



DOM-Based Test Adequacy Criteria for Web Applications



Mehdi Mirzaaghaei



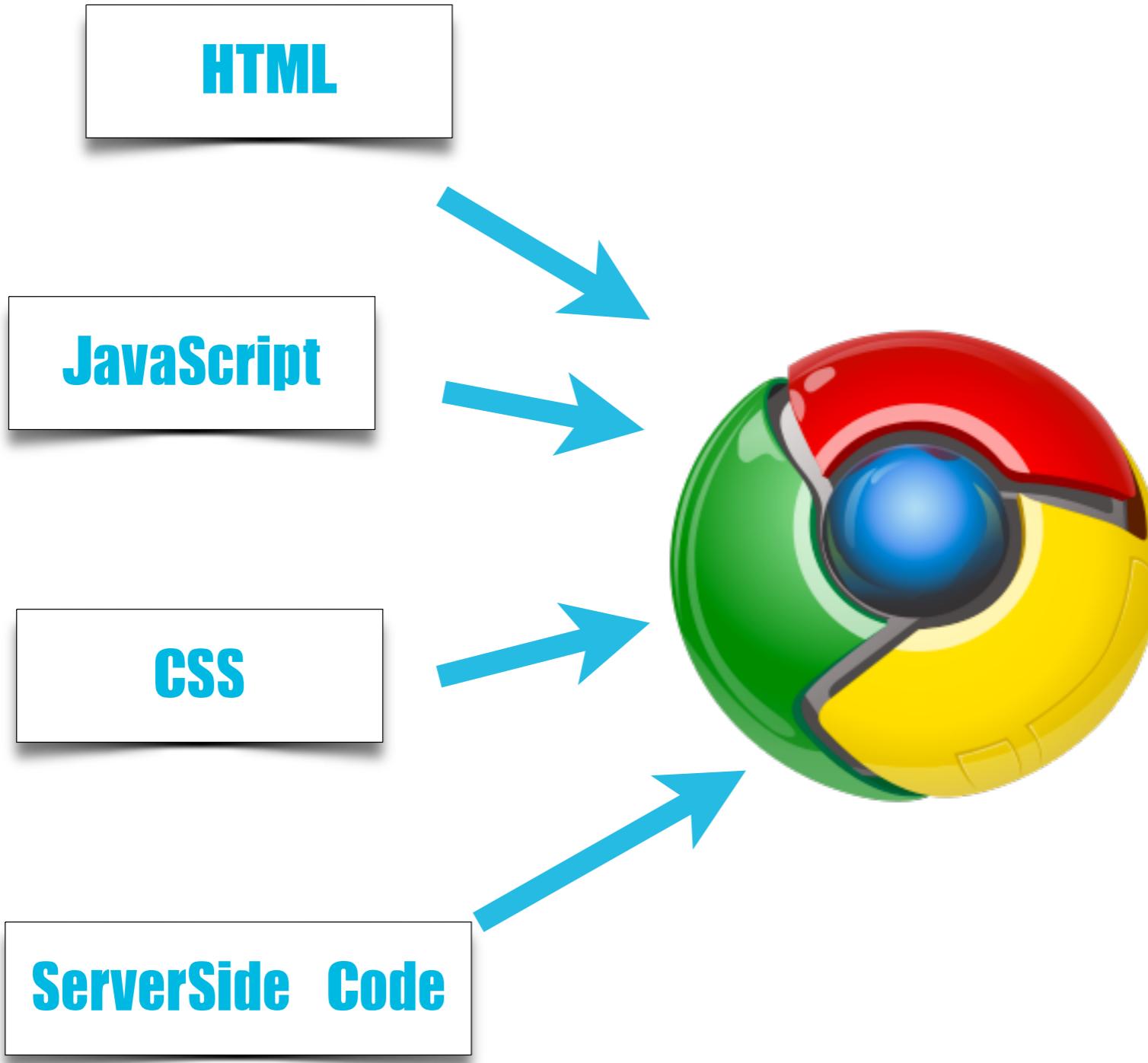
Ali Mesbah

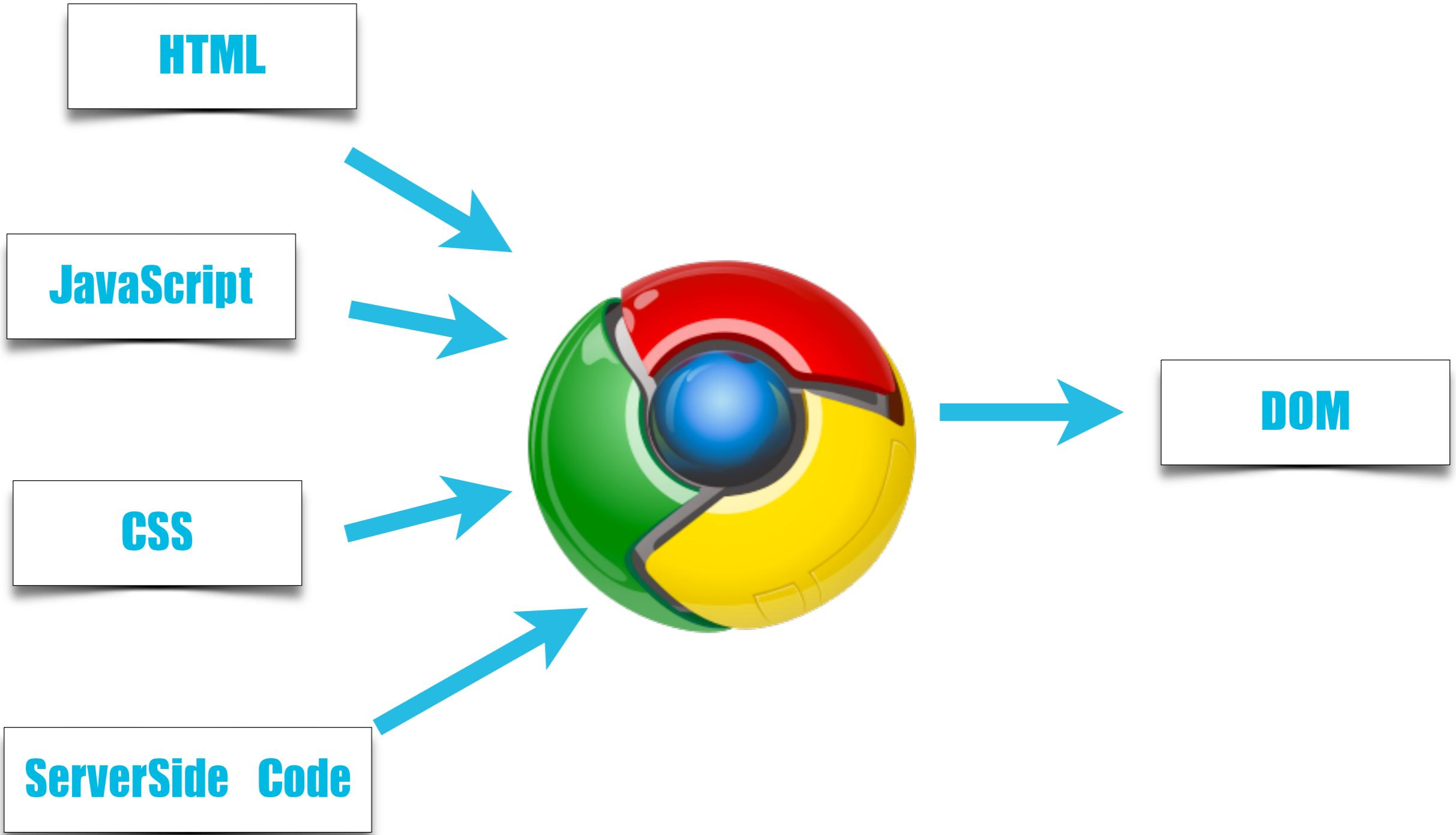
HTML

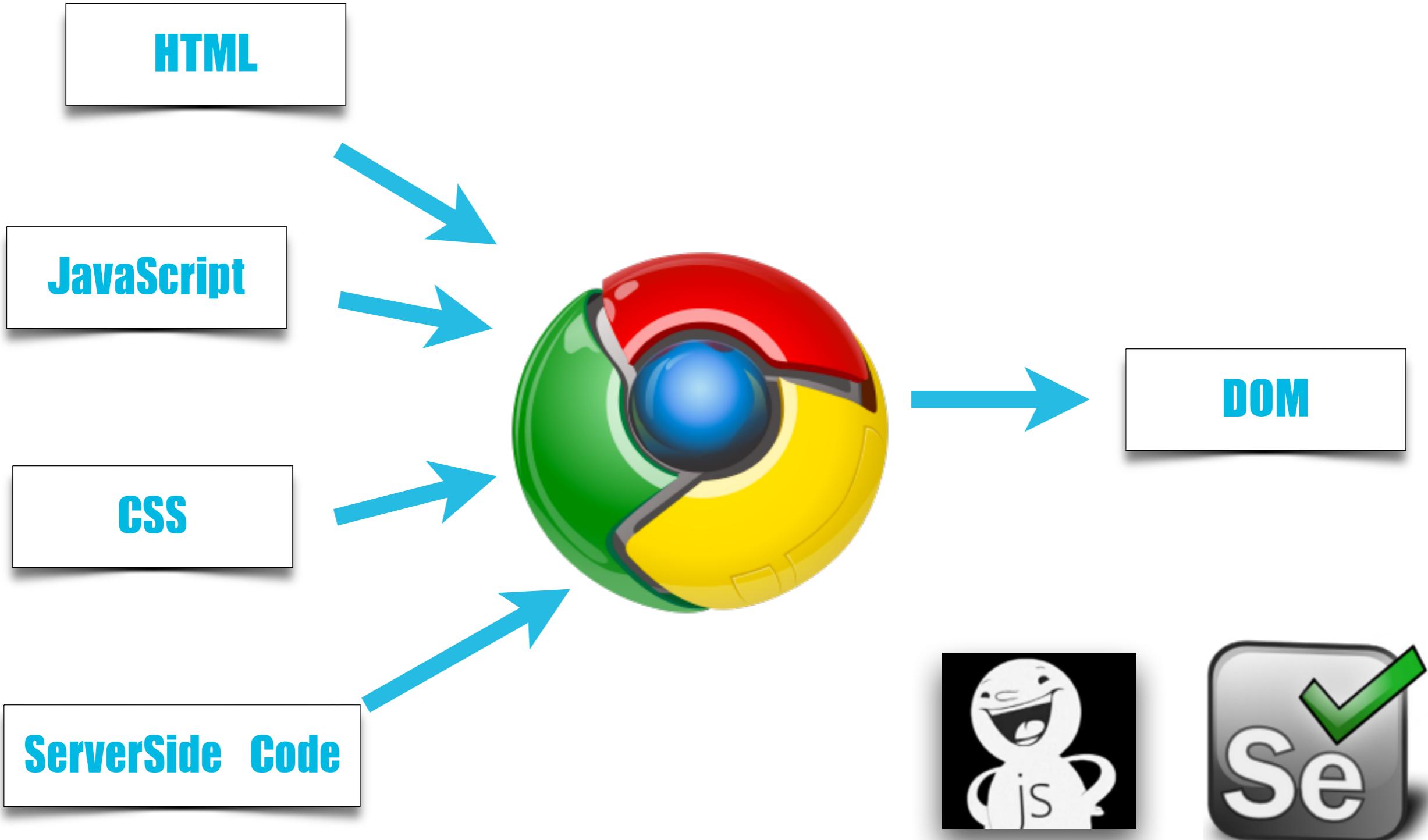
JavaScript

CSS

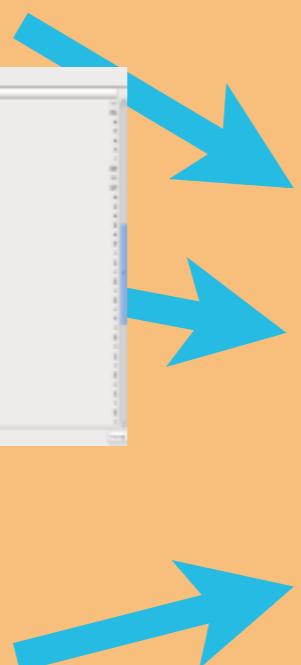
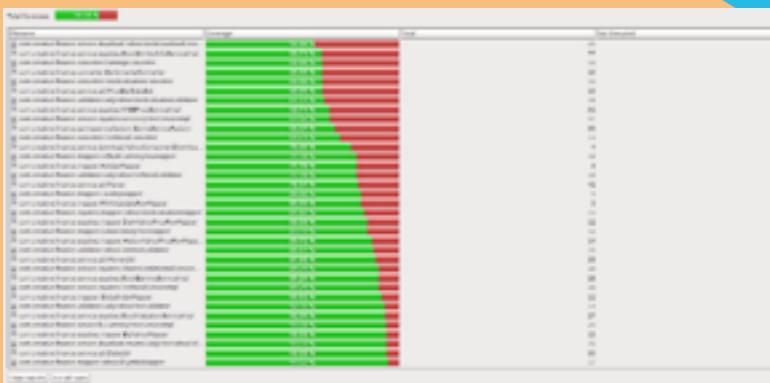
ServerSide Code





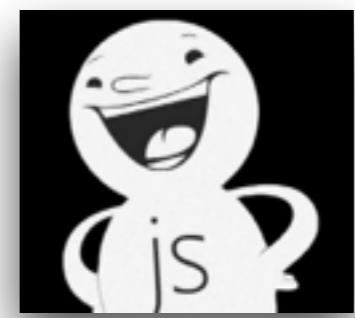


HTML



CSS

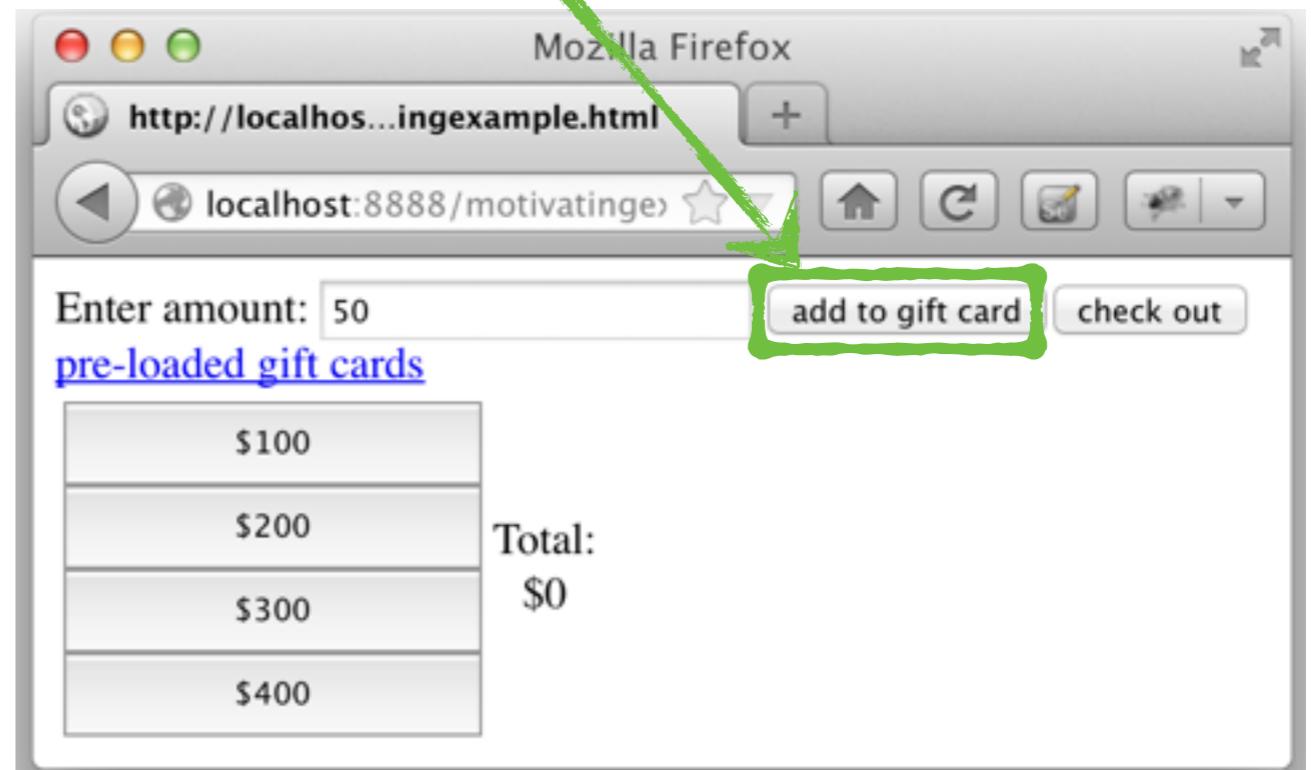
ServerSide Code



```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$50.0", driver.  
        findElement(By.linktext("p")).text());  
}
```



```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$50.0", driver.  
        findElement(By.linktext("p")).text());  
}
```



CSS

```
<style>  
div{  
font-size: 12pt;  
}  
</style>
```

JavaScript

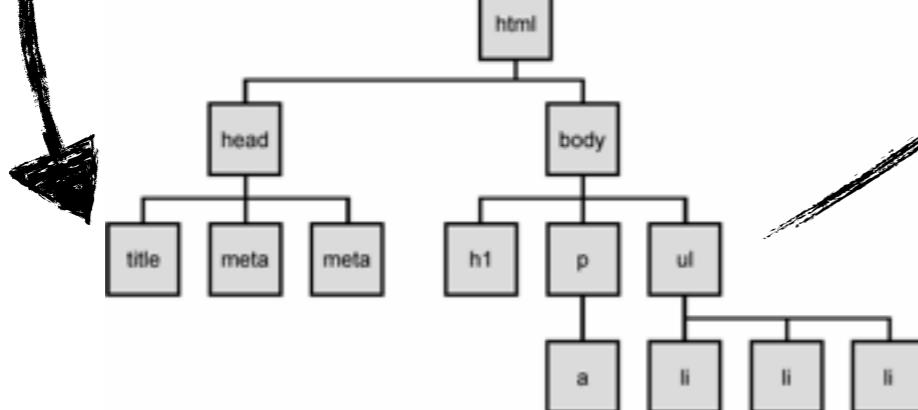
```
function addTotal(x){  
document.getElementById("p1").innerHTML="$"+x;  
}
```

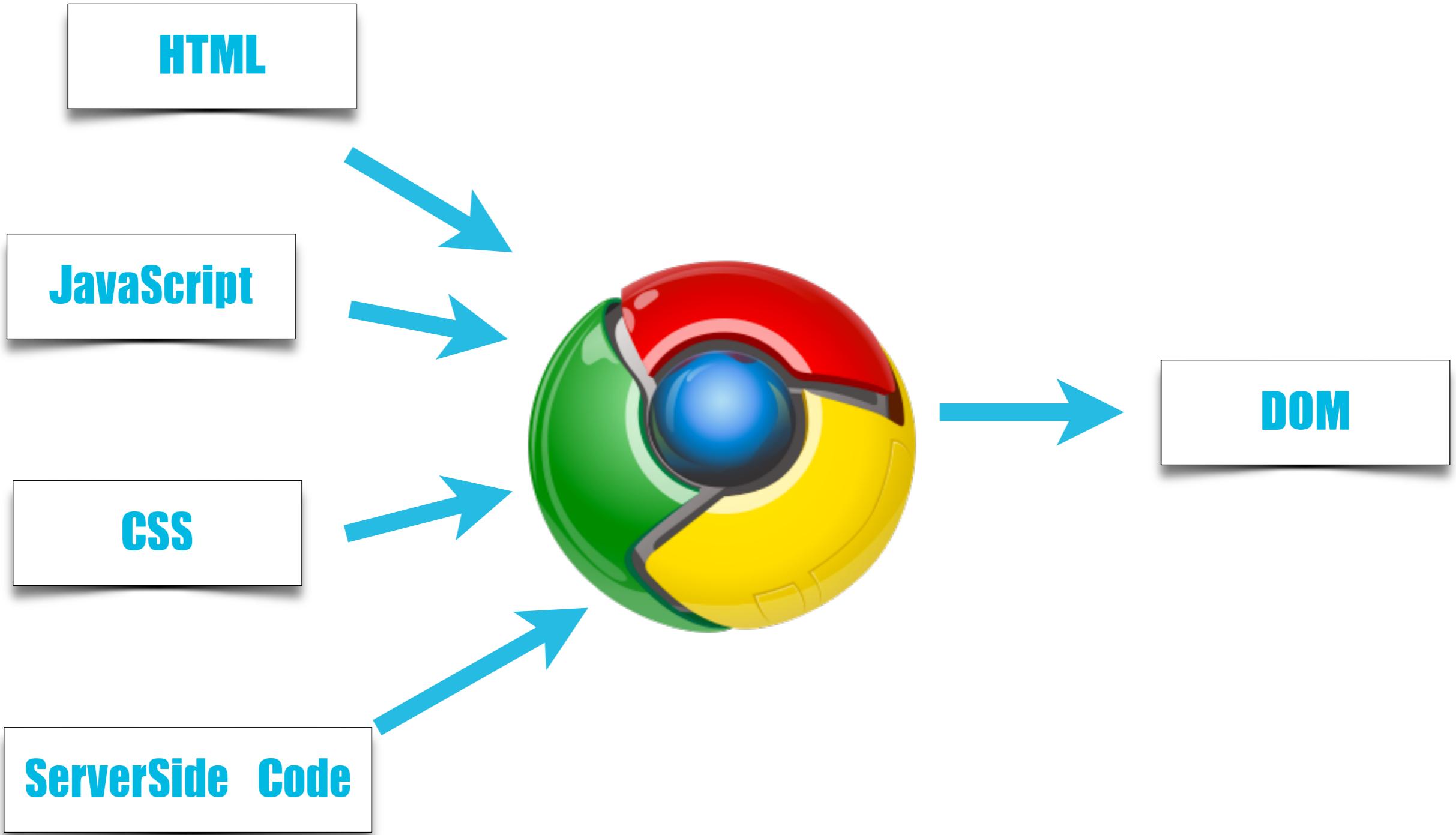
HTML

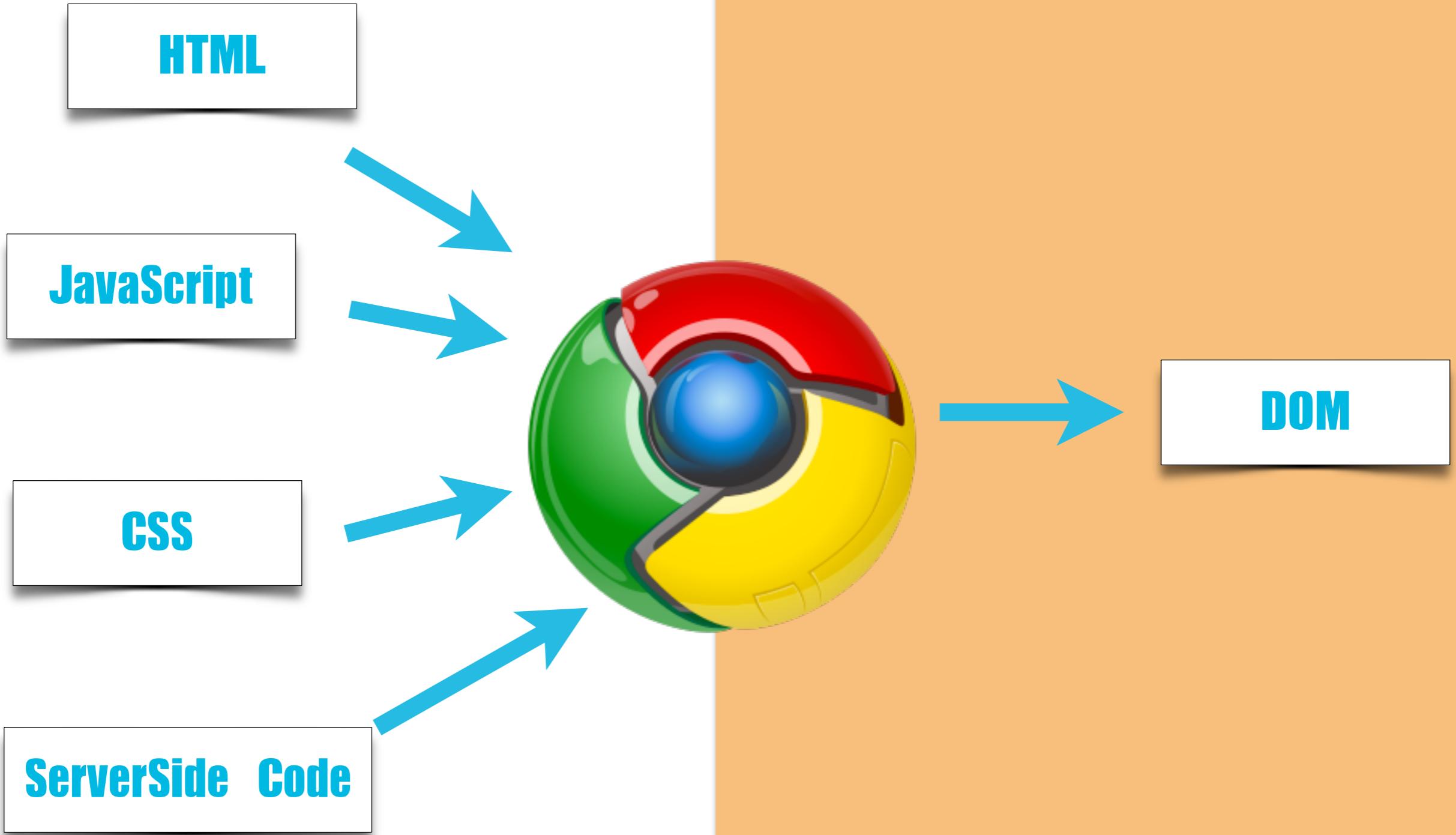
```
Enter amount: <input id="amount" type="text" value="0" />  
<input id="add2cart" value="add" type="button" onclick="addTotal(amount.value)" />  
<input onclick="addTotal(150); " value="\$100" />  
<input onclick="addTotal(250); " value="\$200" />  
<input onclick="addTotal(350); " value="\$300" />  
<input onclick="addTotal(400); " value="\$400" />  
Total:<div coverage="true" id="payable"></div>
```

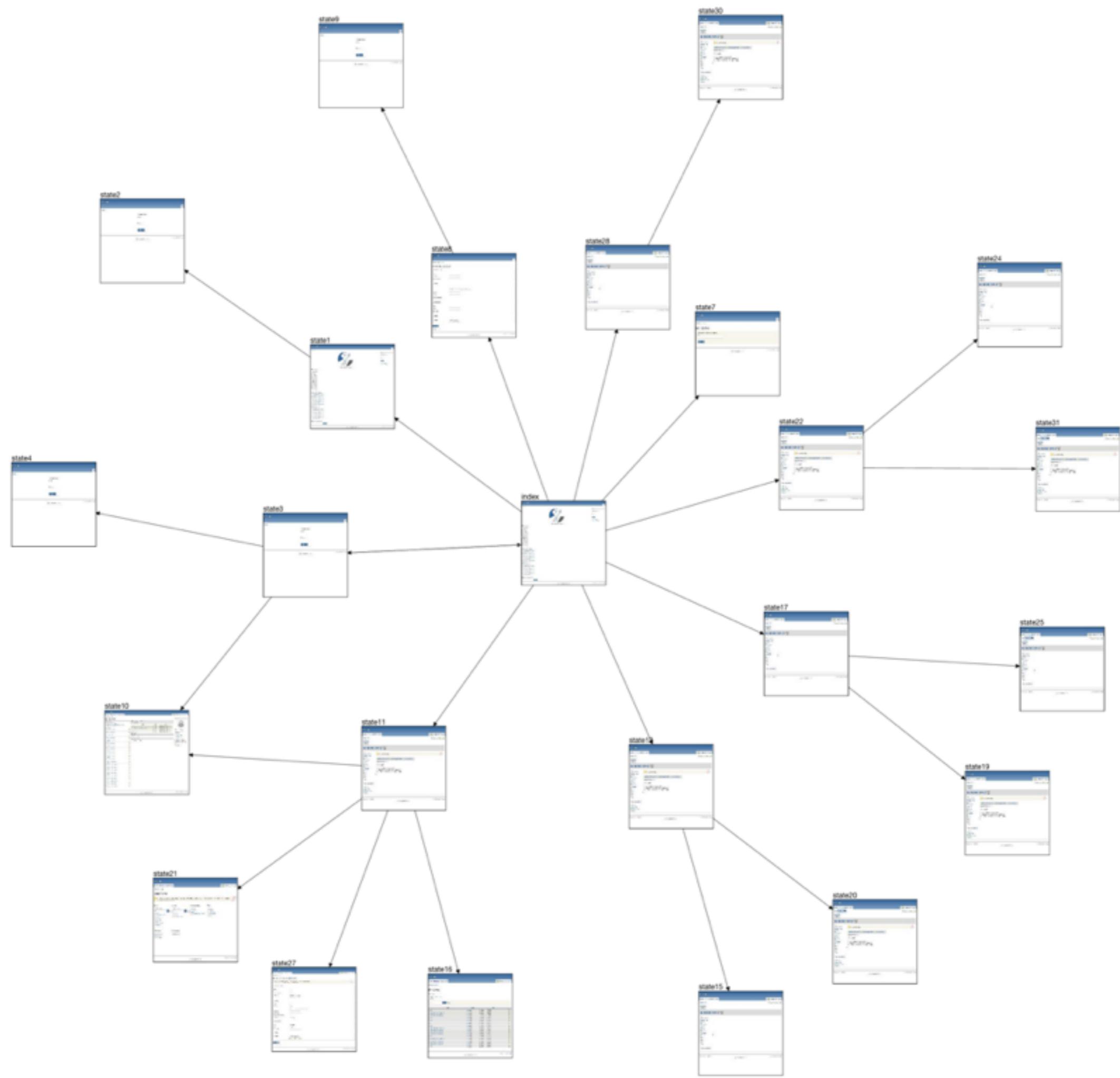
@Test

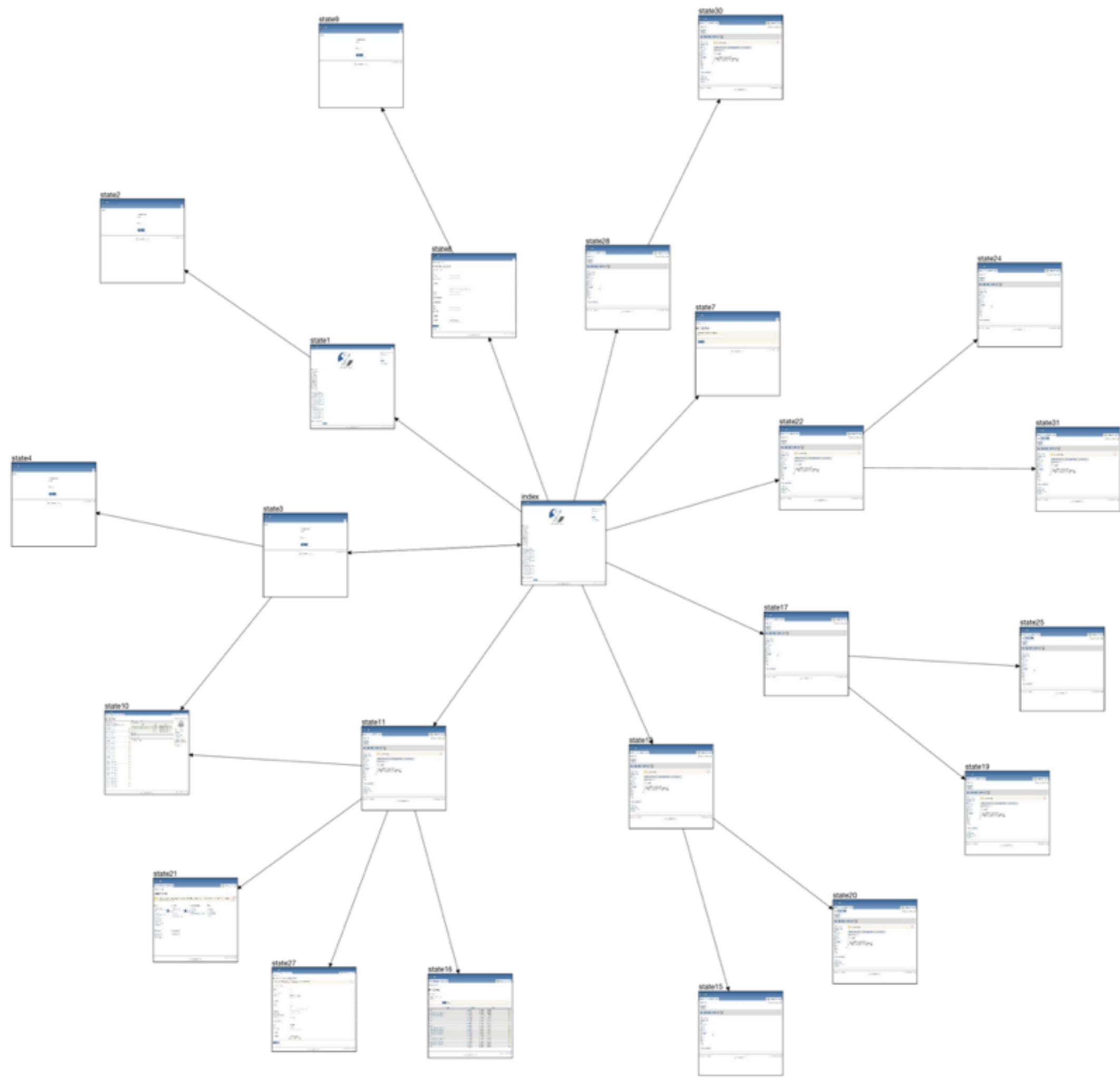
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driver = new FirefoxDriver();  
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driver.findElement(By.id("add2cart")).click();  
assertEquals("$50.0", driver.  
findElement(By.linktext("p")).text());  
}
```

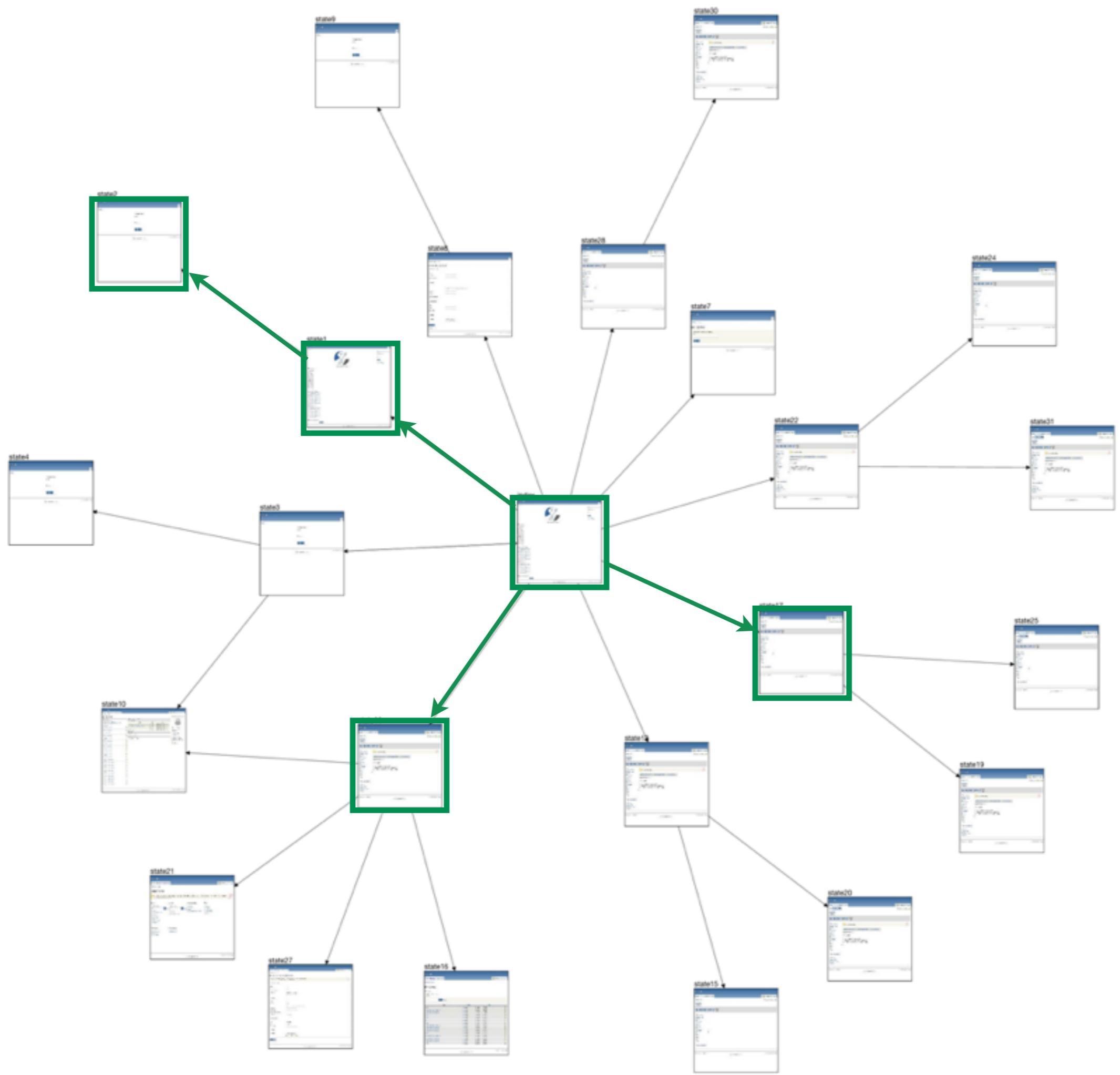


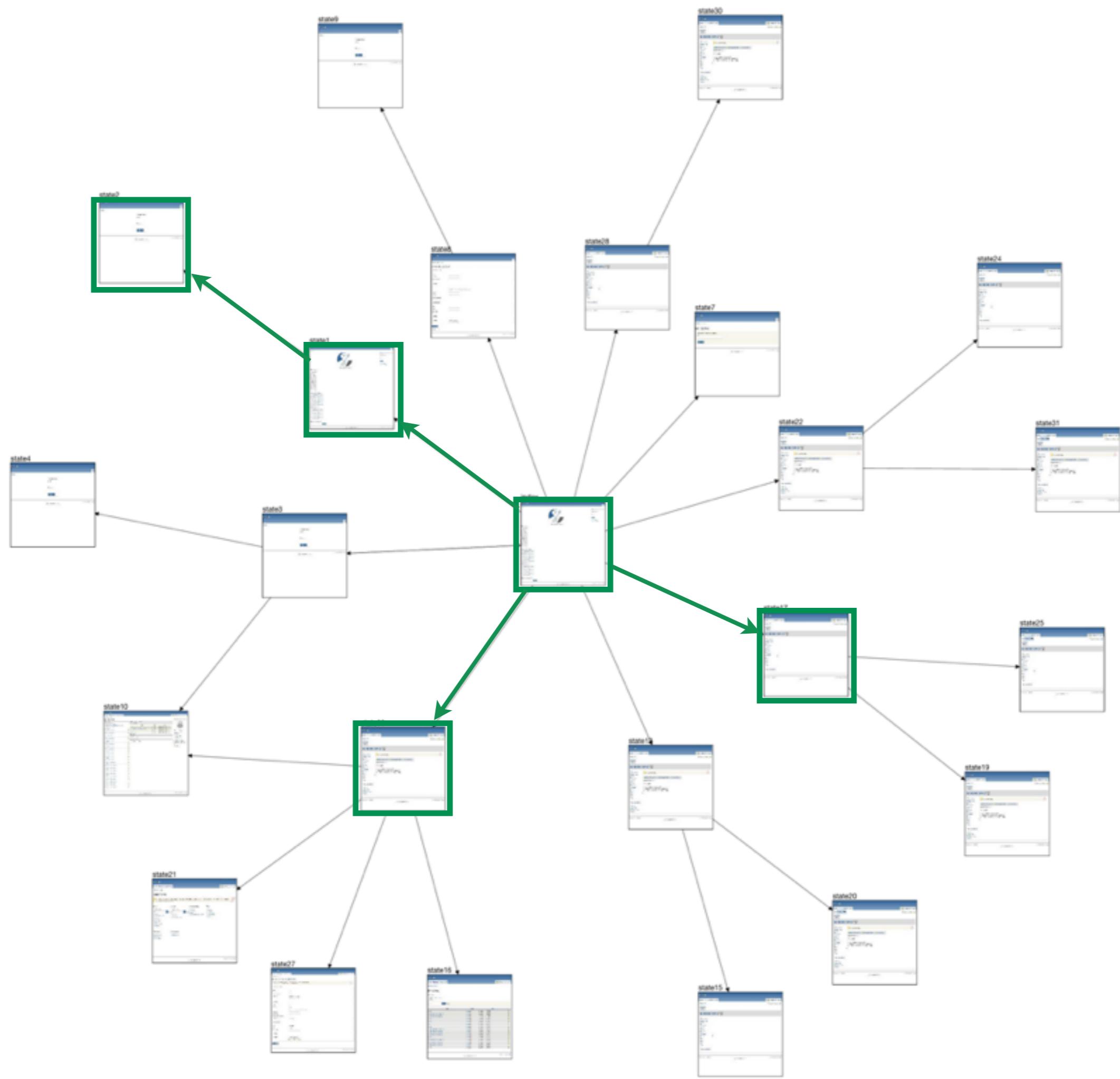












The screenshot shows the Claroline administration interface. At the top, there are two smaller windows showing different parts of the system: one with a file tree and another with a list of users.

The main window has a blue header bar with the Claroline logo, a search bar containing "localhost:8888/claroline-1.11.7/", and a menu bar with "Claroline", "My desktop", "My messages", "Platform administration", "mm nainy", "Manage my account", and "Logout".

The main content area has a breadcrumb navigation: "Claroline > Administration".

ADMINISTRATION

Users

Search for a user Go Advanced

- User list
- Send a message to all users
- Create user
- Add a user list
- Manage classes
- Right profile list
- Manage user desktop
- Merge user accounts

Courses

Search for a course Go Advanced

- Course list
- Create course
- Manage course categories

Platform configuration

- Configuration
- Edit text zones
- Modules
- Manage administrator email notifications

Tools

System Info
Files statistics
Platform statistics
Scan technical fault
Upgrade

Claroline.net

- Register my campus
- Support forum
- Claroline.net news

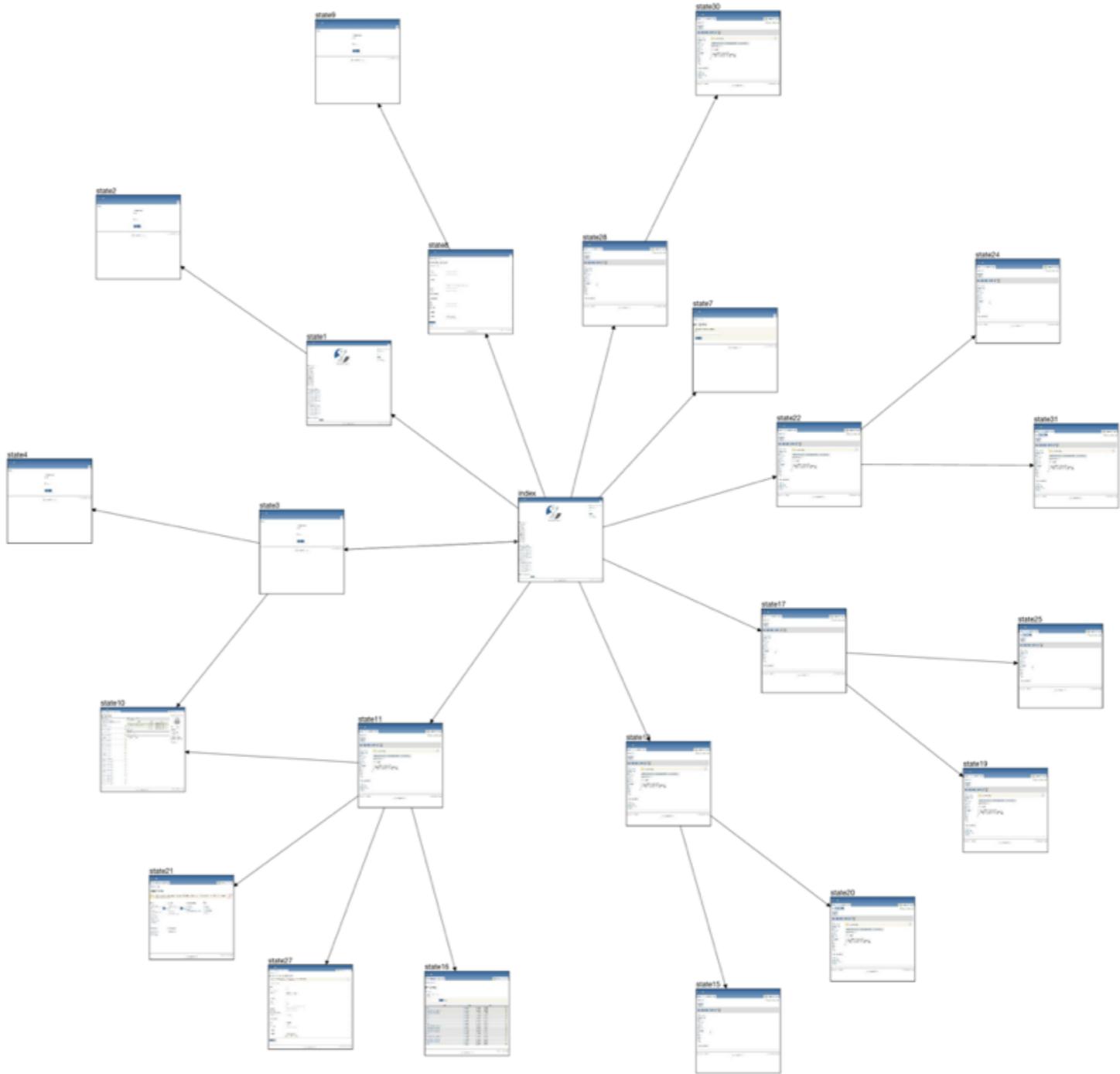
Communication

- Internal messaging

Powered by Claroline © 2001 - 2013

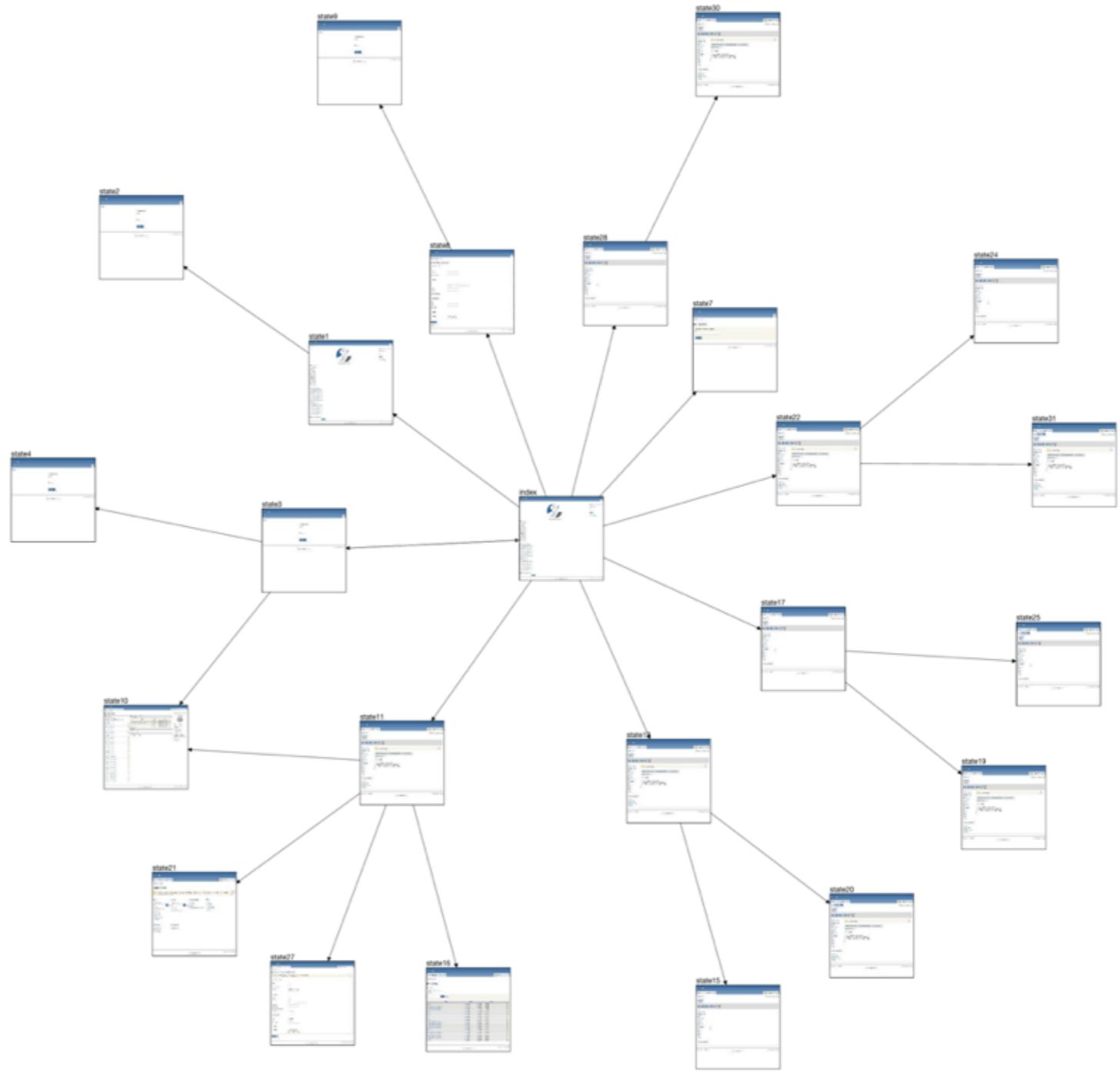
Administrator for Claroline : Nainy Nainy

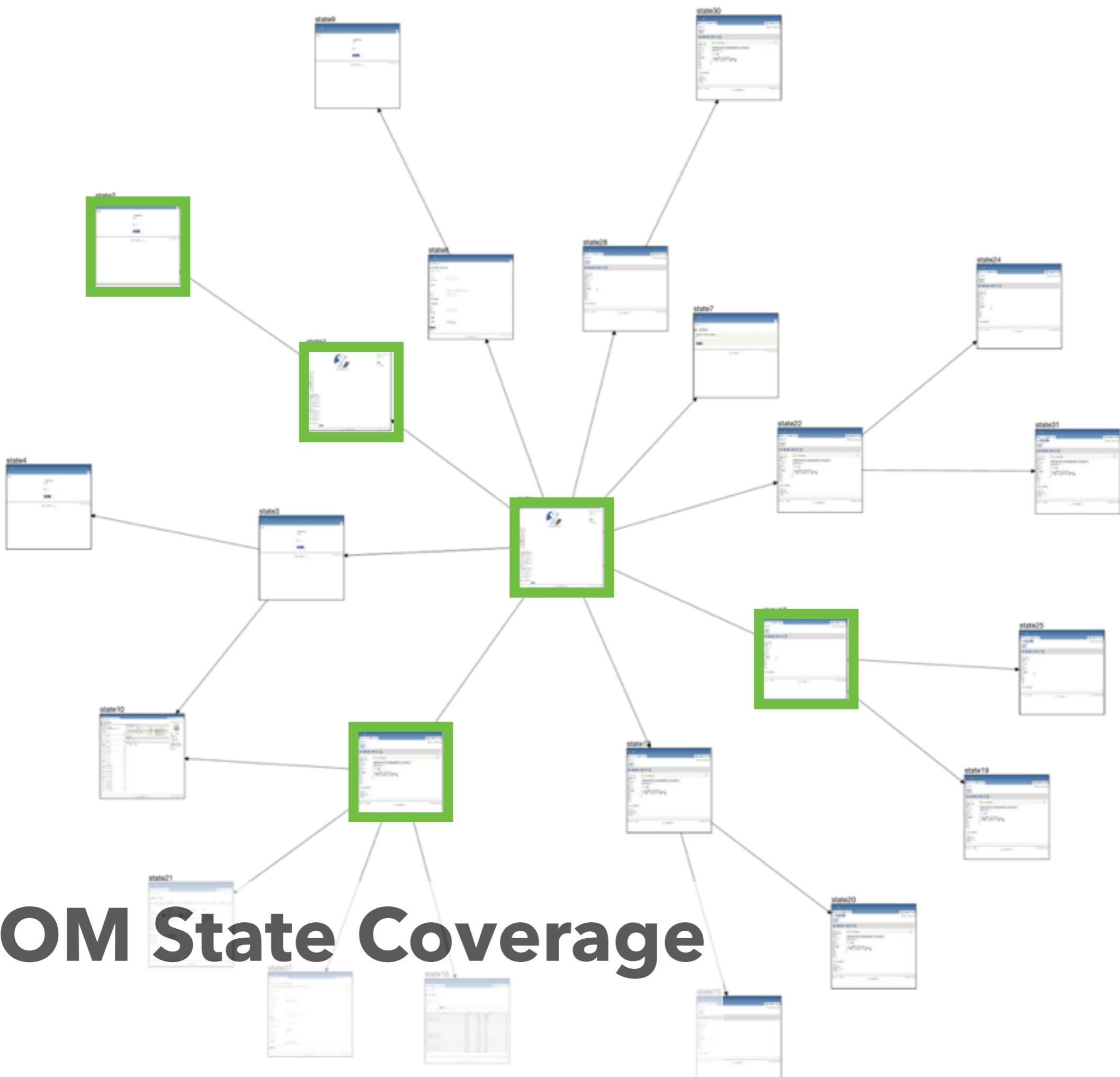
Inter-State Coverage Criteria



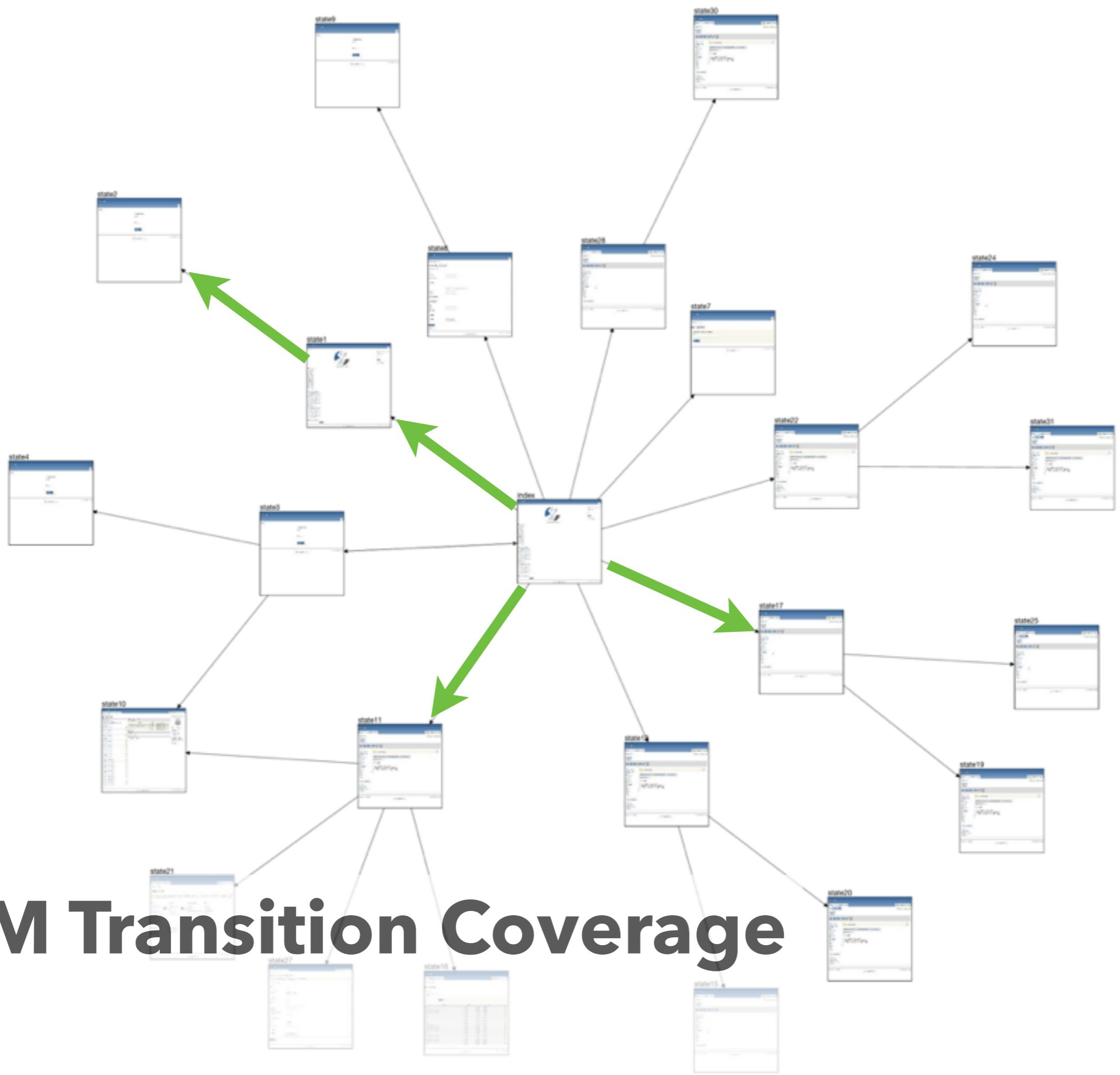
Inter-State Coverage Criteria

- DOM State
- DOM Transition





DOM State Coverage



Intra-State Coverage Criteria

The screenshot shows the Claroline platform interface. At the top, there's a header bar with the Claroline logo, a search bar, and navigation links like 'My desktop', 'My messages', and 'Platform administration'. A user profile for 'Nainy Nainy' is visible on the right, showing a placeholder user icon, email (mehdi@gmail.com), phone (7788814476), and administrative code. Below the header, the main content area is titled 'MY DESKTOP'. It includes sections for 'My course list' (listing courses like AAOC112 - Engineering Graphics), 'Welcome message' (which is currently hidden), 'My 5 last messages' (listing recent messages from Nainy Nainy), 'My calendar' (showing no events), and 'Latest announcements' (showing no announcements). A note at the bottom right of the sidebar indicates that the text zone can be edited by the platform administrator.



Intra-State Coverage Criteria

Explicit Element

The screenshot shows the Claroline web interface. At the top, there's a header bar with the Claroline logo, a search bar, and navigation links like 'My desktop', 'My messages', and 'Platform administration'. On the right, a user profile for 'Nainy Nainy' is displayed, showing a placeholder user icon, email (mehdi@gmail.com), phone (7788814476), and administrative code. Below the header, the main content area is titled 'MY DESKTOP'. It features several sections: 'My course list' (with a link to 'Manage my courses'), 'Welcome message' (with a 'Show/Hide' link), 'My 5 last messages' (listing recent messages from 'Nainy Nainy' about course creation), 'My calendar' (showing no events), and 'Latest announcements' (showing no announcements). A note on the right says: 'This text zone is displayed to each user. Platform administrator can change its content or remove it by editing the textzone_right.inc.html file.' At the bottom, it says 'Administrator for Claroline : Nainy Nainy'.



Intra-State Coverage Criteria

Explicit Element
Actionable Element

The screenshot shows a web browser window for the Claroline platform. The URL is `localhost:8888/claroline-1.11.7/`. The page title is "Claroline". The main navigation menu includes "My desktop", "My messages", and "Platform administration". A user profile for "Nainy Nainy" is visible, showing an icon, email (mehdi@gmail.com), phone (7788814476), and administrative code. The dashboard features several sections: "MY DESKTOP" with "My course list" (listing courses like AAOC112 - Engineering Graphics), "Welcome message" (with a "Show/Hide" link), "My 5 last messages" (listing messages from Nainy Nainy), "My calendar" (showing no events), and "Latest announcements" (showing no announcements). A note on the right says: "This text zone is displayed to each user. Platform administrator can change its content or remove it by editing the `textzone_right.inc.html` file." At the bottom, it says "Powered by Claroline © 2001 - 2013" and "Administrator for Claroline : Nainy Nainy".



Intra-State Coverage Criteria

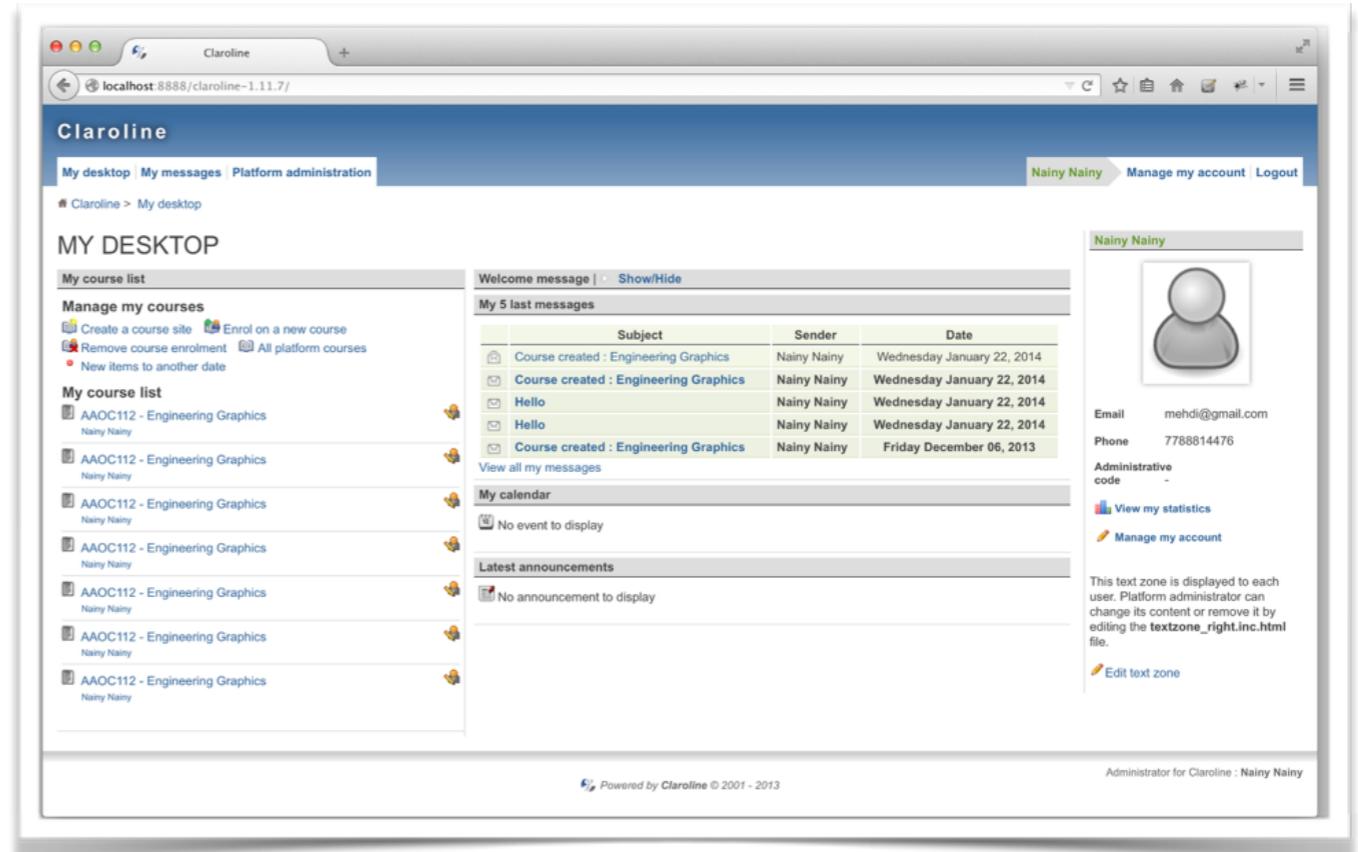
Explicit Element
Actionable Element
Implicit Element

The screenshot shows the Claroline platform interface. At the top, there's a header with the Claroline logo and navigation links like 'My desktop', 'My messages', and 'Platform administration'. A user profile for 'Nainy Nainy' is visible on the right, showing an icon, email (mehdi@gmail.com), phone (7788814476), and administrative code. Below the header, the main content area is titled 'MY DESKTOP'. It includes sections for 'My course list' (listing courses like AAOC112 - Engineering Graphics), 'Welcome message' (which is currently hidden), 'My 5 last messages' (listing recent messages from Nainy Nainy), 'My calendar' (showing no events), and 'Latest announcements' (showing no announcements). A note at the bottom right says: 'This text zone is displayed to each user. Platform administrator can change its content or remove it by editing the textzone_right.inc.html file.' The footer indicates the site is 'Powered by Claroline © 2001 - 2013'.



Intra-State Coverage Criteria

Explicit Element
Actionable Element
Implicit Element
Checked Element



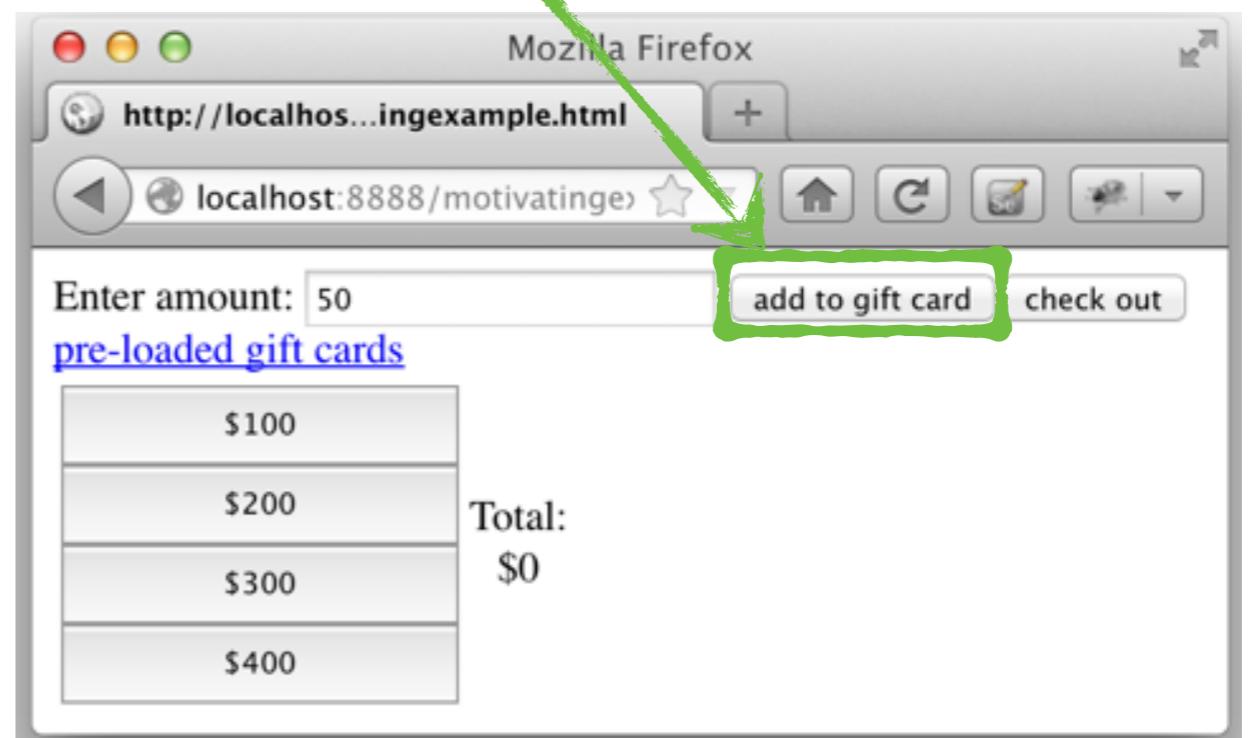
Explicit Element Coverage

```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$50.0", driver.  
        findElement(By.linktext("p")).text());  
}
```

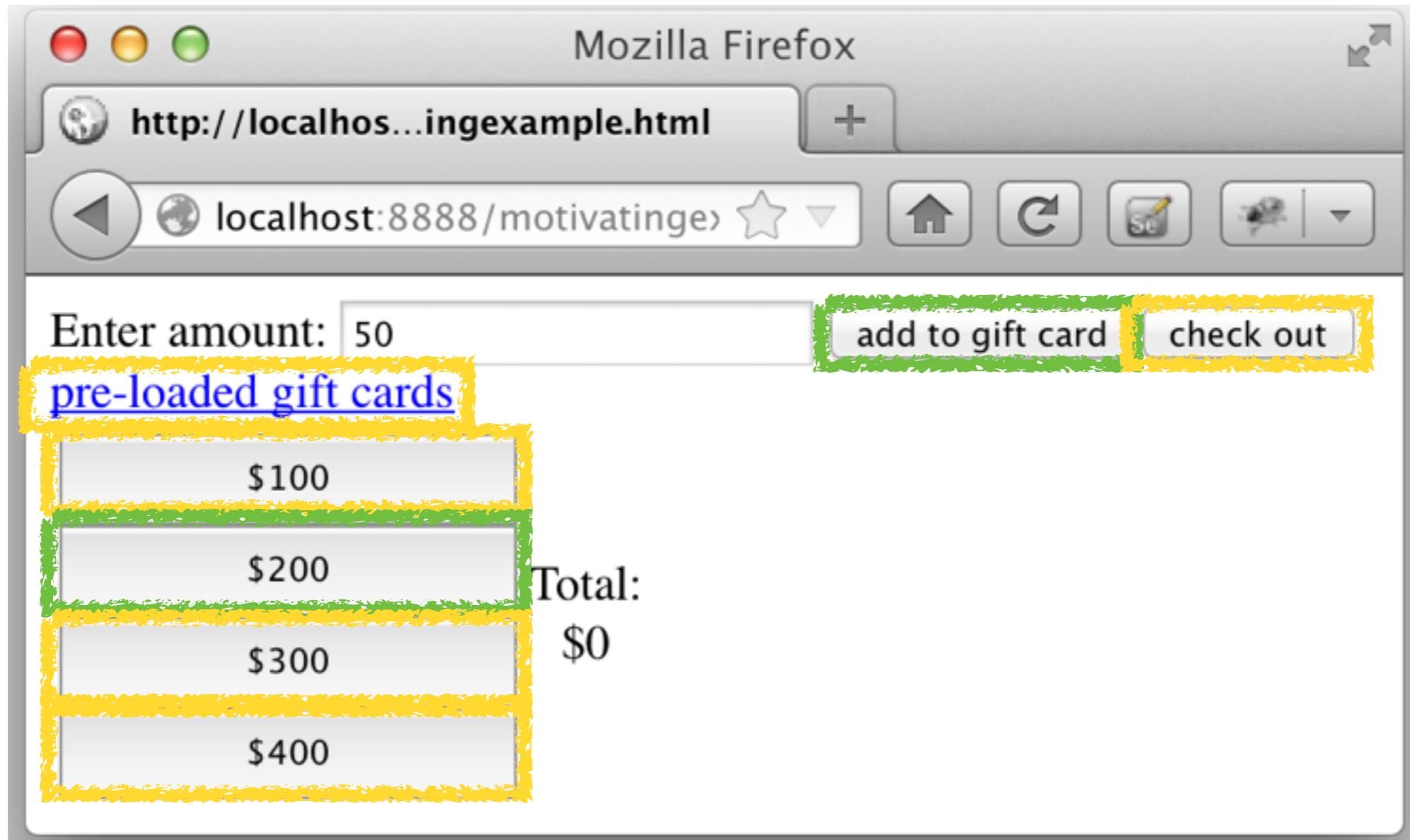


Explicit Element Coverage

```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$50.0", driver.  
        findElement(By.linktext("p")).text());  
}
```



Actionable Element Coverage



Implicit Element Coverage

```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$0", driver.  
        findElement(By.linktext("p1")).text());  
}
```



Implicit Element Coverage

```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$0", driver.  
        findElement(By.linktext("p1")).text());  
}
```



```
<input id="add2cart" value="add"  
      onclick="addTotal(amount.value)">
```

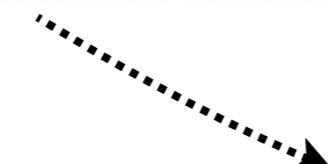


Implicit Element Coverage

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@Test  
public void testShoppingCard() {  
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<input id="add2cart" value="add"  
      onclick="addTotal(amount.value)">
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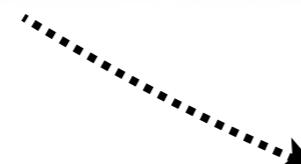
```
function addTotal(x){  
    document.getElementById("p1").innerHTML="$"+x;  
}
```

Implicit Element Coverage

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    driver.findElement(By.id("add2cart")).click();  
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```



```
function addTotal(x){  
    document.getElementById("p1").innerHTML="$"+x;  
}
```



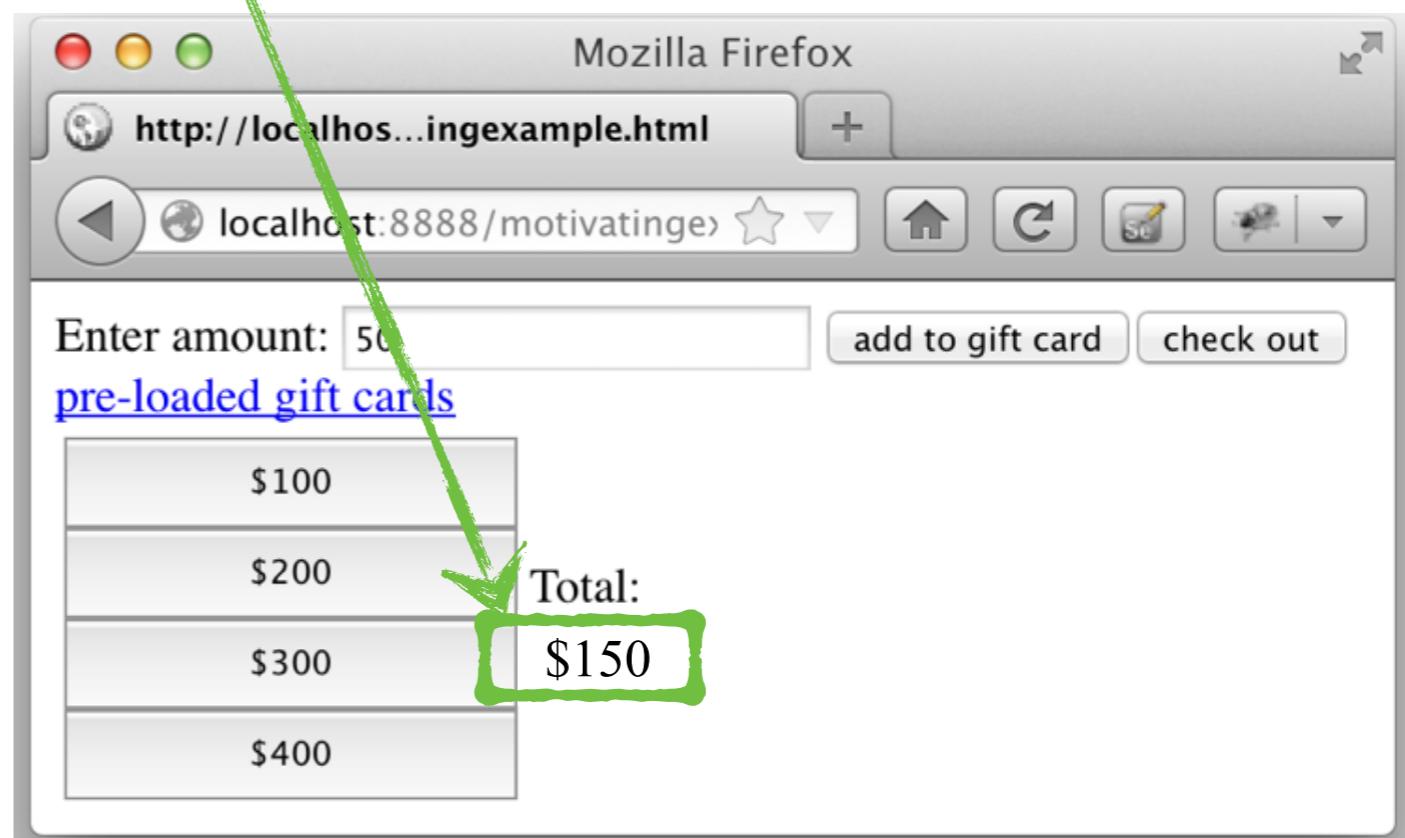
Checked Element Coverage

```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$150", driver.  
        findElement(By.linktext("p1")).text());  
}
```



Checked Element Coverage

```
@Test  
public void testShoppingCard() {  
    driver = new FirefoxDriver();  
    driver.get(url);  
    driver.findElement(By.id("add2cart")).click();  
    assertEquals("$150", driver.  
        findElement(By.linktext("p1")).text());  
}
```





DOMCoverage

Instrument Test suite

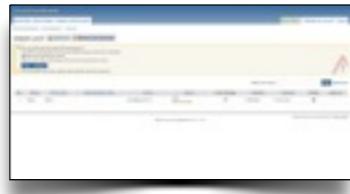
Execute the Test Suite and Collect Data



DOM State Abstraction

Test Suite

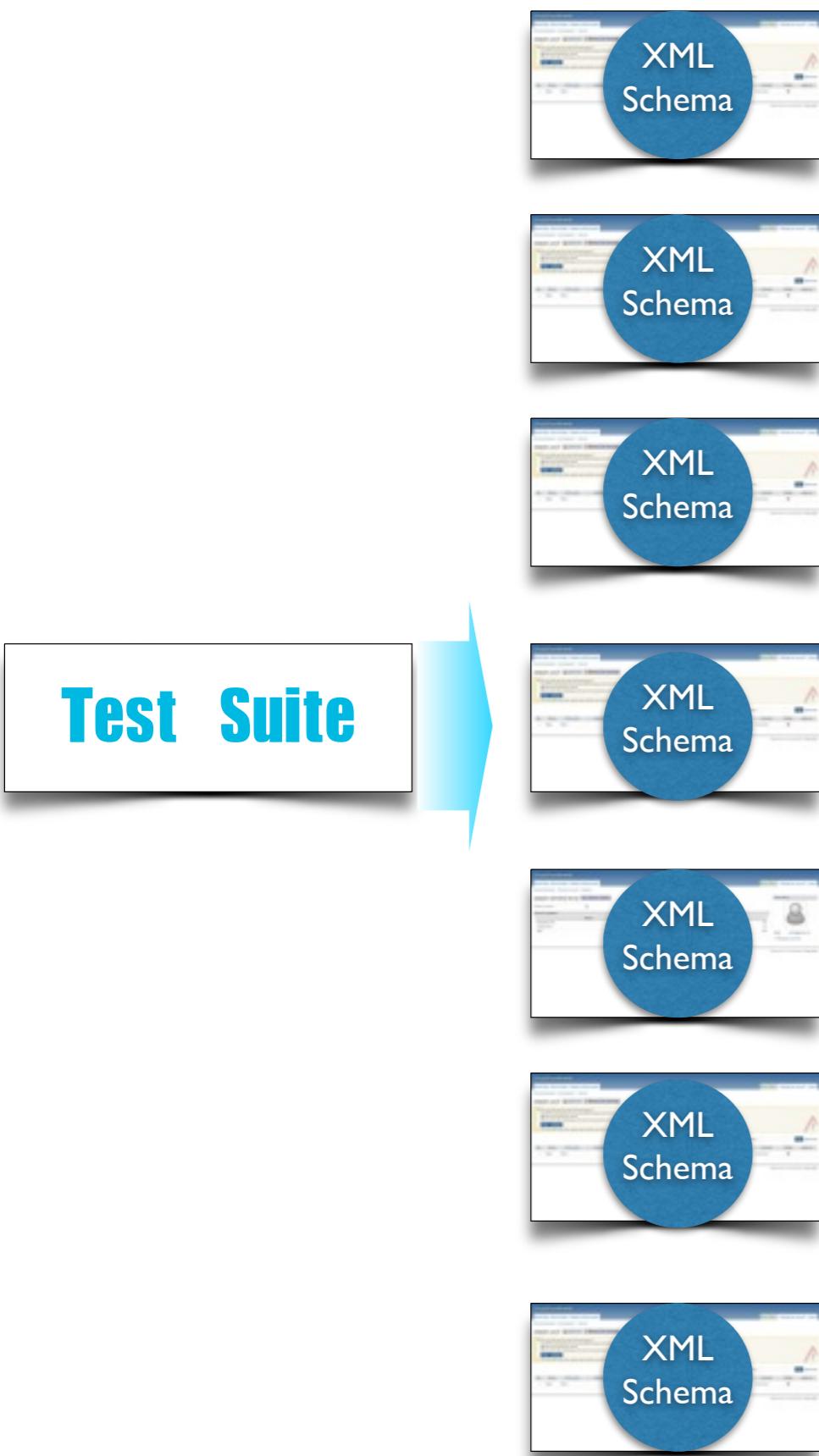
DOM State Abstraction



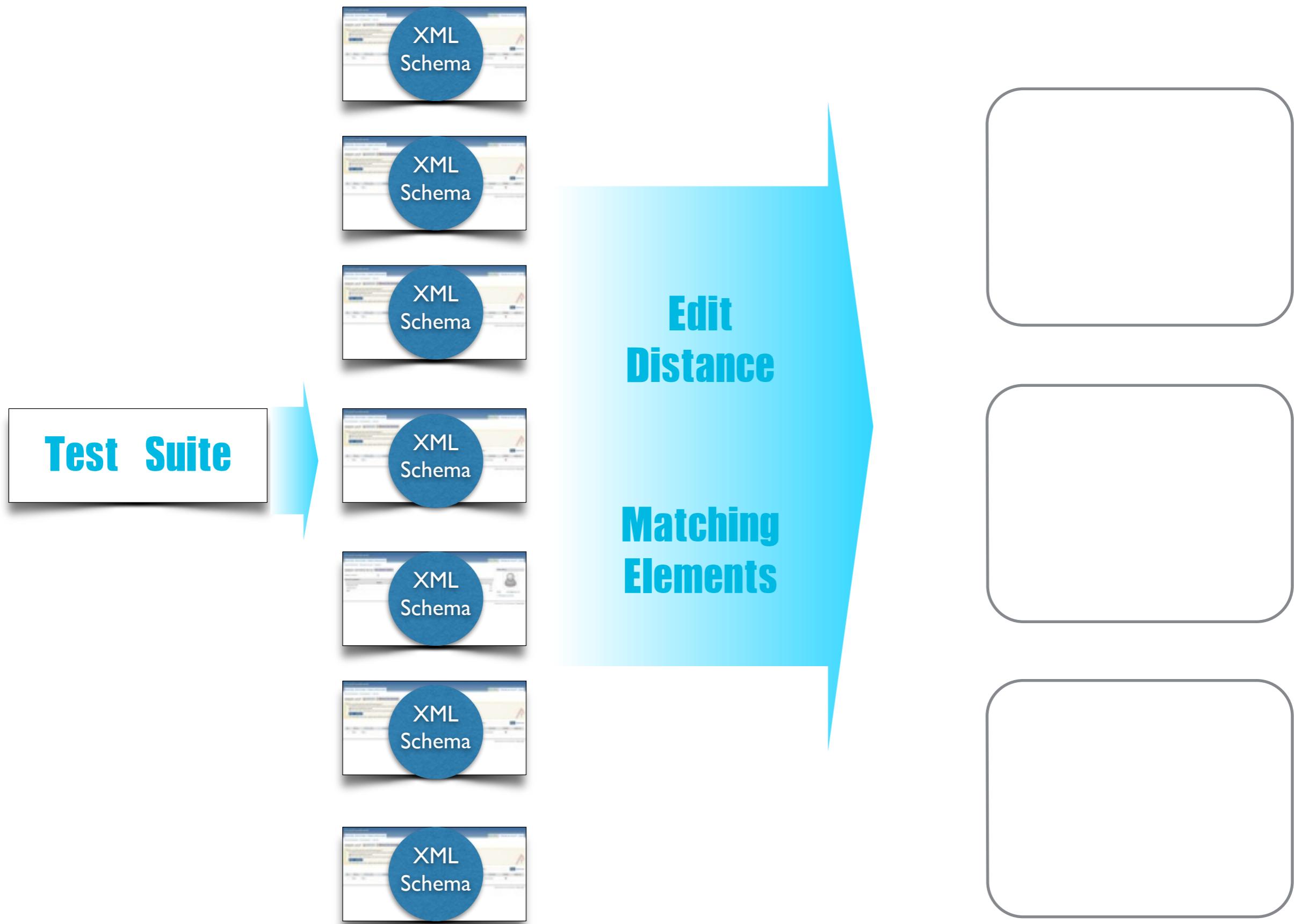
Test Suite



DOM State Abstraction



DOM State Clustering



DOM State Clustering

Test Suite

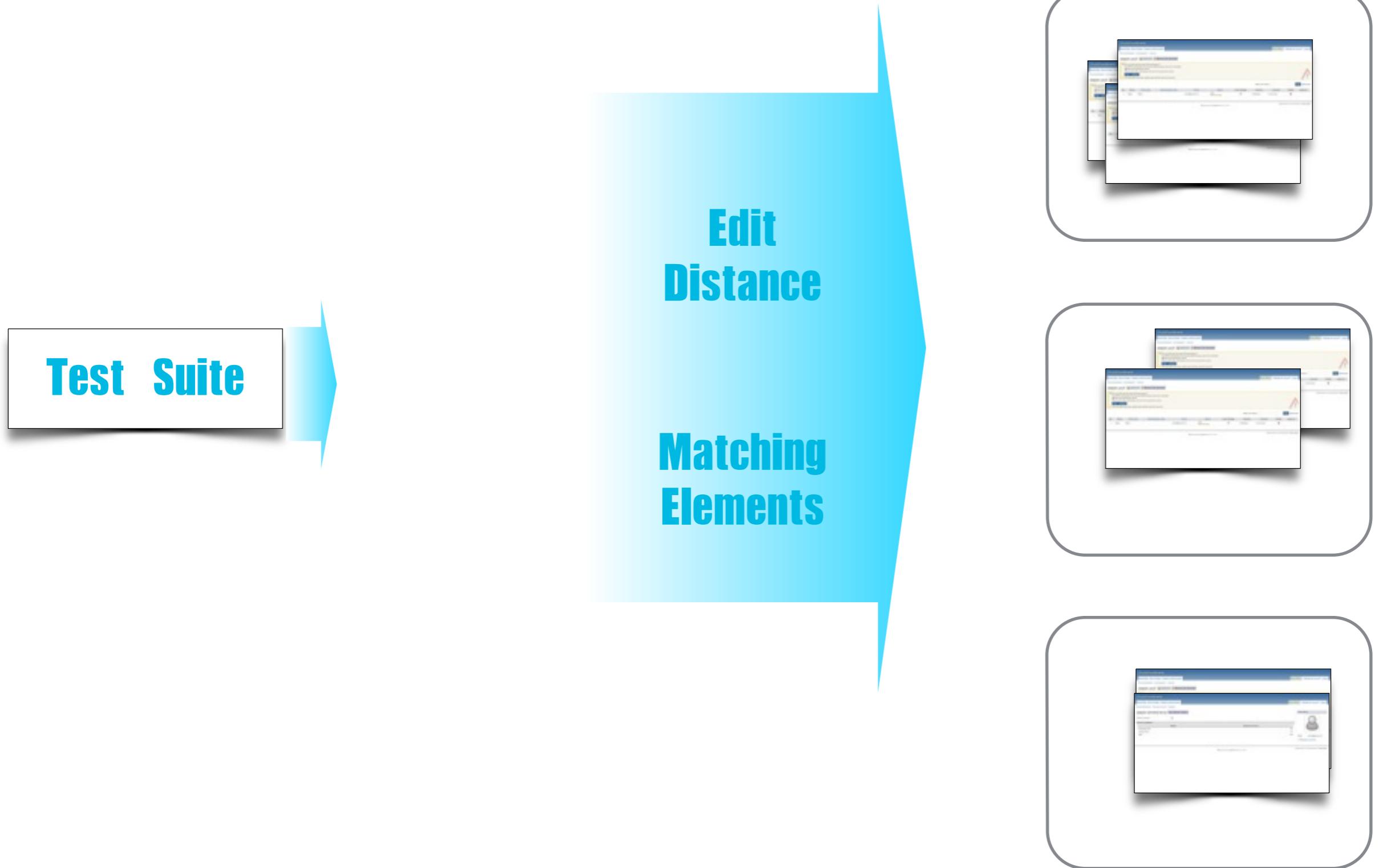


Edit
Distance

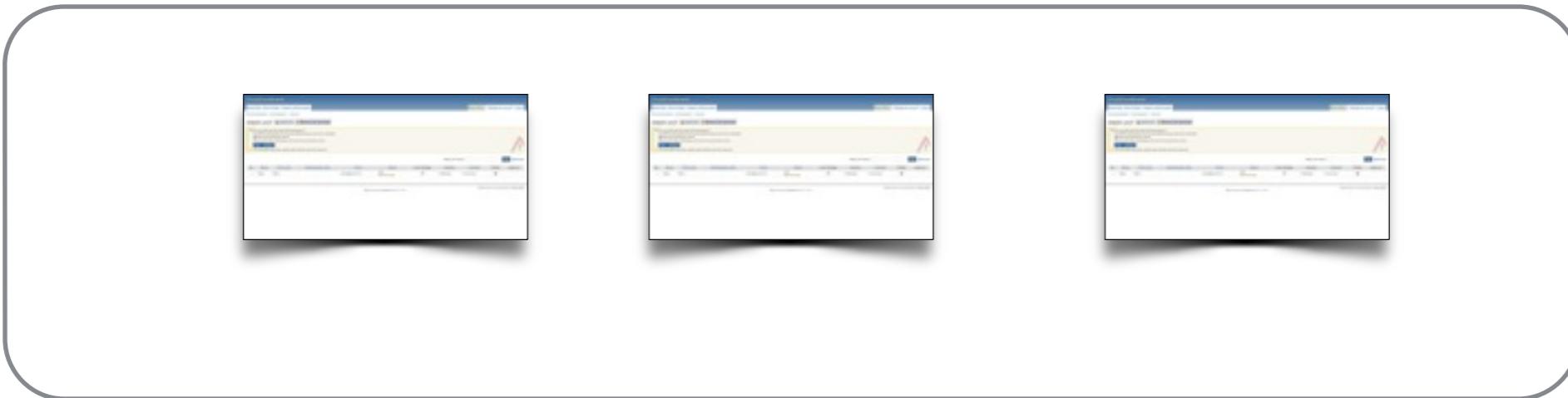
Matching
Elements



DOM State Clustering

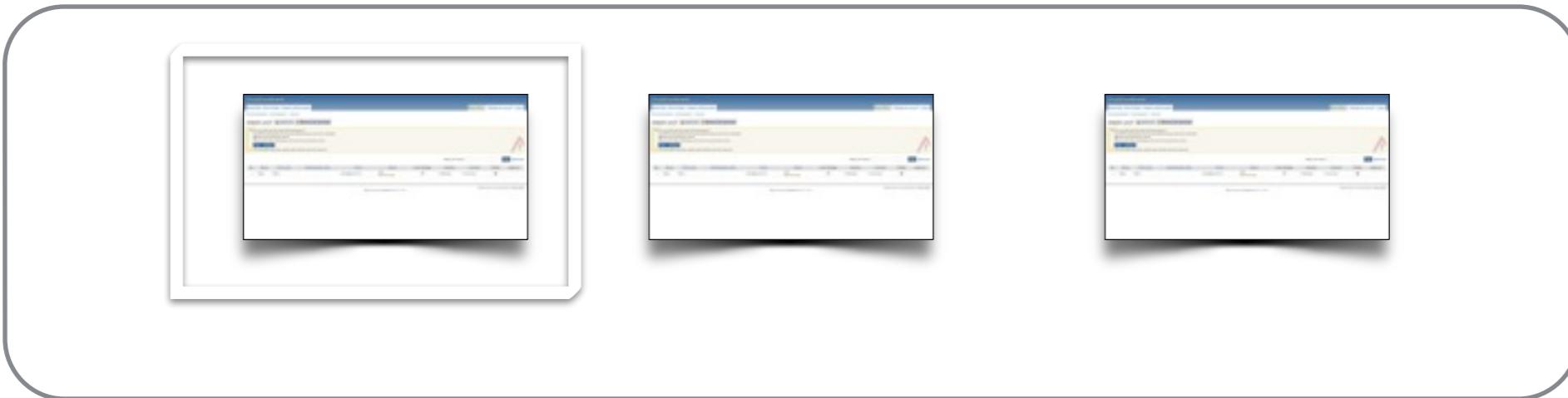


Merging States in Clusters



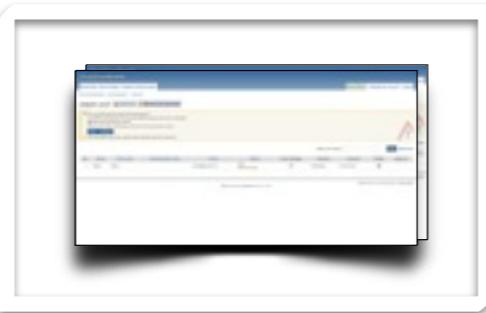
- Find biggest DOM State in Cluster
- Merge Covered Elements

Merging States in Clusters



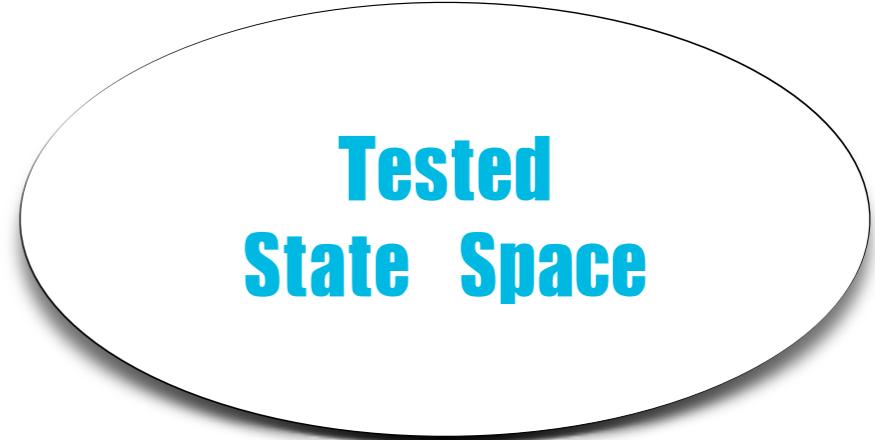
- Find biggest DOM State in Cluster
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Merging States in Clusters



- Find biggest DOM State in Cluster
- Merge Covered Elements

Extracting Inter-state Coverage

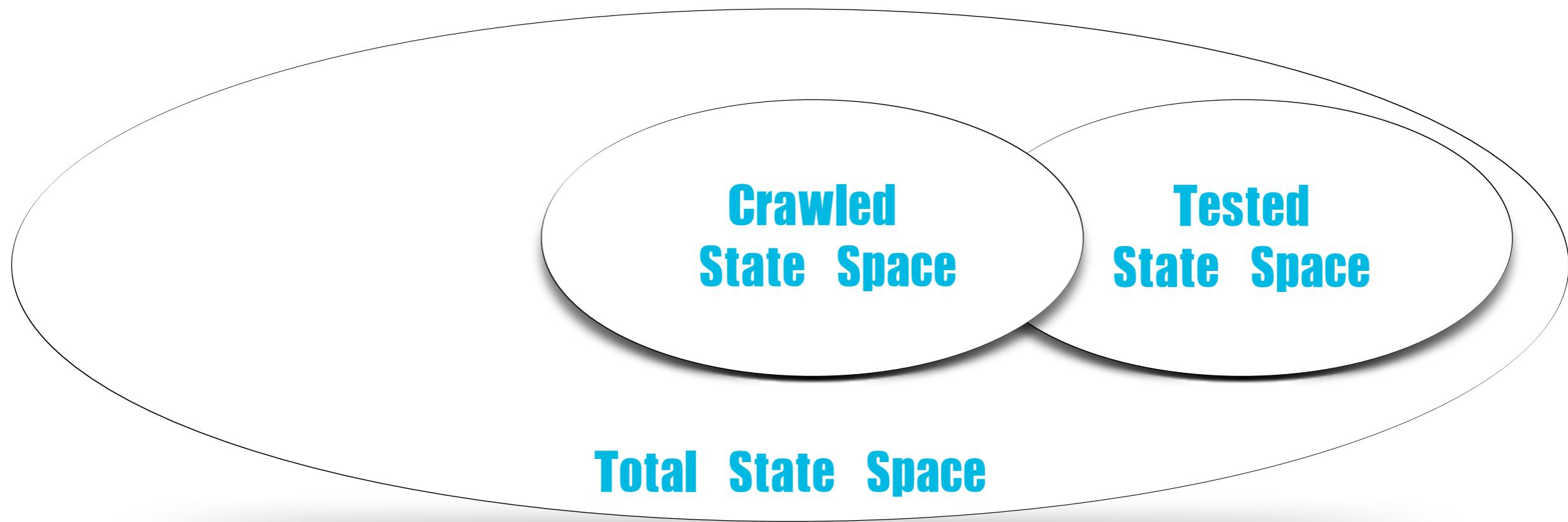


Tested
State Space

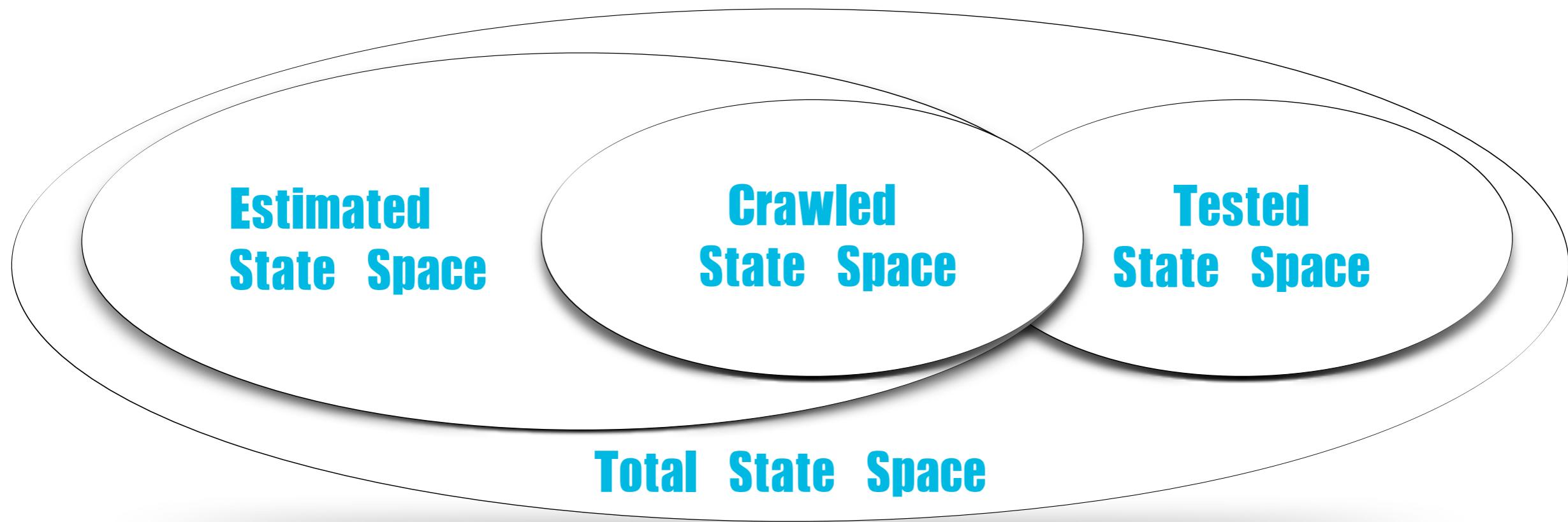
Extracting Inter-state Coverage



Extracting Inter-state Coverage



Extracting Inter-state Coverage

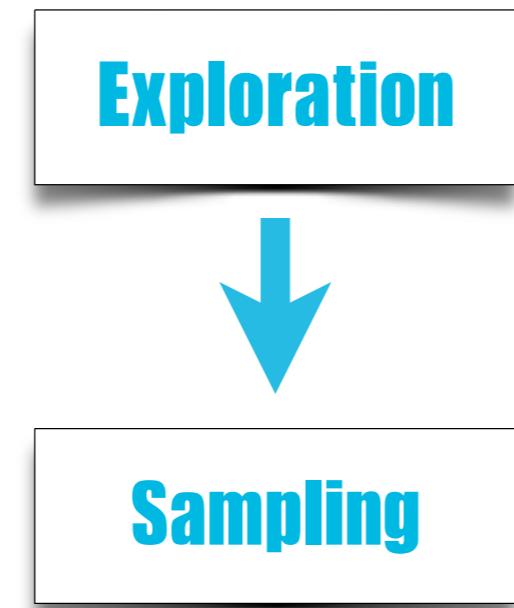


State Space Estimation

State Space Estimation

Exploration

State Space Estimation



State Space Estimation



Implementation



github.com/saltlab/DomCovery



Implementation



Selenium
TestSuite
(Java)



DOM
Coverage
Report

DomCoverage Coverage Report

ch/development/git/DomCoverage/DomcoverageOutput/gallerywithclickable/8/Domcoverage-DomStates-report/index.html#

DomCoverage State graph Statistics

Crawl overview

DomCoverage State inspector

Intra-State Coverage of state32

Direct Element Coverage	28.6 (2 / 7)
Indirect Element Coverage	0.0 (0 / 7)
Asserted Element Coverage	0.0 (0 / 7)
Clickable Element Coverage	28.6 (2 / 7)

Screenshot Captured DOM

? ?My PhotoGallery? Administration Region

Welcome! Login to Your Phormer

Administrator's password:

Login

Update Your Phormer (?)

Great! You're running last version of Phormer, which is 3.3!

This PhotoGallery is powered by Phormer, a simple PHP Photo Gallery Manager, under GPL.

DomCoverage Coverage Report

DomCoverage State graph Statistics

Crawl of \${crawledUrl} at Sun Nov 10 19:28:28 PST 2013

Crawled by DomCoverage 3.4-SNAPSHOT

29

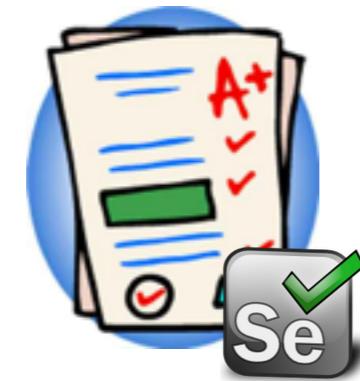
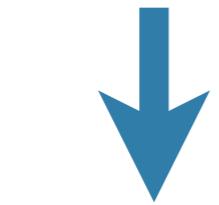
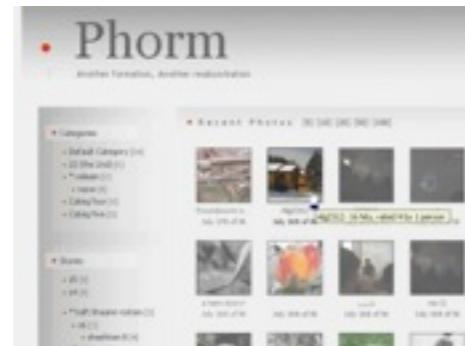
Evaluation

**Is DOM coverage correlated
with the Code coverage?**

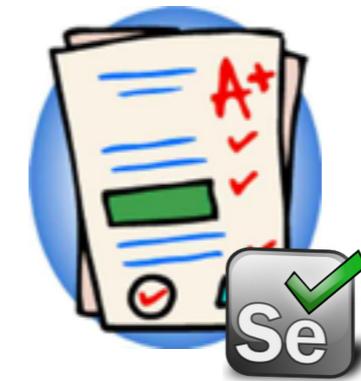
**How effective
is DOMCoverage?**



6 KLOC



300 KLOC



Correlation



Code-Based Coverage

	State	Transition	Explicit	Implicit	Checked	Actionable
Function						
Statement						
Branch						

Kandall Correlation Coefficient

Code-Based Coverage	Dom-Based Coverage					
	State	Transition	Explicit	Implicit	Checked	Actionable
Function	0.18					
Statement		0.19				
Branch			0.06			

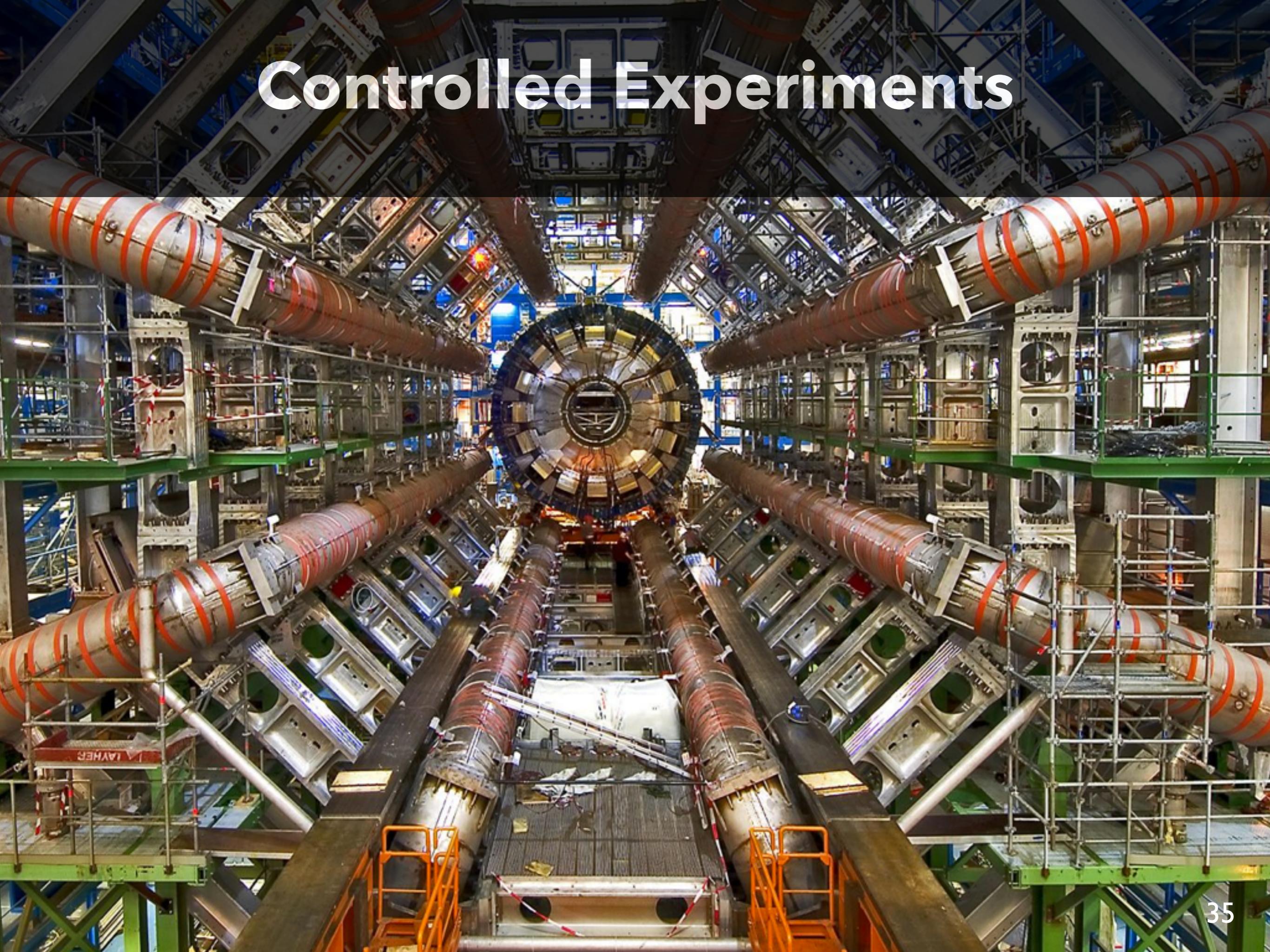
Kandall Correlation Coefficients

Code-Based Coverage	Dom-Based Coverage					
	State	Transition	Explicit	Implicit	Checked	Actionable
Function	0.18	0.17	-0.07	0.43	-0.16	0
Statement	0.19	0.19	-0.15	0.47	-0.26	-0.09
Branch	0.06	0.03	-0.06	0.43	-0.15	-0.05

Kandall Correlation Coefficients

Code-Based Coverage	Dom-Based Coverage					
	State	Transition	Explicit	Implicit	Checked	Actionable
Function	0.18	0.17	-0.07	0.43	-0.16	0
Statement	0.19	0.19	-0.15	0.47	-0.26	-0.09
Branch	0.06	0.03	-0.06	0.43	-0.15	-0.05

Controlled Experiments



Experiment Design

Experiment Design



Experimental Object

Experiment Design



Experimental Object



Experimental Subjects

Experiment Design



Experimental Object

Experimental Subjects

Experimental Group
Domcovery



Experiment Design



Experimental Object

Experimental Subjects

Experimental Group
Domcovery

Controlled Group
JSCover, FireBug, ...

Tasks



Tasks

- T1: Locating the **explicit** elements covered by a test suite
- T2: Locating the **actionable** elements accessed via a test suite
- T3: Locating the **implicit** elements asserted in a test suite
- T4: Locating the **checked** elements covered by a test suite



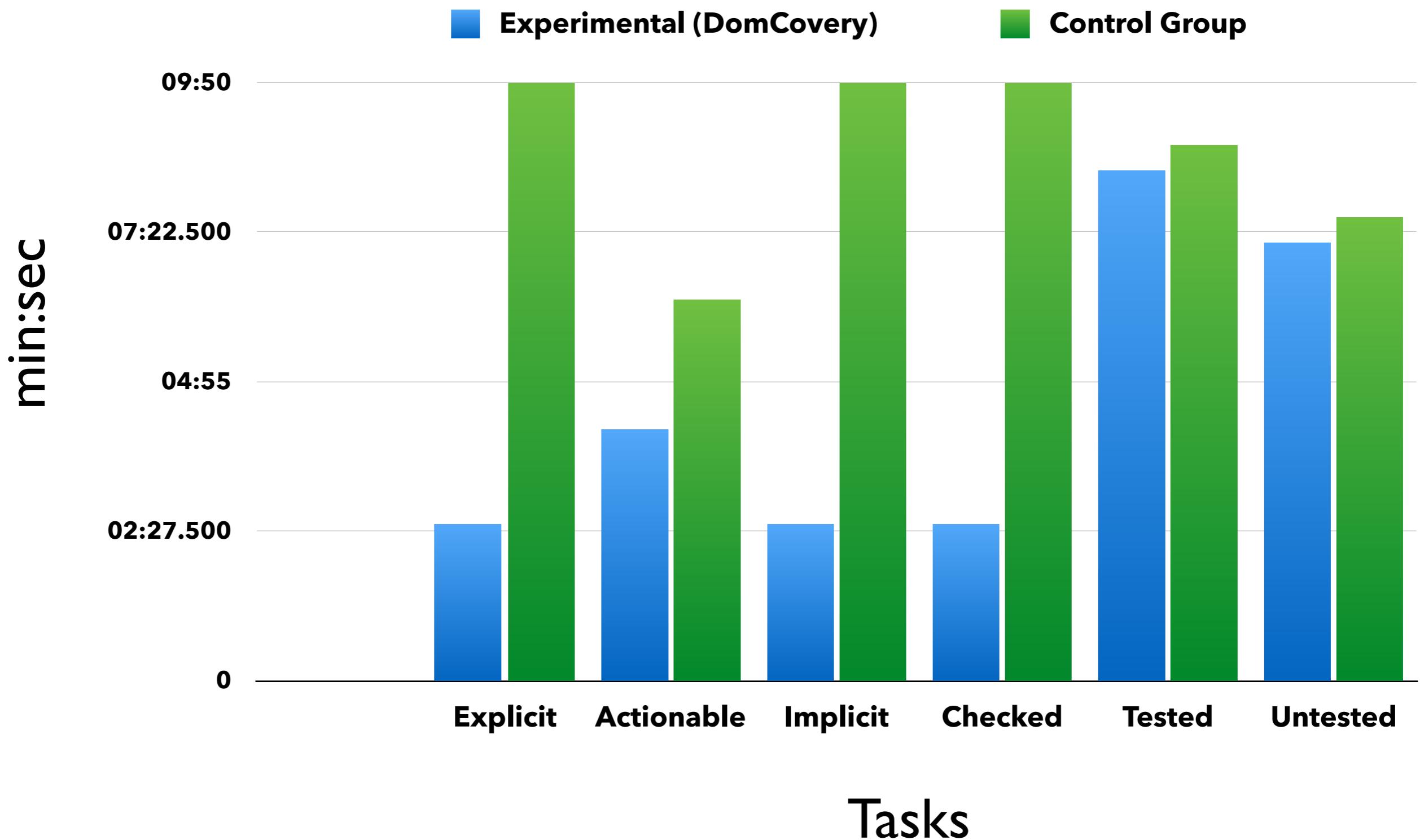
Tasks

- T1: Locating the **explicit** elements covered by a test suite
- T2: Locating the **actionable** elements accessed via a test suite
- T3: Locating the **implicit** elements asserted in a test suite
- T4: Locating the **checked** elements covered by a test suite

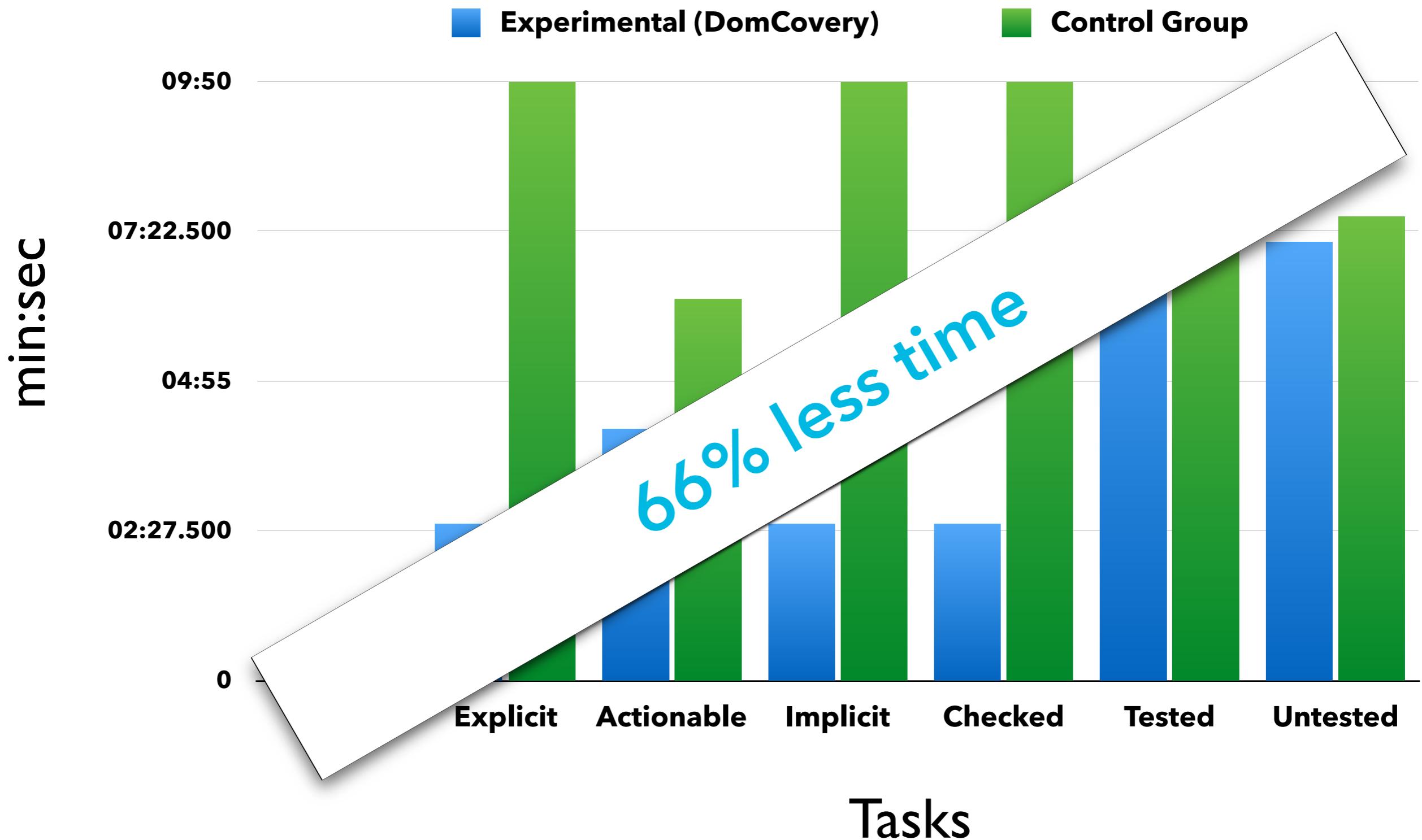
- T5: Identifying the **features under tests** given a test suite
- T6: Identifying the **untested features** given a test suite



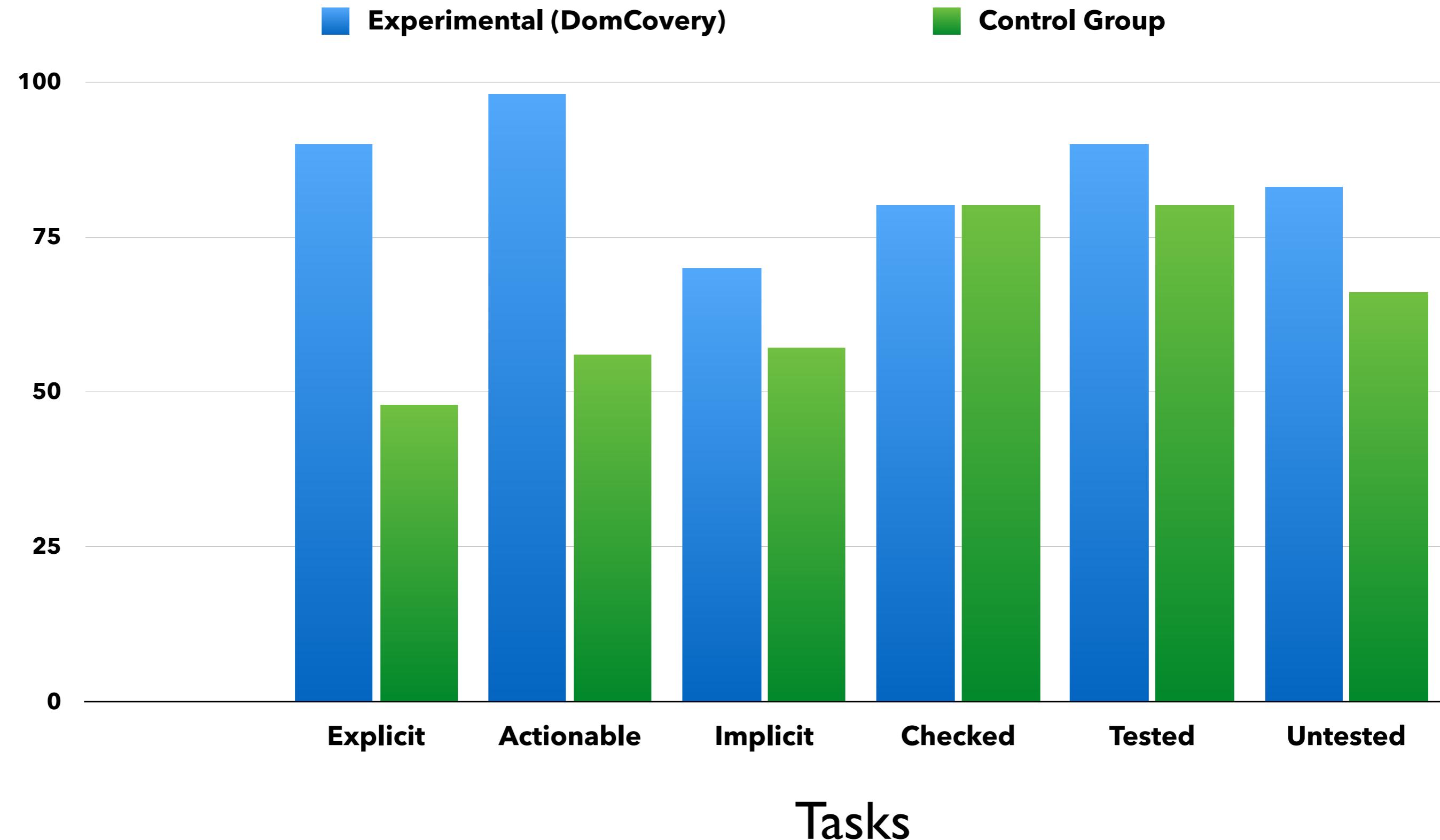
Completion Time



Completion Time

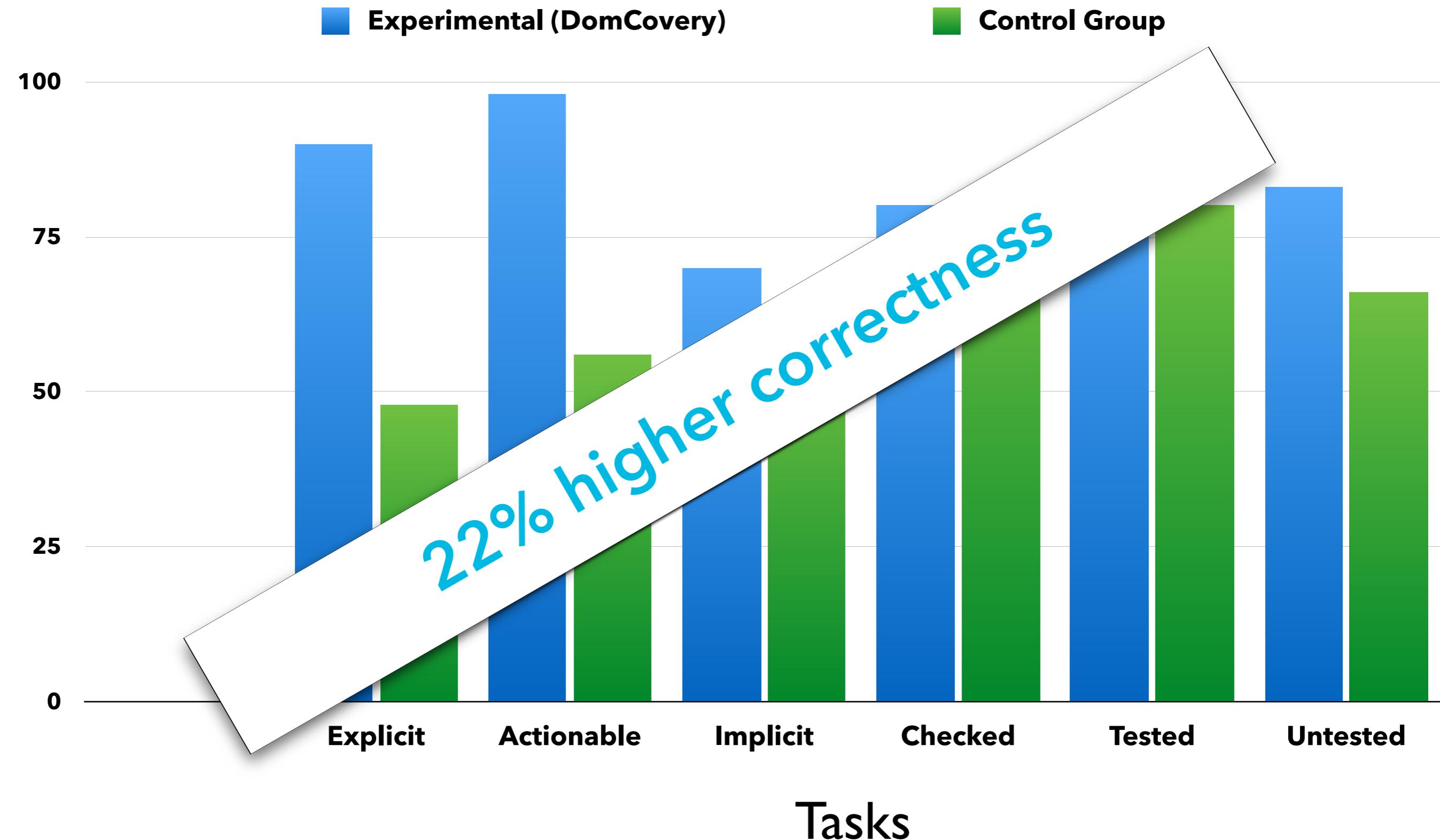


Correctness



Tasks

Correctness



Summary

Summary

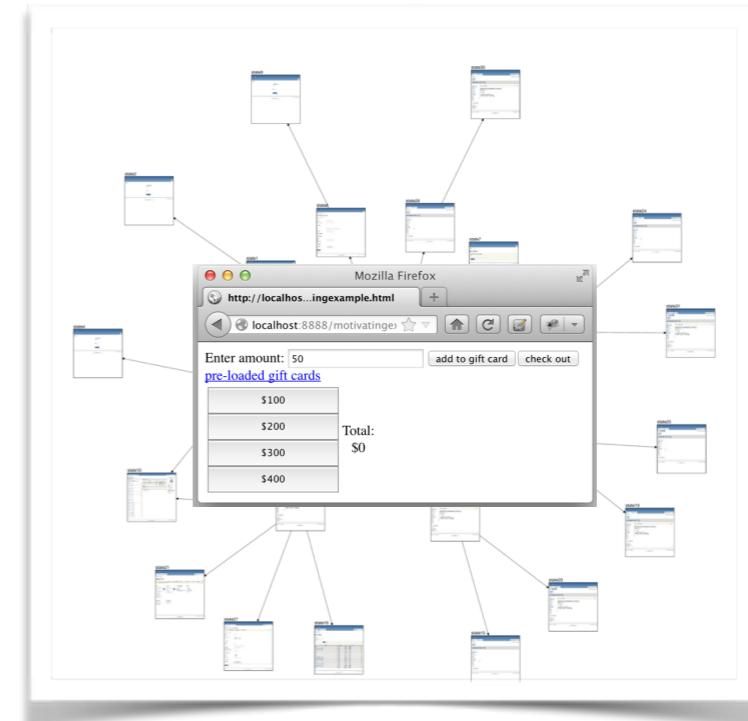


DOM-based coverage criteria

Summary



DOM-based coverage criteria

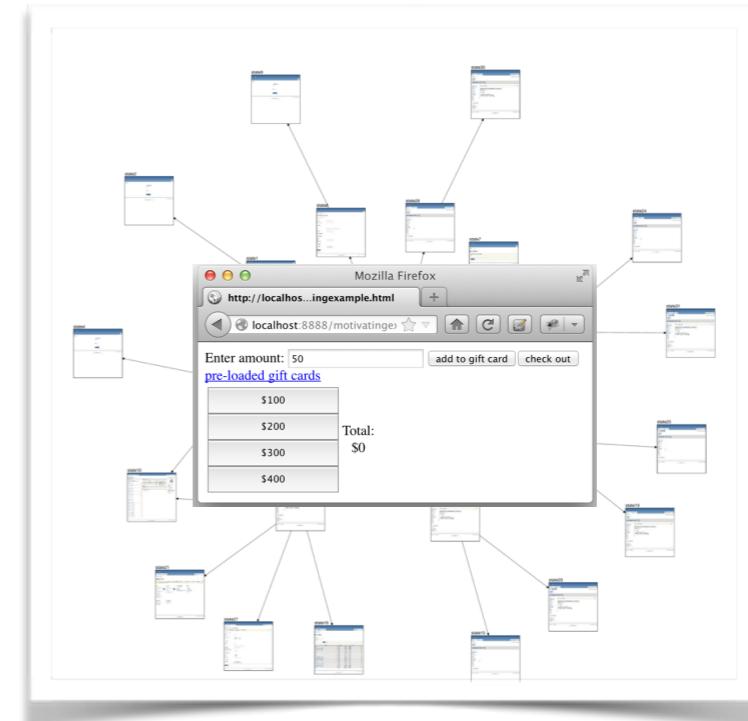


**2 inter-state and 4 intra-state
adequacy criteria**

Summary



DOM-based coverage criteria

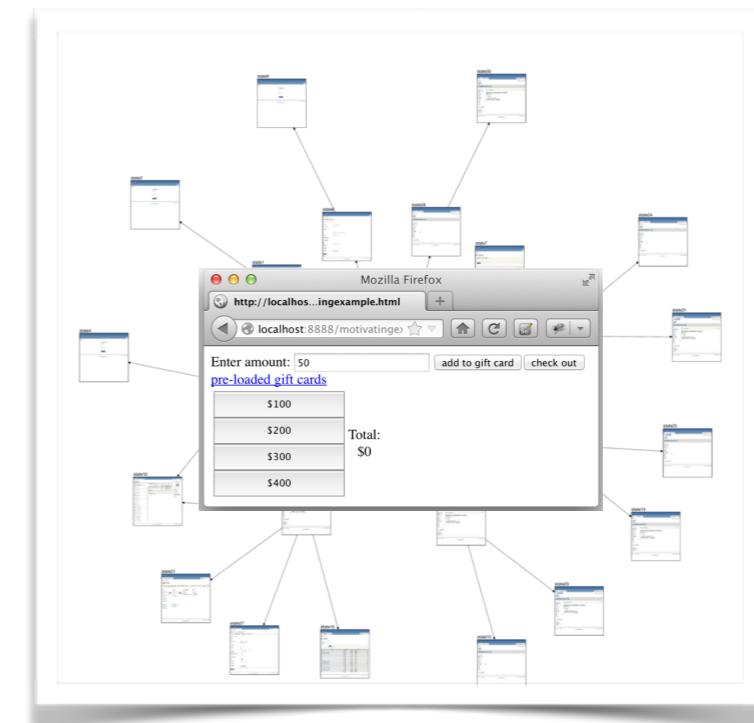


Domcovery

Summary



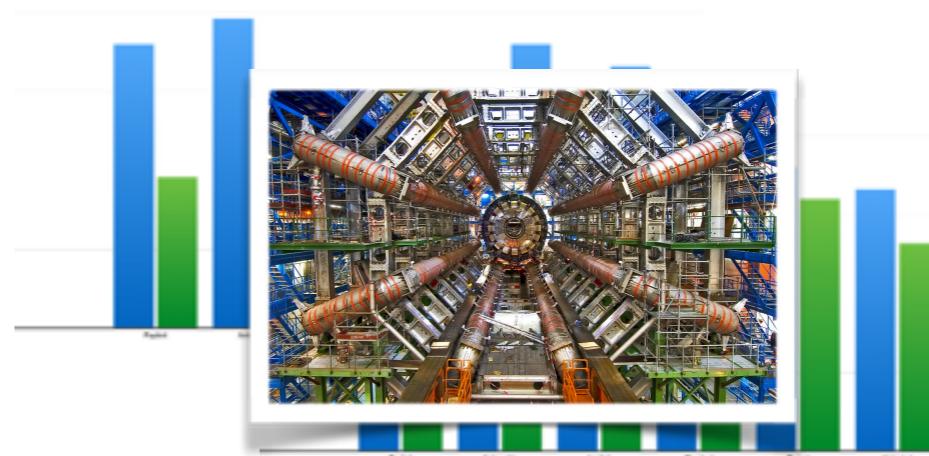
DOM-based coverage criteria



**2 inter-state and 4 intra-state
adequacy criteria**



Domcovery

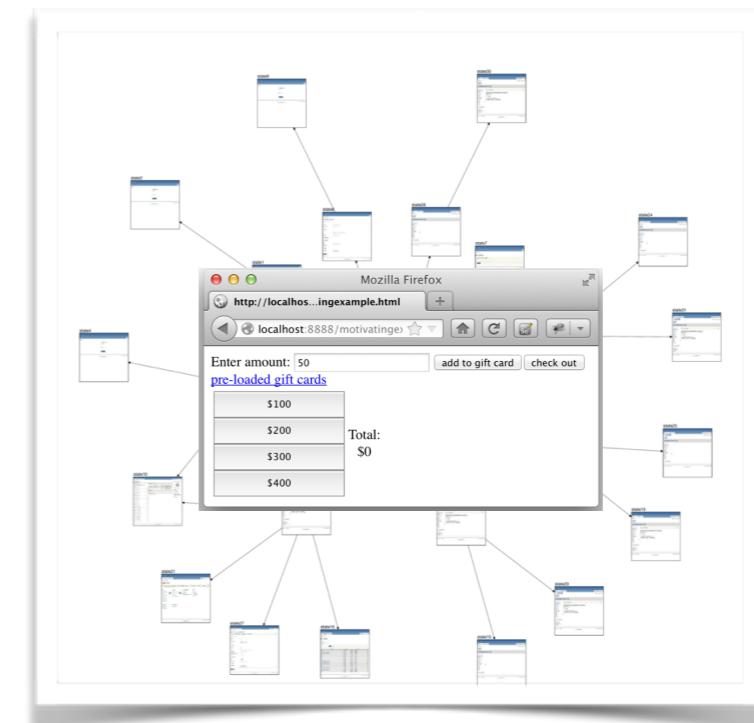


**Correlation/
Controlled experiment**

Summary



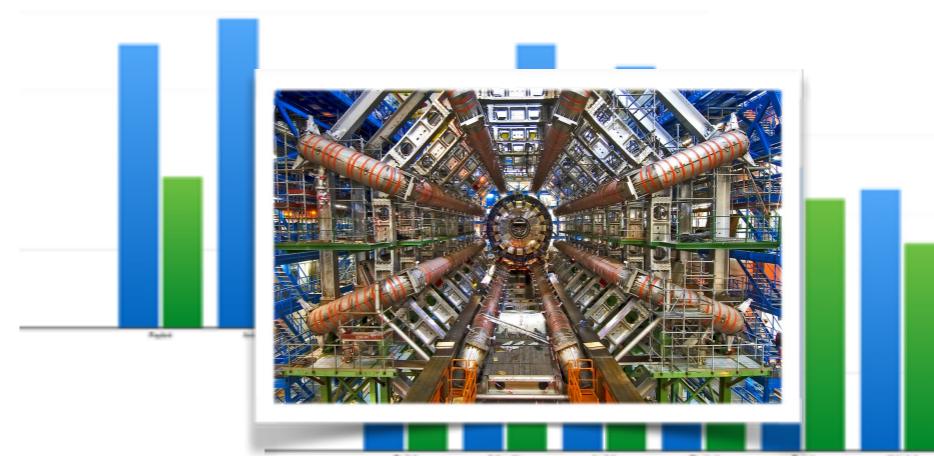
DOM-based coverage criteria



2 inter-state and 4 intra-state adequacy criteria



Domcovery



**Correlation/
Controlled experiment**