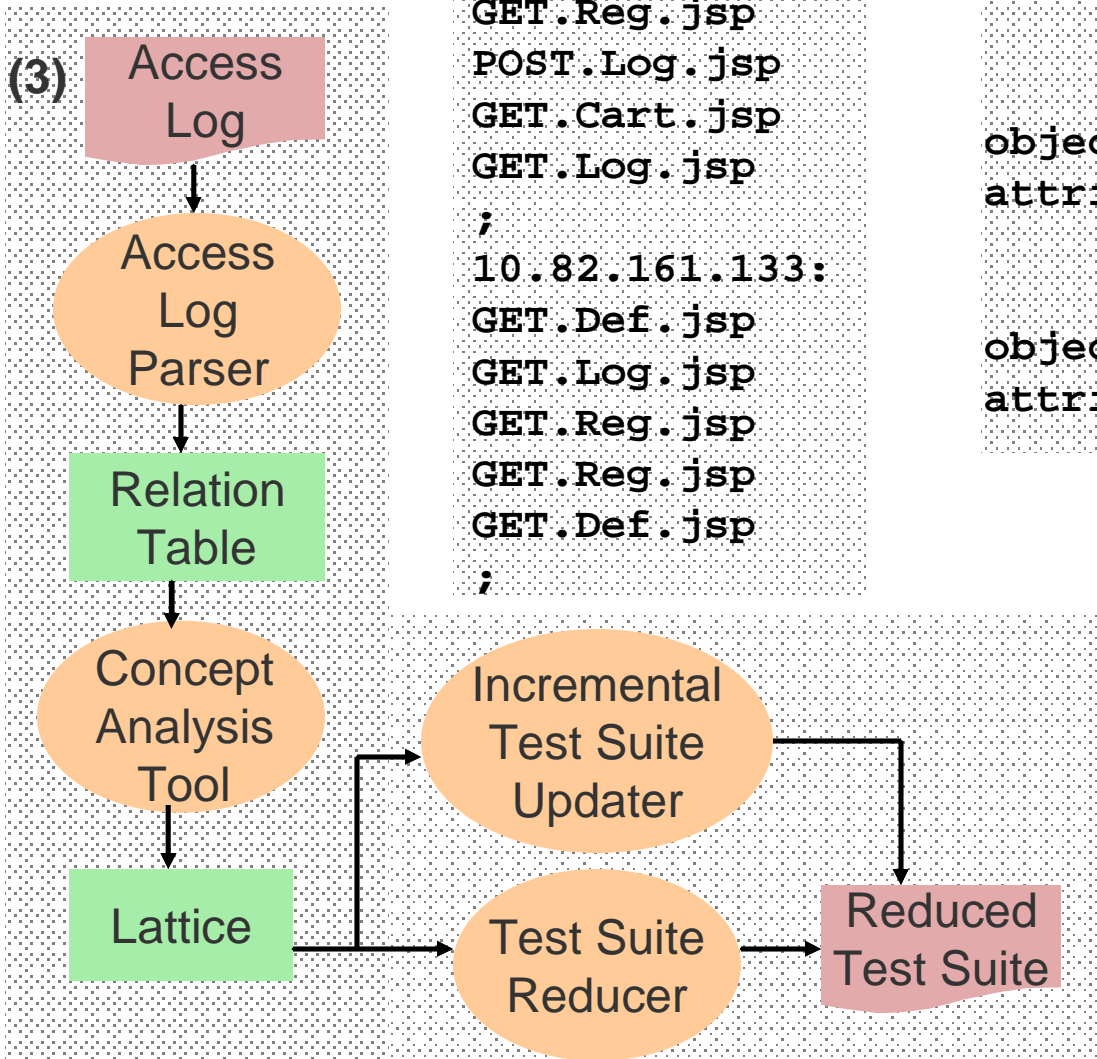
- Set of objects, O: user sessions, **us**
- Set of attributes, A: URLs, **u**
- Relation, R: **us** requests **u**
- Concept analysis identifies all **concepts** (O_i, A_j) for a tuple (O, A, R)
- **Concepts** form a partial order

```
Relation Table
10.197.37.159:
GET.Def.jsp
GET.Reg.jsp
GET.Reg.jsp
POST.Log.jsp
GET.Cart.jsp
GET.Log.jsp
;
10.82.161.133:
GET.Def.jsp
GET.Log.jsp
GET.Reg.jsp
GET.Reg.jsp
GET.Def.jsp
;
```



```
Concept Lattice (Initial Suite)
objects[000]: 10.82.161.133
attributes[000]:
    GET.Def.jsp
    GET.Reg.jsp
    GET.Log.jsp
objects[001]:10.197.37.159
attributes[002]:
    POST.Log.jsp
    GET.Cart.jsp
objects[002]:
attributes[002]:
```

Test Case Generation and Suite Reduction

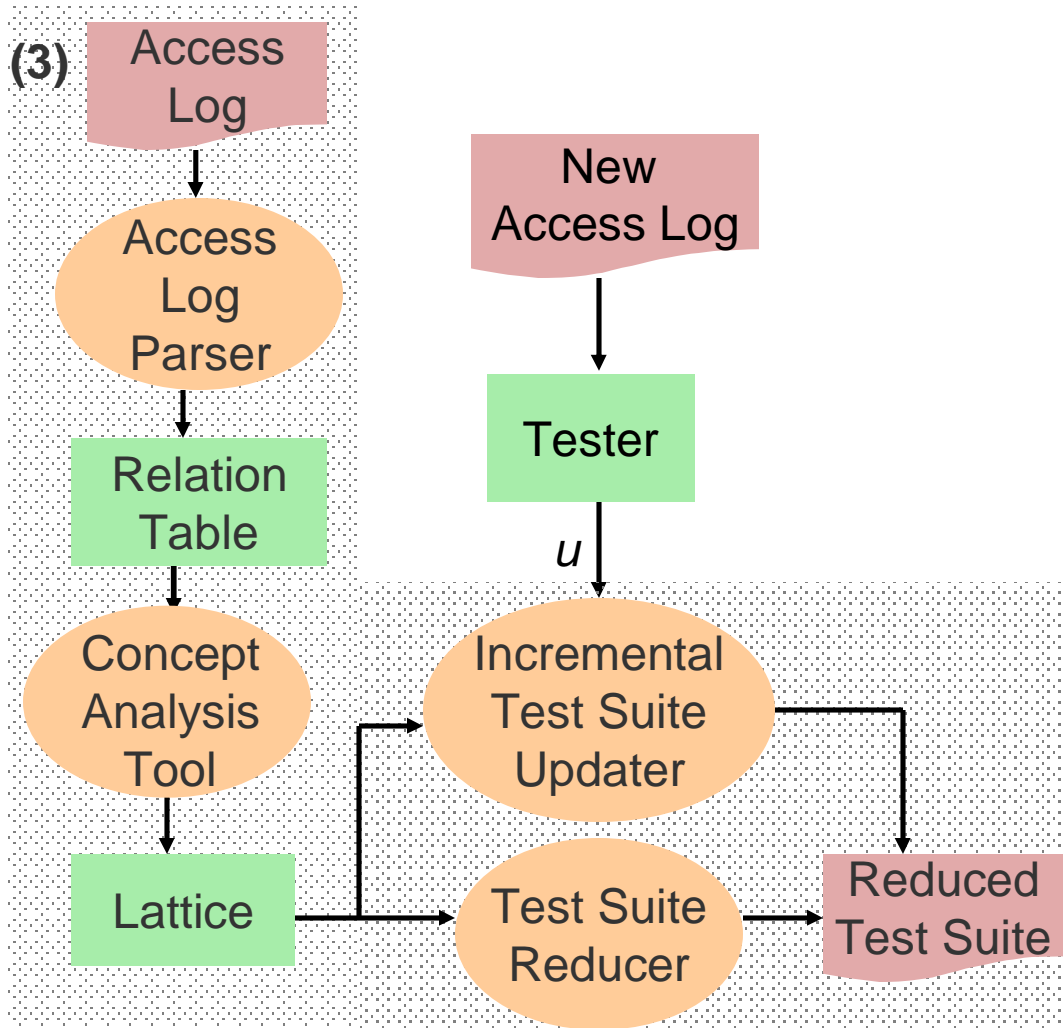


Relation Table
10.197.37.159:
GET.Def.jsp
GET.Reg.jsp
GET.Reg.jsp
POST.Log.jsp
GET.Cart.jsp
GET.Log.jsp
;
10.82.161.133:
GET.Def.jsp
GET.Log.jsp
GET.Reg.jsp
GET.Reg.jsp
GET.Def.jsp
;

Concept Lattice (Initial Suite)
objects[000]: 10.82.161.133
attributes[000]:
 GET.Def.jsp
 GET.Reg.jsp
 GET.Log.jsp
objects[001]:10.197.37.159
attributes[001]:
 POST.Log.jsp
 GET.Cart.jsp
objects[002]:
attributes[002]:

Apply heuristic *test-all-exec-URLs* for test suite reduction
Reduced test suite
contains URL requests
in session **10.197.37.159**

Incremental Test Suite Update



Concept Lattice (Initial State)

```

objects[000]:10.197.827.1659.133
attributes[000]:
  GET.Def.jsp
  GET.Reg.jsp
  GET.Log.jsp
  GET.Reg.jsp

```

```

objects[001]:10.197.37.159
attributes[001]:
  Log.jsp

```

```

  POST.Log.jsp

```

Updated Concept Lattice

```

objects[000]:10.82.161.133
objects[002]:10.4.133.131
attributes[002]:
  Log.jsp

```

```

attributes[000]:
  GET.Reg.jsp
  GET.Def.jsp
  GET.Reg.jsp
  GET.Def.jsp
  GET.Log.jsp

```

```

objects[001]:10.197.37.159
attributes[001]:
  POST.Log.jsp
  GET.Cart.jsp

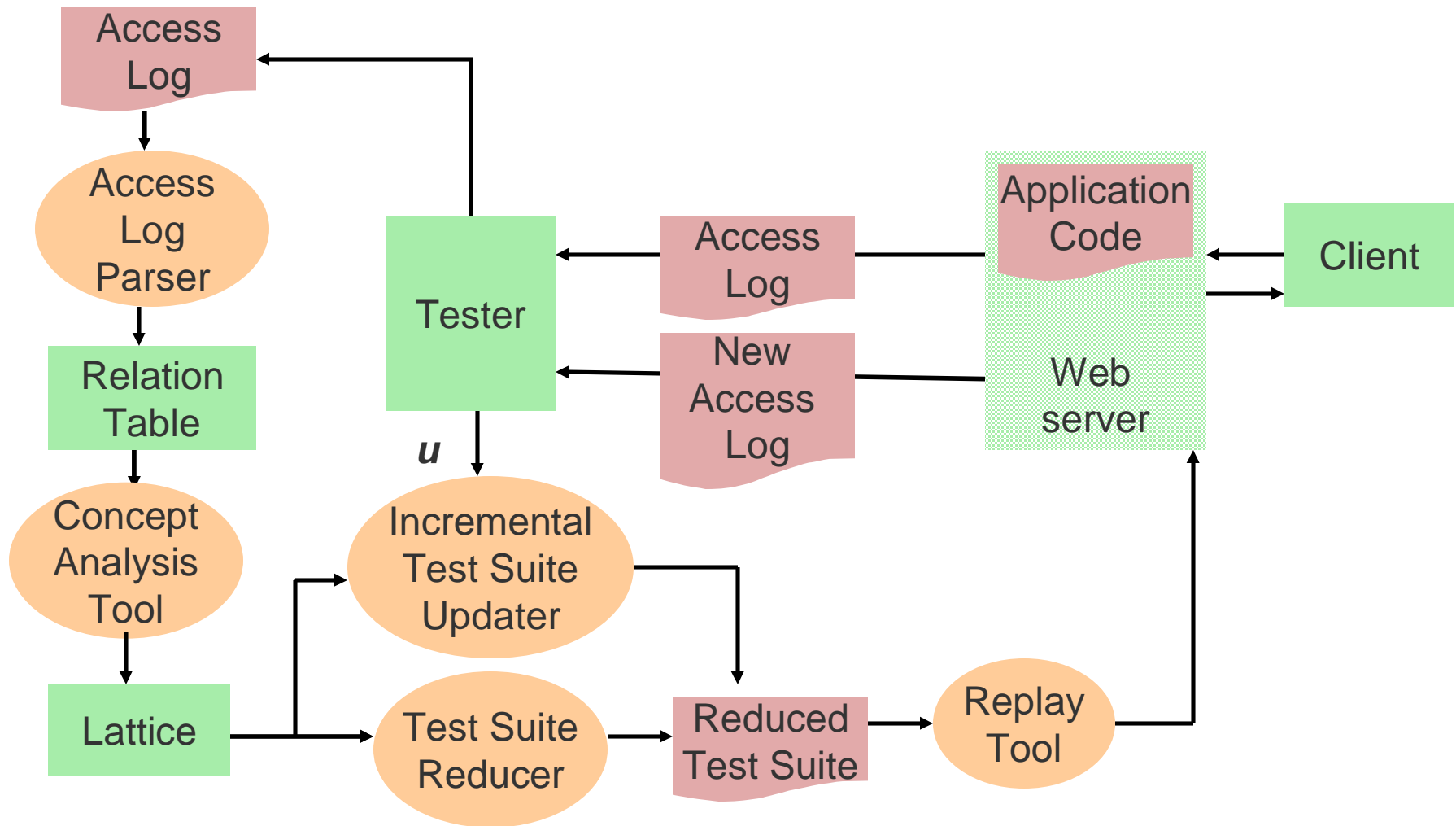
```

```

objects[002]:
attributes[002]:

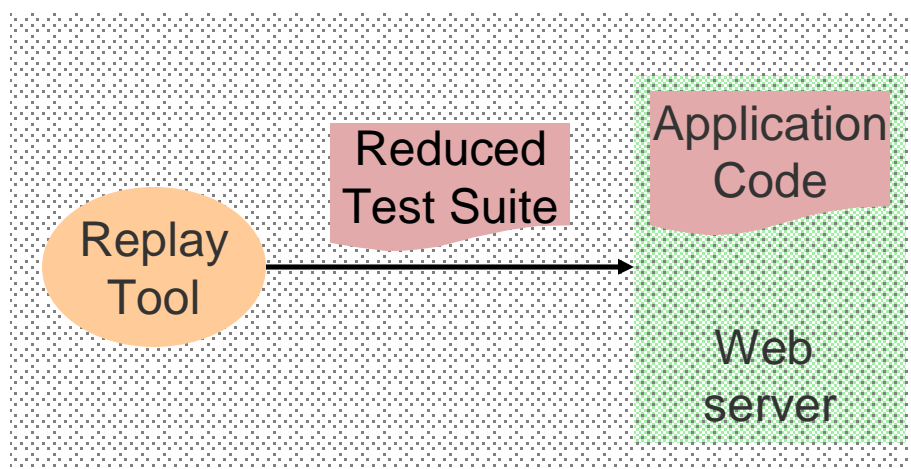
```

Replay Tool



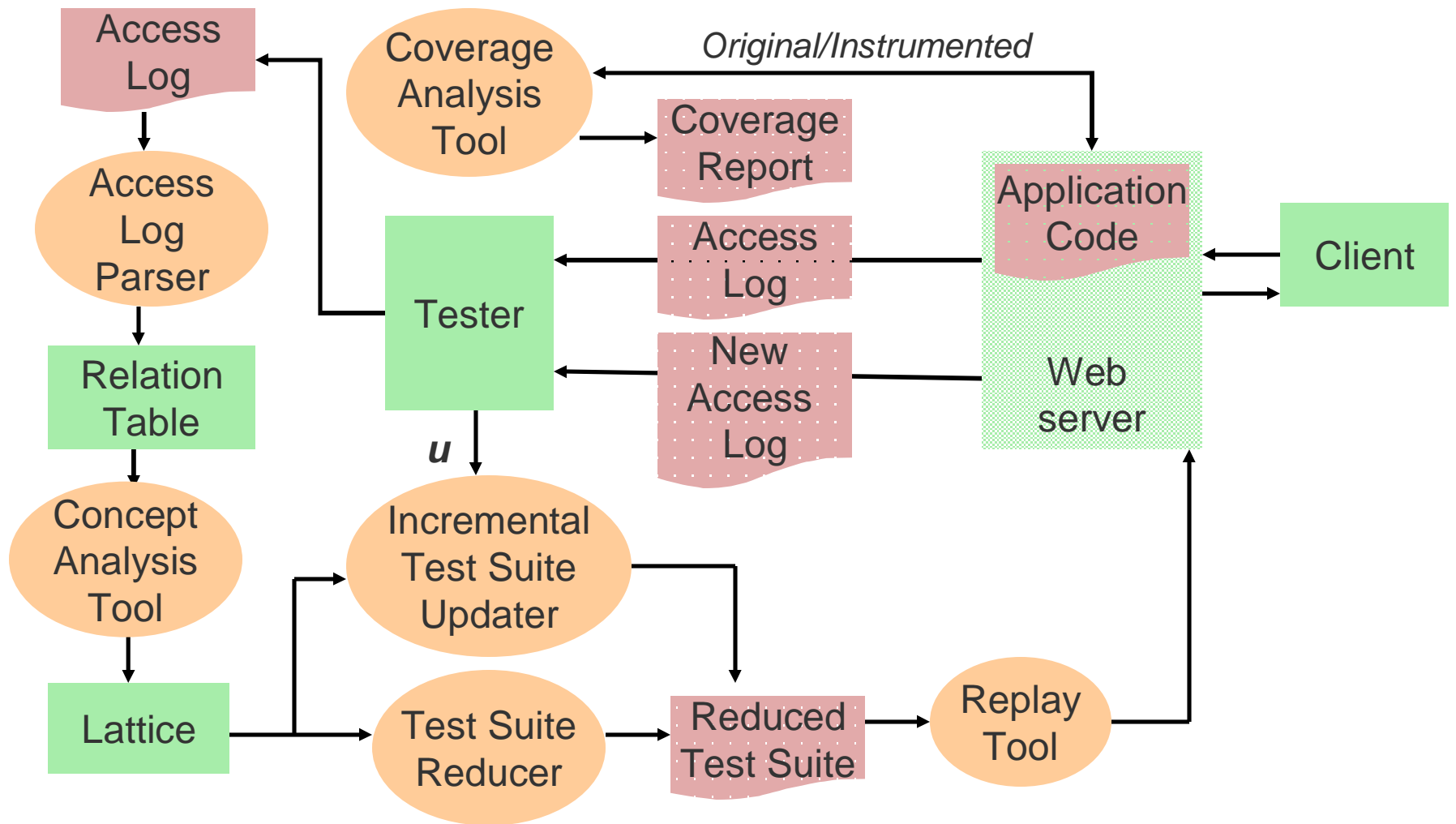
Replay Tool

- Use `wget` to replay user sessions
- Invoke `wget` on each request in logged sessions
- Replay sessions with cookie information
- Restore state of the database to initial state



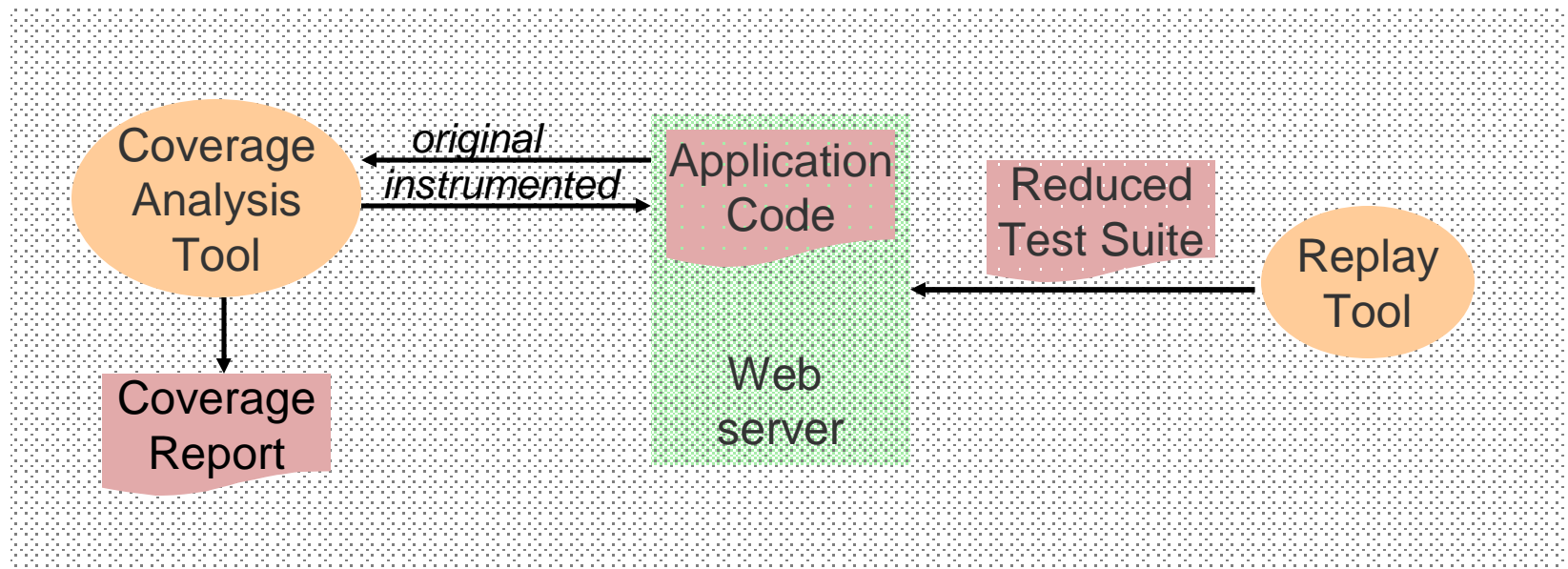
```
wget -P files -a log
-post-data="Password=hello&
Login=bobmason"
--header
"Cookie:JSESSIONID=hWEoagtfrEti"
http://dwalin.cis.udel.edu:8080/
bookstore/Log.jsp
```

Coverage Analysis

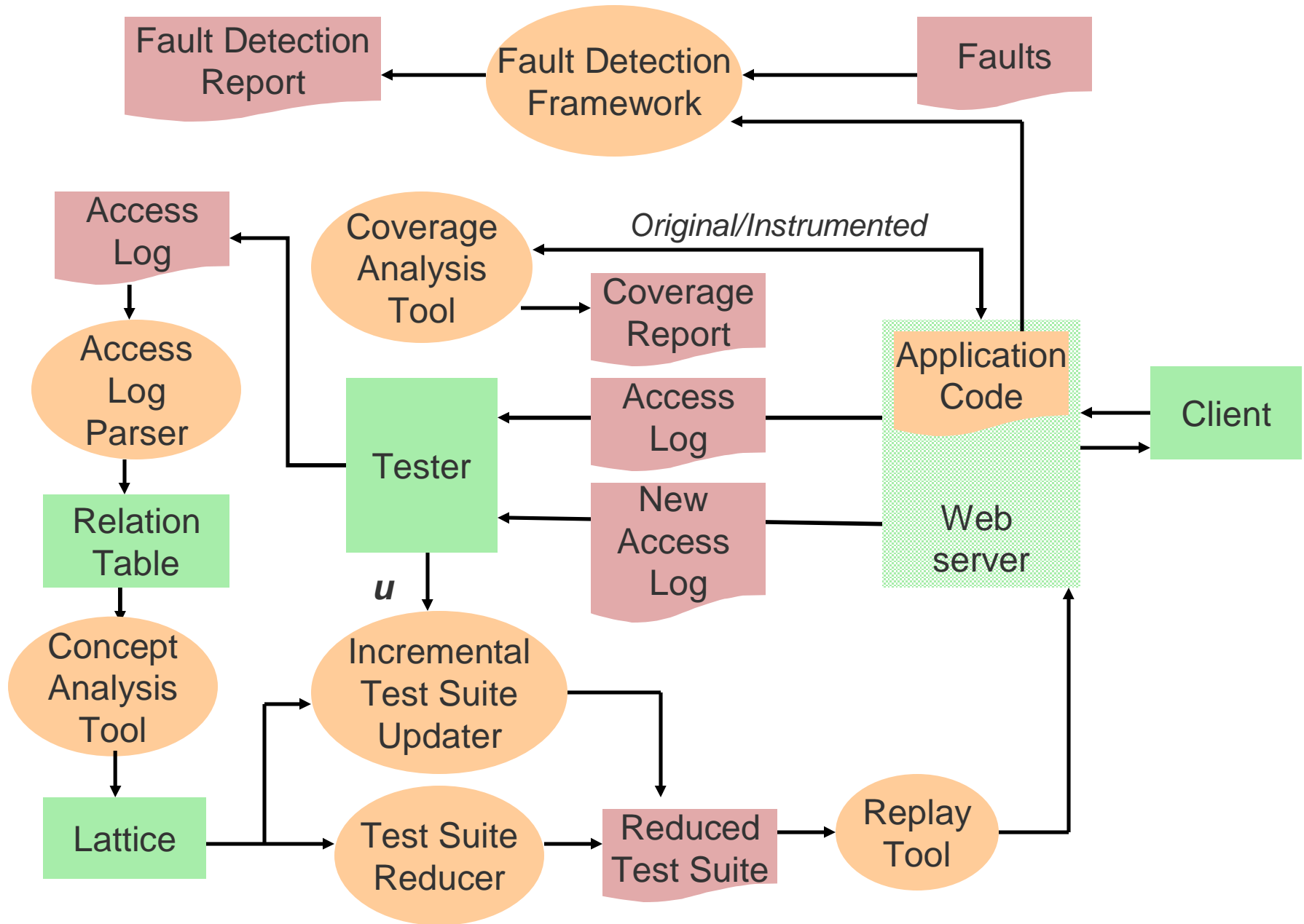


Coverage Analysis

- Use **Clover** to instrument and generate coverage reports
- **Clover** generates percent of statement, methods covered

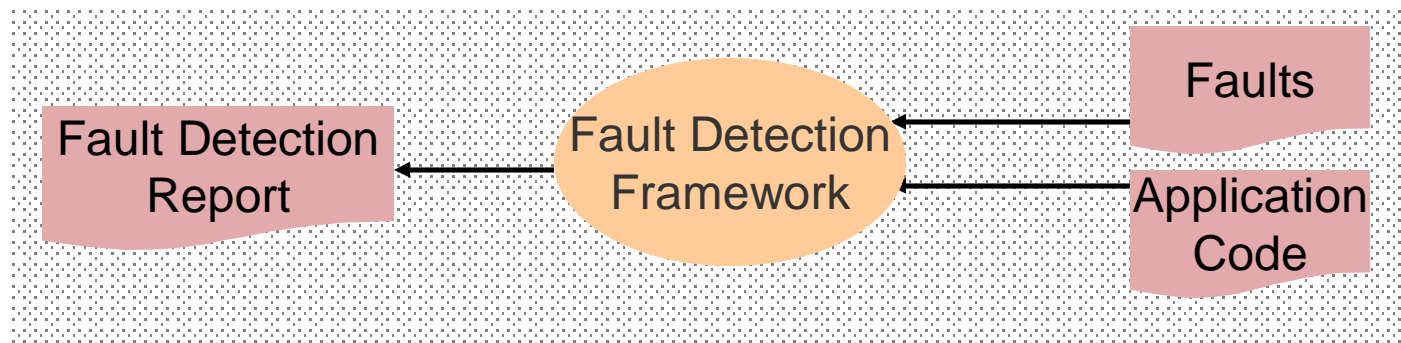


Oracle and Fault Detection

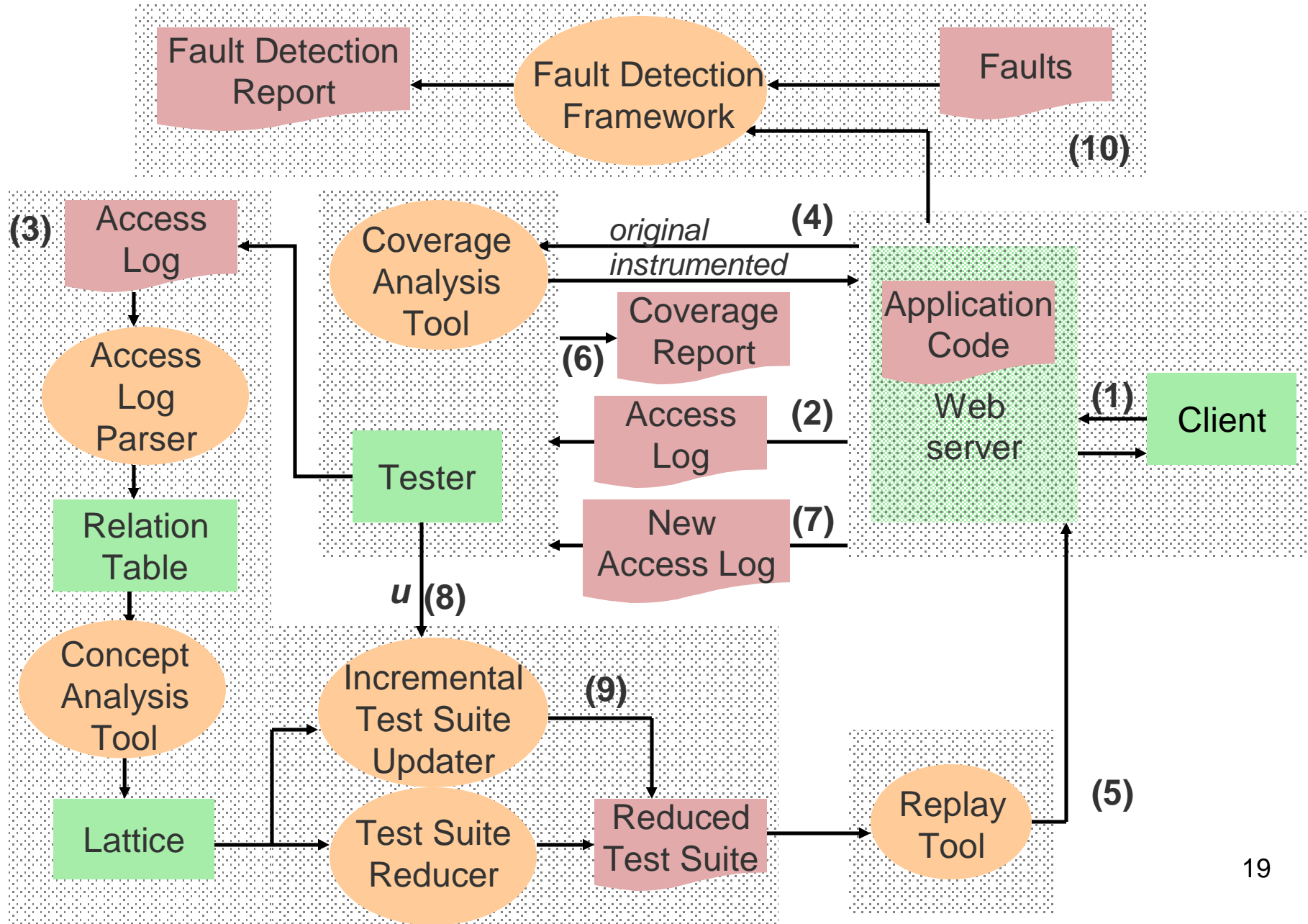


Oracle and Fault Detection

- On replaying user sessions through
 - Correct version of application generates expected result
 - Faulty versions of application generates actual result
- **Diff** the expected and actual result to determine the number of faults detected



Initial Prototype of Testing Framework



Case Study

- Bookstore application
 - 9748 lines of code
 - 385 methods
 - 11 classes
- JSP front-end, MySQL backend
- Resin web server
- 123 user sessions
- 40 faults

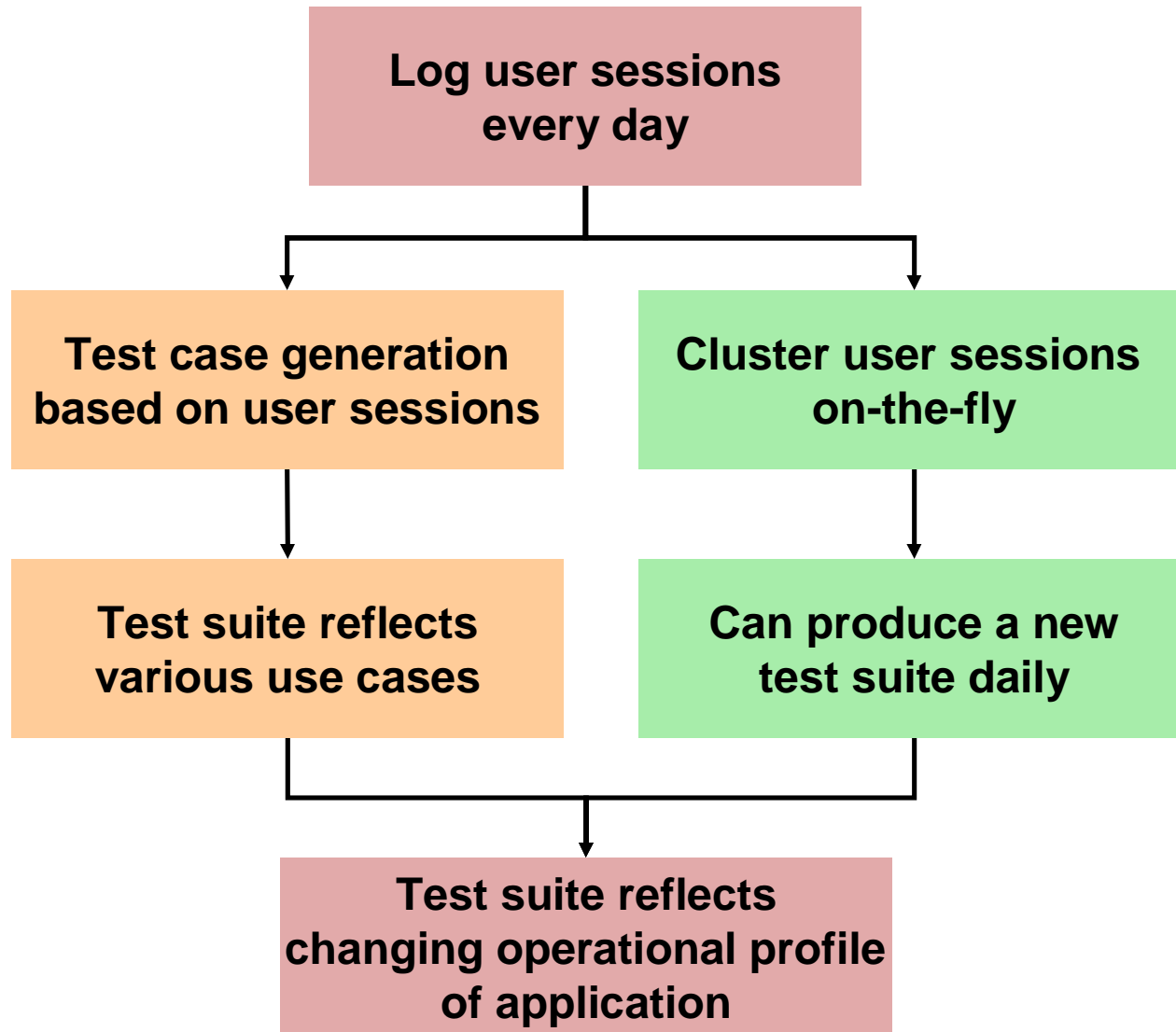
Costs and Scalability

- Number of sessions in original suite: 123
- Number of sessions in reduced suite: 15

Component	Execution Time	Component Output	Output Space
Test case generation and suite reduction	19s	Reduced test suite	1MB
Replay tool execution	16m56s	Pages retrieved	152MB
Coverage analysis	1m52s	Coverage report/ clover database	3.5MB
Test oracle	14s	Diff output	0.5MB

- Percent reduction in test suite size: 87.8%
- During incremental update original suite of sessions not maintained

Changing Operational Profiles of Application



State of the Art

- **Functional testing**
 - Link, form testers
 - Test the **functionality** of application
- **Program-based testing**
 - Liu et al. (2000)
 - Ricca and Tonella (2001)
 - Di Lucca et al. (2002)
 - Test case generation **not completely automated**
- **User-session-based testing**
 - WebKing and Rational Robot
 - Generated test cases may **not be adequate**
 - Elbaum et al. (2003)
 - Reduction technique employed **is not scalable**

Conclusions

- Comprehensive framework to automate testing of web-based software
- Focuses on scalability and evolving the test suite with the changing operational profile of application
- Insight into usability, costs and scalability of approach

Future Work

- Investigate additional heuristics
- Larger web applications
- More user sessions
- Augment with regression testing component

Acknowledgments

- **Sara Sprenkle** and **Emily Gibson** for their editorial suggestions
- **HiperSpace** lab members for their comments and insights on the presentation

Questions