Experiments with JavaScript Clone Detection

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Introduction of Code Clones

Code Cloning

- Copying code fragments and reusing them with or without modification
- 7% to 23% of the code in a typical software system has been cloned. (Baker, WCRE 1995; Roy, WCRE 2008)

Previous Works

- Empirical Study of Code Clones
  - Cai, FASE 2011; Roy, WCRE 2008, Kim, FSE 2005
- Survey of Clone Detection Research
  - Pate, JSEP 2011; Roy, Technical Report 2007
- Evaluation of Clone Detection Tools
  - Roy, SCP 2009; Bellon, TSE 2007
- Study of Clones in Script Languages / Web Applications
  - Roy, IWSC 2010; Basit, ICWE 2005; Calefato, JWE 2004

Use of JavaScript

- 98 out of 100 most popular websites use JavaScript (Guarnieri, ISSTA11)
- Use of dynamic features is evident in websites (Richards, ECOOP11, PLDI10; Zorn, WebApps10)

Experiment Overview

Research Questions

- What are the main differences in code clone properties in Javascript web, Javascript standalone, and Java projects?
- How many consistent and inconsistent code clones are in Javascript web, Javascript standalone, and Java projects?

Experiment Subjects

- 18 subjects in total, 6 each in
  - JavaScript in web pages
  - JavaScript standalones
  - Java projects
- web development framework, GUI framework, build tool, etc.

Tools for Clone Detection

- Tree-based clone detection
  - SAFE (for JavaScript)
    - Formal Specification and Implementation of a Scalable Analysis Framework for ECMAScript, FOOL 2012
  - Deckard (for Java)
    - Scalable and Accurate Tree-based Detection of Code Clones, ICSE 2007

Metrics

- Clone localization
- Size of cloned code
- Clone coverage
- Files associated with clones
- Consistent / inconsistent function clones / cloned fragments

Clone Localization

- Same file and same directory
- Same directory but different files
- Different directories
- The location of a clone pair is a factor in software maintenance (Kapser, ELISA 2003)

Size of Cloned Code

- Average lines of cloned code
- Maximum lines of cloned code
- Give information about the scale of the cloned code in a system

Clone Coverage

- The ratio of cloned code to the total lines of code
- An increase in the number of clones over time can indicate a decline in the structure and maintainability of a software system (Barbour et al, 2012)

Files Associated with Clones

- A file is associated with clones if it has at least one method that forms a clone pair with another method in the same file or a different file
- It tells us that whether the clones are from some specific files, or scattered among many files all over the system
- From a maintenance point of view, a lower value is better, since clones localized to certain specific files may be easier to maintain (Roy, IWSC 2010)

Inconsistent Clones

- A substring s of the code is called an inconsistent clone, if there is another substring t of the code such that their edit distance is below a given threshold and that t has no significant overlap with s (Juergens, ICSE 2009)
- Half of the changes to code clone groups are inconsistent changes (Krinke et al, 2007)
- Inconsistent changes to clone groups are directly related to the maintenance problems (e.g. bug-fixing or update) (Roy et al, 2007)

Inconsistent Clones

```
gestureTouchesDragged: function(evt, touches) {
  var gestures = this.get("gestures"), idx, len
= gestures.length, g;
  for (idx = 0; idx < len; idx++) {
    g = gestures[idx];
    g.unassignedTouchesDidChange(evt, touches);
  }
},
```

```
gestureTouchEnd: function(touch) {
  var gestures = this.get("gestures"), idx, len
= gestures.length, g;
  for (idx = 0; idx < len; idx++) {
    g = gestures[idx];
    g.unassignedTouchDidEnd(touch);
  }
}
```

Function Clones

- Entire functions are copied rather than fragments
- A high number of function clones in a software system could increase significantly the cost of maintenance (Lague et al, 1997)
- Finding function clones in scripted web pages for the purpose of eliminating duplicated code can be seen as a first step to introduce refactoring (Calefato et al, 2004)

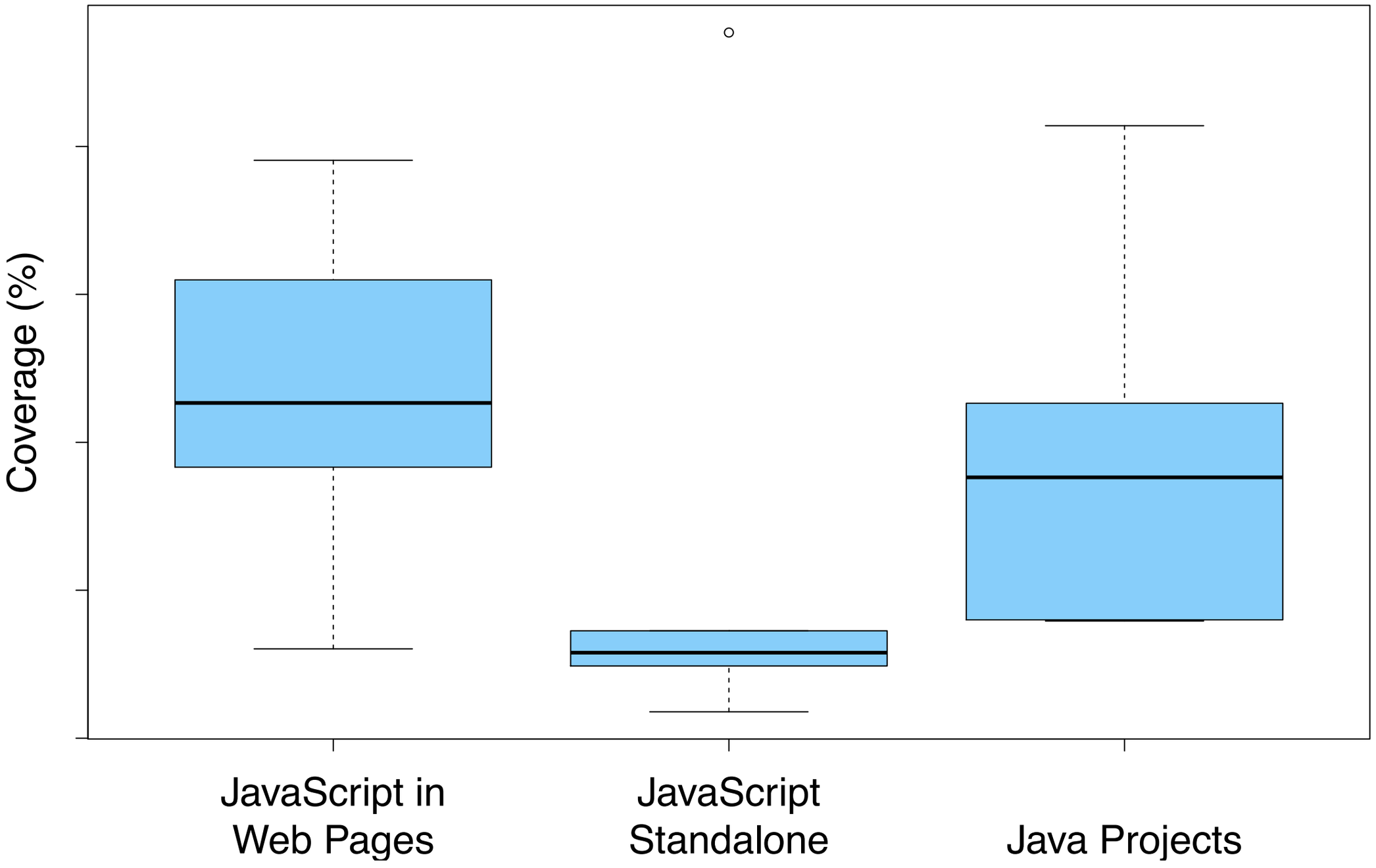
Results

Clone Localization

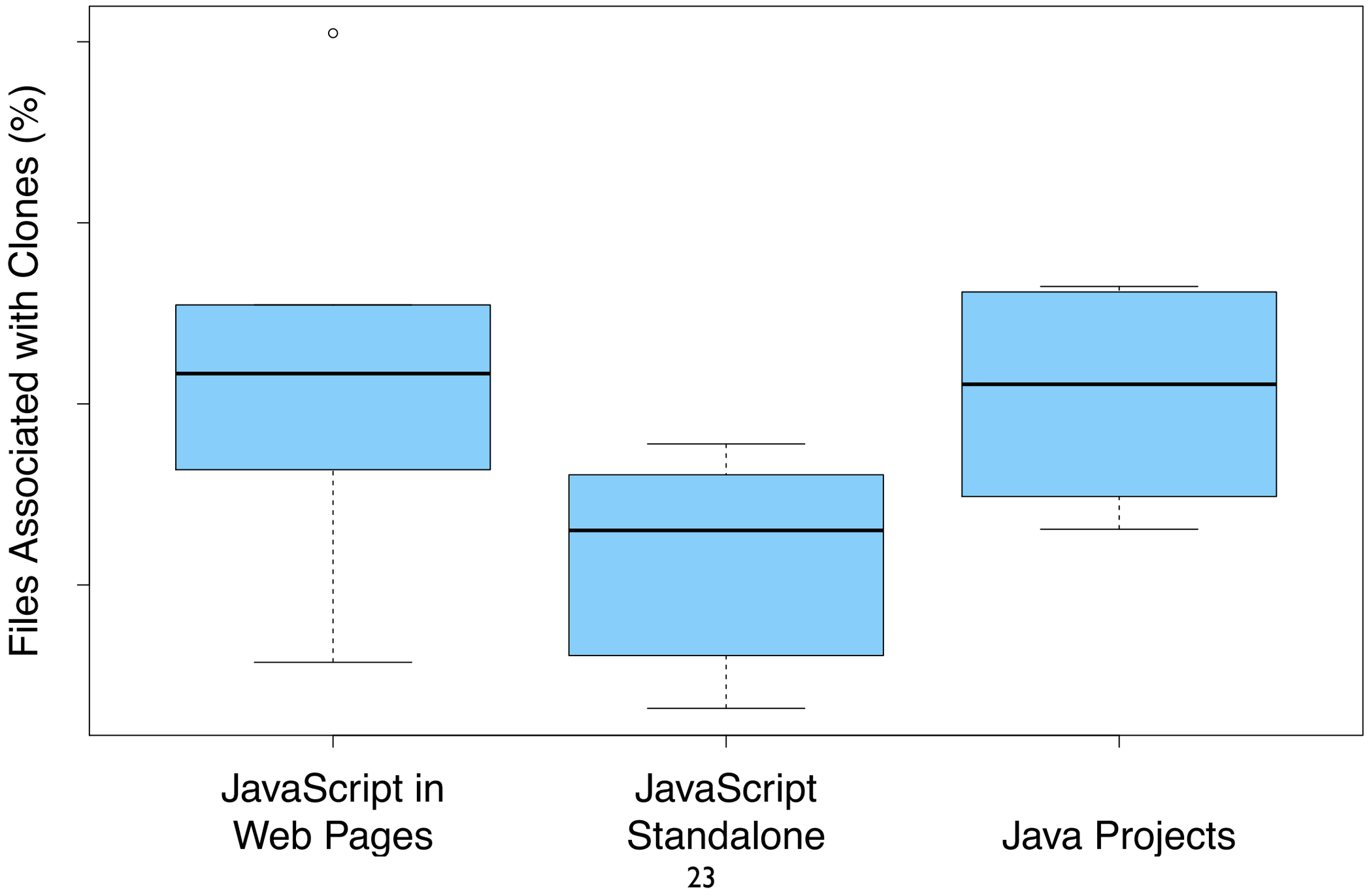
Size of Cloned Code

	Average Lines of Cloned Code	Standard Deviation	Maximum Lines of Cloned Code
JavaScript in Web Pages	10.50	2.95	262
JavaScript Projects	15.33	11.00	550
Java Projects	12.33	4.46	299

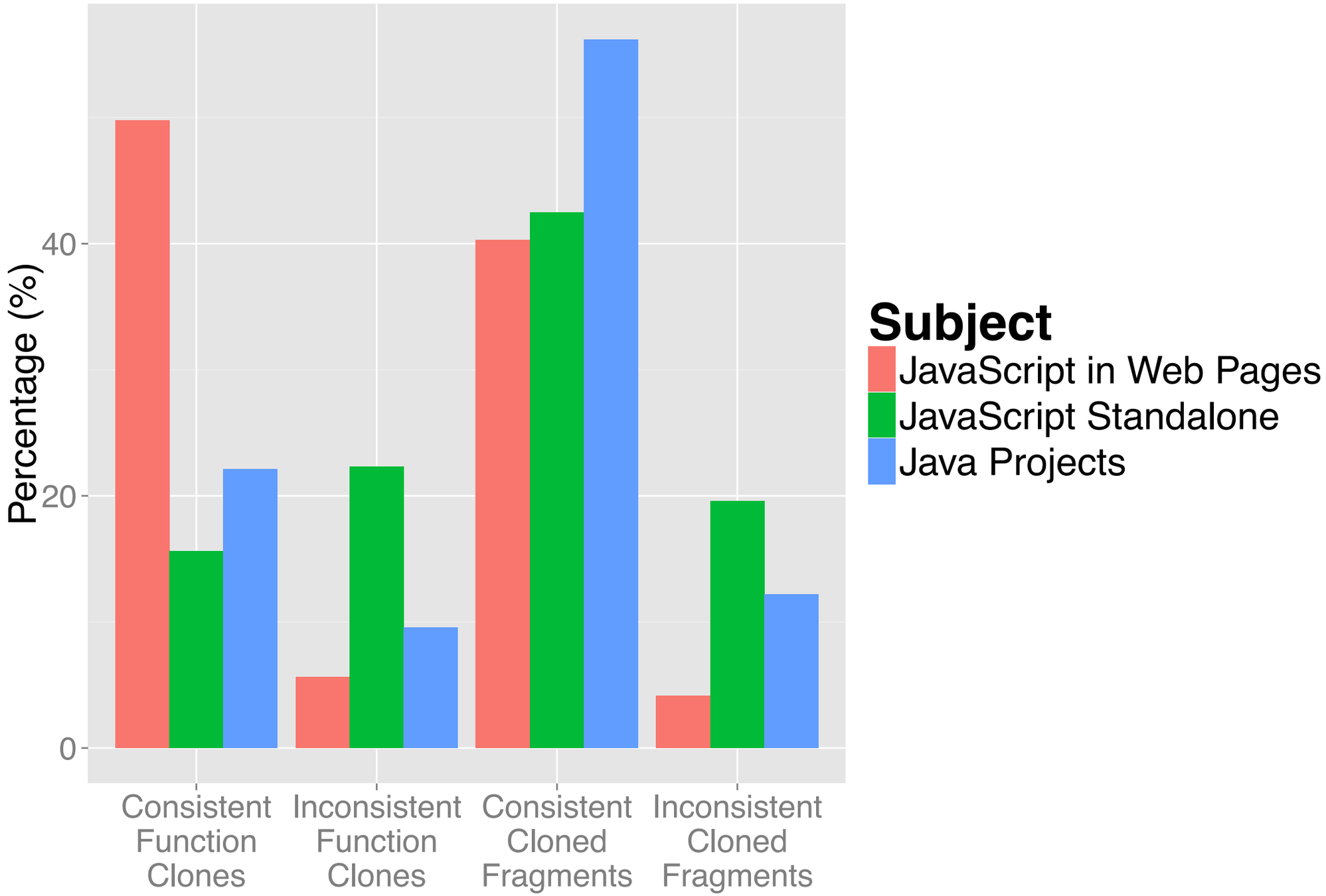
Clone Coverage



Files Associated with Clones



Consistent / Inconsistent Function Clones / Cloned Fragments



Threats to Validity

- Representativeness of open source projects and websites
- Only a single configuration is used
- Only two languages are used

Summary

- Most of the clones of JavaScript in web pages are from different directories
- JavaScript standalone has the lowest coverage and files associated with clones
- JavaScript in web pages contains the largest amount of consistent clones

Conclusion

- We have conducted clone detection experiments on properties of different projects and found that they are indeed different
- The differences are clues to which systems require more efforts in software maintenance
- Future work: Automatic refactoring

Thank You