

Synode: Understanding and Automatically Preventing Injection Attacks on Node.js

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February 20, 2018

This Talk



**Node.JS and
Injections**



**Empirical
Study**



Synode



Evaluation

This Talk



**Node.JS and
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**Empirical
Study**

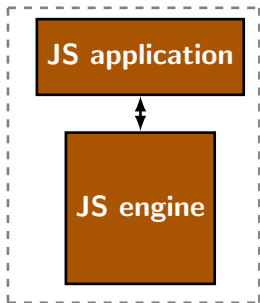


Synode

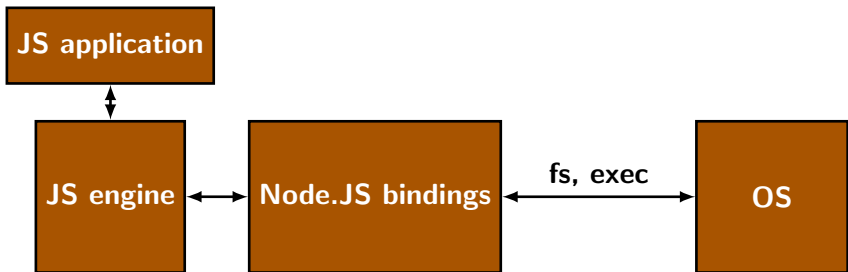


Evaluation

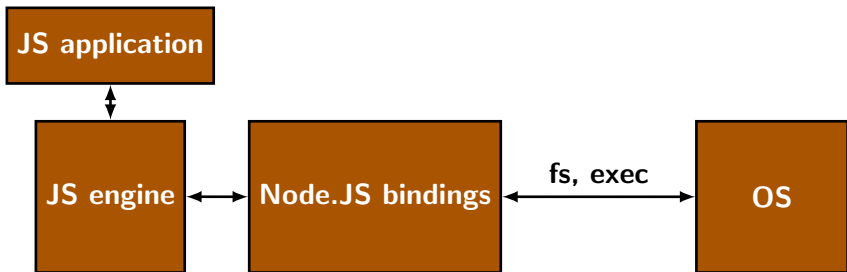
Node.js 101



Node.js 101

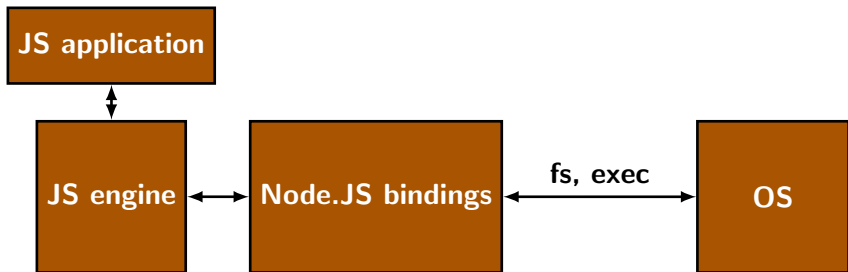


Node.js 101



Node Package Manager

Node.js 101

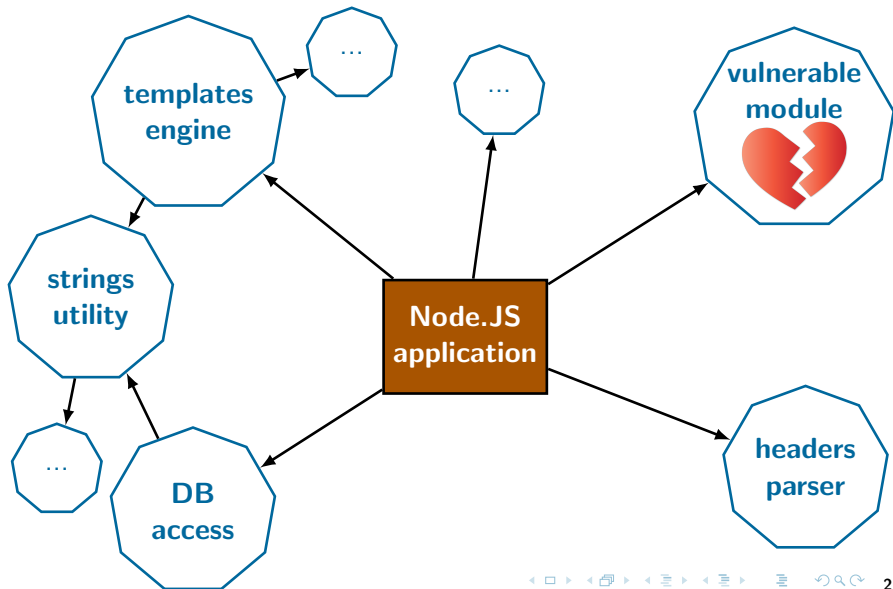


Node Package Manager



Node Security Project

Typical Node.JS Application



Running Example

```
function backupFile(name, ext) {  
  var cmd = [];  
  cmd.push("cp");  
  cmd.push(name + "." + ext);  
  cmd.push("~/localBackup/");  
  
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Malicious Payload

```
backupFile("-h && rm -rf * && echo ", "")
```

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Synode



Evaluation

236,337

packages

2.471

average number of
package dependences

816,840,082

lines of JavaScript code

>40,000

C files

7,685

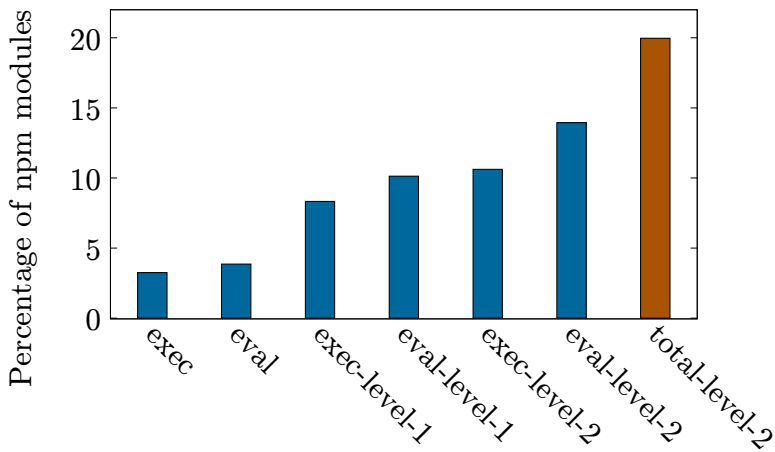
number of packages
containing exec

9,110

number of packages
containing eval

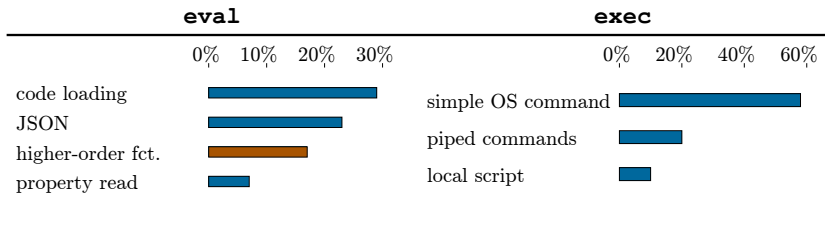
February
2016

Dependences on Injection APIs



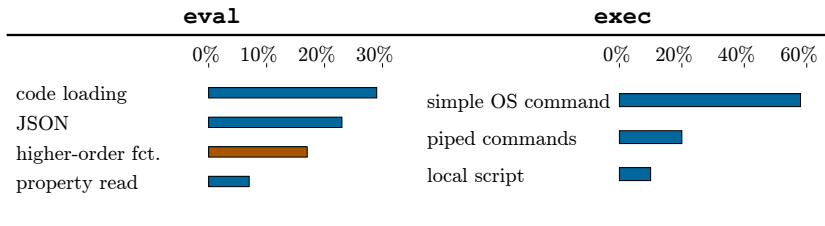
Data Passed to Injection APIs

Manual inspection of **150** call sites



Data Passed to Injection APIs

Manual inspection of **150** call sites



58% contain user-controlled data, out of which:

- **90%** perform no check on this data
- **9%** use regular expressions

Submitted Bug Reports

Affected module	Confirmed	Time until fixed
mixin-pro	yes	1 day
modulify	no	–
proto	yes	155 days*
mongoosify	yes	73 days
summit	yes	–
microservicebus.node	yes	–
mobile-icon-resizer	yes	2 days
m-log	–	–
mongo-edit	–	–
mongo-parse	yes	–
mock2easy	–	–
mongui	–	–
m2m-supervisor	–	–
nd-validator	–	–
nameless-cli	–	–
node-mypeople	–	–
mongoosemask	–	–
kmc	–	–
mod	–	–
growl	yes	–

**180 days
after
reporting**

– indicates a lack response and * an incomplete fix

multiple dependences

on average each module has 2.5 direct dependences

no sanitization

only 9% use sanitization, often broken

unresponsive developers

within six months only 25% of the issues were fixed

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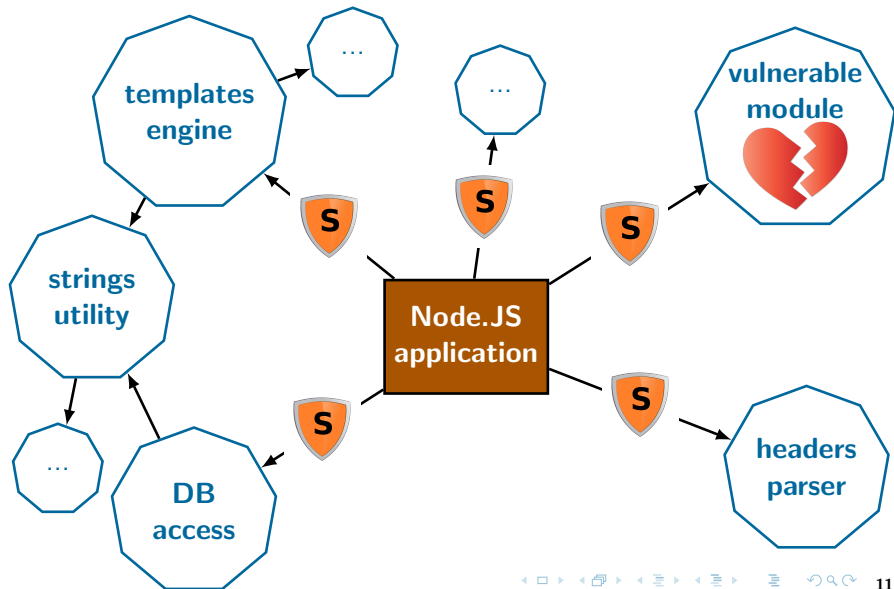


Synode



Evaluation

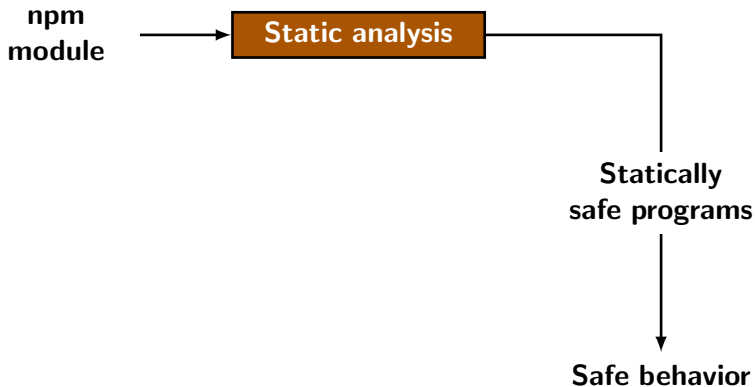
Safe Use of Modules with Synode



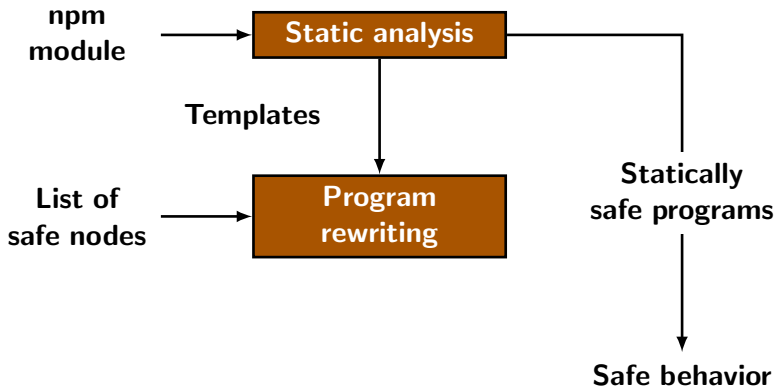
Overview of Synode



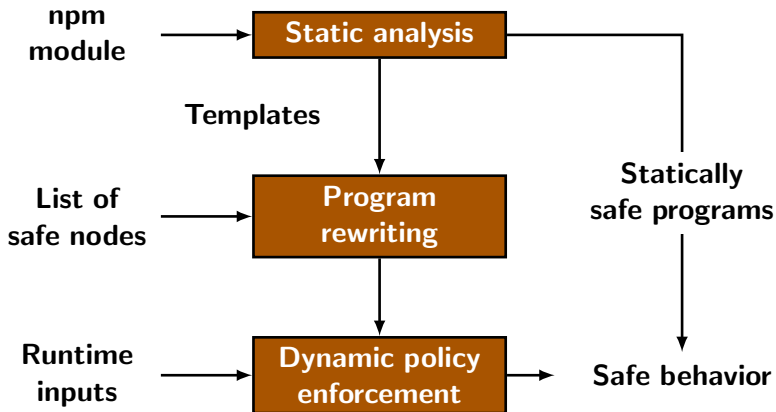
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Static Phase

1. Intra-procedural backward data flow analysis:
 - Over-approximates strings passed to injection APIs
 - Unknown parts to be filled at runtime

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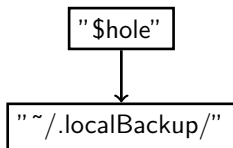
"\$hole"

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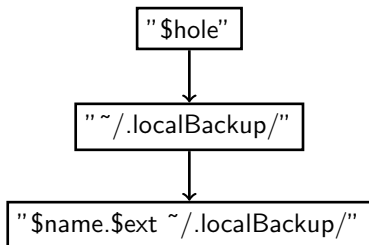


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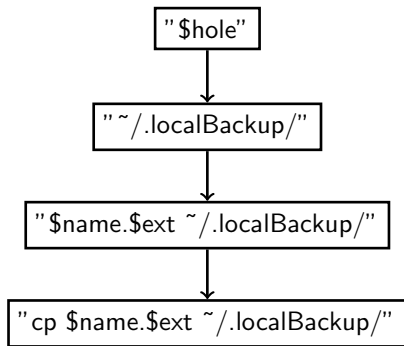


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Static Phase

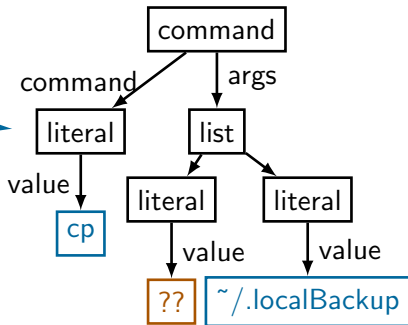
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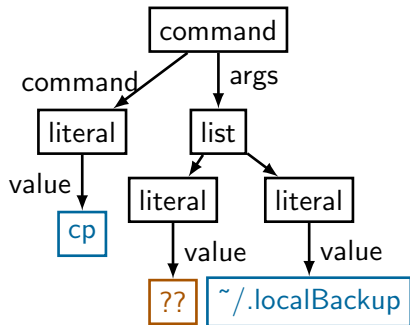
"cp \$name.\$ext ~/.localBackup"



Runtime Phase

Enforce policy on strings passed to injection APIs

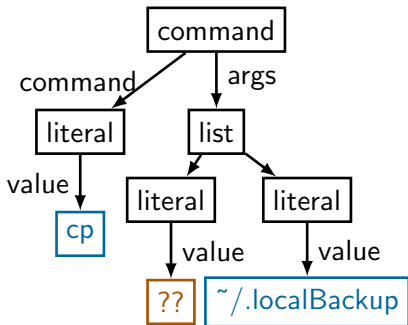
Policy:



Runtime Phase

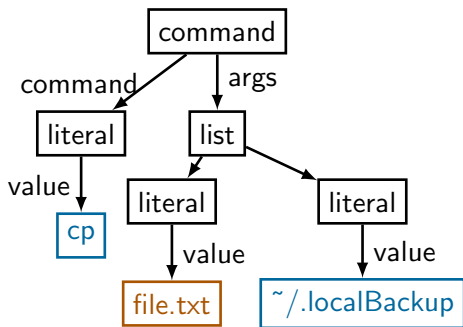
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Policy:



Runtime string:

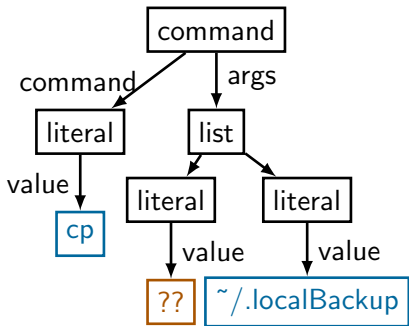
`"cp file.txt ~/localBackup"`



Runtime Phase

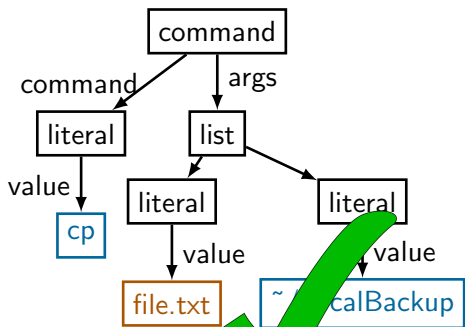
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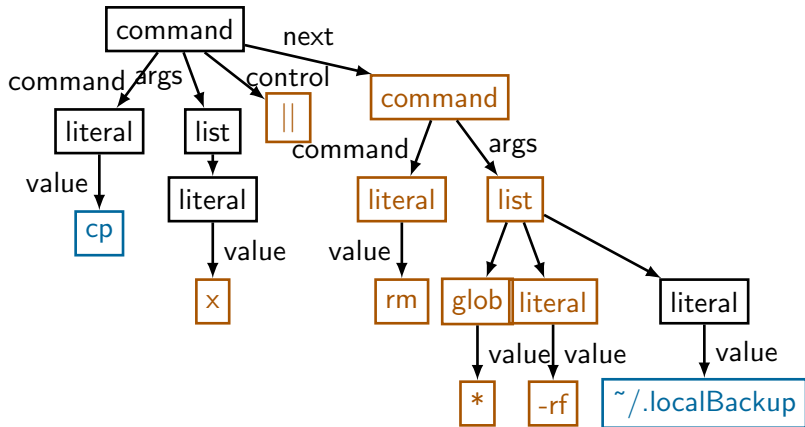
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Runtime Phase

Runtime string:

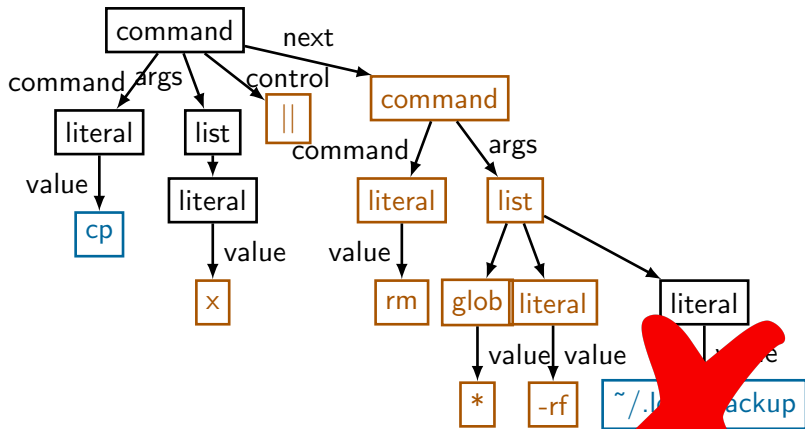
"cp x || rm * -rf ~/.localBackup"



Runtime Phase

Runtime string:

"cp x || rm * -rf ~/.localBackup"



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Evaluation

Evaluation: Static Phase

Setup

- 51K call sites of injection APIs

Precision

- **36.7%** of the call sites statically safe
- **63.3%** to be checked at runtime

Context

- most call sites have at least:
 - 10 constant characters per template
 - 1 unknown per template

Performance

- 4.4 seconds per module

Evaluation: Runtime Phase

Setup

- 24 modules
- 56 benign and 65 malicious inputs

Results

- **zero** malicious inputs that we do not stop
- five benign inputs that we incorrectly stop
- overhead: 0.74 milliseconds per call

Conclusions

Study of injection vulnerabilities

- First large-scale study of Node.js security
- `exec` and `eval` are prevalent in npm ecosystem
- Developers are slow to react

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Prevention of injections

- Automatic and easy to deploy
<https://github.com/sola-da/Synode>
- Small overhead and high accuracy

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Open challenges

- More precise static analysis
- Automatic generation of attacks

Example Limitation: Array.map()

```
var keys = Object.keys(dmenuOpts);  
var dArgs = keys.map(function(flag) {  
    return '-' + flag + ' "' + dmenuOpts[flag] + '"';  
}).join(' ');  
  
var cmd = 'echo | dmenu -p "Password:" ' + dArgs;  
exec(cmd);
```

Inferred template

```
'echo | dmenu -p "Password:" $dArgs'
```

Implementation



- Intraprocedural static analysis
- Based on **Google Closure Compiler**
- Policy for unknown parts:
 - **exec**: literal
 - **eval**: literal, identifier, property, array expression, object expression, member expression, expression statement

Beyond eval and exec

- `vm.runIn*Context()`

```
var vm = require('vm');
vm.runInThisContext(
    "console.log(' " + input + " );");
```

- `execa` module (1,000 dependents)

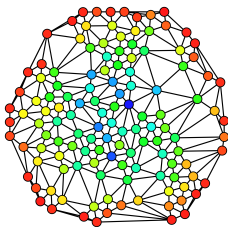
```
module.exports.shell = function(cmd) {
  args = ['-c', cmd]
  childProcess.spawnSync("/bin/sh", args);
}
```

Why is the Application Domain Unique?

20 out of 66 advisories are injections (Node Security Project)



Bad habits



**Unnecessary
code reuse
(see left-pad)**



No sandbox