DOMPLETION

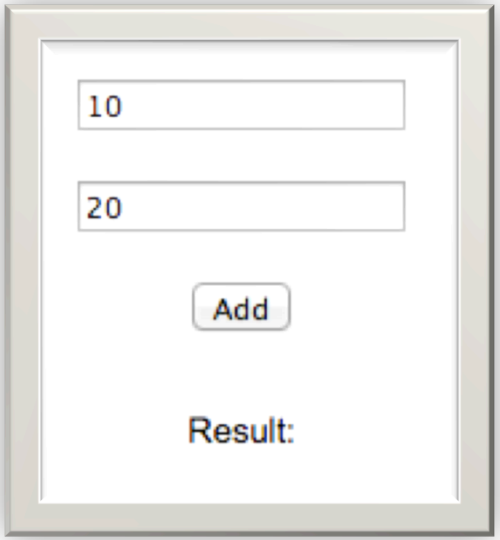
DOM-Aware JavaScript Code Completion

An approach to assist the Web Developers in writing DOM manipulating JavaScript code

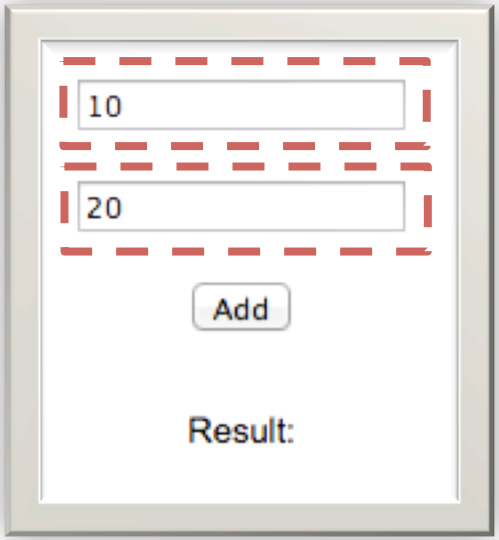
Kartik Bajaj, Karthik Pattabiraman, Ali Mesbah
University of British Columbia
{kbajaj, karthikp, amesbah}@ece.ubc.ca

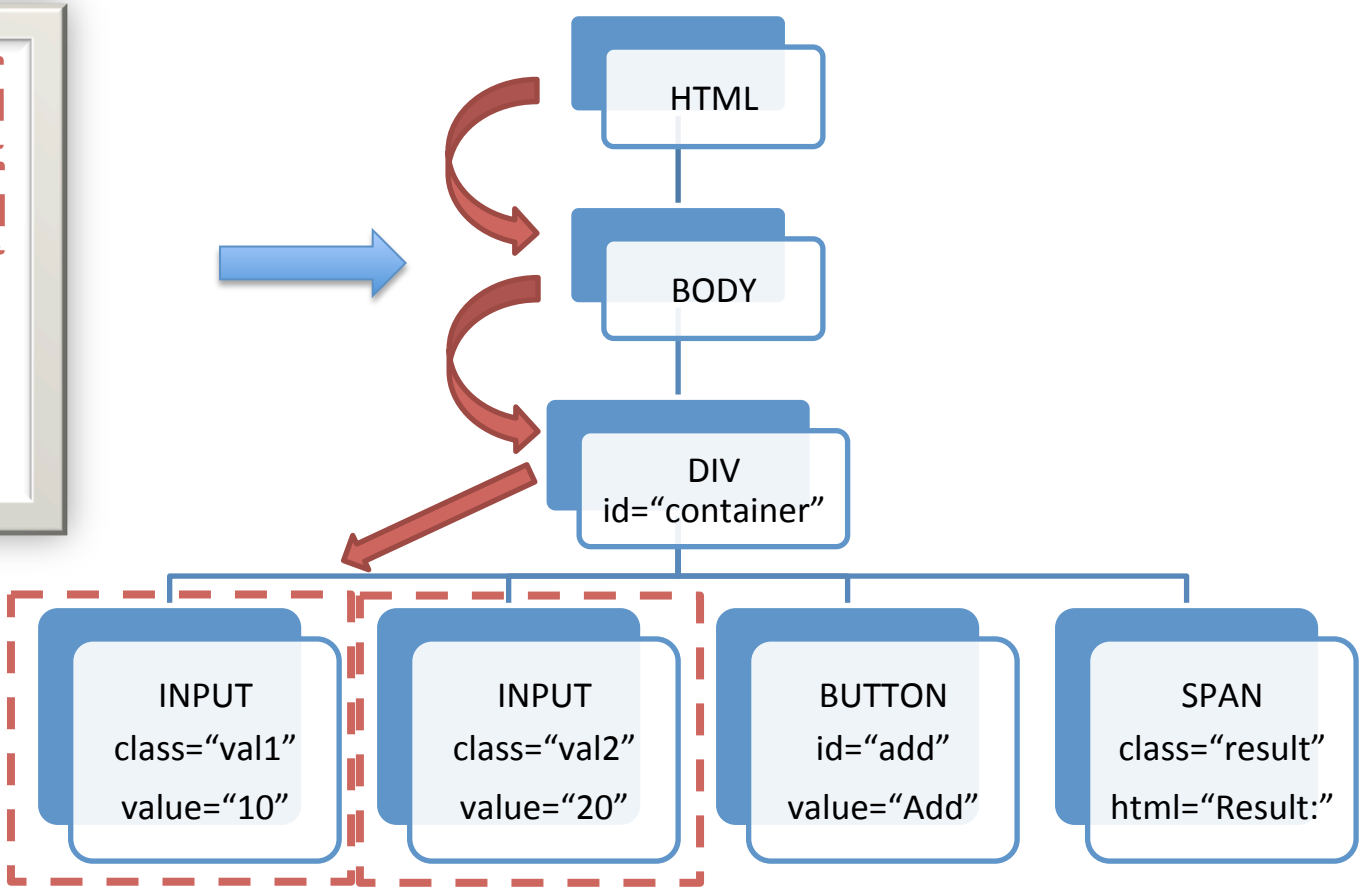
Running Example (JavaScript)

```
1.  function add(a,b) {
2.      return a + b;
3.  }
4.
5.  var input1 = 10;
6.  var input2 = 20;
7.  if(input1 != 0) {
8.      var sum = add(input1,input2);
9.      alert(sum);
10. } else {
11.     var sum = input2;
12.     alert(sum);
13. }
```



Document Object Model (DOM)

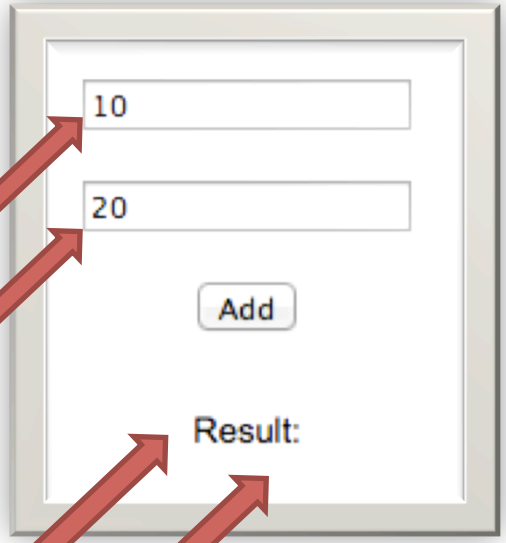





```
document.getElementsByClassName("val1");
document.getElementsByClassName("val2");
document.getElementsBy
document.getElementsBy
```

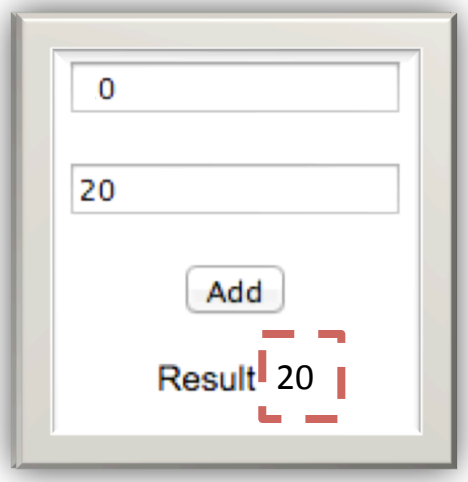
DOM JavaScript Interaction

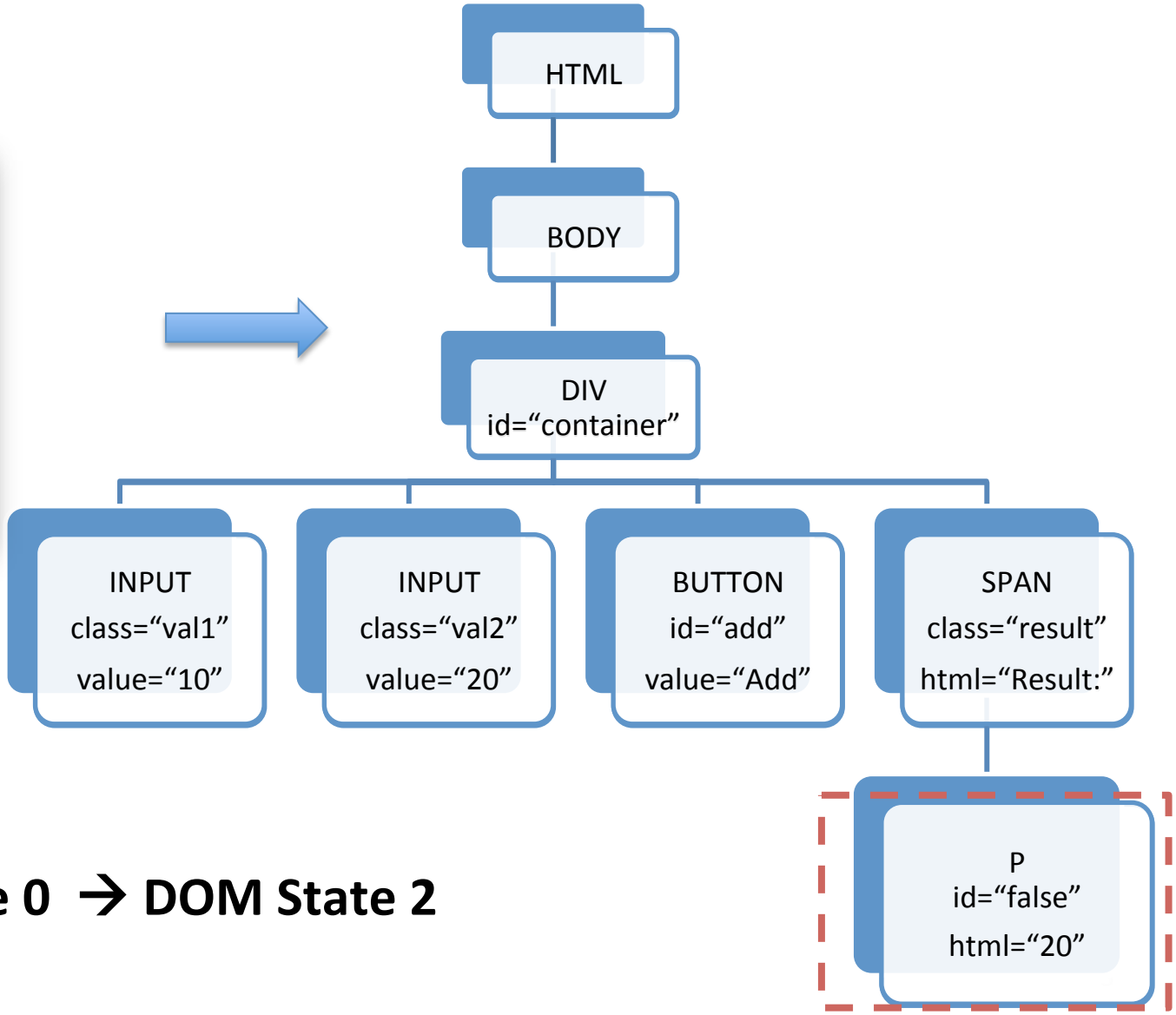
```
1.   function add(a,b) {
2.     return a + b;
3.   }
4.
5.   var input1 = 10;
5'.  var input1 = document.getElementsByClassName("value")[0].value;
6.   var input2 = 20;
6'.  var input2 = document.getElementsByClassName("value")[0].value;
7.   if(input1 != 0) {
8.     var sum= add(input1,input2);
9.     alert(sum);
9'.    var html = "<p id='true'> + add(input1,input2) + "</p>";
9''.   document.getElementById("result").innerHTML += html;
10.  } else {
11.    var sum = input2;
12.    alert(input2);
12'.   var html += "<p id='false'>" + sum+ "</p>";
12''.  document.getElementById("result").innerHTML += html;
13.  }
```



Updated DOM State(s)

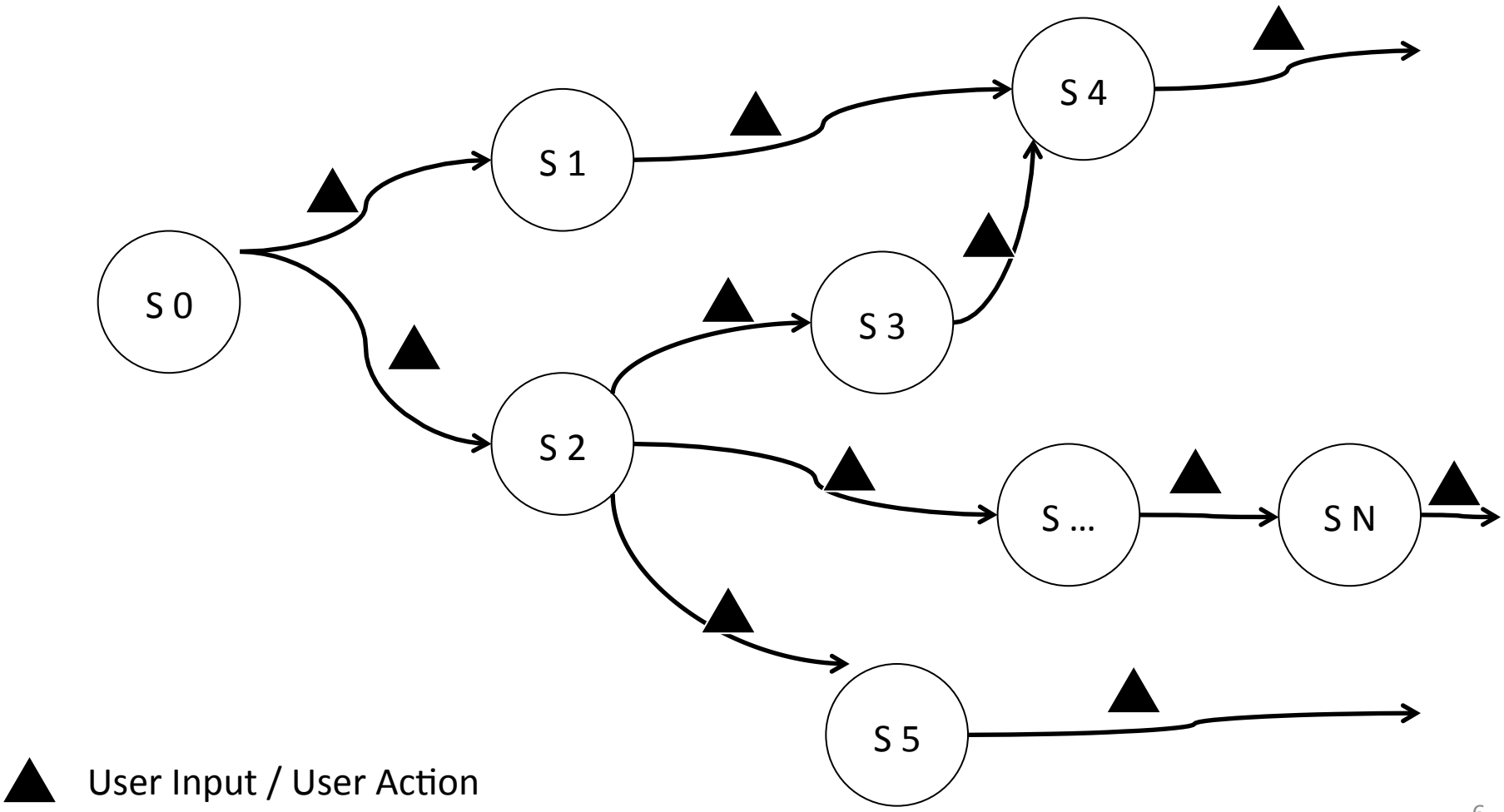
Input 2





DOM State 0 → DOM State 2

DOM State Transition



Challenges

Is this class name correct?
Does the element exist in DOM?

Does it have the property “value”?

```
3. }
4.
5. var input1 = document.getElementsByClassName(“val1”)[0].value;
6. var input2 = document.getElementsByClassName(“val2”)[0].value;
7. if(input1 != 0) {
8.   var sum= add(input1,input2);
9.   var html = “<p id=‘true’> + add(input1,input2) + “</p>”;
10.   document.getElementById(“result”).innerHTML += html;
11. } else {
12.   var sum = input2;
13.   var html += “<p id=‘false’>” + s  </p>”;
14.   document.getElementById(“re  innerHTML += html;
15. }
```

What is the updated DOM structure?

Straw man Approach

Manually inspect the DOM

Develop, Execute, Repeat

Tedious and time consuming

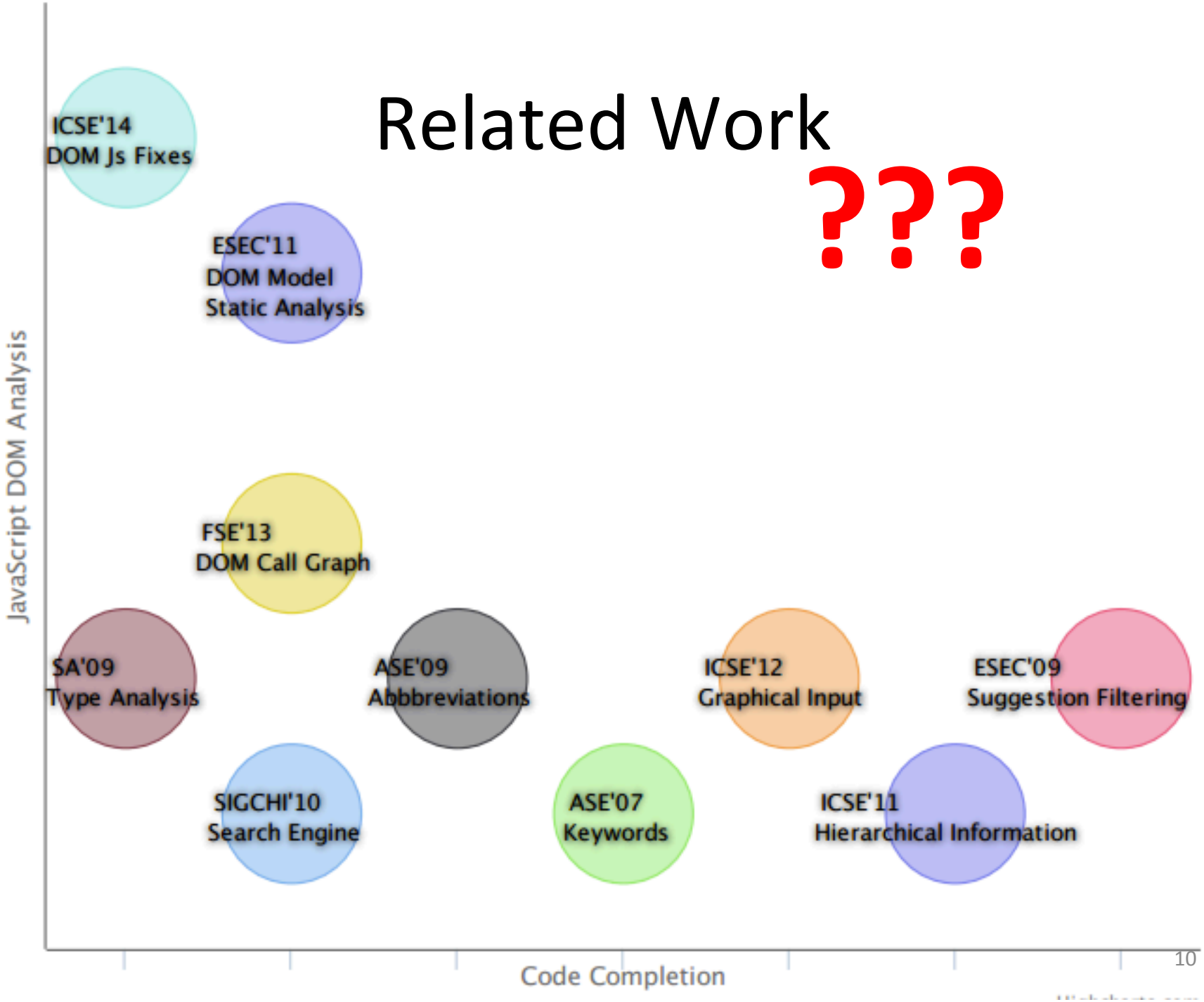
Problem Statement

- JavaScript code is challenging to develop and analyze
  - Handling interactions between JS and DOM [MSR'14][ESEM'13]

- Lack of tool support [ESEM'13]
  - Instant feedback required

Related Work

???



Proposed Solution

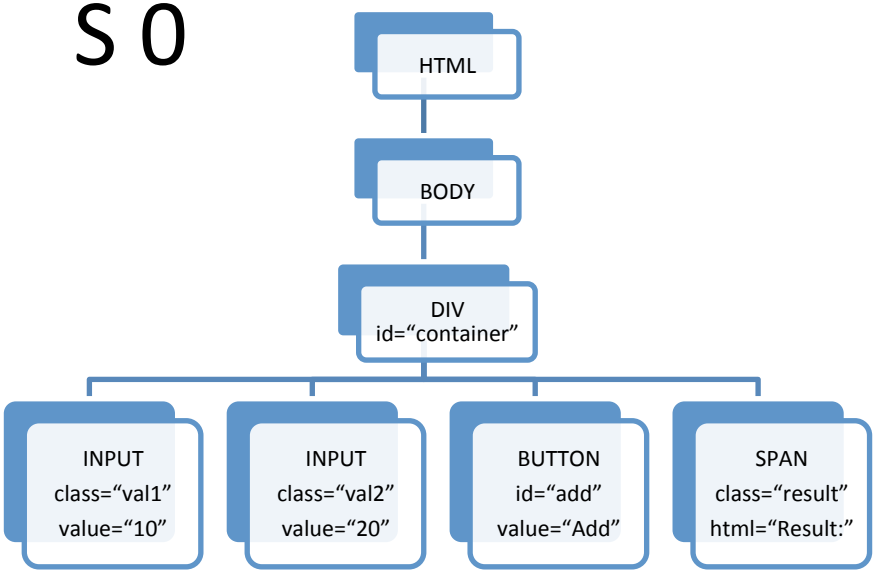
Analyze each DOM state and assist the developer while writing JavaScript Code

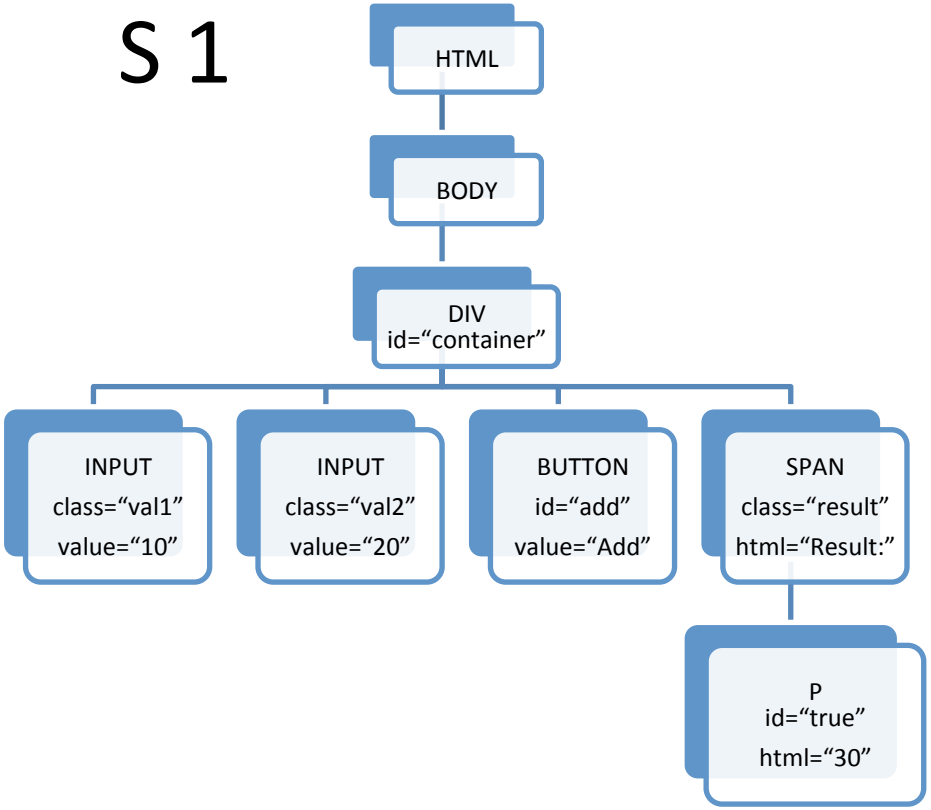
BUT

Number of DOM states can be infinite!!!

Intuition

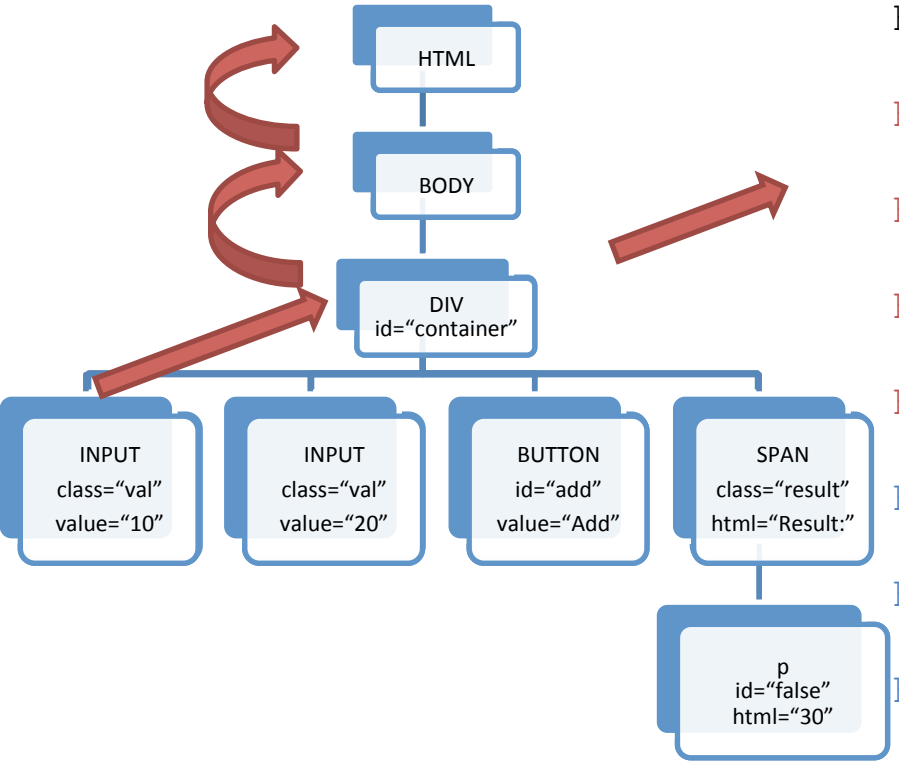
DOM states exhibit patterns





DOM Element Locators

S 2




```
html body div#container input.val1
html body div#container input.val2
html body div#container button#add
html body div#container span.result
html body div#container input.val1
html body div#container input.val2
html body div#container button#add
html body div#container span.result p#true
html body div#container input.val1
html body div#container input.val2
html body div#container button#add
html body div#container span.result p#false
```

Compression Techniques

```
html body div#container input.val1
html body div#container input.val1.val2
html body div#container input.val2
html body div#container input.val{\d}
html body div#container button#add

html body div#container span.result

html body div#container input.val1

html body div#container input.val2

html body div#container button #add

html body div#container span.result p#true
html body div#container span.result p#true#flase
html body div#container input.val1

html body div#container input.val2

html body div#container button #add

html body div#container span.result p#false
```

Duplicates Removed

Similar IDs combined

Similar classes combined

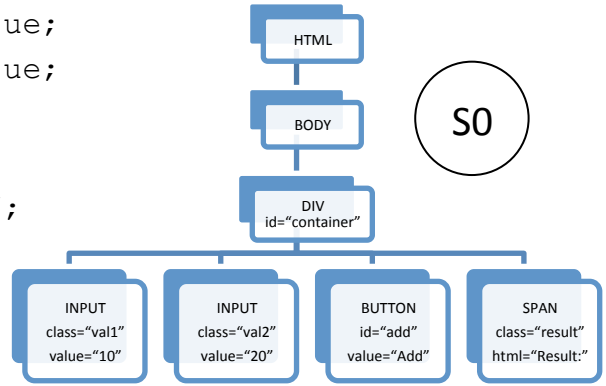
DOM Analysis

- Manual
- Automatic

- Crawl available DOM states.
- Convert each DOM state to a list of DOM Element Locators.
- Detect patterns in DOM Element Locators.

JavaScript Code Analysis

```
function add(a,b) {
    return a + b;
}

var input1 = document.getElementsByClassName("val1")[0].value;
var input2 = document.getElementsByClassName("val2")[0].value;
if(input1 != 0) {
    var sum= add(input1,input2);
    var html = "<p id='true'> + add(input1,input2) + "</p>";
    document.getElementById("result").innerHTML += html;
} else {
    var sum = input2;
    var html += "<p id='false'>" + sum+ "</p>";
    document.getElementById("result").innerHTML += html;
}
```



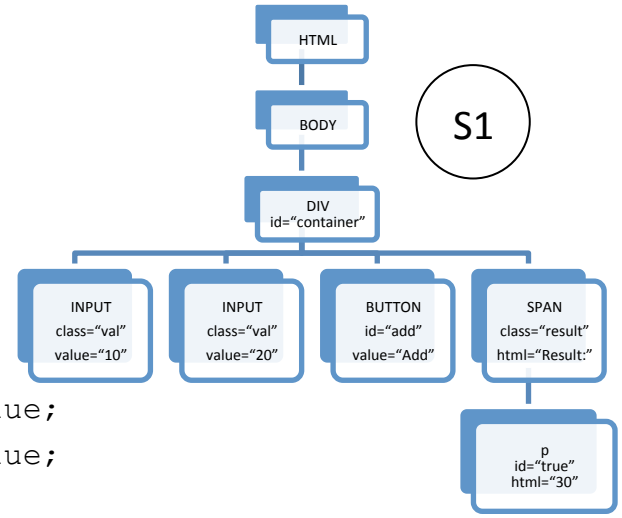

```
.....
if(condition) {
    then-statements;
} else {
    else-statements;
.....
```

```
.....
condition;
log true;
then-statements;
.....
```

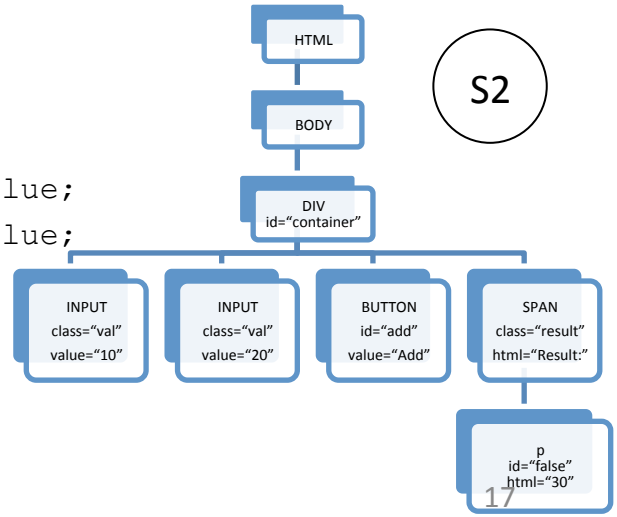
```
.....
condition;
log false
else-statements;
.....
```

Example

```
function add(a,b) {
      return a + b;
}

var input1 = document.getElementsByClassName("val1")[0].value;
var input2 = document.getElementsByClassName("val2")[0].value;
input1 != 0;
dompleteLog("main",true);
var sum= add(input1,input2);
var html = "<p id='true'> + add(input1,input2) + "</p>";
document.getElementById("result").innerHTML += html;
```



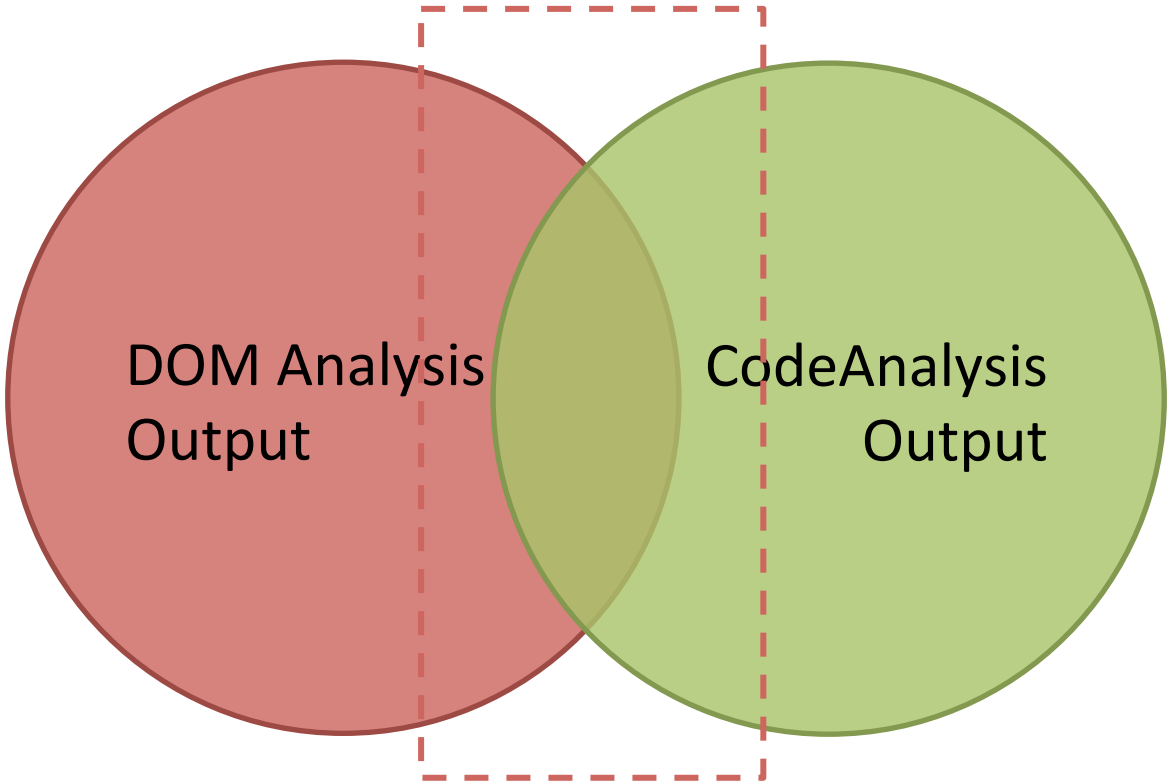
```
function add(a,b) {
      return a + b;
}

var input1 = document.getElementsByClassName("val1")[0].value;
var input2 = document.getElementsByClassName("val2")[0].value;
input1 != 0;
dompleteLog("main",false);
var sum = input2;
var html += "<p id='false'>" + sum+ "</p>";
document.getElementById("result").innerHTML += html;
```



Code Analysis

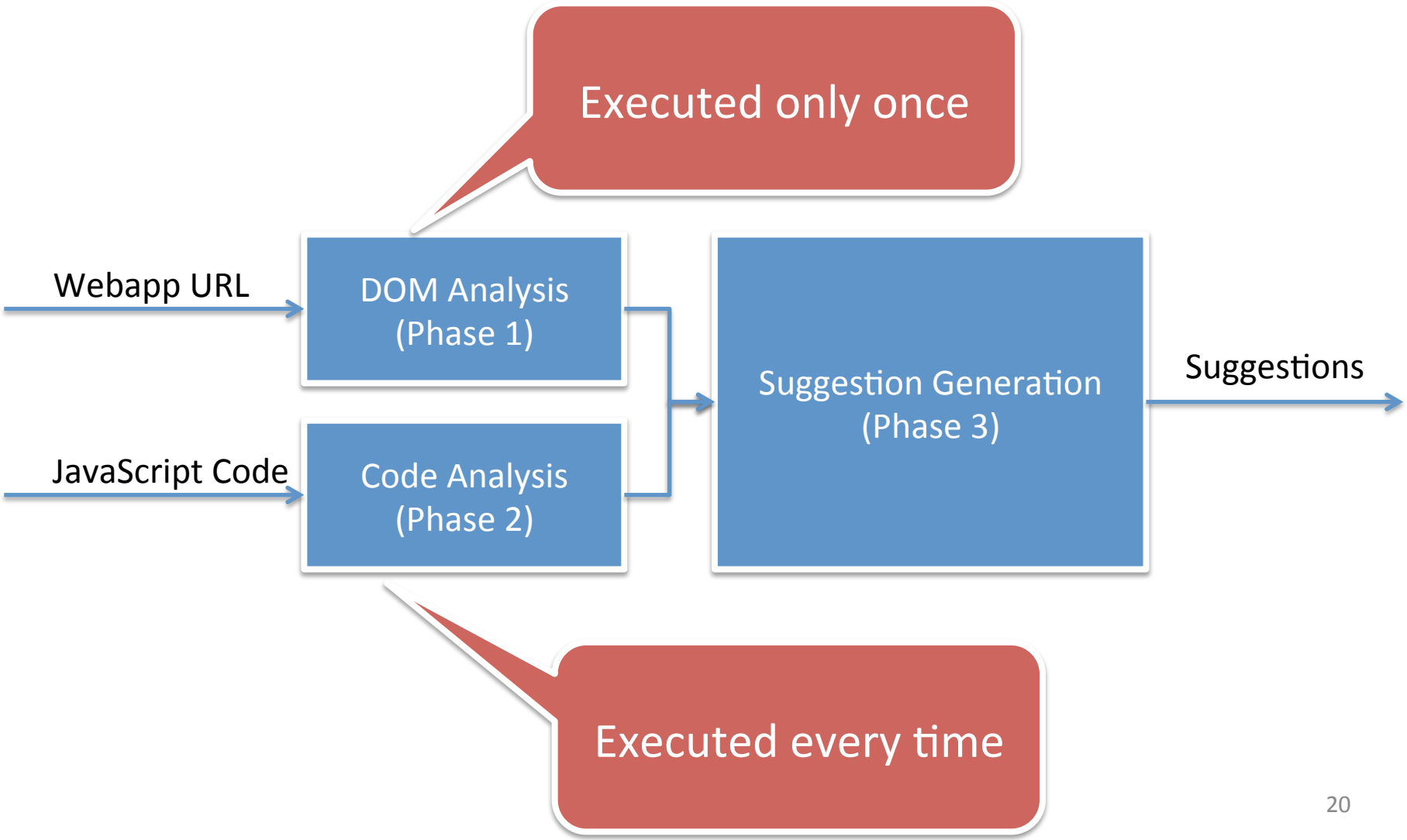
- Generate possible code paths
- Execute JavaScript code
- Intercept calls to DOM API
- Analyze Logs

Suggestion Generation



Suggestions

Approach Summary



DOMpletion
(Brackets IDE Plugin)

https://github.com/saltlab/dompletion

Brackets

Live Development

Esprima

Screenshot

```
1  a = document.getElementById('maincol').innerHTML;
2
3  if(a == "header") {
4      elem = document.getElementById('headerBar');
5  } else {
6      elem = document.getElementById('photoBoxes');
7  }
8  elem.getElementsByClassName('
```

```
Path: 0 VeryTitle          (span) DOM Level: 1
Path: 1 photoBox            (div) DOM Level: 1
Path: 0 topHeadAround         (a) DOM Level: 2
Path: 1 titlePhotoBox      (span) DOM Level: 2
Path: 1 darkdot            (span) DOM Level: 2
Path: 1 spc                (span) DOM Level: 2
Path: 1 rate             (select) DOM Level: 2
Path: 1 dot                (span) DOM Level: 3
```

Evaluation

RQ1: Do DOM element locators converge?

RQ2: How accurate are the code completion suggestions?

- Precision
- Recall

RQ3: What is the performance overhead incurred?

Experimental Objects

RQ1: Convergence

Crawled each application randomly, until the number DOM element locators tend to stabilize.

facebook

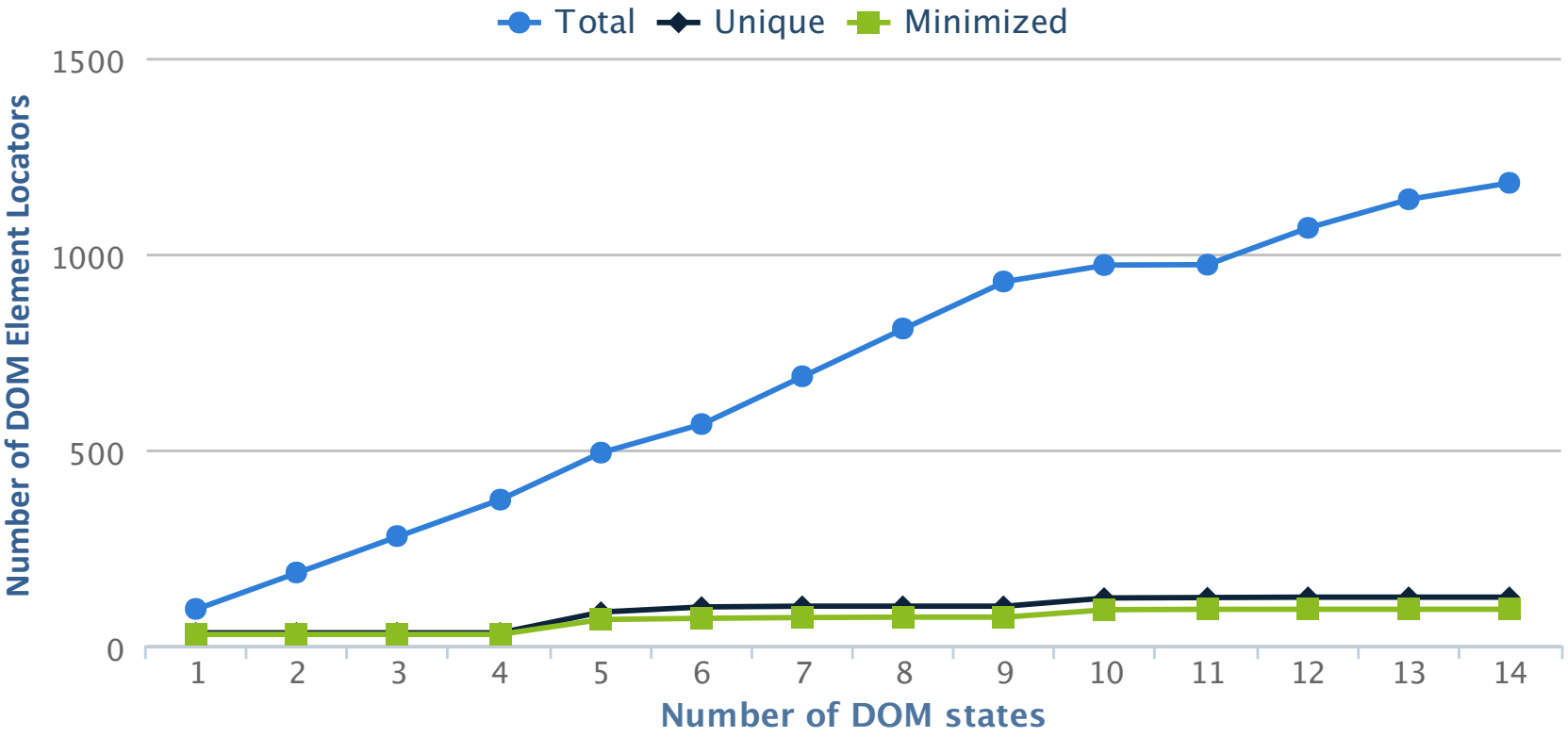
bing

WIKIPEDIA
The Free Encyclopedia

BLOG + WORDPRESS

BLOG + AJAX
Asynchronous Javascript And XML

RQ1: Results



Phormer

RQ2: Performance

Performed code-completion in the existing JavaScript Code.

Compared results with the existing values used in the code.

RQ2: Execution

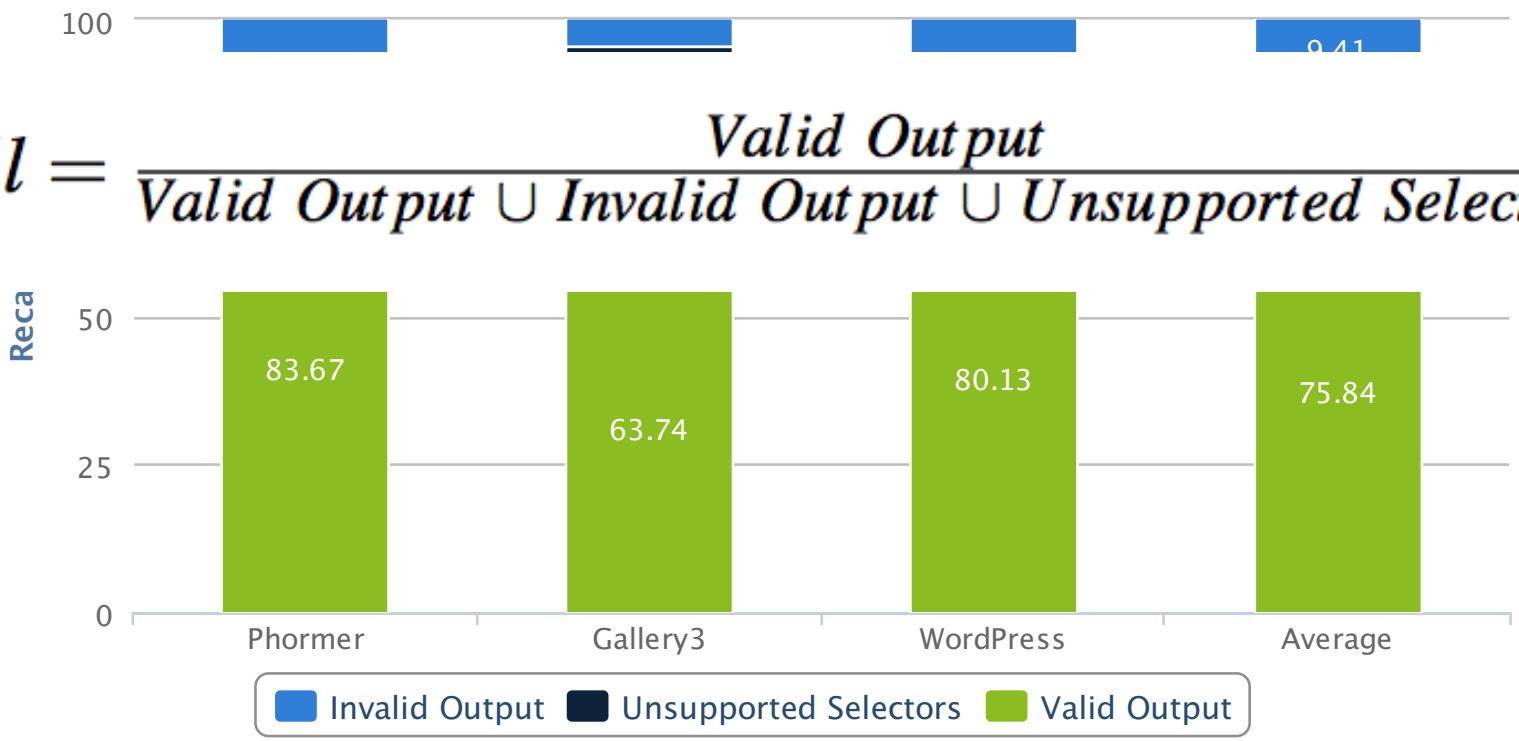
Actual Suggestion

“val2”

```
1.  function add(a,b) {
2.    return a + b;
3.  }
4.  var input1 = document.getElementsByClassName(“val1”)[0].value;
5.  var input2 = document.getElementsByClassName(“val2”)[0].value;
6.  var input2 = document.getElementByClassName(“
7.  if(input1 != 0) {
8.    var sum= add(input1,input2);
9.    var html = “<p id=‘true’> + add(input1,input2) + “</p>”;
10.   document.getElementById(“result”).innerHTML += html;
11. } else {
12.   var sum = input2;
13.   var html += “<p id=‘false’>” + sum+ “</p>”;
14.   document.getElementById(“result”).innerHTML += html;
15. }
```

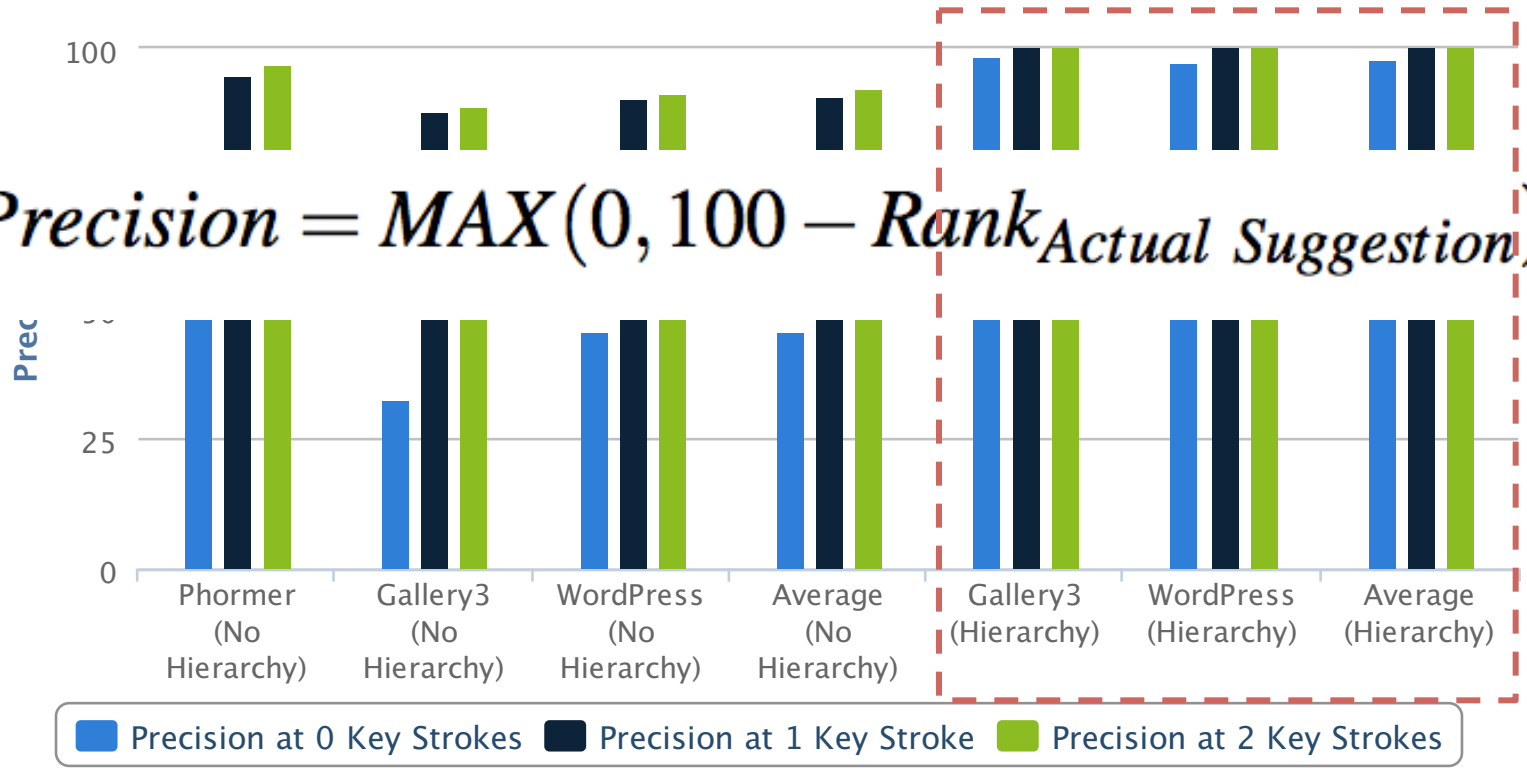
RQ2: Results (Recall)

$$Recall = \frac{Valid\ Output}{Valid\ Output \cup Invalid\ Output \cup Unsupported\ Selectors}$$



RQ2: Results (Precision)

$$Precision = MAX(0, 100 - Rank_{Actual\ Suggestion})$$



RQ3: Performance

DOM Analysis Phase

- Crawled each web application until DOM element locators merge.
- Recorded time elapsed by the end of each state

Code Analysis Phase

- Recorded time taken to list the suggestions

RQ3: Results

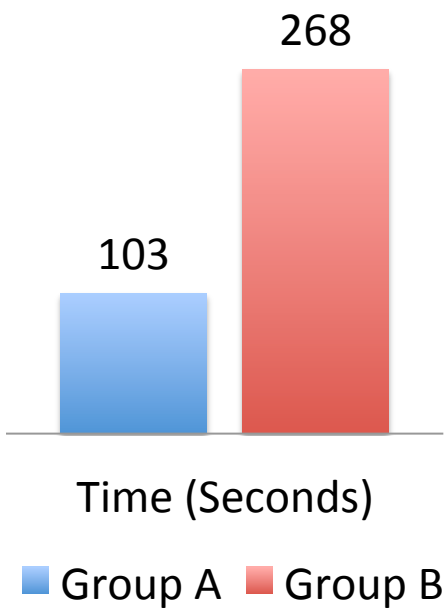
- DOM Analysis
  - 173 seconds (3 minutes approx.)

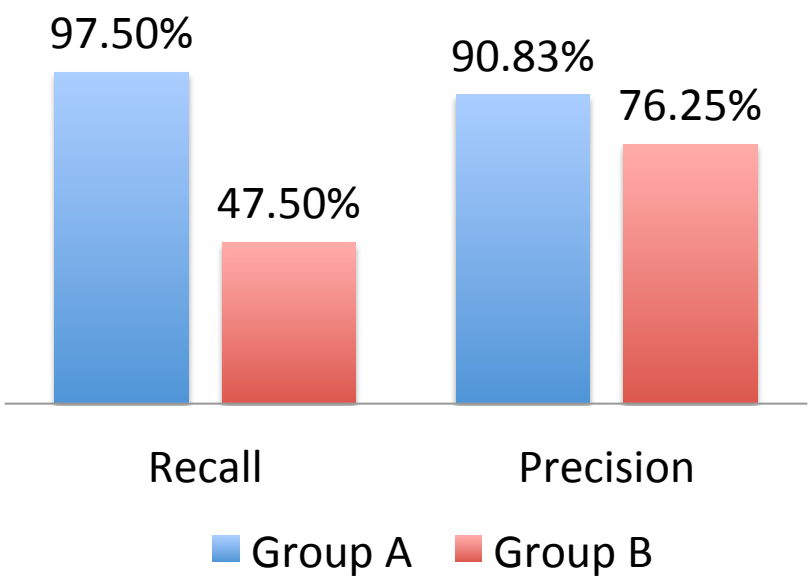
Incurred only once

- Code Analysis
  - Min time: 1 second
  - Max time: 6 seconds
  - Avg. time: 2.8 seconds

User Study

- 9 Participants
  - 5 → Group A : Using DOMpletion
  - 4 → Group B : Without DOMpletion
- 4 Tasks to analyze the DOM JavaScript interactions





Contributions

1. Discussed challenges behind DOM based code completion.
2. Fully automated code completion technique using static and dynamic analysis of JavaScript code and DOM.
3. Implementation in an open source tool called DOMpletion.
4. Empirical evaluation to assess DOMpletion.

https://github.com/saltlab/dompletion

Up to 83 % Recall and 90% Precision

2.8 seconds average time

Precision

$$precision = \left(\frac{totalSuggestions - actualSuggestion}{totalSuggestions} \right) * 100$$

$$precision = \left(\frac{1000 - 300}{1000} \right) * 100 = 70\%$$

$$precision = \left(\frac{max(0, 100 - actualSuggestion)}{100} \right) * 100$$

$$precision = max(0, 100 - actualSuggestion)$$