Improving the Security and Robustness of Modern Web Browsers

Charles Reis

General Examination

May 14, 2007

Is Browsing Safe?

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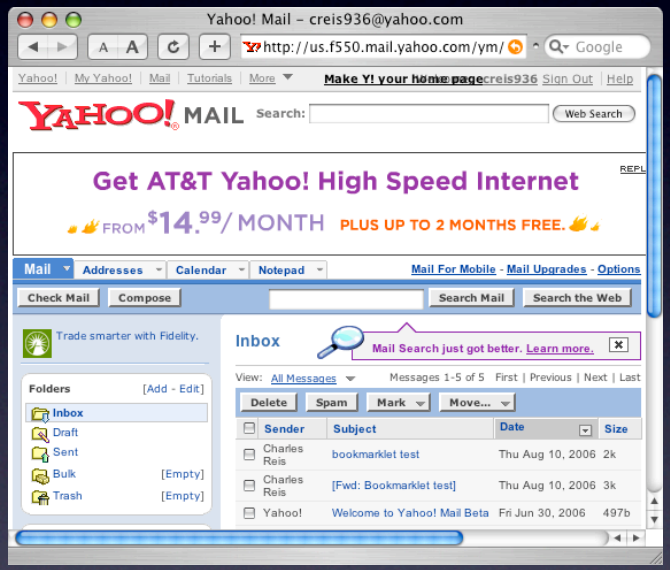
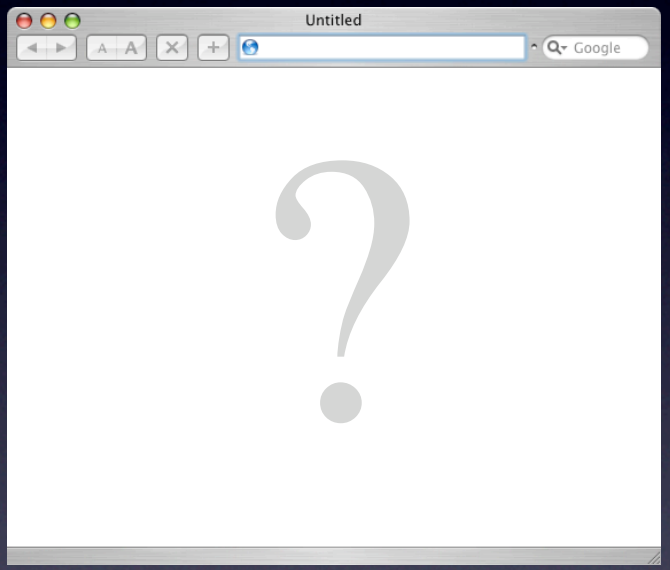


Web Mail

Movie Rentals

Search Results



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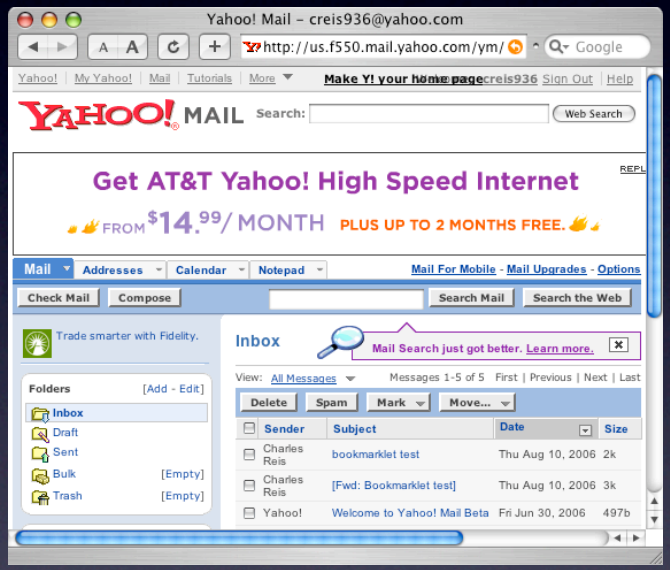

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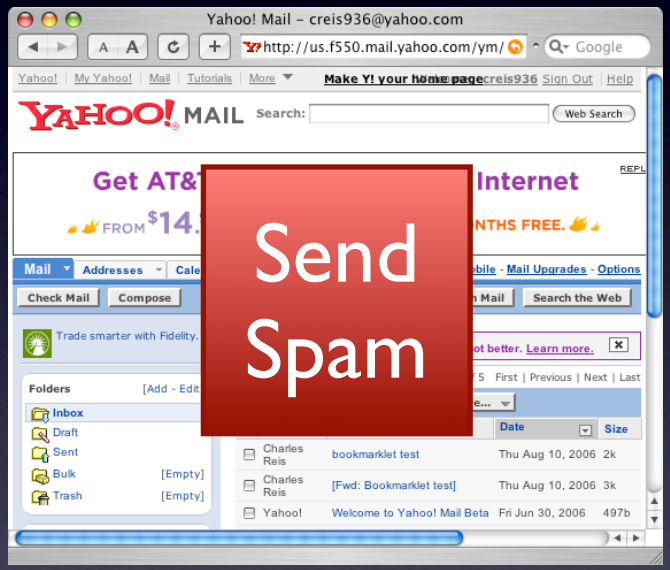

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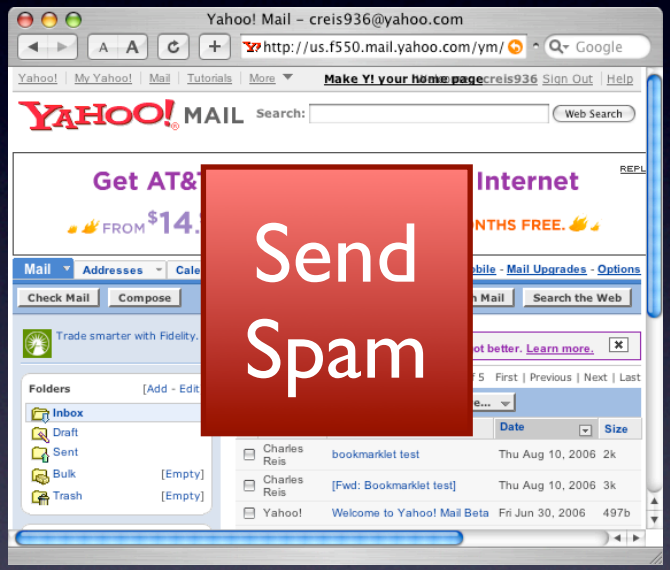

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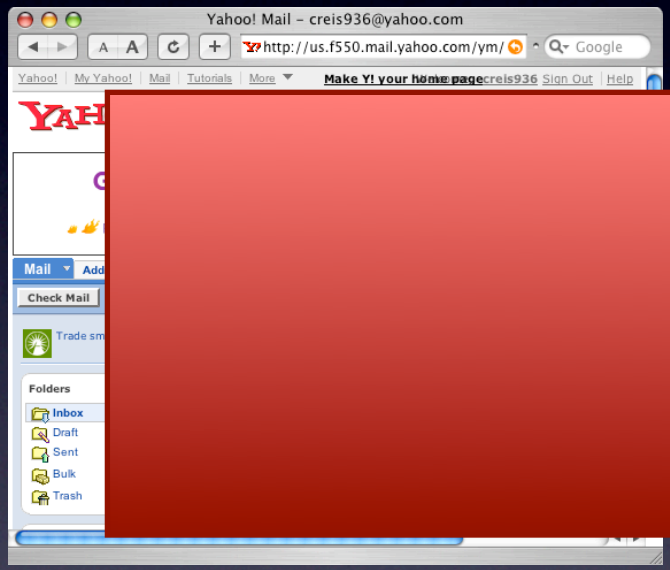

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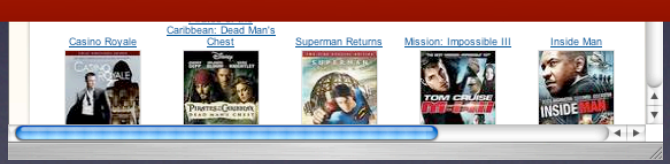

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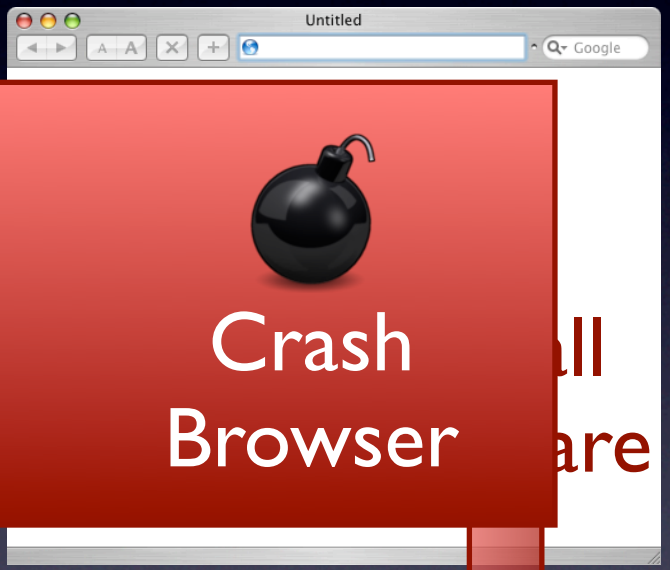

Crash Browser

How did we get here?

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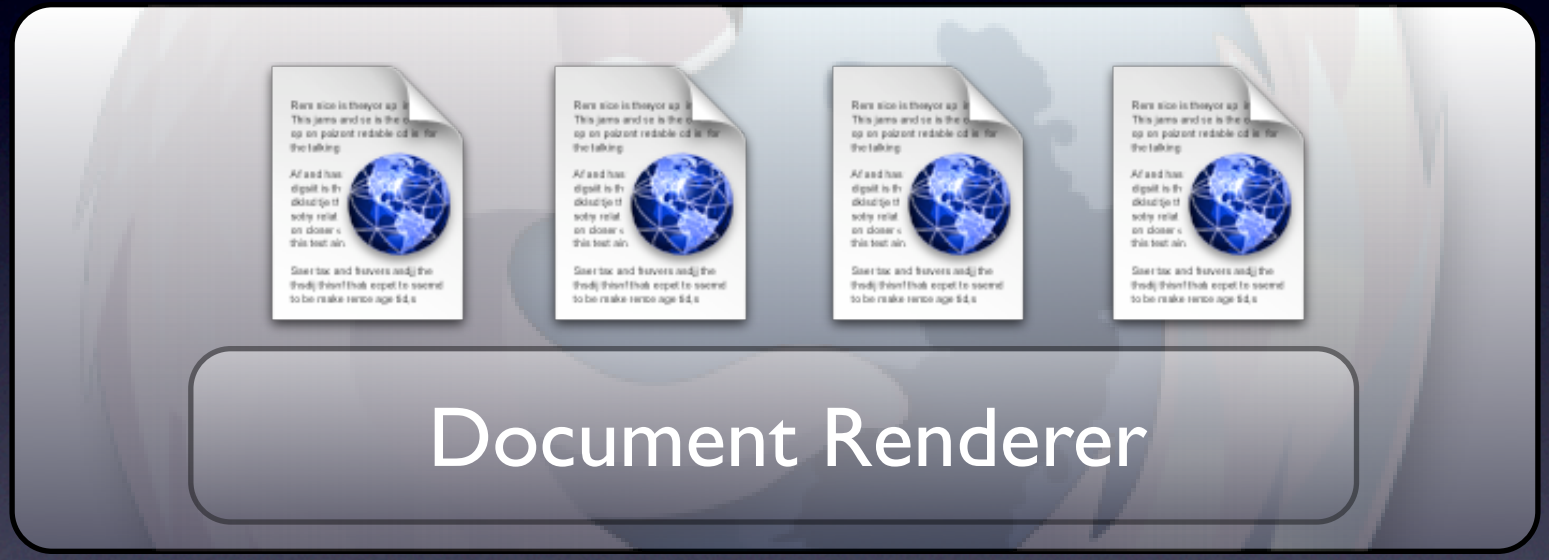
- Browsers have evolved



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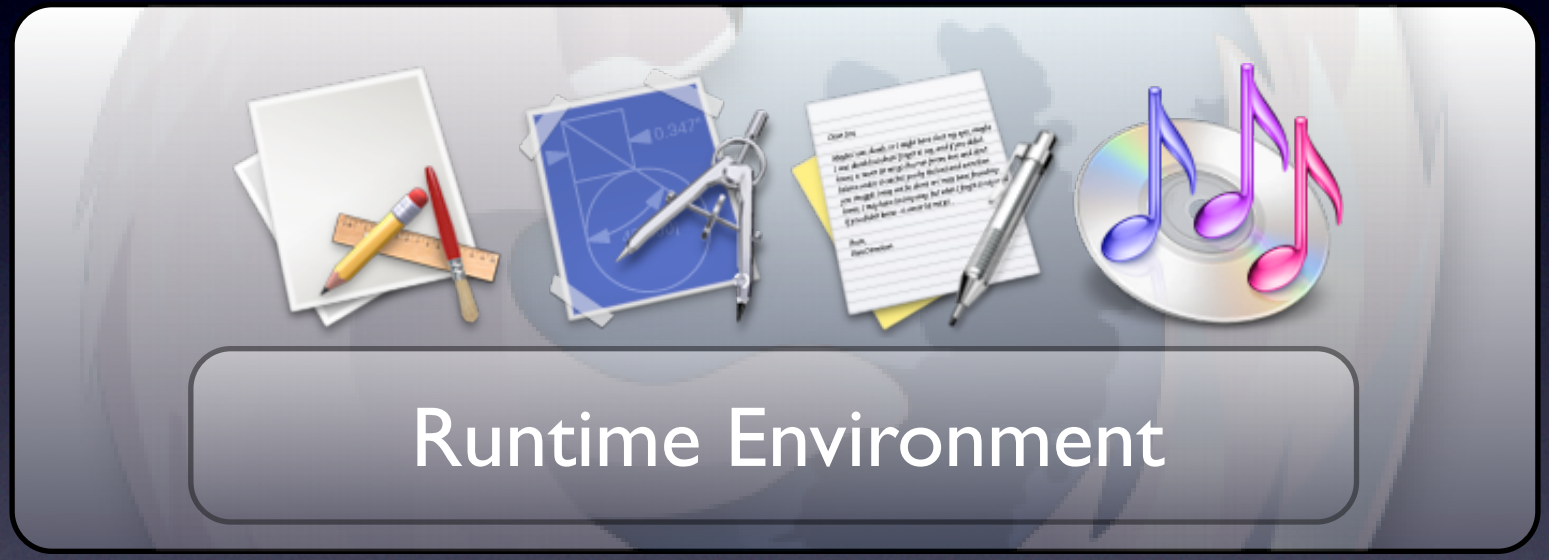

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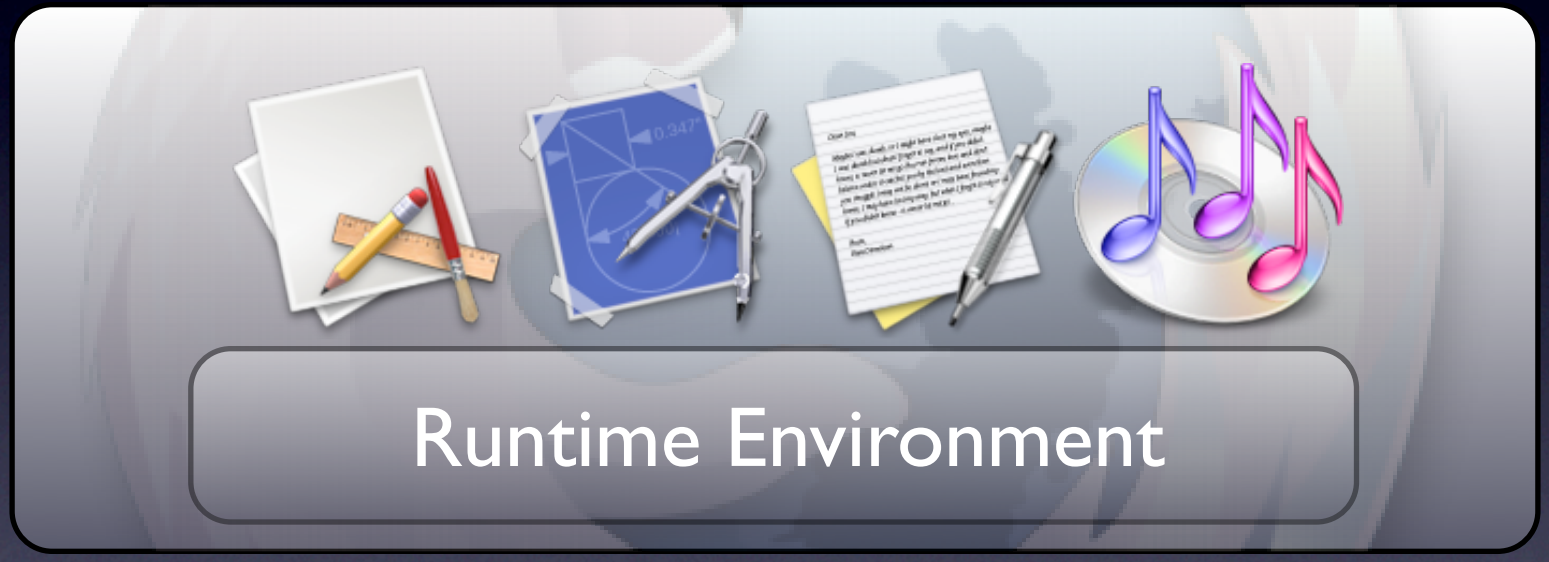

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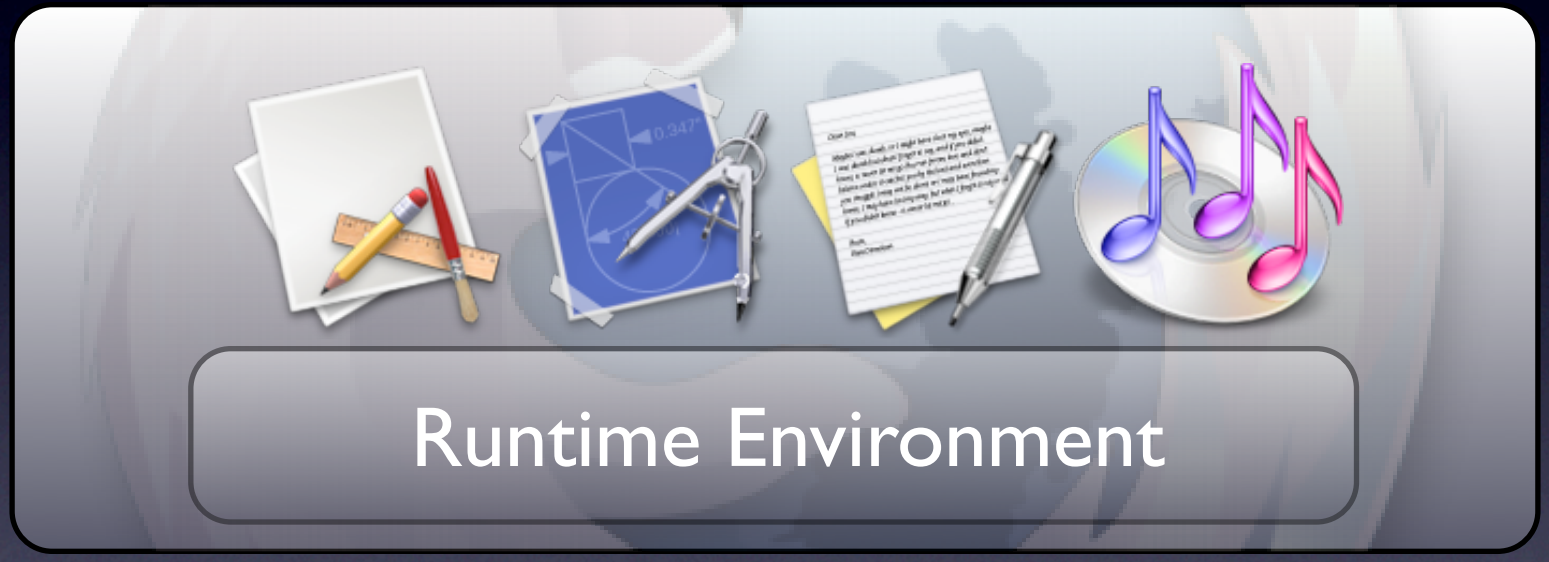

- Now analogous to OS
- Convenience has trumped security

Hypothesis

Mechanisms from OS research can improve the security and robustness of modern web browsers.

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- Focus on **Isolation** and **Interposition**

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Mechanisms from OS research can improve the security and robustness of modern web browsers.

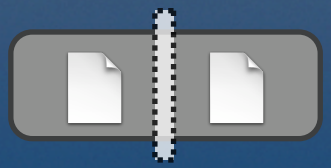
- Focus on **Isolation** and **Interposition**
- Evaluate **Safety**, **Backwards Compatibility**, and **Efficiency**

Outline

Motivation

Threats

Isolation

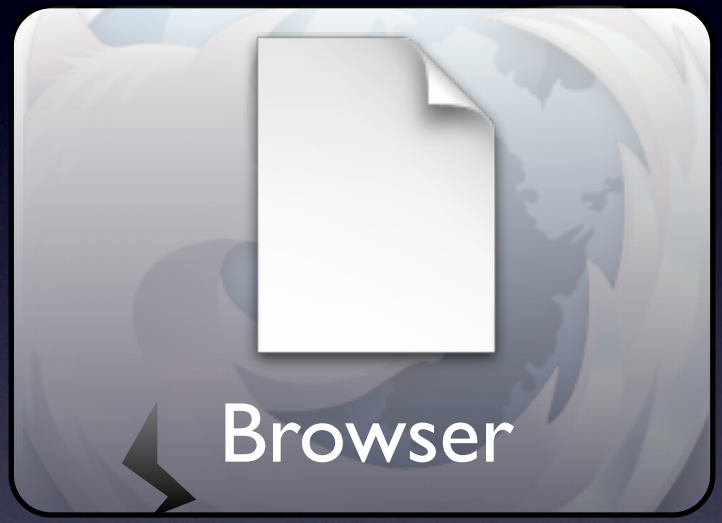


Interposition

Future Work

Conclusion

1. Browser Vulnerabilities



Operating System

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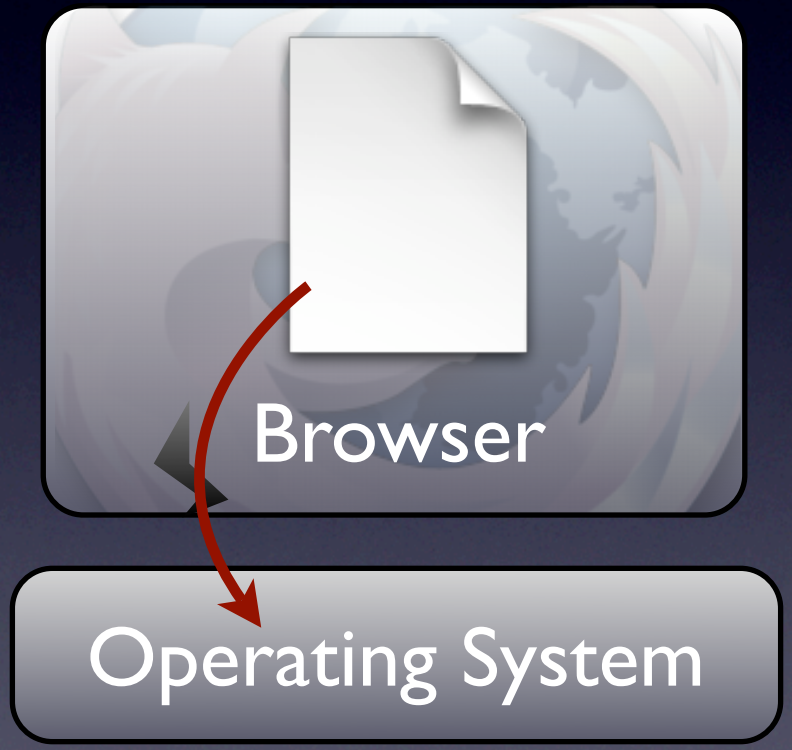

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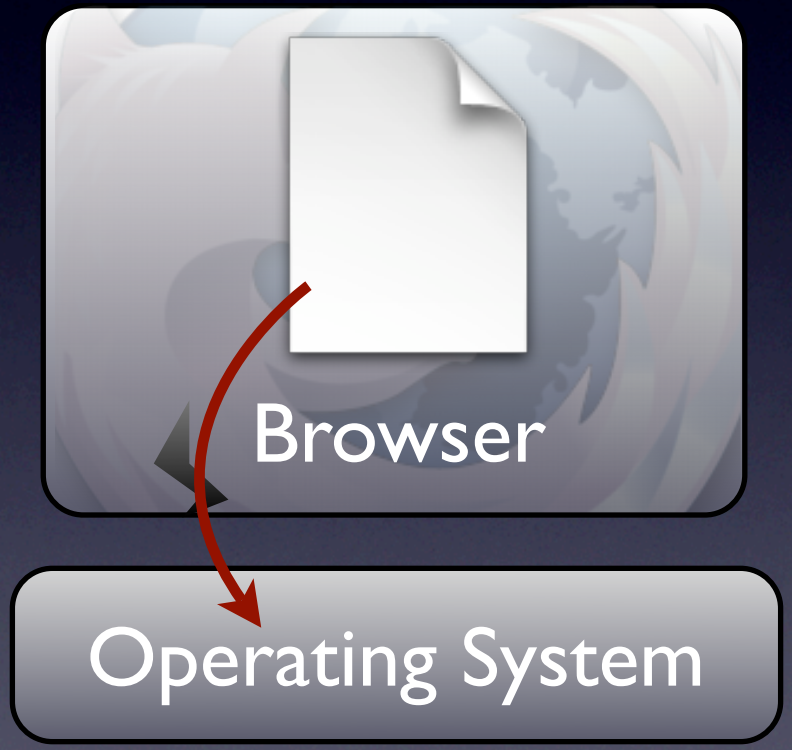

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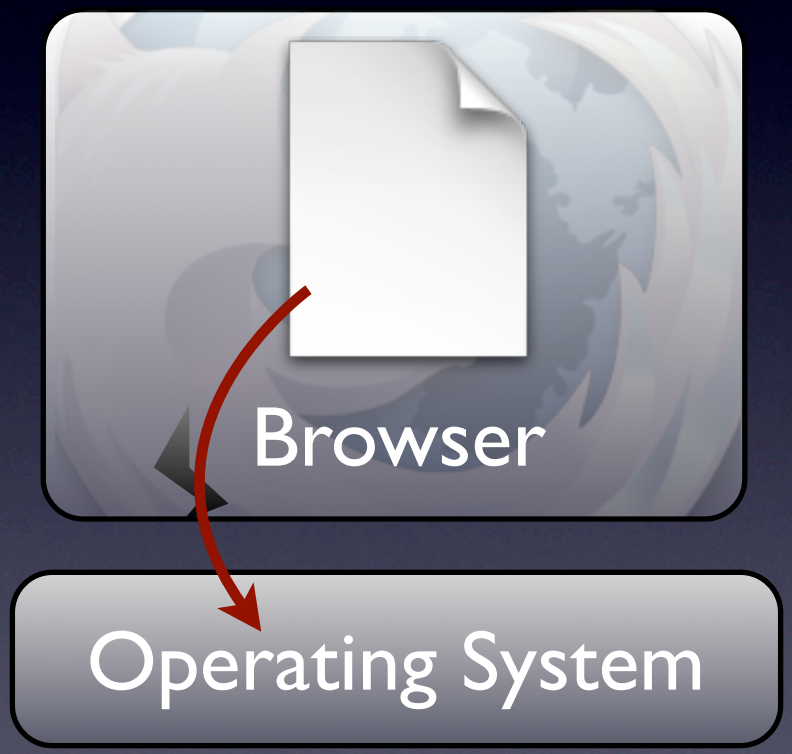

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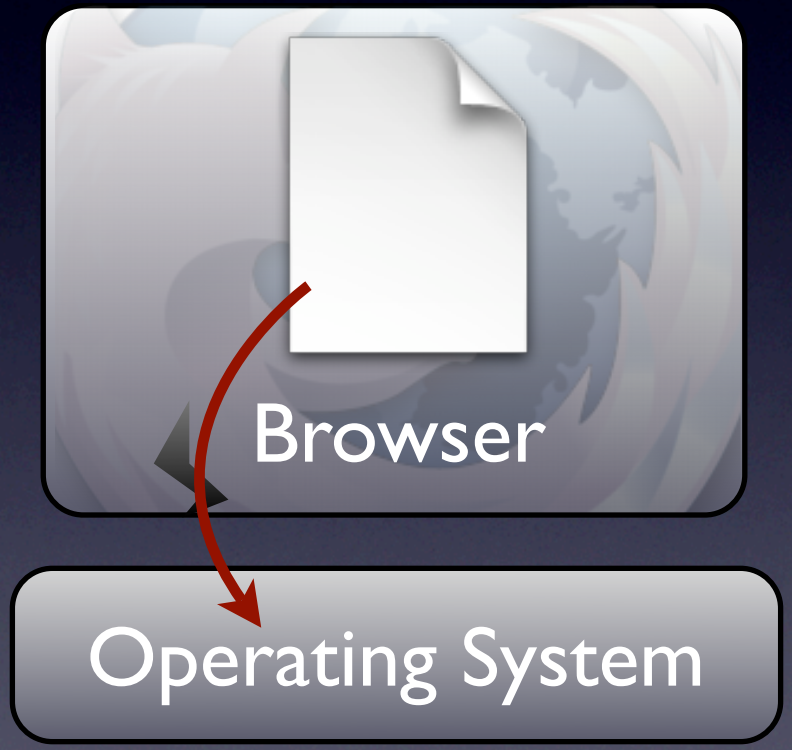

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- **Proposal**: filter exploits

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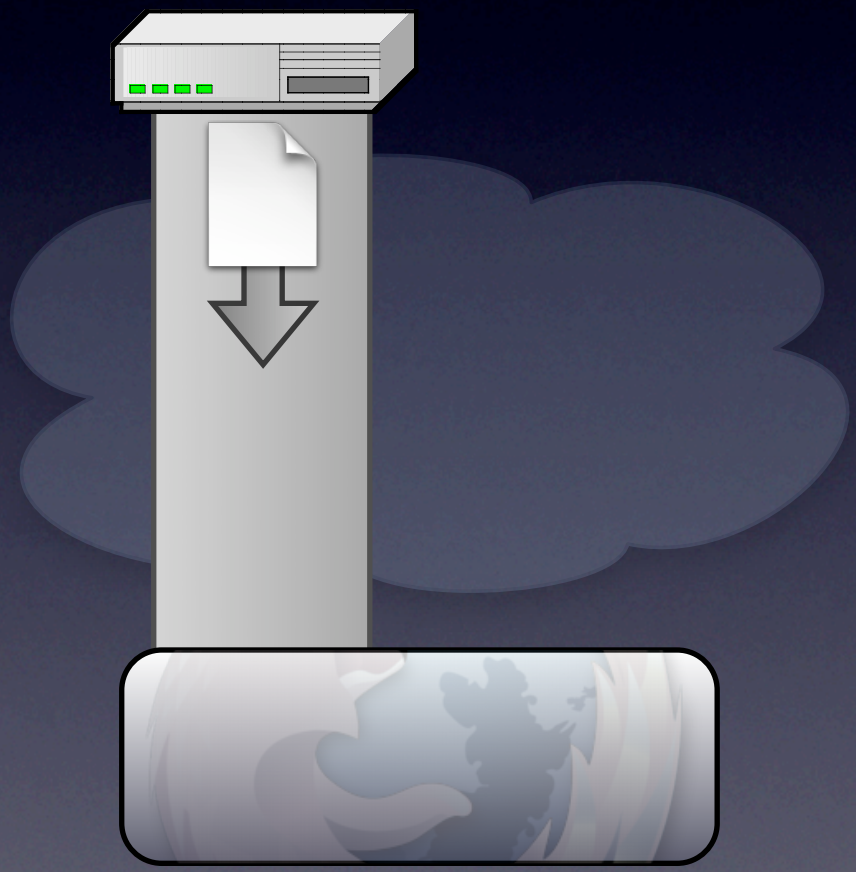
Trusted Site



Browser

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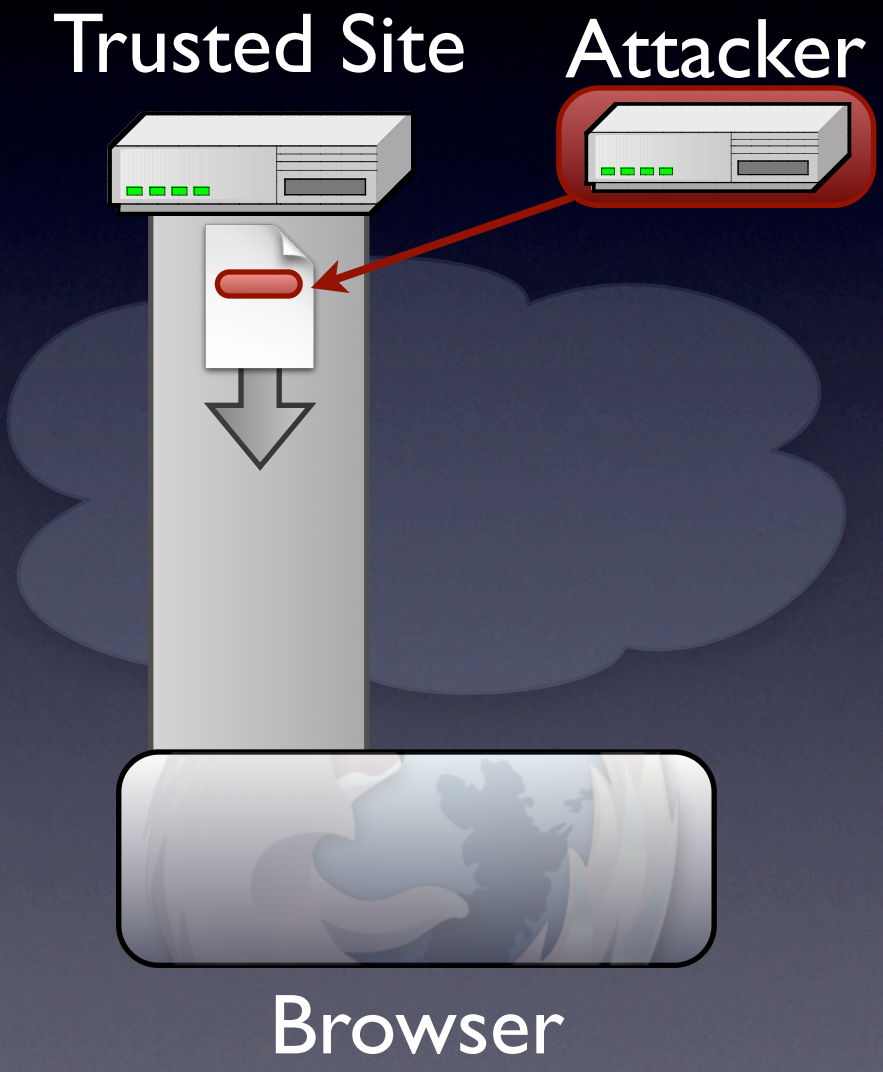

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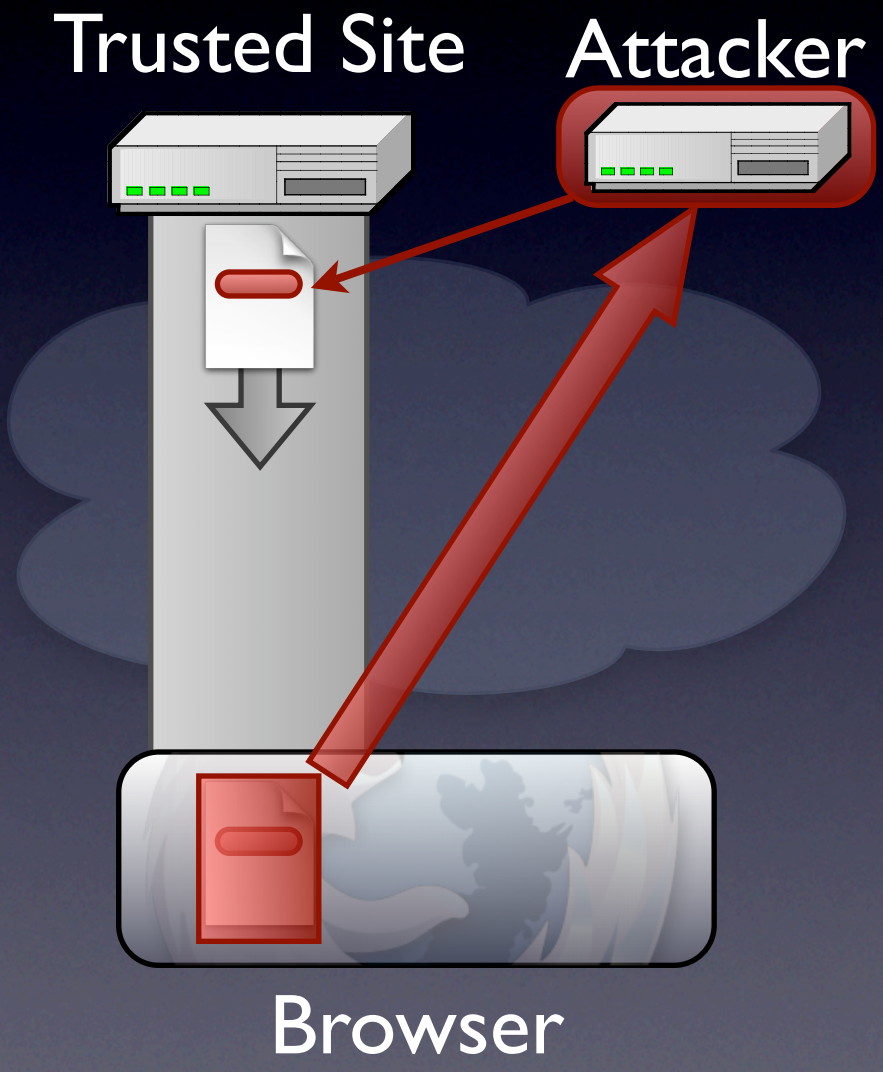

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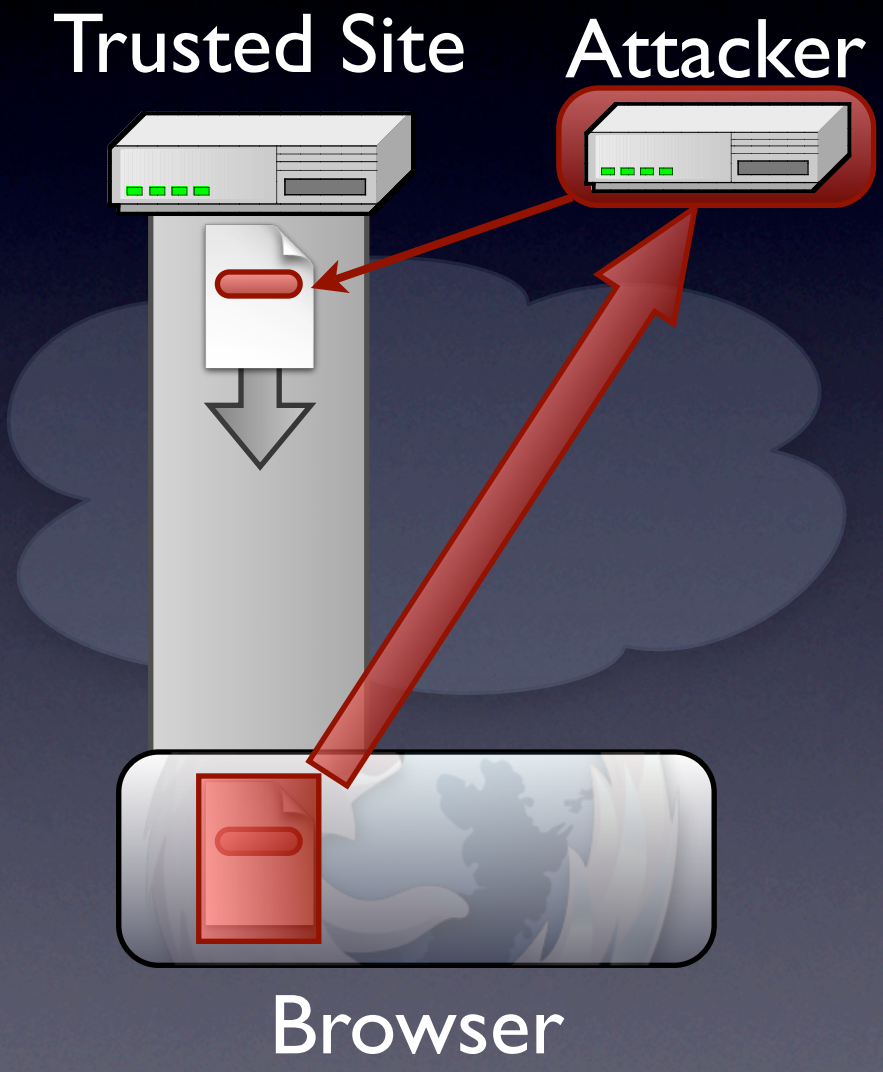

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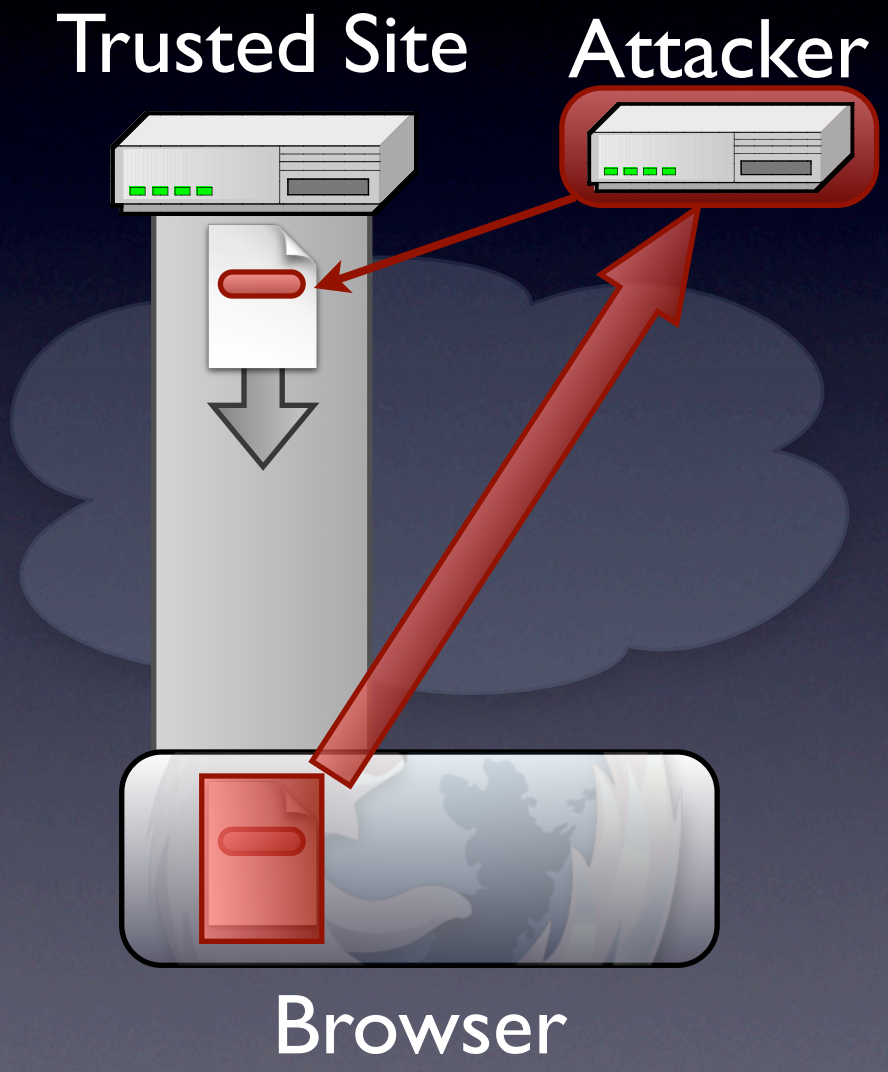

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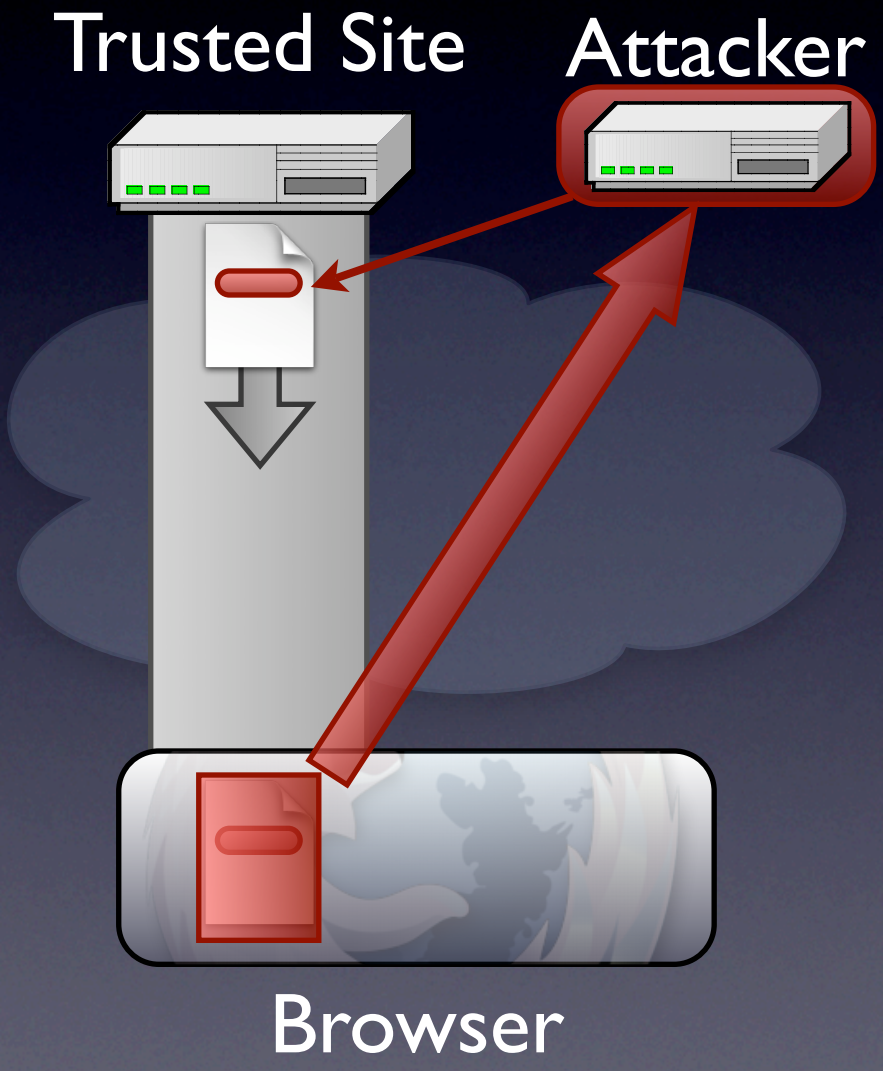

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- **Proposal**: whitelists

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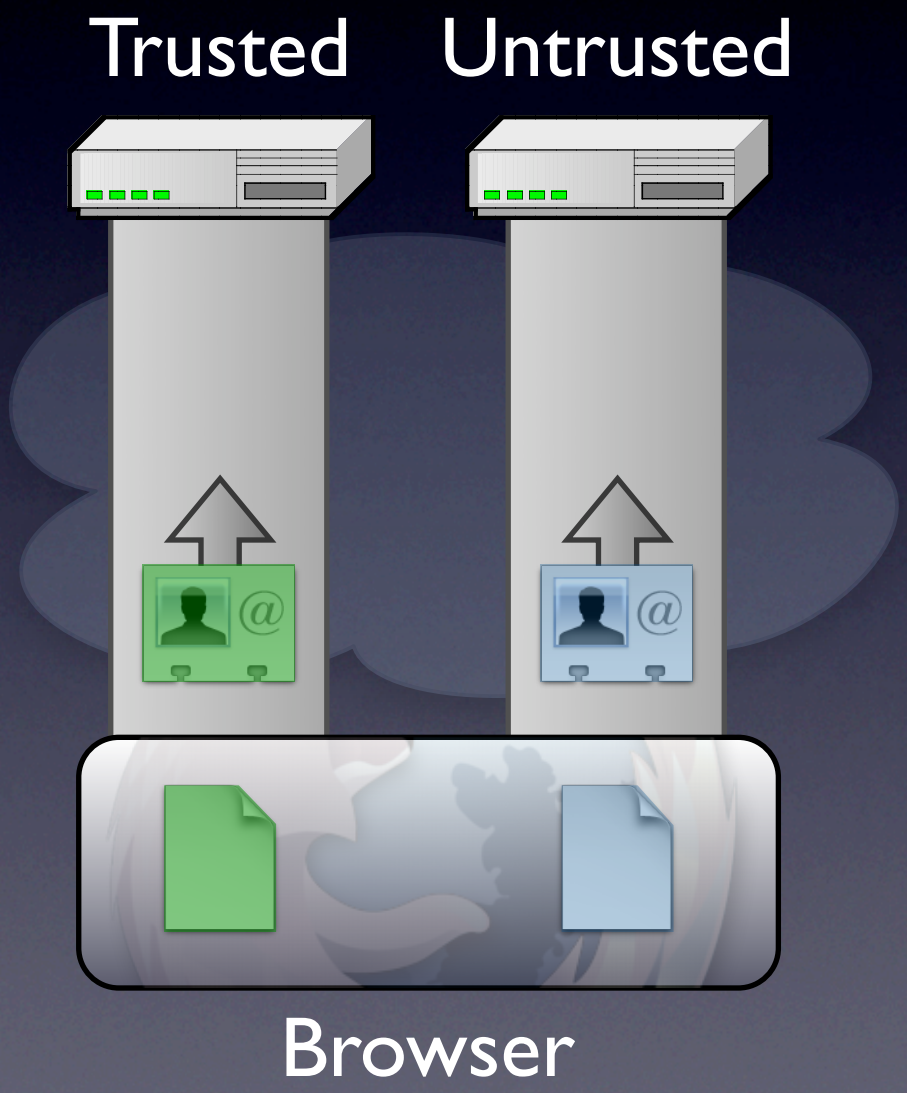

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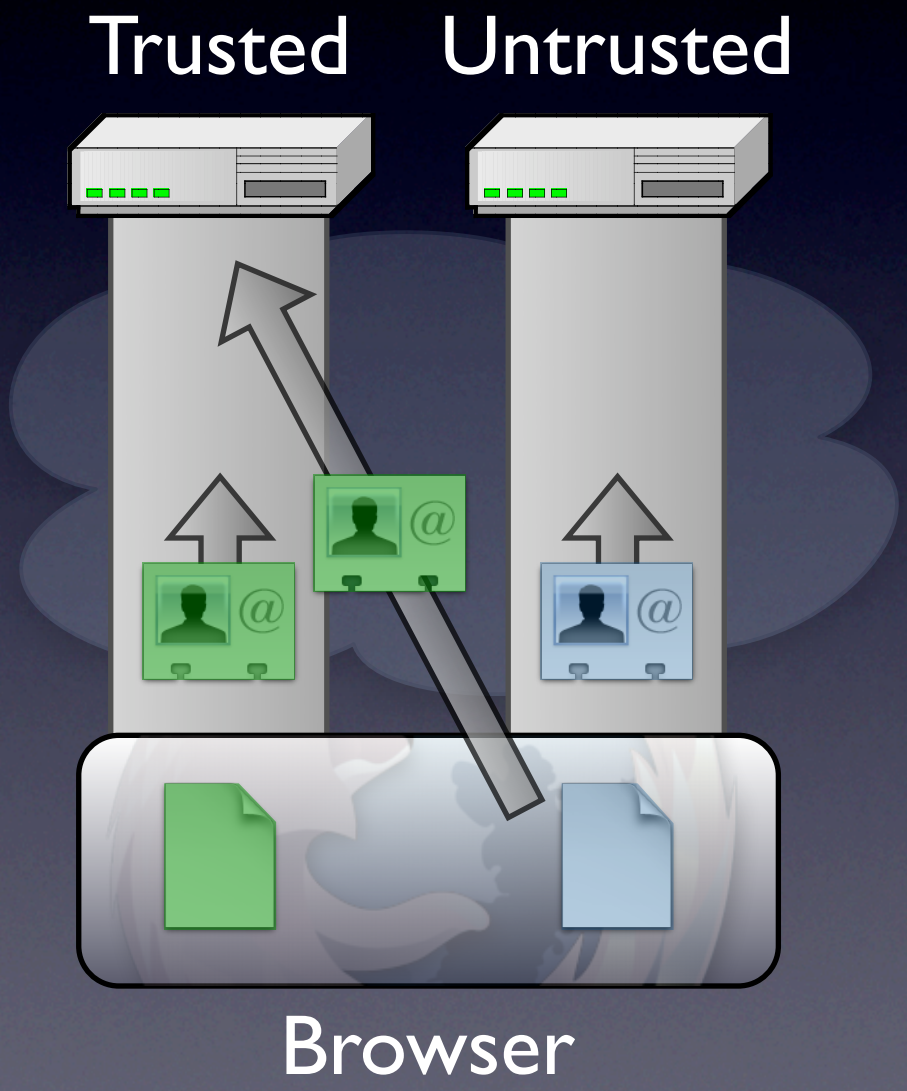

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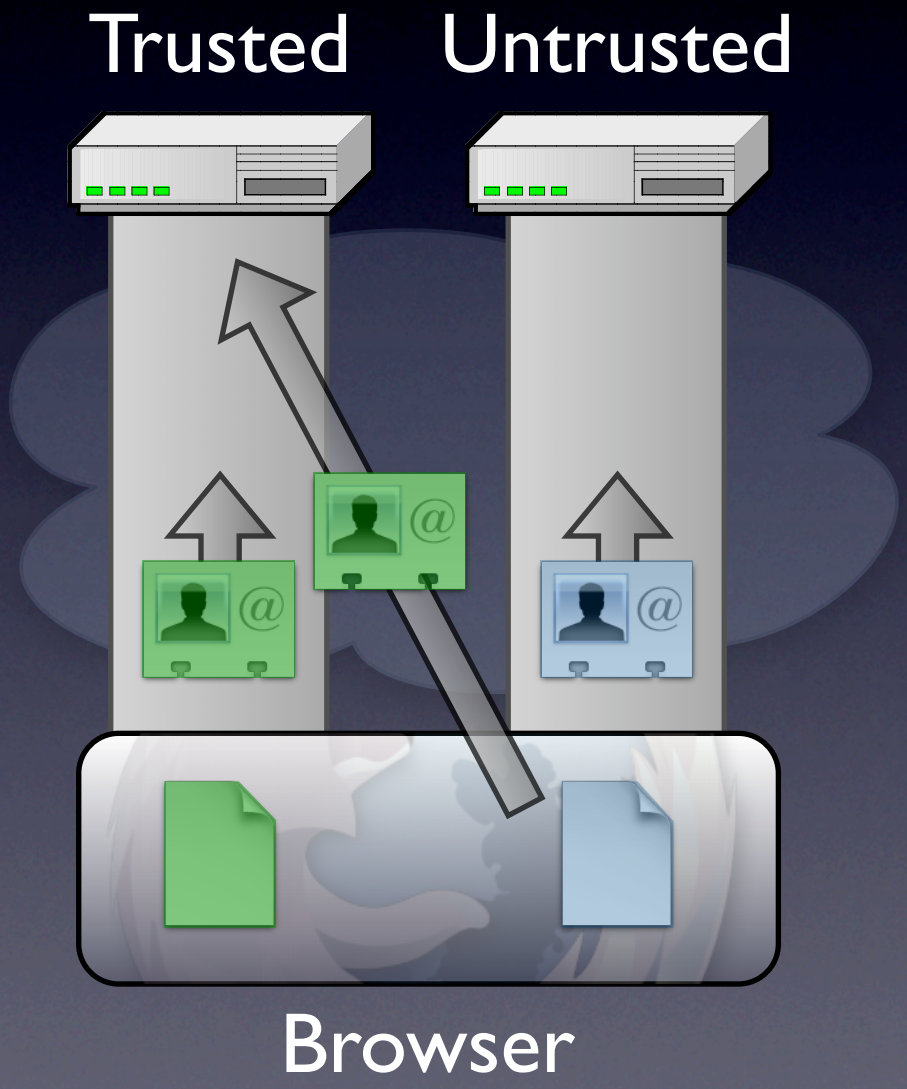

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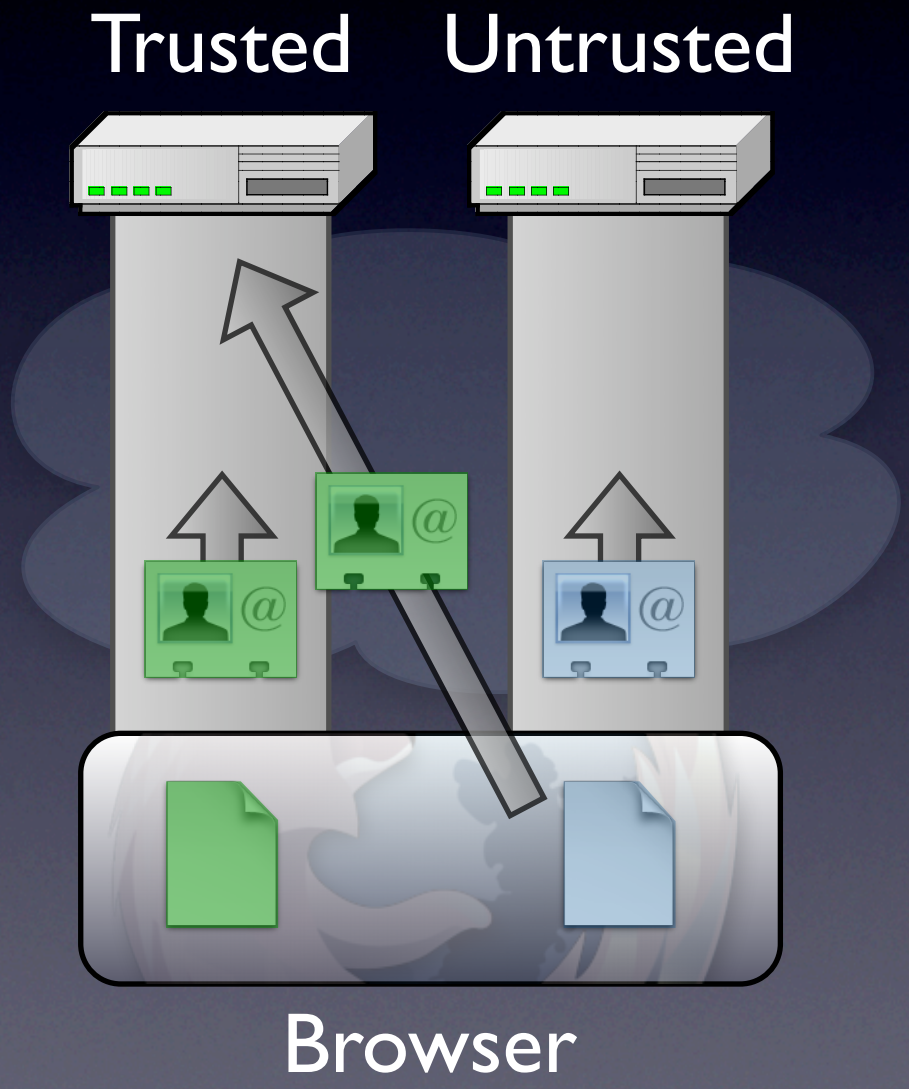

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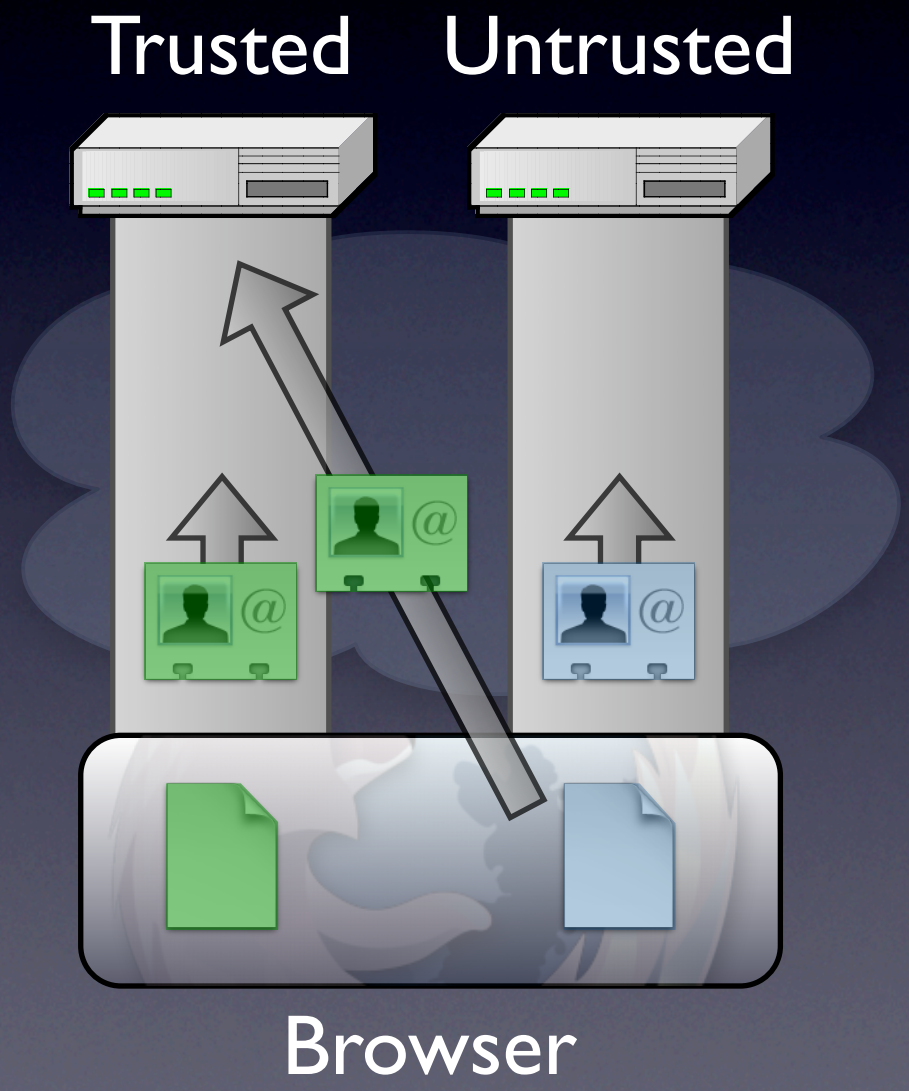

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- **Existing Proposals**: Proxies *[Jovanovic 06]*, block suspicious requests *[RequestRodeo]*
- **Proposal**: browser sessions

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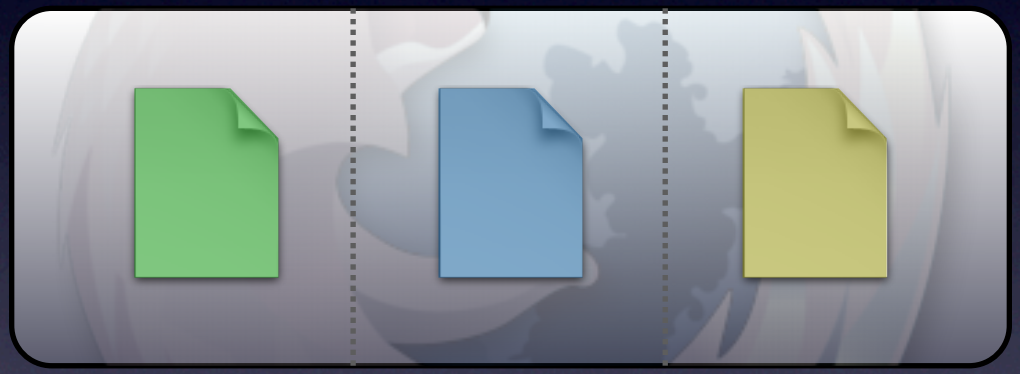

Browser

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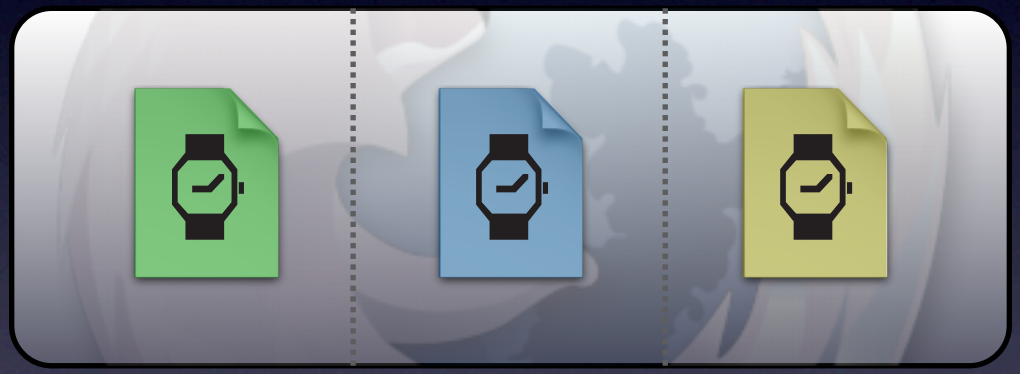

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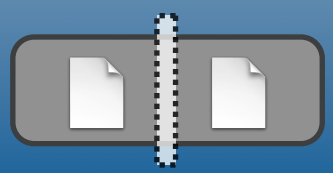

Interposition

Future Work

Conclusion

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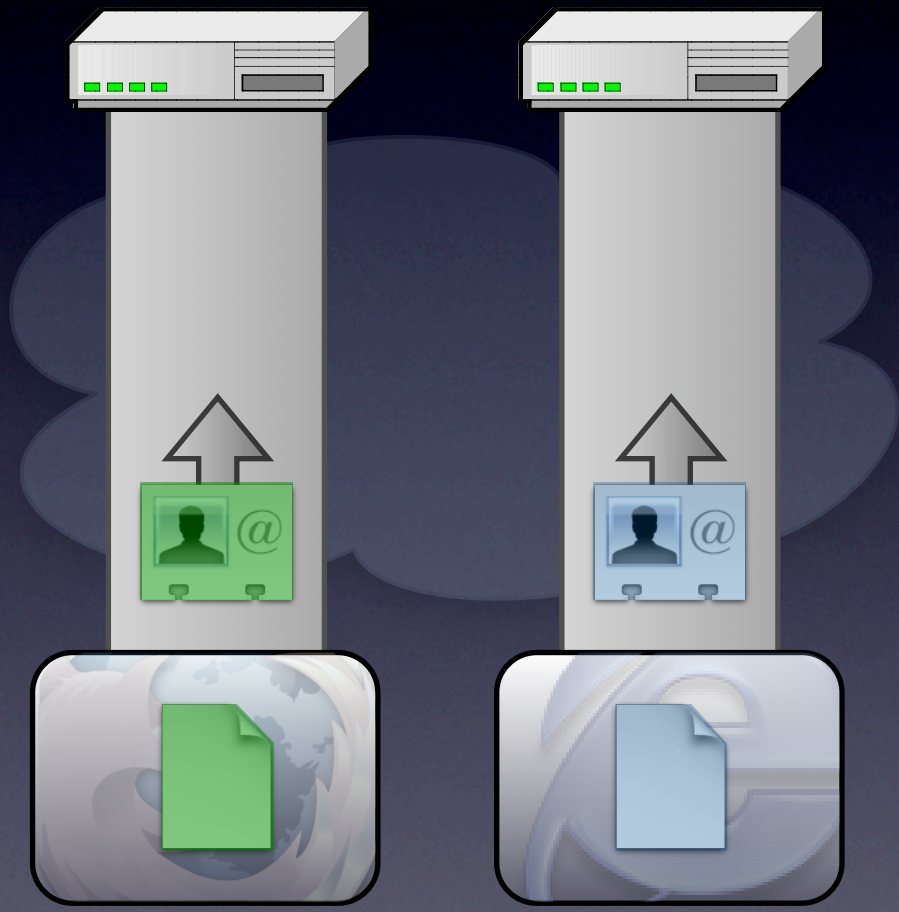
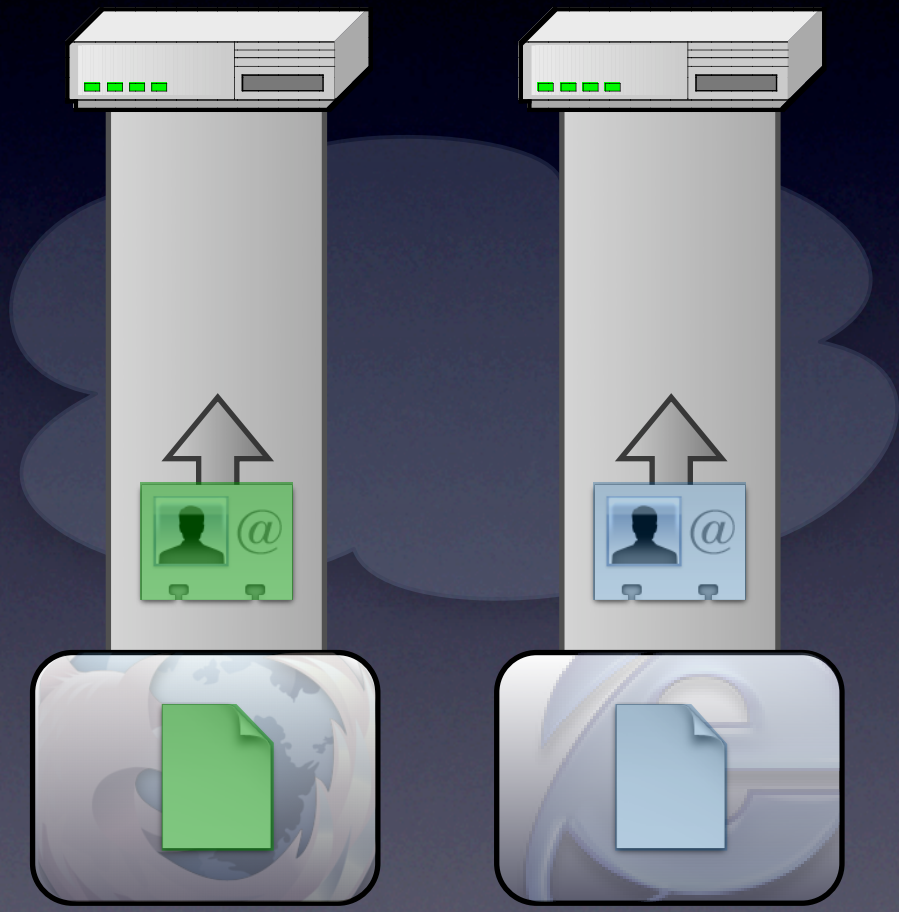


Isolating Web Content

- Some threats addressed by using multiple browsers



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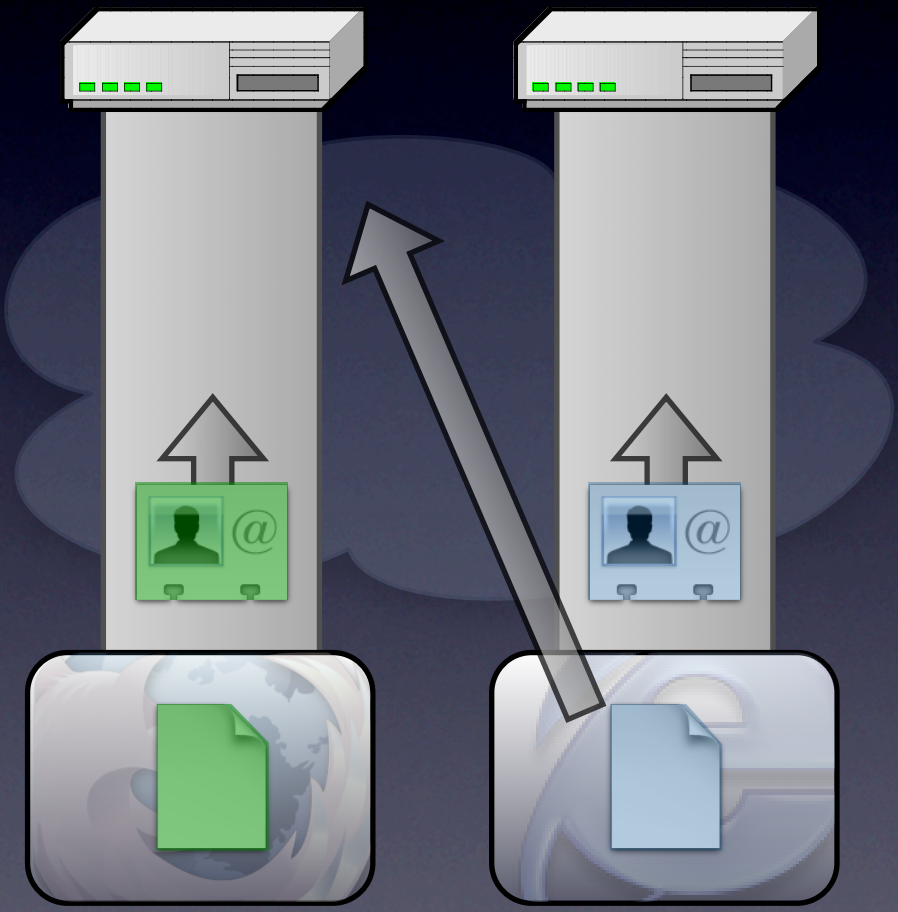

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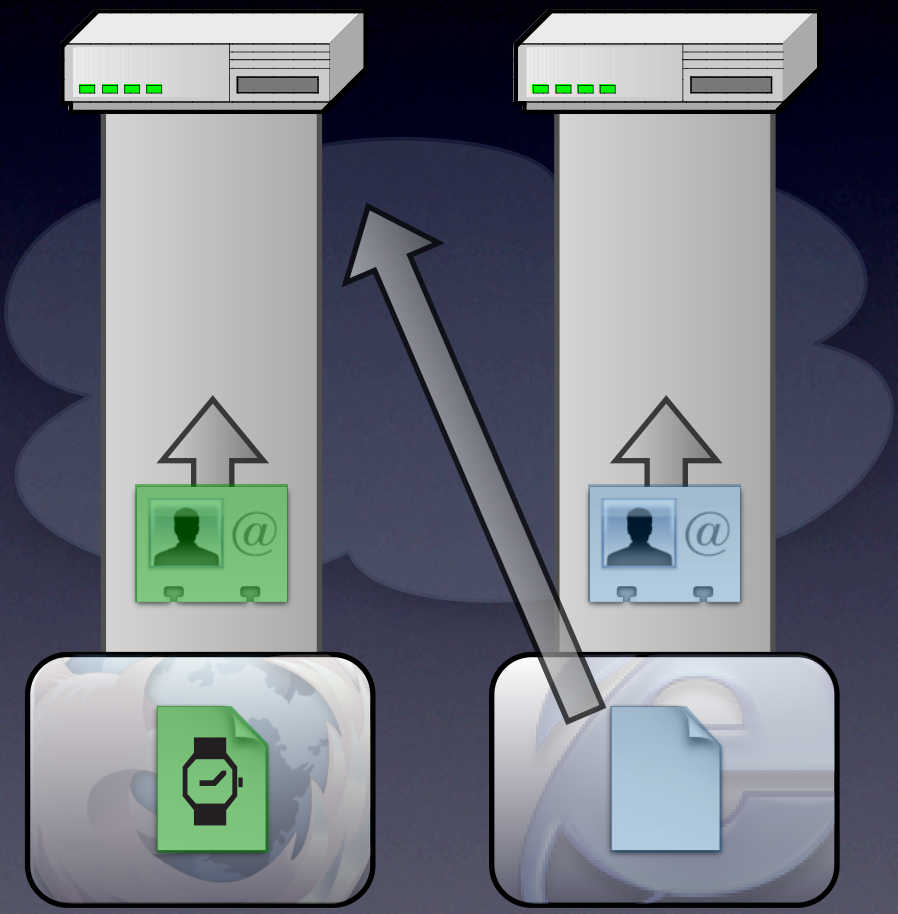

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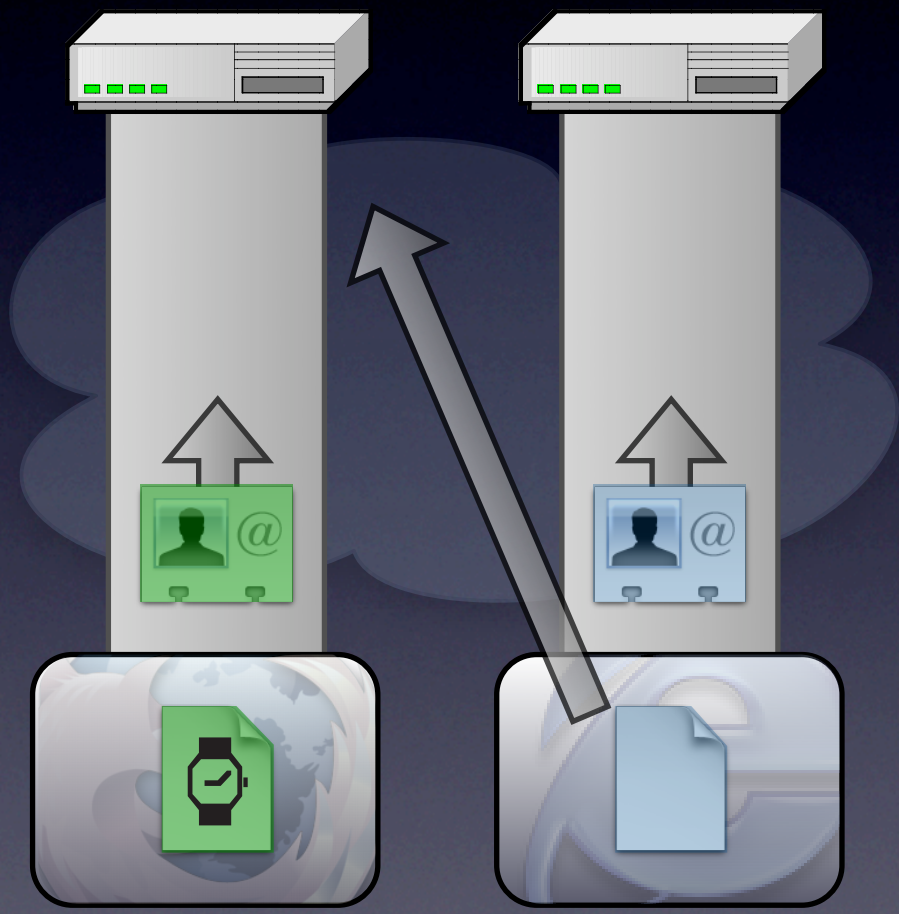
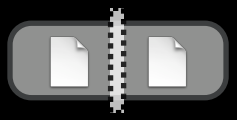
4. *Resource contention*

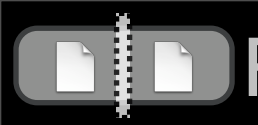
Goal: capture this idea within a single browser





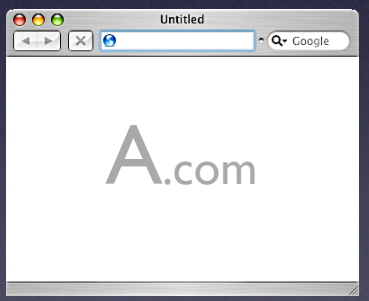
Isolation in OS

- Processes
- Lightweight fault domains
  [Wahbe 93, Swift 03]
- Covert channels
  [Lampson 73]



Proposal:

Decompose Browser



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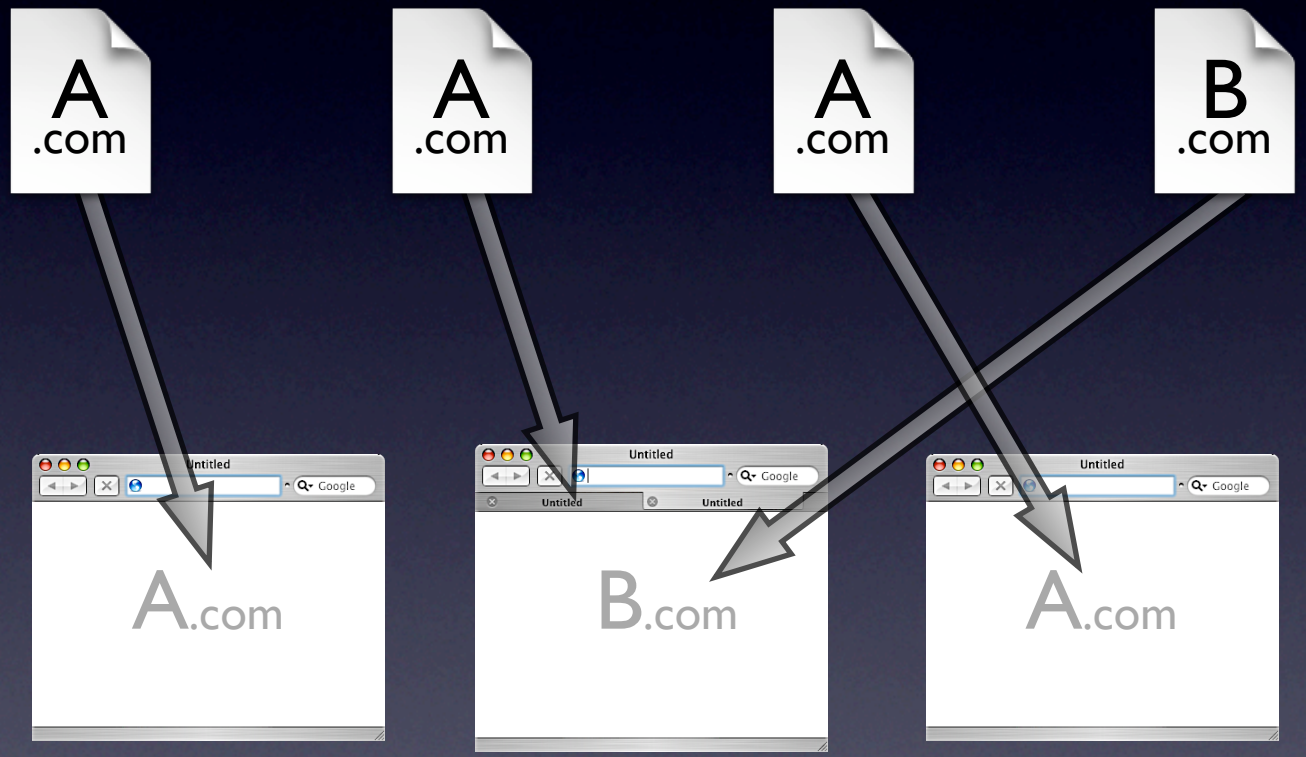

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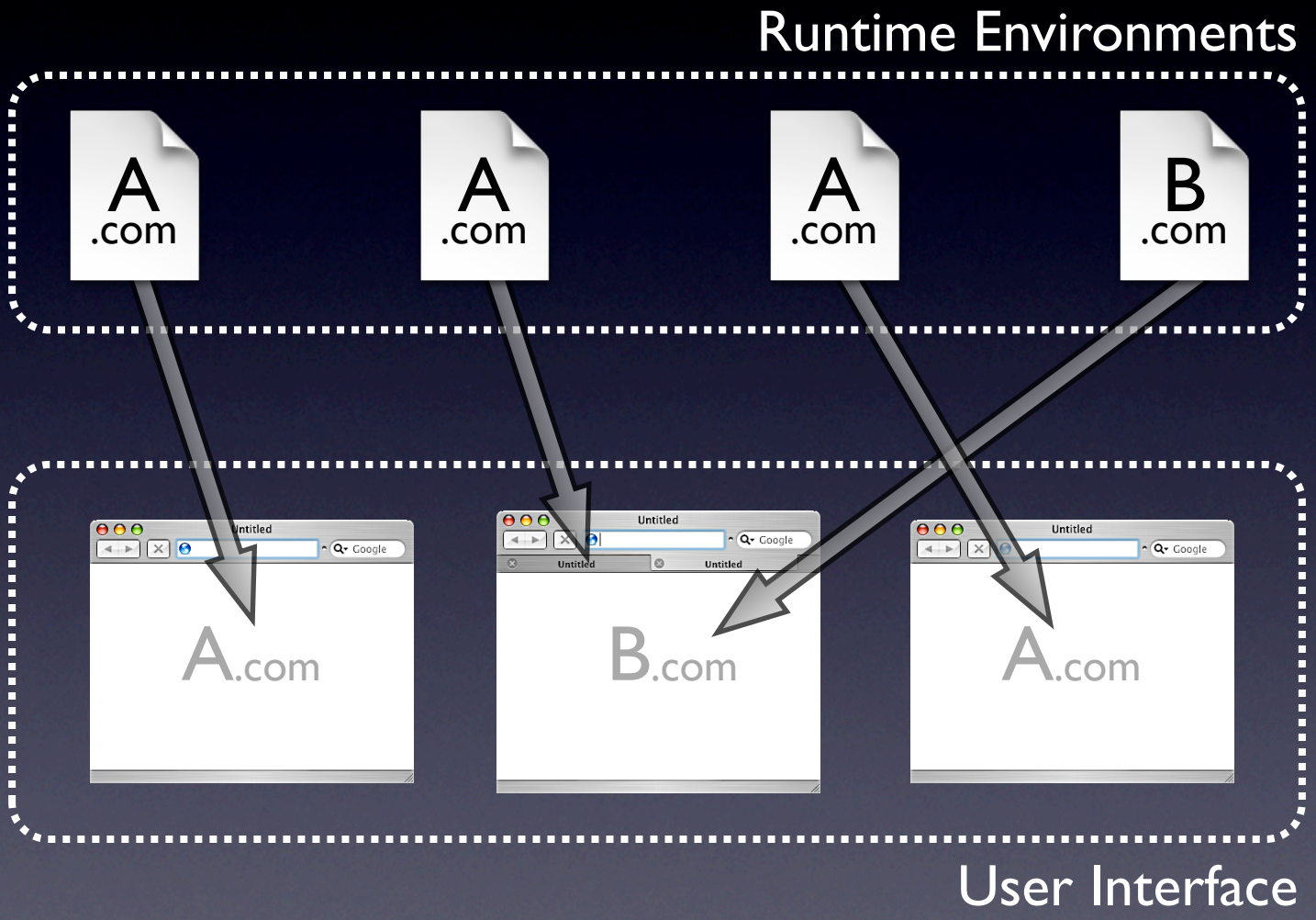

Proposal:

Host

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- All documents from a hostname

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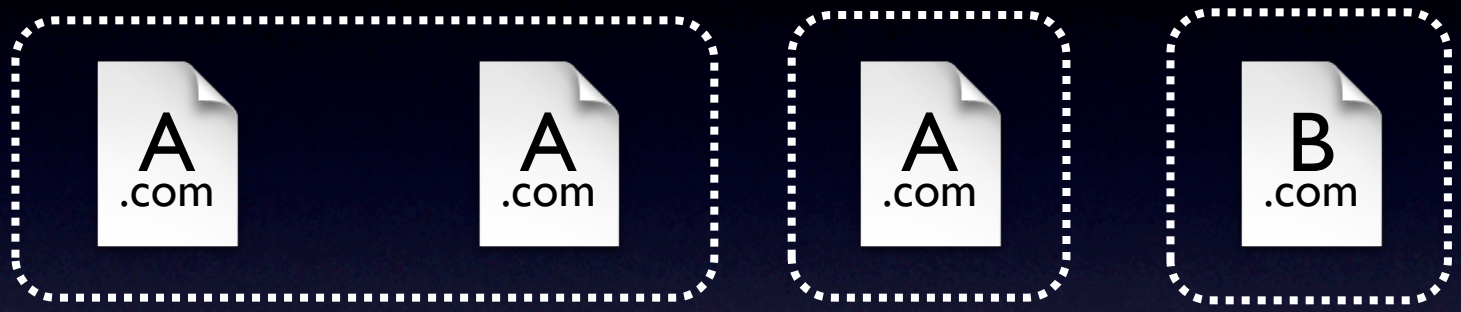
- **Preliminary work:** process per host

Host

- All documents from a hostname
- **Preliminary work:** process per host
- **Proposal:** partition of storage
  - Cache *[Felten 00]*, visited links *[Jackson 06]*, persistent cookies

Session



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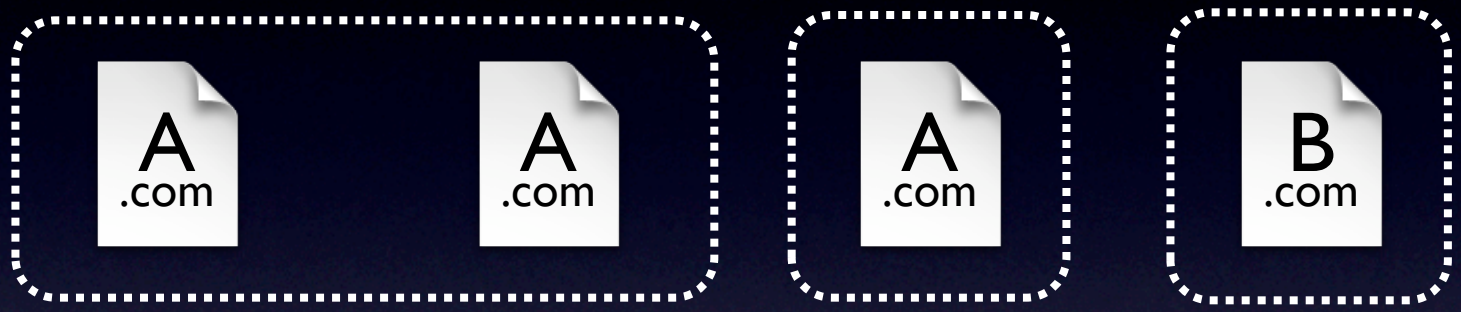

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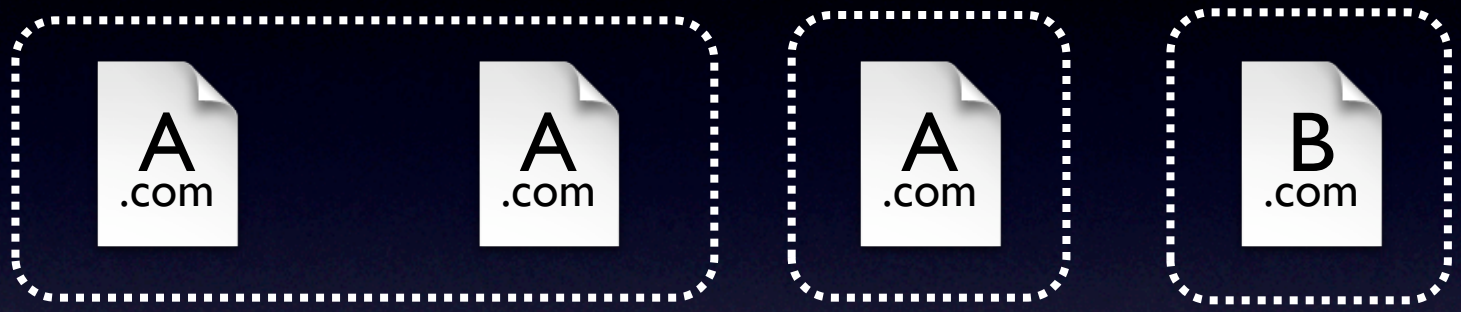

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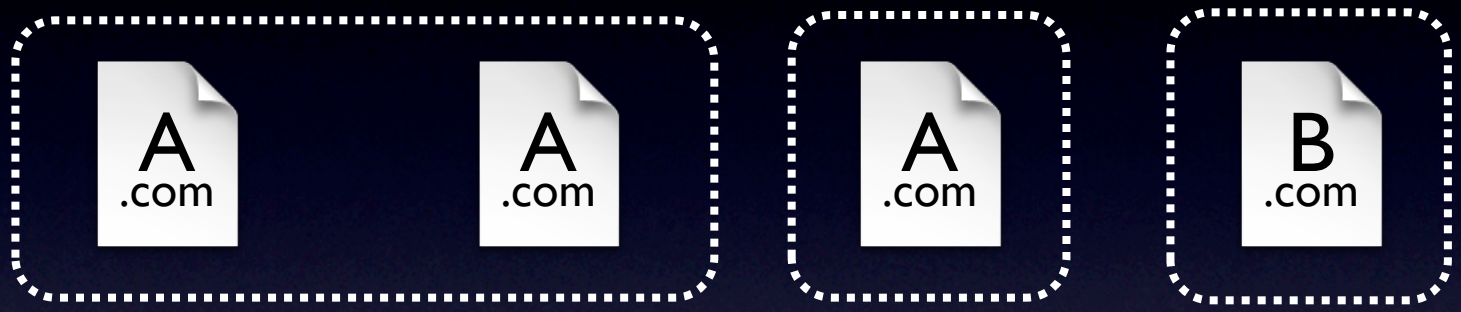

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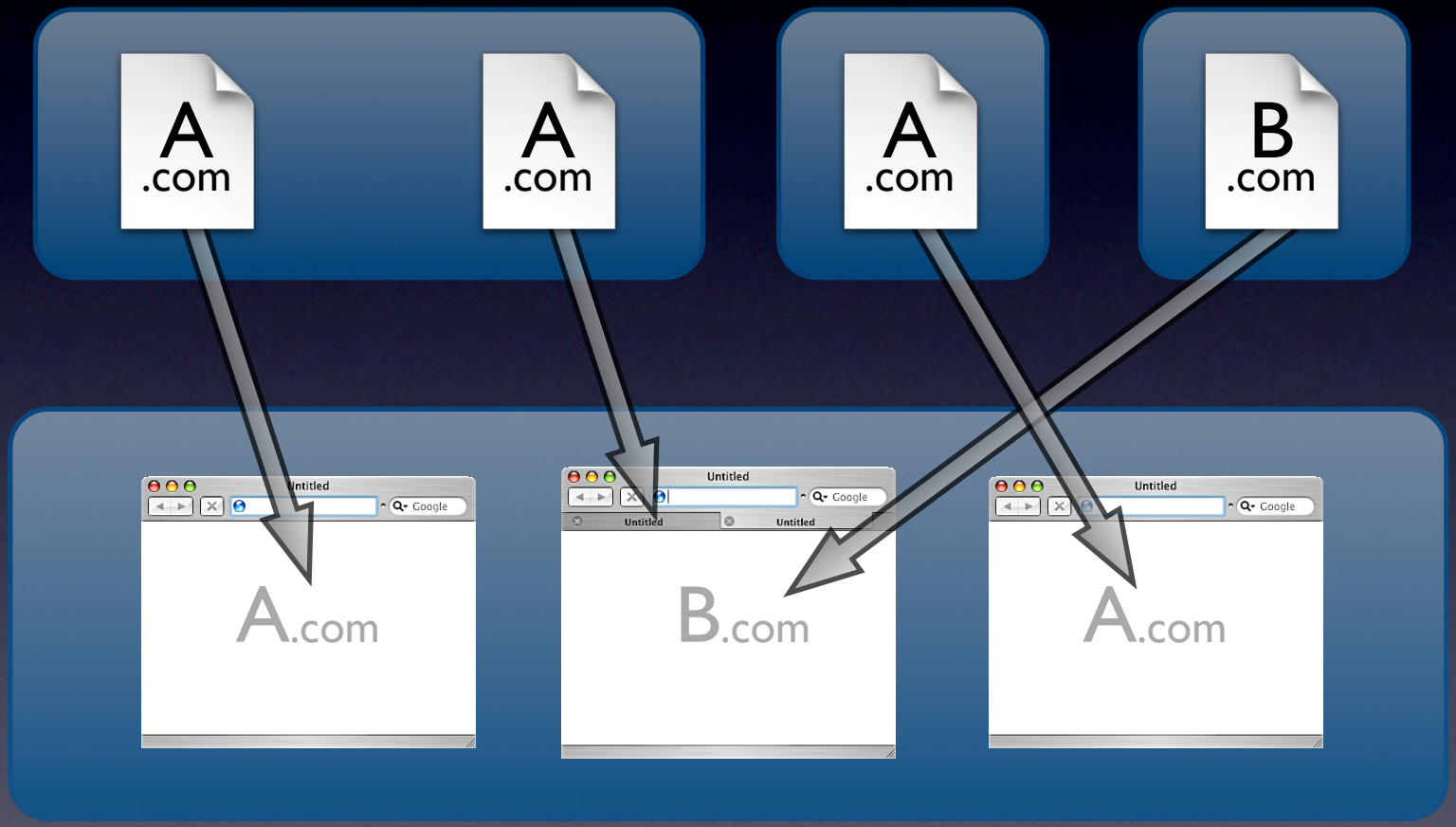
- Separate runtime environments

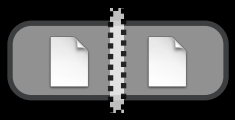
Proposal:

Isolation with Processes



Methodology

- Implement with KDE web browser
- Challenges:
  - What to isolate or share across sessions?
  - How to keep overhead low?
  - Will use of cookies need to change?



Proposal:

Evaluation

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- **Back Compat**: test popular content
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  - Characterize use of cookies
- **Efficiency**: overhead of sessions, calls
  - Are lightweight domains needed?

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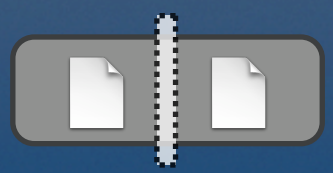
Threats

Isolation



Interposition

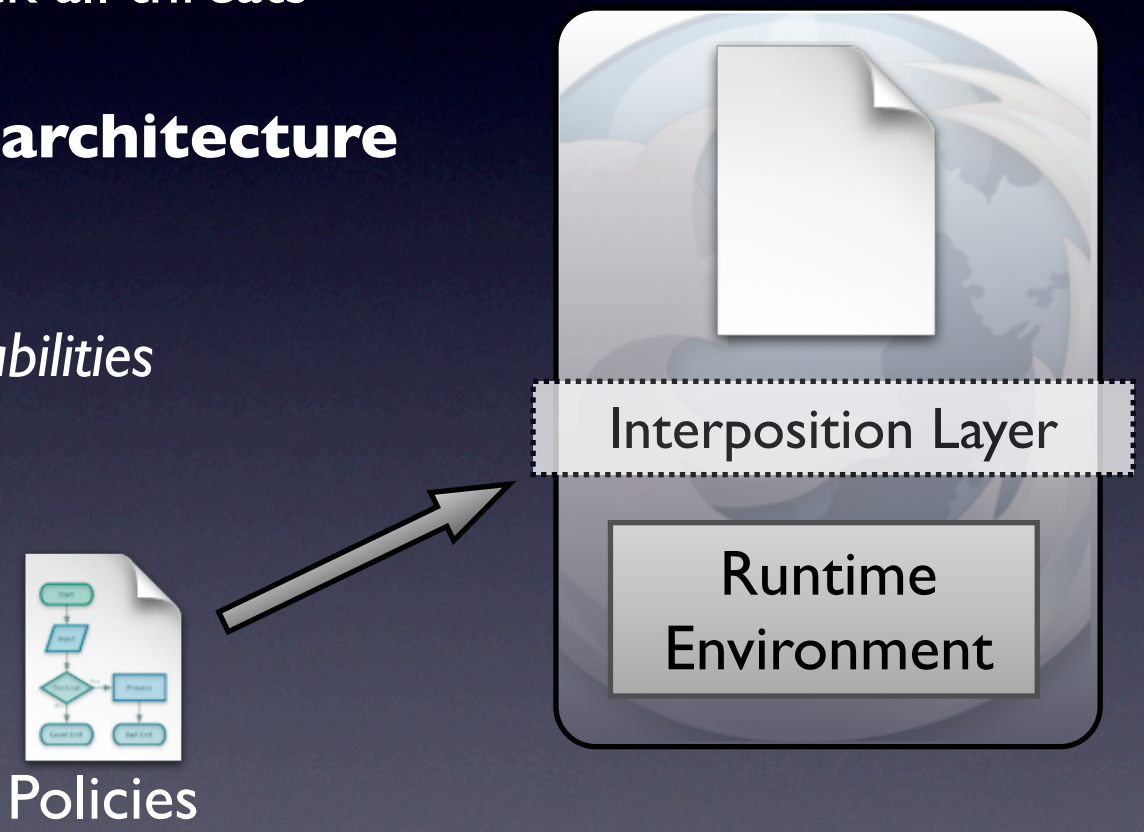
Future Work

Conclusion

Interposition & Policies

- Fixed policy doesn't block all threats
- **Extensible security architecture**
  [Wallach 97]

  1. *Defend browser vulnerabilities*
  2. *Block XSS attacks*

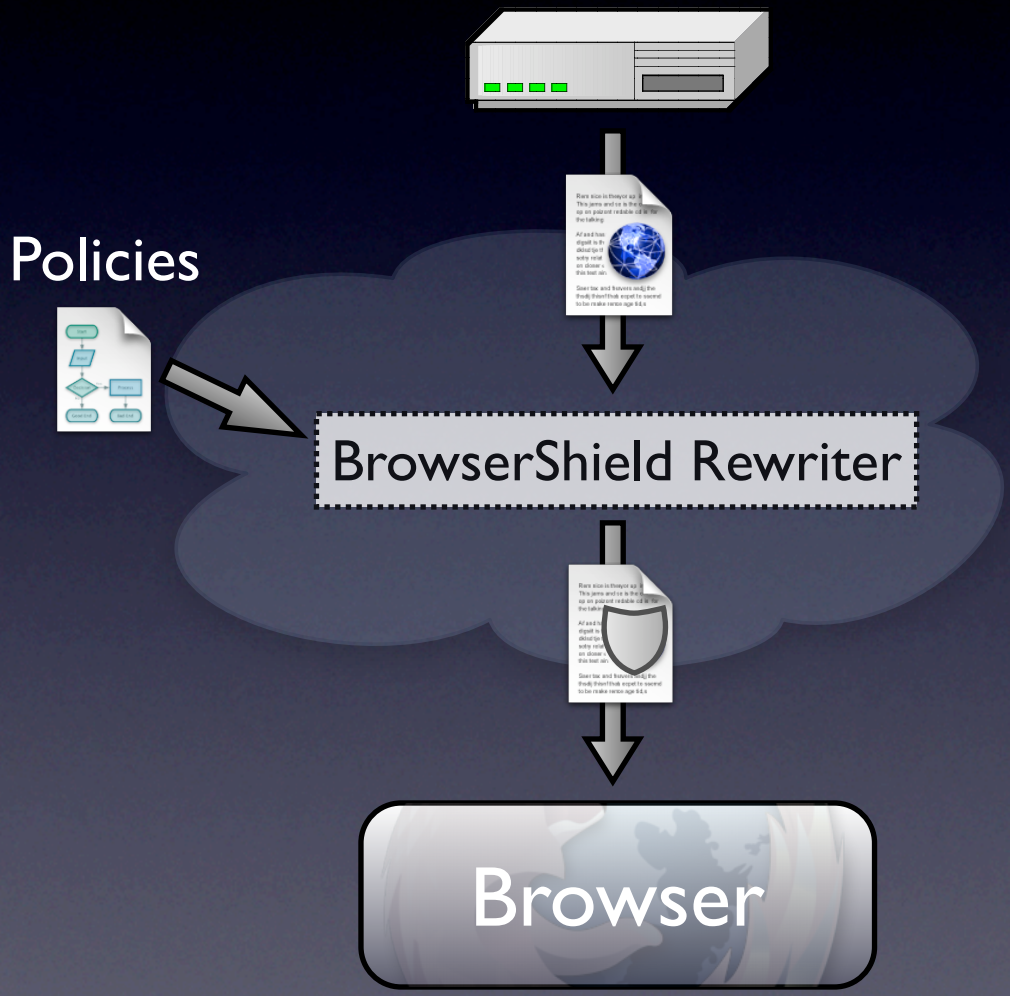


Interposition in OS

- System call interposition
  [Goldberg 96, Garfinkel 04]
- Code rewriting
  [Erlingsson 00]
- Vulnerability Filtering
  [Wang 04]

Preliminary Work:

BrowserShield



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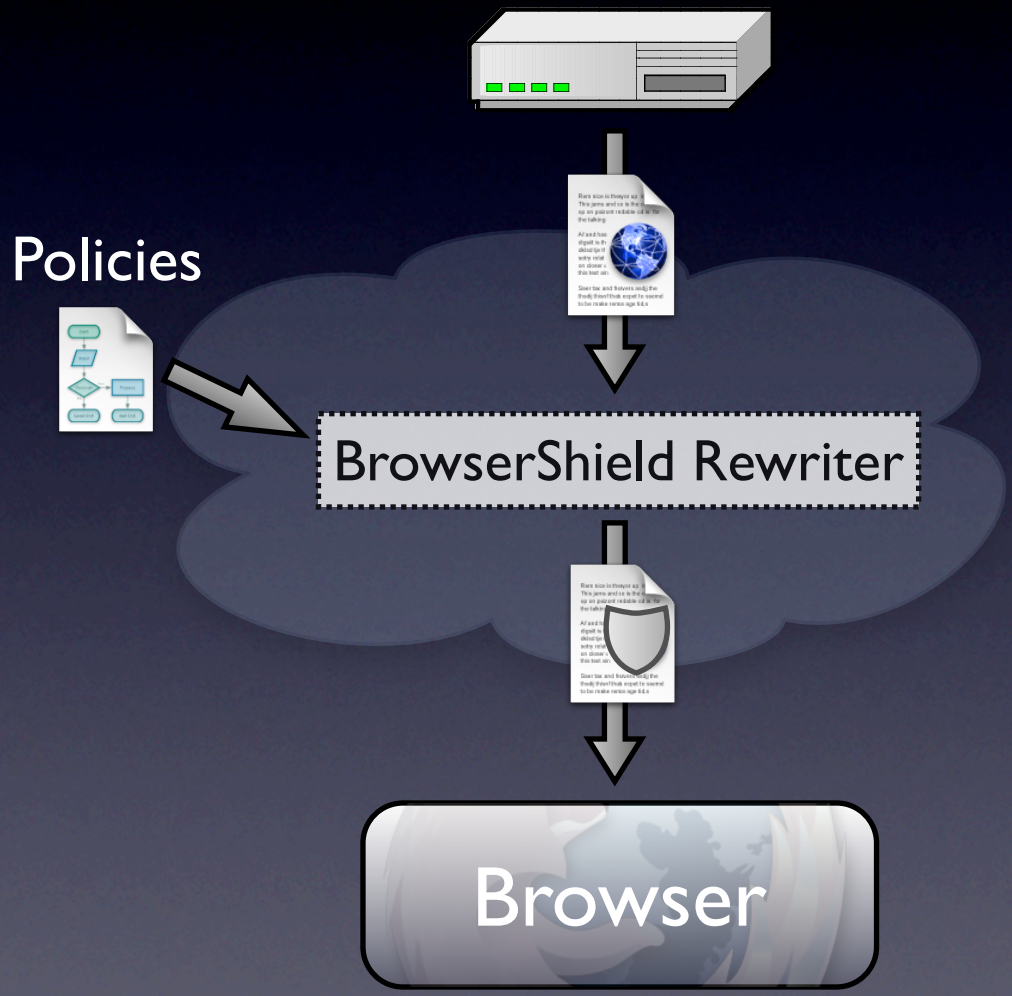
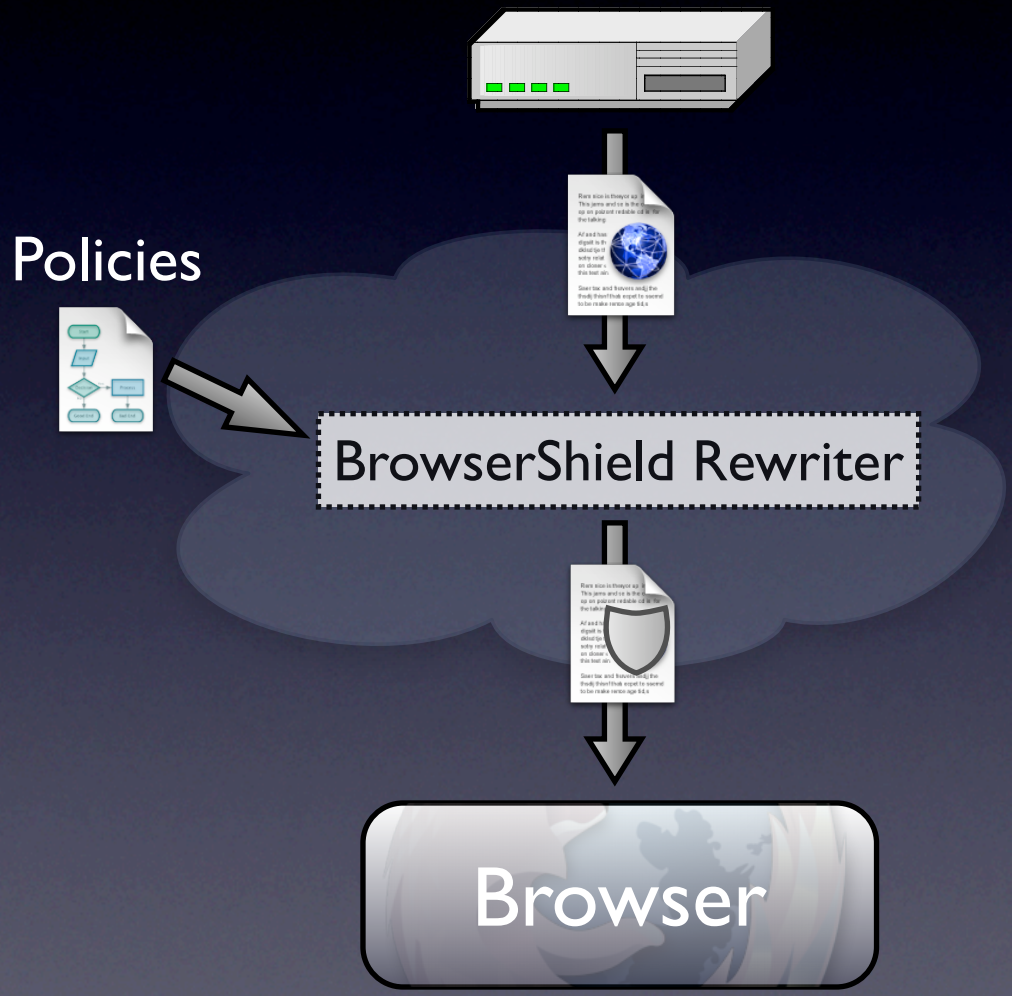


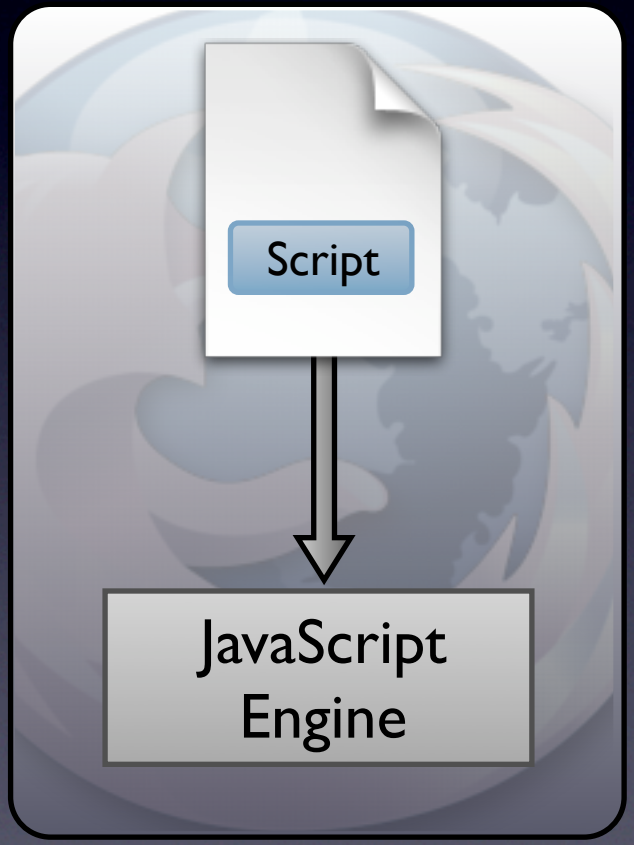
- **Code Rewriting**
  - Interpose on HTML and JavaScript code

BrowserShield



- **Code Rewriting**
  - Interpose on HTML and JavaScript code
- **Vulnerability Policies**
  - Block all exploits of known vulnerabilities

Script Whitelists



Script Whitelists

- **Intercept JavaScript**
  - Independent of quirky HTML parsing

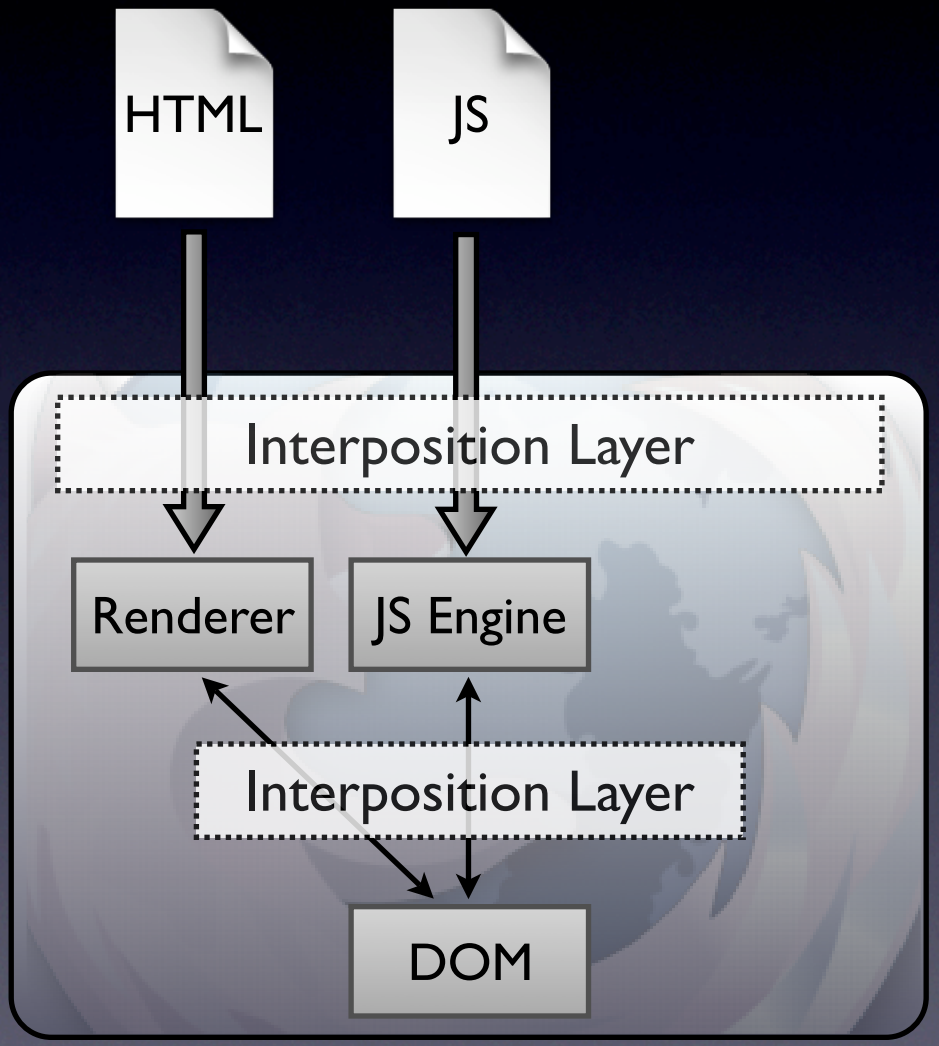
Preliminary Work:

Script Whitelists

- **Intercept JavaScript**
  - Independent of quirky HTML parsing
- **Page provides whitelist**
  - Prevents XSS attacks
  - Practical to deploy

Proposal:

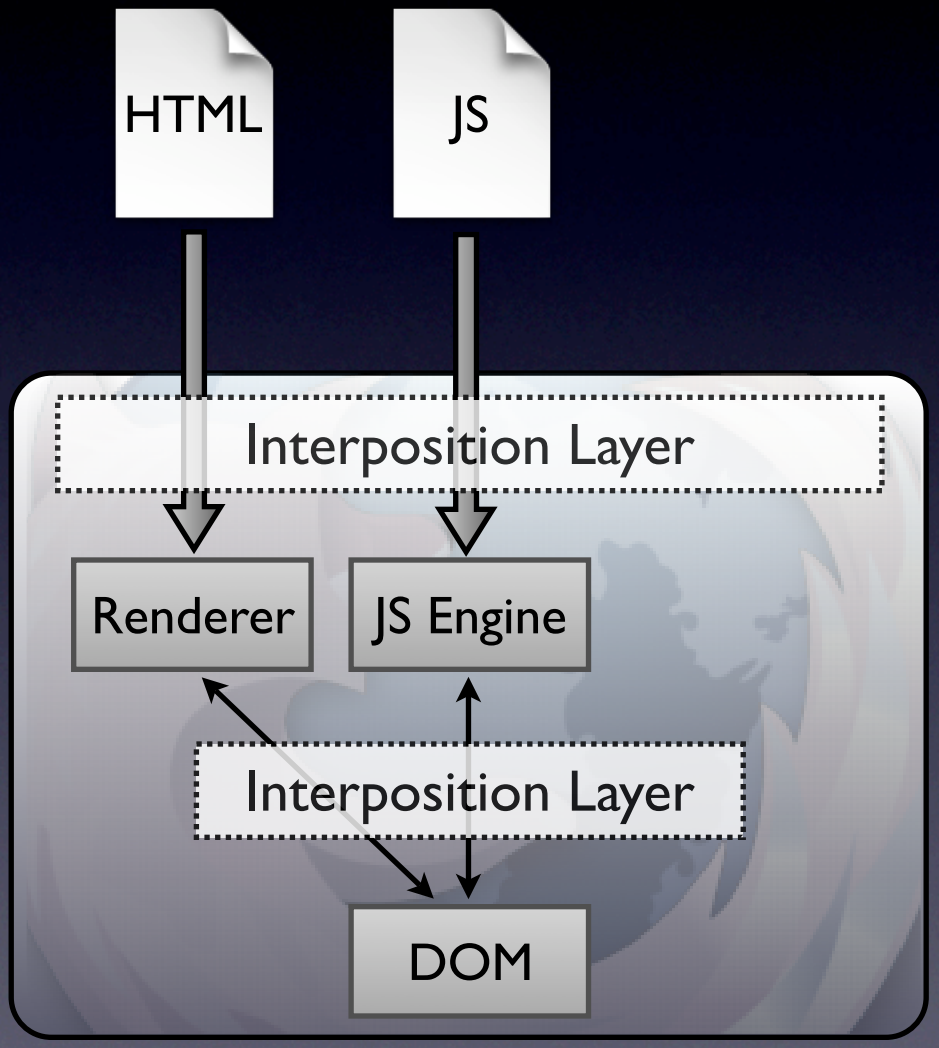
Interposition Layer



Proposal:

Interposition Layer

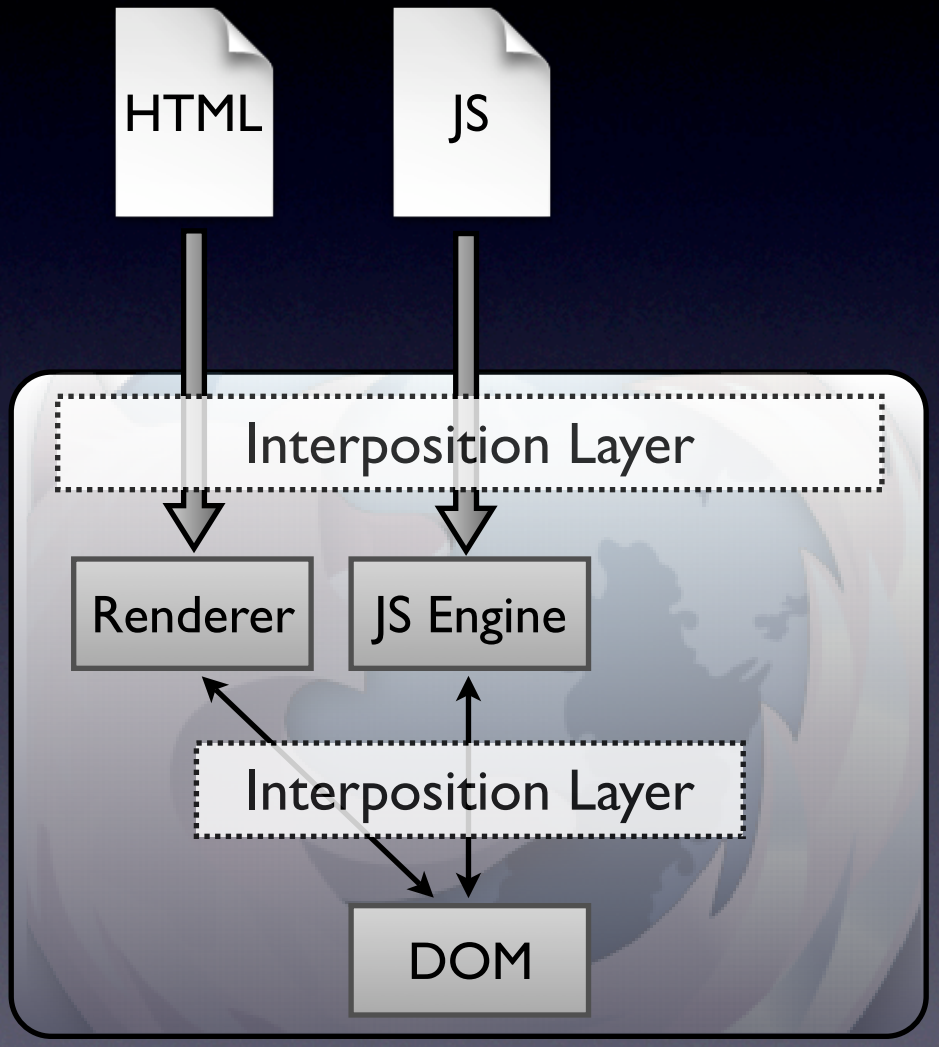
- Interpose *within* browser



Proposal:

Interposition Layer

- Interpose *within* browser
- Uniform policies for web content of all formats



Proposal:

Interposition Layer

- Interpose *within* browser
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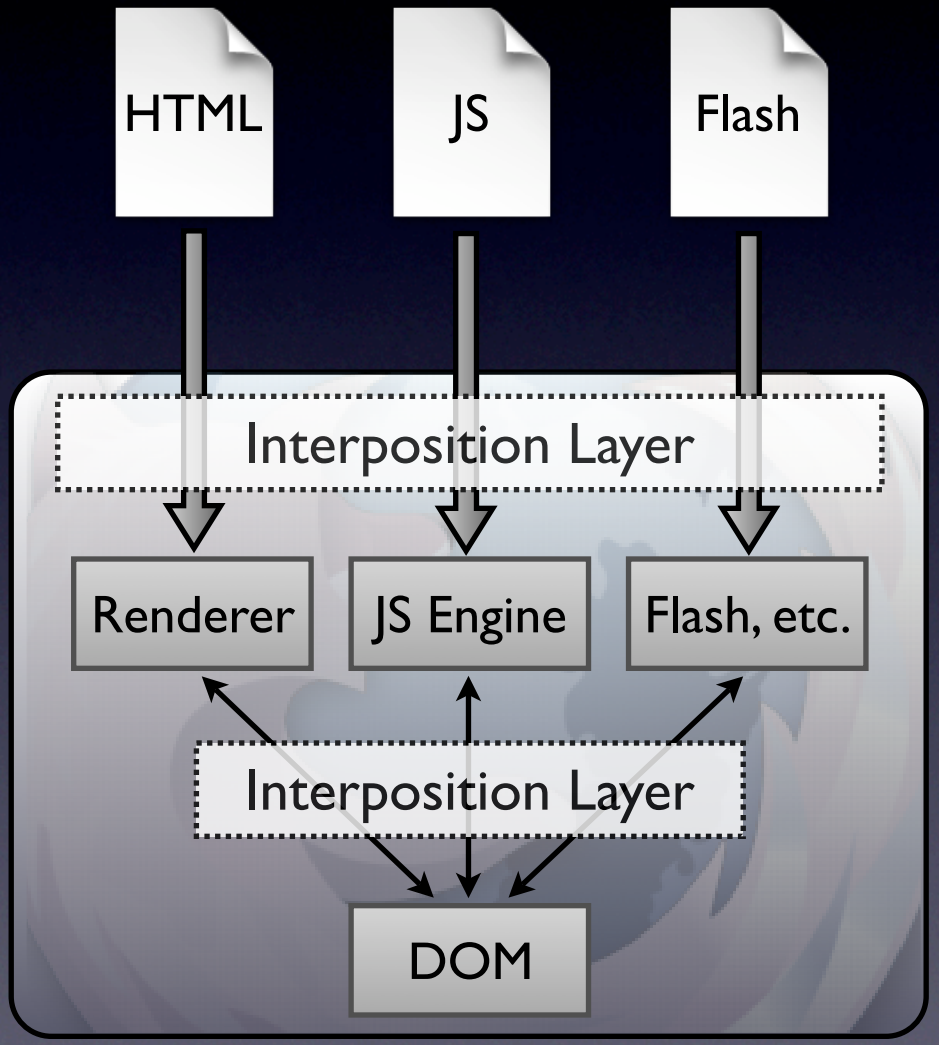
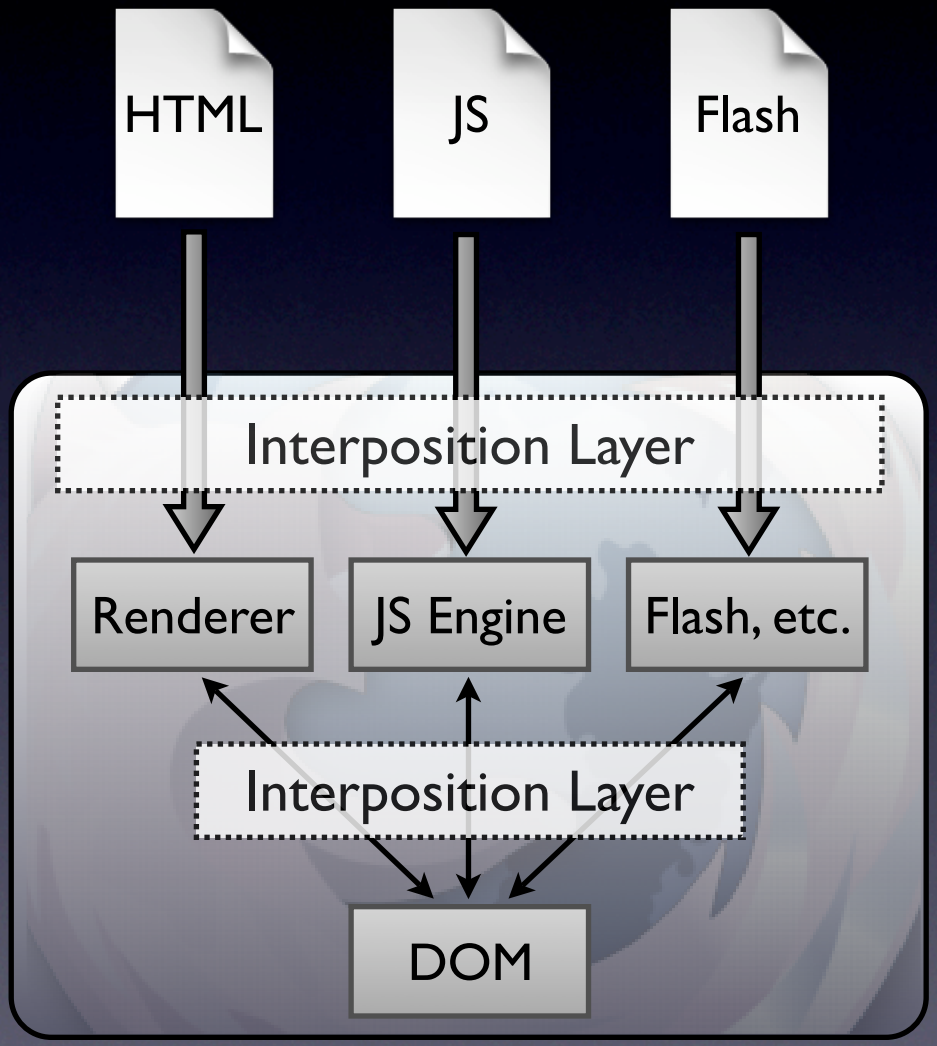


Proposal:

Interposition Layer

- Interpose *within* browser
- Uniform policies for web content of all formats
- Expose *hooks* for policies:
  - Raw input (e.g., HTML), DOM access, Communication



Proposal:

Security Policies

- **Policy hierarchy**
  - Browser, extensions, sessions, documents
- **Build sample policies**
  - Vulnerability shields
  - Script whitelists

Proposal:

Methodology

- Implement in Firefox (extension API)
- Challenges:
  - How to specify policies?
  - Expressive with low overhead?
  - How much can plugins be confined?

Proposal:

Evaluation

Evaluation

- **Safety**: can it support safer policies?
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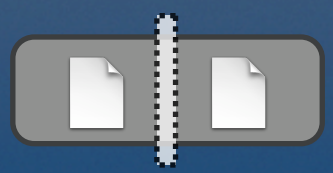
- **Safety**: can it support safer policies?
  - Test defense against exploits, XSS
- **Back Compat**: do policies break pages?
  - Same popular content tests
- **Efficiency**: overhead of layer and policies?
  - Micro/macro benchmarks

Outline

- Motivation
- Threats
- Isolation



- Interposition

- **Future Work**
- Conclusion

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- **Communication** between sites
  - *Better support for "mashups"*
- Support for new **phishing defenses**
  - *Visual indicators of sessions*
- Platform for deploying **security research**
  - *Distribute as policies*

Conclusion

- OS mechanisms can improve web browsers
  - **Isolation** prevents interference
  - **Interposition** allows flexible policies
- Will prevent threats with few costs