Featherweight Firefox

Formalizing the Core of a Web Browser

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Pop Quiz!

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a) Yes
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d) All of the above.

e) None of the above.

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Which of the following can a script do to cause the browser to run (or re-run) some other script?

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Question 3

A handler for a button click can always get a reference to the window in which the user clicked.

a) True

b) False

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True. The handler can just use the expression `self` (or `window`).

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b) False

No, false. `self` is statically scoped to refer to the window where the code is defined.

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a) True

No, true. Button handlers can always check the `ownerDocument` property of the button node.

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b) False

No, false. If a different handler runs first, it may move the button node to a different window!

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- Web scripts are event-driven (user input, network responses, timer events, etc.).
- Web scripts have interesting language constructs (first-class functions, dynamic evaluation, `self`, etc.).

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- We want to perform a rigorous study of browser information security policies.
- This demands a rigorous definition of browser behavior.

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- Make the semantics deterministic, modulo the order of input events.
- Model the BOM operations semantics but not the details of the JavaScript langauge.
- Omit all security mechanisms.

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- includes many key browser features.
- operates in a small-step style.
- is declarative (in the style of logical inference rules).
- is written down in a strongly-typed programming language (OCaml).

Included Features

- Multiple windows and pages
- Mutable document node trees
- Buttons and text boxes with handlers
- Network requests and responses with cookies
- Scripts with first-class functions, `eval`, and AJAX requests

Omitted Features

- Browsing history
- HTTP error codes and redirects
- “timeout” events in scripts
- `javascript:` URLs
- `file:` URLs

Related Work

Whole Browser Formalizations

- HTML5

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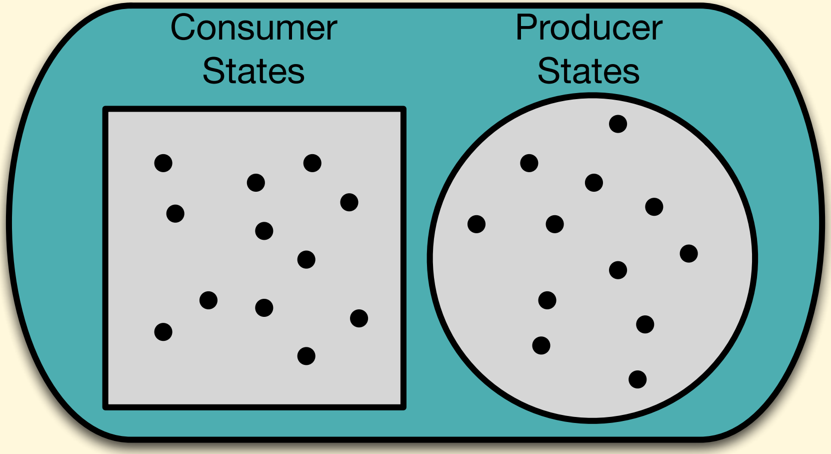
- Yoshihama, Tateishi, Tabuchi, and Matsumoto: *Information-Flow Based Access Control for Web Browsers* (IEICE Transactions, May 2009).

Other Formalizations

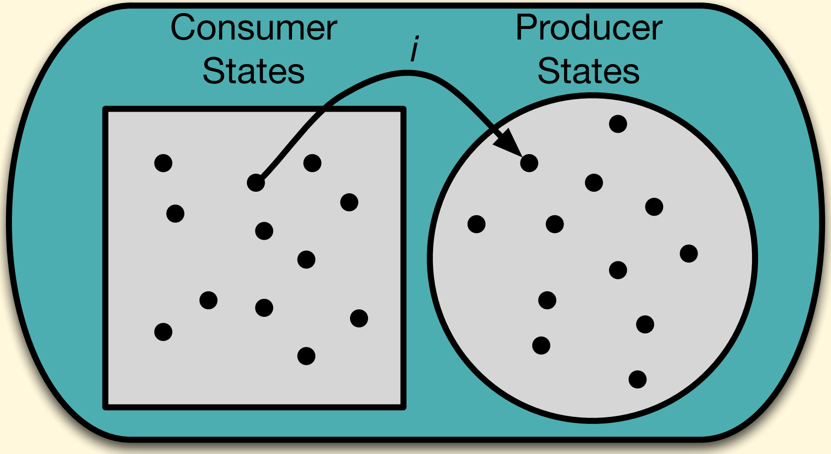
- Maffeis, Mitchell, and Taly: *An Operational Semantics for JavaScript* (ASPLAS 2008).
- Gardner, Smith, Wheelhouse, and Zarfaty: *Local Hoare Reasoning About DOM* (PODS 2008).
- Akhawe, Barth, Lam, Mitchell, and Song: *Towards a Formal Foundation of Web Security* (CSF 2010).

Formalization Details

Reactive Systems



Reactive Systems



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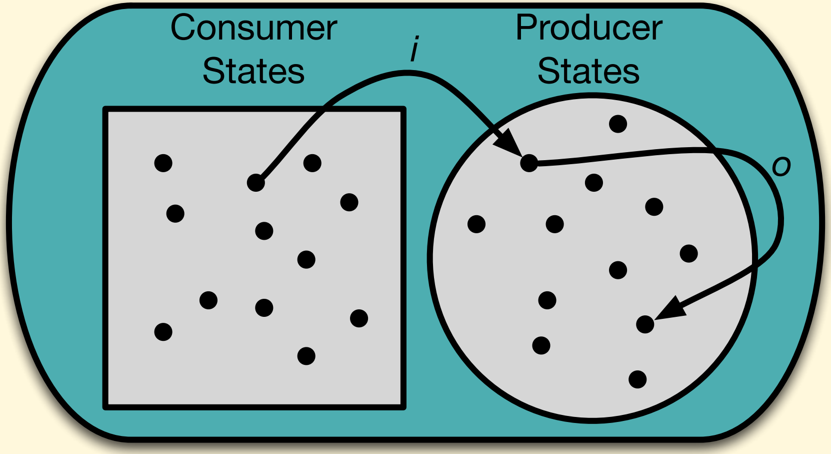

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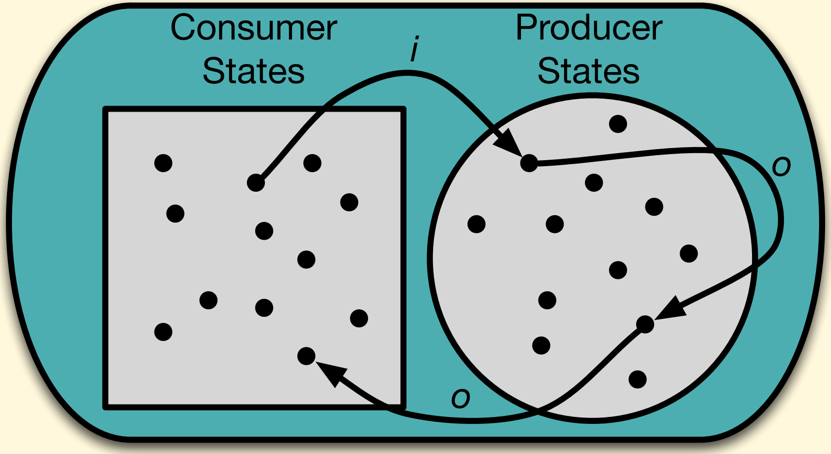
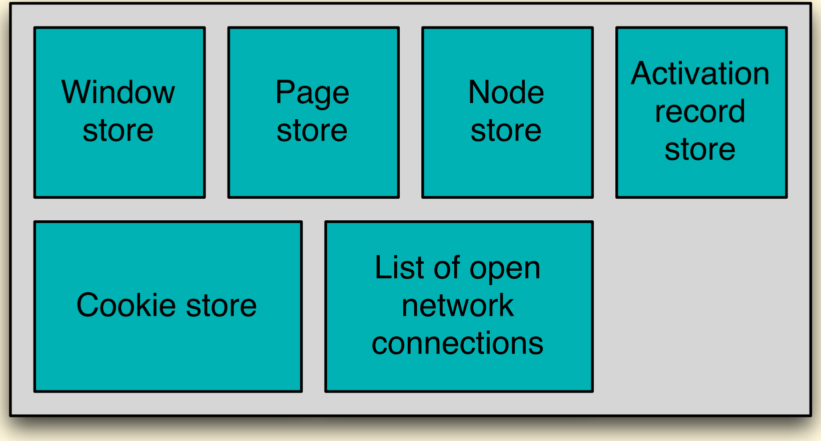
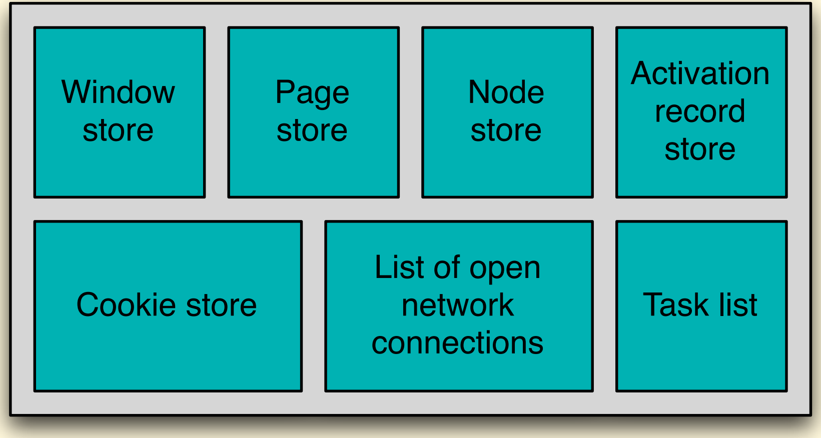


Web Browser Consumer State



Web Browser Producer State



Window store

Page store

Node store

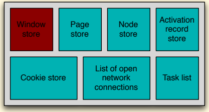
Activation record store

Cookie store

List of open network connections

Task list

Window Store



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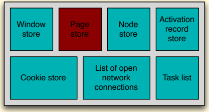
window:

name	string (optional)
opener	reference to a window (optional)
current page	reference to a page

Page Store



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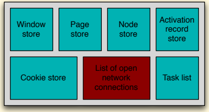
page:

address	URL
root node	reference to a node
environment	reference to an activation record
script queue	list of scripts or placeholders

Network Connection List



network connection:

- connection for document request:
  URL, reference to a window
- connection for script request:
  URL, reference to a node
- connection for AJAX request:
  URL, reference to a page, expression

Selected Inputs

From the user:

- `load_in_new_window`(*url*)
- `click_button`(*win*, *n*)

From the network:

- `receive`(*d*, *n*, *resp*)

Selected Outputs

To the user:

- `win_closed`(*win*)
- `page_updated`(*win*, *doc*)

To the network:

- `send`(*d*, *req_uri*, *cookies*, *msg*)

What’s Next?

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- Others may be interested in slightly different features.
- The semantics may need to be translated to a different machine-consumable form.

Work in Progress

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- Define security policies for the browser in terms of “reactive noninterference” (Bohannon, et al., CCS 2009).
- Prove the soundness of some enforcement mechanisms for these policies.
- Gain a better understanding of end-to-end web browser security.

Thank You