Performance Issues and Optimizations in JavaScript: An Empirical Study

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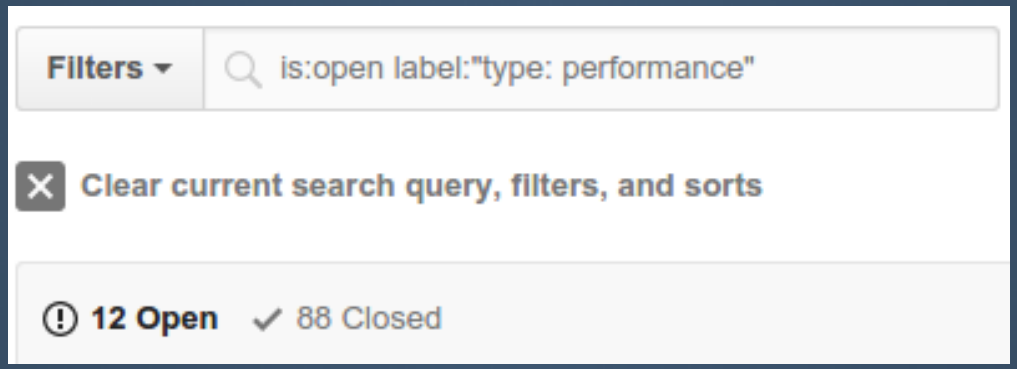
JavaScript
is slow!

JavaScript is ~~slow~~ fast!

Why Do Developers Optimize JavaScript?

- Still possible to write slow code



- Compiler optimizations are limited
- Deopts and bailouts

This Talk: Empirical study of performance issues and optimizations in JavaScript

Contributions

Better understanding of
performance issues in JavaScript

Set of reproducible
performance problems [1]

[1] https://github.com/marijaselakovic/JavaScriptIssuesStudy

Who Benefits From This Study?

Application developers

Developers of program analyses

Developers of JS engines

Motivating Example

Iterates over all properties of *arg*

```
for (var prop in arg) {
    if (arg.hasOwnProperty(prop)) {
        .....
    }
}
```

Provides enumerable properties of *arg*

```
var updates = Object.keys(arg);
for (var i=0, l=updates.length; i<l; i++) {
    var prop = updates[i];
    ......
}
```

Ember.js pull request 11338

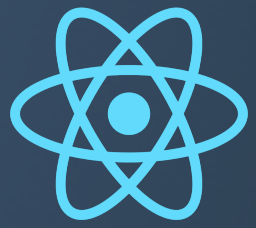
Methodology

Subject programs

- 16 popular JavaScript projects
- High number of pull requests

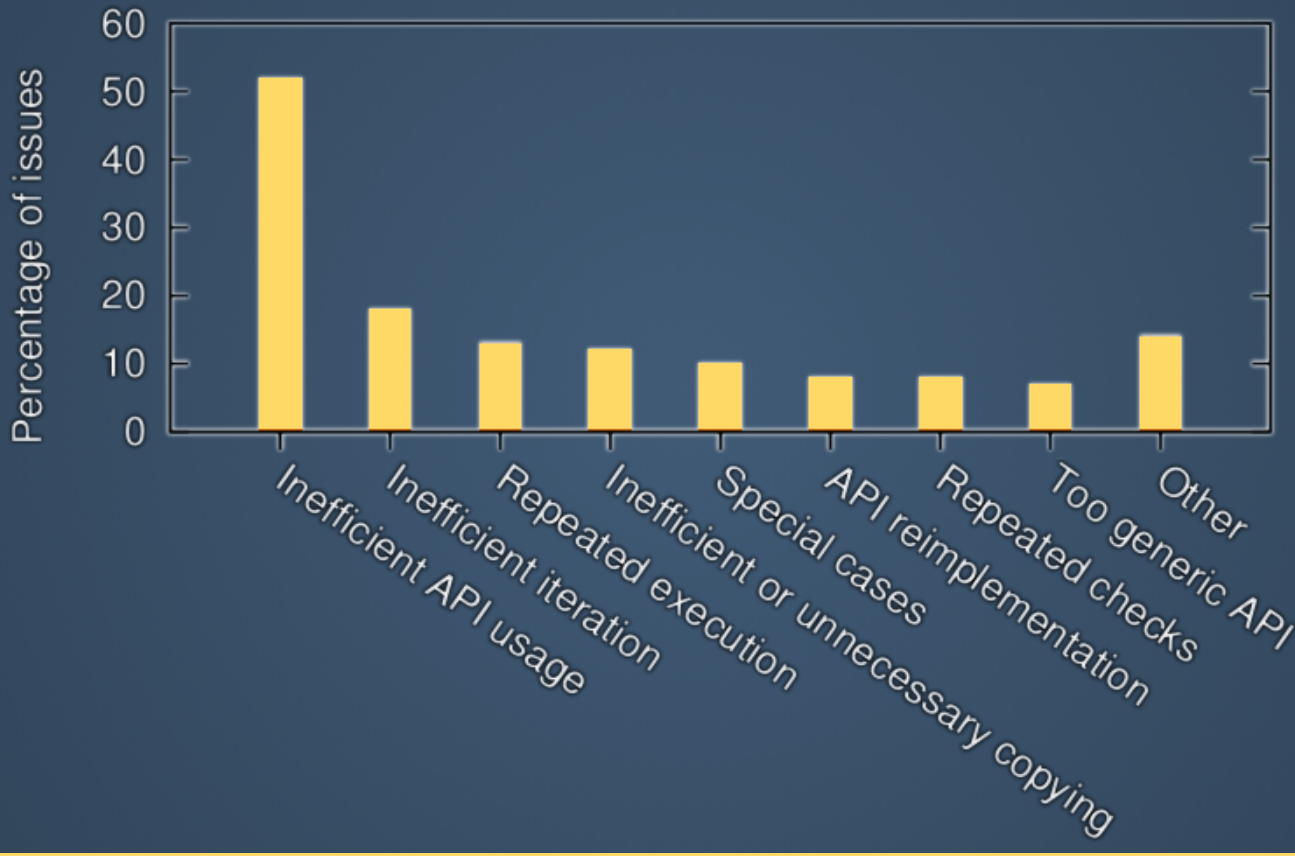
Selection of performance issues

- ~100 performance issues
- Reproducible
- Confirmed and accepted optimizations



What are the main root causes of performance issues in JavaScript?

Most Prevalent Root Causes



52% of all issues are caused by ***inefficient API usage***

Inefficient API Usage

Multiple functionally equivalent ways to do the same

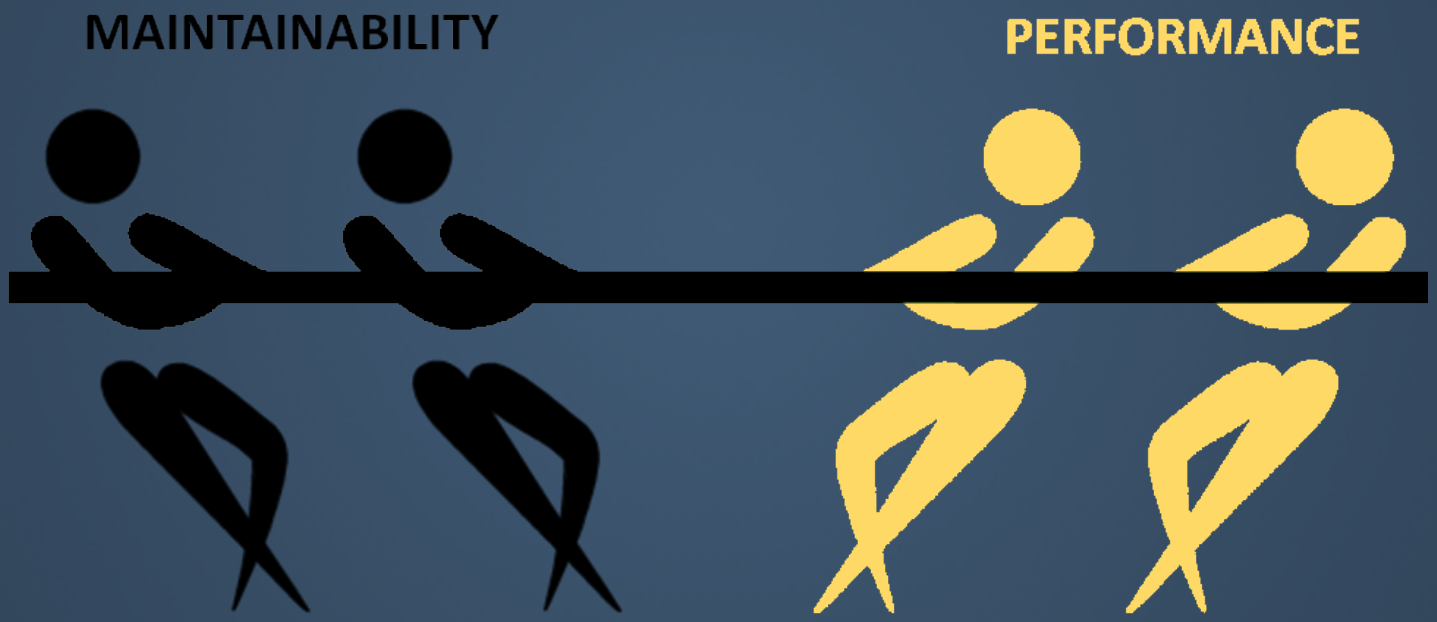
```
str.split("'").join("\\'")
```

```
str.replace(/'/g, "\\'")
```

Relatively small number of root causes

How complex the optimizations are?

Performance vs. Maintainability



Complexity of Optimizations

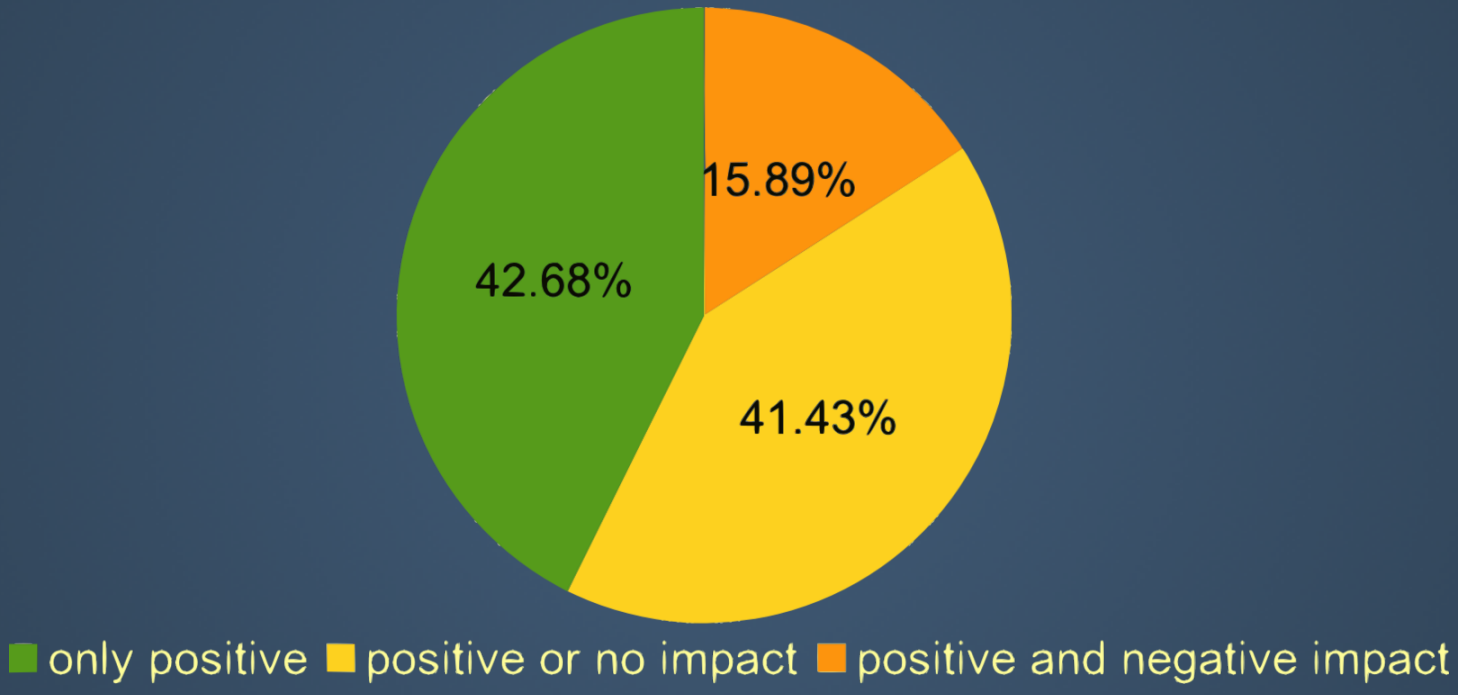
Slow code ⟶ Fast code

- Median: 10 lines
- 37.5% do not modify **number of statements**
- 47.2% do not modify **cyclomatic complexity**
- 14.43% decrease **cyclomatic complexity**

Relatively simple changes can speedup JavaScript code

What is the performance impact of optimizations?

Performance Impact



Developers apply optimizations that degrade performance

Are there recurring optimization patterns?

Recurring Optimizations

- 29 studied instances are recurring
- AST-based static analysis
- 139 new instances
- Reported 10 optimizations, 5 accepted

Many optimizations are instances of recurring patterns

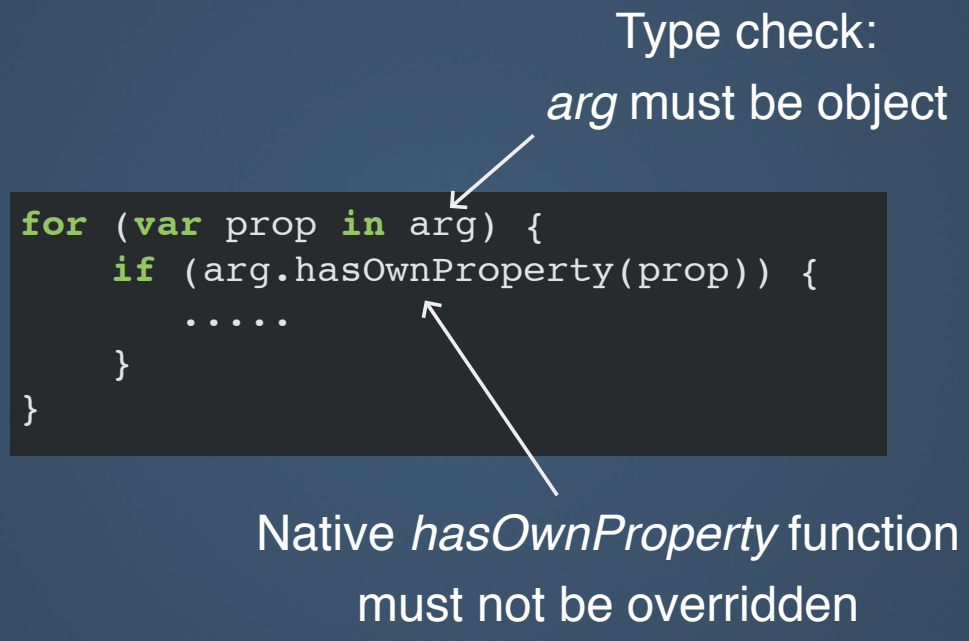
For the full list of reported optimizations, see
https://github.com/marijaselakovic/JavaScriptIssuesStudy

Can recurring optimizations be applied automatically?

Automatically Applying Recurring Patterns

"Apparently, V8's JIT engineers require that we, as JavaScript developers perform this very simple transformation, since they do not seem capable of performing it themselves"
(Developer of Ember.js)

Preconditions for Automatic Transformations



Challenging to statically analyze these preconditions in JavaScript

Conclusions

Systematic study of JavaScript performance issues

- **Small number** of root causes
- **Inefficient API usage**
- Relatively **simple** changes
- Many instances of **recurring** patterns

Thank you! Questions?

Instances of Recurring Patterns

- Use JQuery *empty* function instead of *html(' ')*

```
body.html('')
```

```
body.empty()
```

- Instead of checking object type with *toString* use *instanceof* operator

```
Object.prototype.toString.
 call(err) === '[object Error]'
```

```
err instanceof Error
```

- Prefer for loop over functional processing of array

```
styles.reduce(
  function (str, name) {
    return ...;
  }, str);
```

```
for (var i=0; i< styles.length; i++) {
     var name=styles[i];
      str = ...;
    }
return str;
```