Conflicts of Interest

Approaches to Extensible System Design

Benjamin Lerner

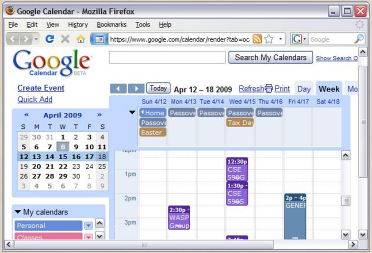
April 17, 2009

The Web is Changing

Then...

- Static text
- Static links

...Now



- Multimedia
- RSS
- AJAX
- Social networks
- Dynamic content

The Browser is Changing

- Scripting
  - Extensive DOM (API between script and page)
  - Performance++ for interactive pages
- New content types (, , , ...)
- New features
  - Tabbed browsing
  - Custom toolbars
  - User scripts
- New kinds of interactions
  - StumbleUpon
  - Twitter
  - Remember the Milk

How to keep up?

- Ignore it: lynx
- Support new content types: …
- Support new features by hard-coding:
- Some support limited new interactions:
- Only one permits arbitrary extension:

Extensibility

- ✔ "A closed system cannot be all things to all people"
- ✔ Extensions customize to fit the user
- ✔ Add "missing" features later as extensions

- ✖ Extensions can cause conflicts, confusion

  - ▶ How can we reason about extensions?

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Can we classify the *extension models* of these systems in a uniform way, and use that description to define the extension model of browsers?

Outline

Browsers and extensions

Browsers	Operating Systems	*Abilities*

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Plugins: Flash, PDF, Java …	Device drivers	*Arbitrary new code*

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Browsers	Operating Systems	*Abilities*
Plugins: Flash, PDF, Java …	Device drivers	*Arbitrary new code*
Extensions	???	*System-wide changes*
User scripts	Remote thread injection	*Limited per-app tweaks*

What can Firefox extensions do?

- New functionality: (just some of thousands)
  - *Web-of-Trust* rates links by "trustworthiness"
  - *Tab Preview* shows thumbnail views of tabs
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- New policies:
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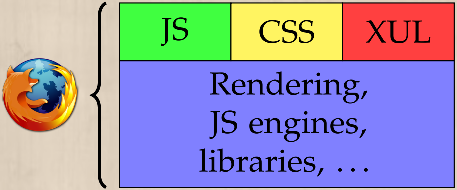
- New appearance:
  - *Personas* are lightweight themes for the browser
  - *Slashdotter* is a site-specific tweaker

How do Firefox extensions work?



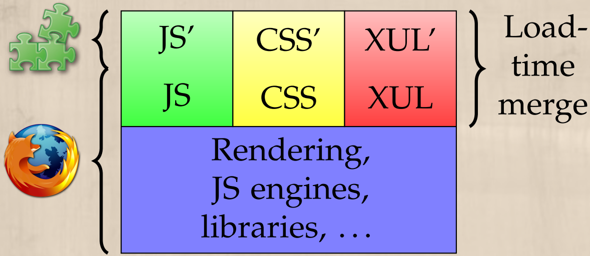
- Firefox defines its UI using scripts, XUL (like HTML) and CSS
- XUL defines a DOM similar to standard web programming

How do Firefox extensions work?

JS′	CSS′	XUL′
JS	CSS	XUL
Rendering, JS engines, libraries, …		

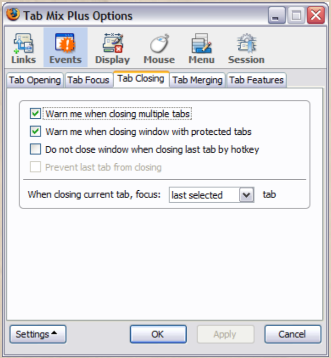
- Extensions also define their UI using scripts, XUL and CSS

How do Firefox extensions work?



- Firefox and extension definitions are *merged* at load time

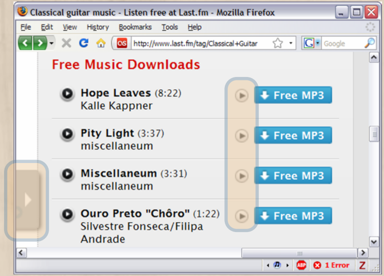
Resource Conflict: TabMix Plus + others




```
var guid_list = {};
/*
The following extensions are integrated or incompatible with Tab Mix Plus
add extensions ID in lowercase.
*/
guid_list[...] = true; // Basics
guid_list[...] = true; // BlankLast
guid_list[...] = true; // Click2Tab
guid_list[...] = true; // Close Tab On Double Click
guid_list[...] = true; // CTC
guid_list[...] = true; // Duplicate Tab
guid_list[...] = true; // Flowing Tabs
guid_list[...] = true; // FLST
guid_list[...] = true; // LastTab
guid_list[...] = true; // MiniT
guid_list[...] = true; // miniT-drag
guid_list[...] = true; // miniT-tabscroll
guid_list[...] = true; // new tab button on tab bar
guid_list[...] = true; // new tab homepage
guid_list[...] = true; // NewTabURL
guid_list[...] = true; // Petite Tabbrowser Extensions
guid_list[...] = true; // ReloadEvery
guid_list[...] = true; // Reload Tab On Double-Click
guid_list[...] = true; // Scrollable Tabs
guid_list[...] = true; // Single Window
guid_list[...] = true; // Stack style tabs
guid_list[...] = true; // superT
guid_list[...] = true; // Tab Bin
guid_list[...] = true; // Tab Clicking Options
guid_list[...] = true; // Tab Mix (original one)
guid_list[...] = true; // Tab to window
guid_list[...] = true; // Tab X
guid_list[...] = true; // Tabbrowser Extensions
guid_list[...] = true; // Tabbrowser Preferences
guid_list[...] = true; // tabdrag-for-tablib
guid_list[...] = true; // TabFX
guid_list[...] = true; // Tabs open ralative
guid_list[...] = true; // tablib
guid_list[...] = true; // Undo Close Tab
guid_list[...] = true; // Undo Close Tab
guid_list[...] = true; // Unread Tabs
```

- TabMix Plus combines dozens of extensions' abilities
- …and either disables *or modifies* them for compatibility
- …and does an incomplete job

Policy Conflict: FoxyTunes + FlashBlock



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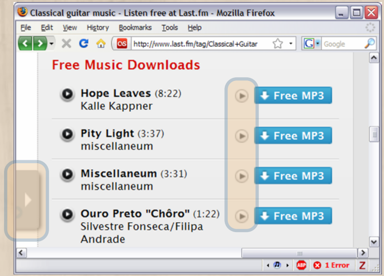

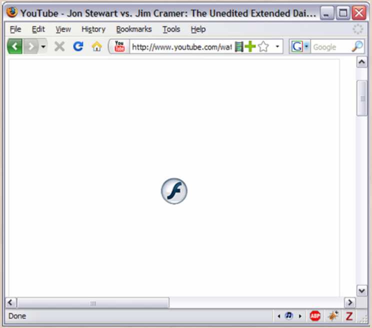

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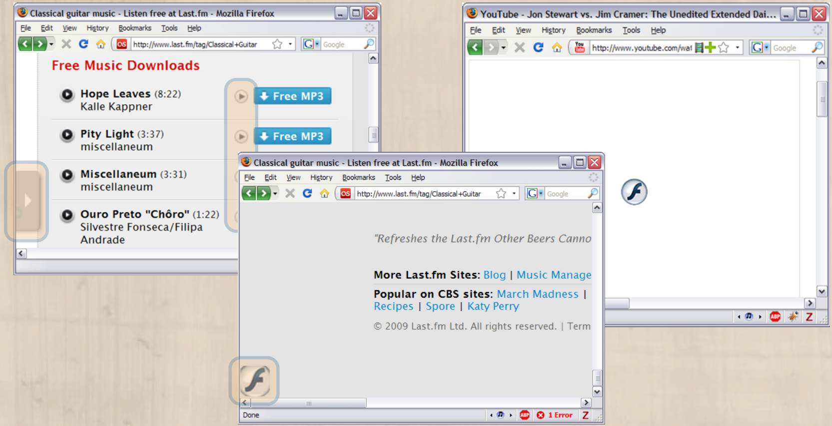

- FoxyTunes inserts a Flash object to stream MP3s
- FlashBlock blocks all Flash, including FoxyTunes'

Temporal Conflict: Linkify + Printify

* *Contrived example*

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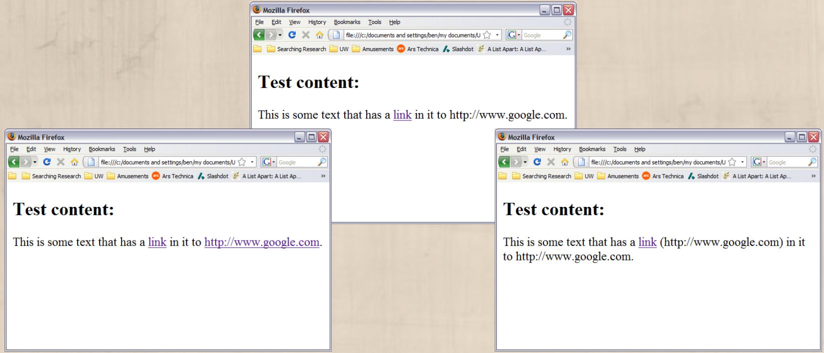

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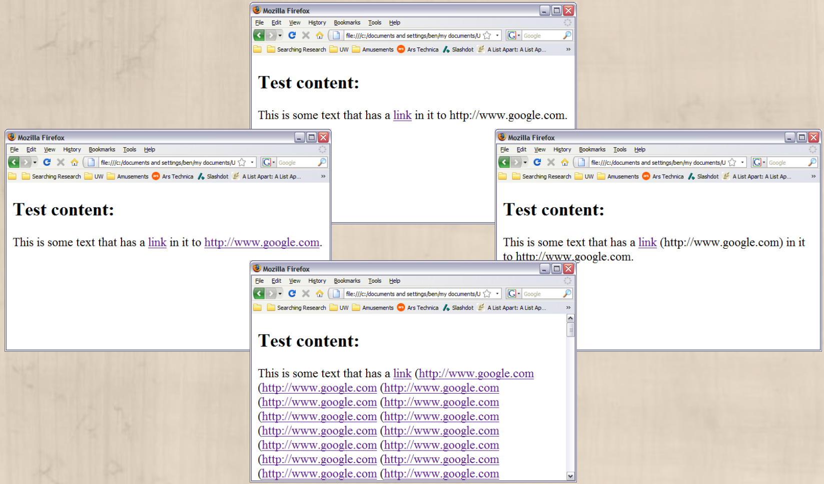

** Contrived example*

So. . . let's reject all interactions?

- Overkill — *some* interactions are good
  - FireBug + Firecookie, YSlow, Jiffy: website debugger + cookies, profilers
  - Lightning + GData: calendar + Google calendar support
  - . . .
- Ill-defined — *which* ones are good?

Recap

- ✔ Browsers merit extensions
- ✔ Extensions *should* interact
- ✖ Extensions can conflict

We need:

- a way to describe these interactions and conflicts
- to resolve conflicts

Extension model

- An *extension model* describes how extensions apply to a base system:
  - what they can do
  - how powerful they are
- It describes how extensions may break each other, too

✔ A fully-designed extension model gives
  - ✔ stable expectations for extension authors
  - ✔ simple expectations for extension *users*

The classification scheme

- Design choices:
  - Behaviors
  - Authorship
  - Integration time
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Design Choices

Cooperation:

- How much support must the application author build in, to support extensions fully?

Antonym: *obliviousness*

- Can the application author pretend extensions don't exist?

Cooperation takes effort, planning

[Filman and Friedman 2000]

Extension Abilities

Pervasiveness:

- How much of the system can be affected by an extension?

Granularity:

- How small of a change is possible?

Higher pervasiveness *often* requires coarser granularity

Troubleshooting Techniques

Conflict:

- What interactions are unwanted?

Detection:

- How early can conflicts be found?
  design → *compile* → *install* → *load* → *run*

Earlier conflict detection usually requires more cooperation

Firefox's extension model

- Design choices:
- Extension abilities:
- Troubleshooting techniques:

Firefox's extension model

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  - Wide JS API
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- Troubleshooting techniques:
  - None, currently

Switching gears

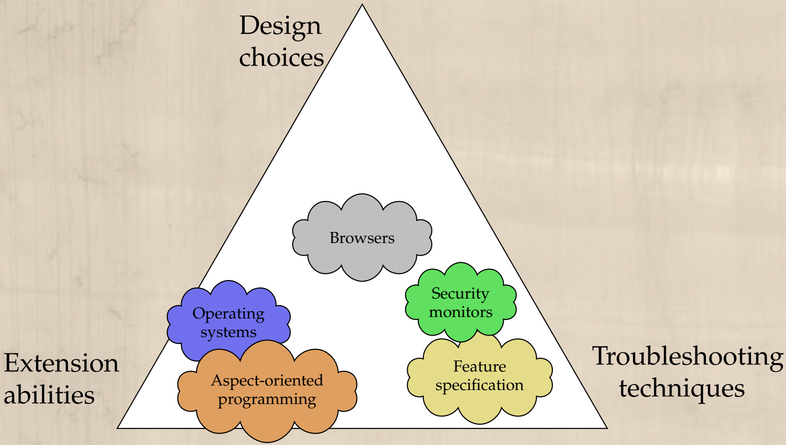
✔ Firefox's extension model is powerful…

✖ …but is not easily analyzable

- Other systems have dealt with adding new code:
  - Aspect-oriented programming
  - Operating systems
- Other systems have dealt with resolving problems:
  - Feature specification
  - Security monitors
- Draw inspiration from these systems

** See paper for details*

How does this apply?



[Denys et al. 2002; Keck and Kuehn 1998; Small and Seltzer 1996]

Primer:
Aspect-oriented programming: adding code

Key idea: In program *P*, when event *E* occurs, take action *A*
Example: “Log the filename on each call to `fopen()`”

Mainline

```
class Web {
  bool showPage(...) {
    ...

    fopen("foo.html");
    ...
    if (...)

      fopen("bar.html");
    ...
    return true;
  }
}
```

Aspect

Before every `fopen`
From `fopen(fname)`
  log `fname`

[Kiczales et al. 2001]

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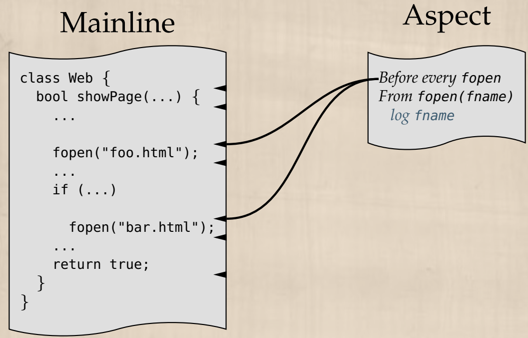

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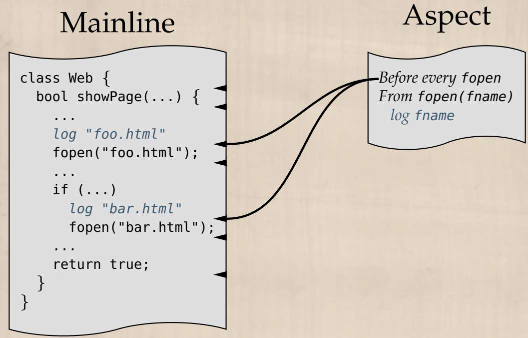

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Operating systems: controlling extensions

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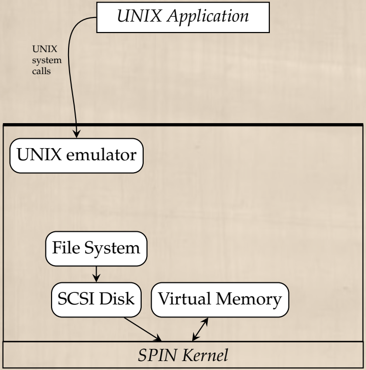
Example: “Add a transactional memory subsystem”



[Saito and Bershad 1998]

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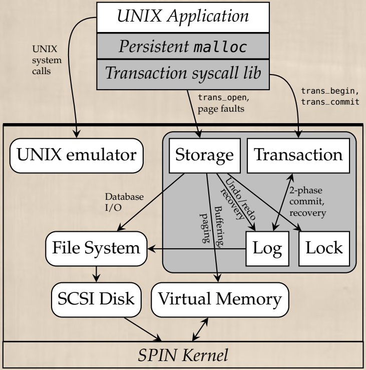

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Feature specification: finding problems

Key idea: Check for conflicts in model of program

Example: "How should call forwarding work?"

Basic phone calls:

$$\mathtt{ALWAYS}(calls(a,b) \rightarrow \mathtt{EVENTUALLY}(talk(a,b) \vee hangup(a)))$$

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- Is there a conflict?
- How to resolve it?
  - How to indicate call-forwarding should "win"?

[Felty and Namjoshi 2003]

Primer:
Security monitors: resolving problems

Key idea: Ensure a program obeys all policies at all times
Example: “Block all pictures in spam in `downloadMsg()`”

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class Mail {
  Msg downloadMsg(...) {
    bin = getIMAPMsg(...);
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    for each (attach in msg) {

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    msg = decodeIMAP(bin);
    spam = Check.isSpam(msg);
    for each (attach in msg) {
      if (spam && Check.isImg(attach)) next;
      bin = get(attach);
      msg.append(decode(bin));
    }
    return msg;
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Extension abilities (1):

Idea: Require more cooperation…

- for granularity and pervasiveness:
  - Let mainline authors declare extension points

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[Dantas and Walker 2006]

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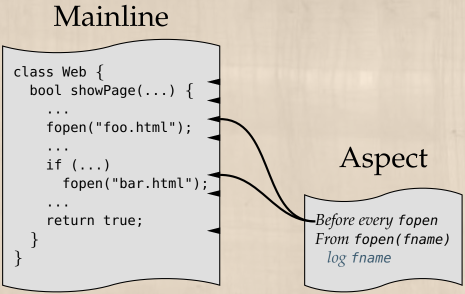

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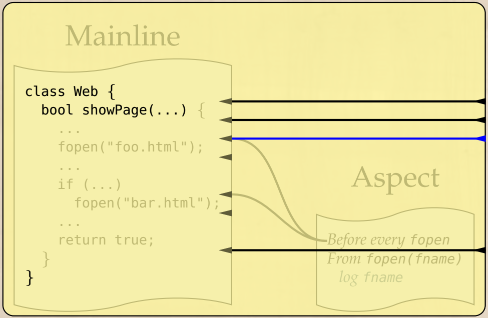

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Module

```
class Web {
  bool showPage(...)        joinpoint construct-Web;
                            joinpoint before-showPage;
                            joinpoint p;



                            joinpoint after-showPage;
}
```

[Aldrich 2005]

Extension abilities (2):

Idea: Sacrifice pervasiveness for modular detection

- Use opaque types for capabilities
  - E.g. a `Console.T*` gives access to a console
  - ✓ Prevents all forged inputs

[Bershad et al. 1995]

Extension abilities (2):

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- Use session types to define protocols
  - E.g. for a network card,
    `READY: NicEvt!` → `?AckEvt` → `READY`
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  - …leads to feature specification

[Hunt and Larus 2007]

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[Hunt and Larus 2007]

- Explicitly declare all resources in a manifest
  - State dependencies, modifications, etc.
  - ✔ Check each manifest modularly against base program

[Plath and Ryan 2001]

Troubleshooting techniques:

Idea: Resolve conflicts…

- by letting extensions extend each other
  - "mediator extensions"

Policy 1

Before every `get`
From `get(attach)`
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Policy 2

Before every `get`
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[Bauer et al. 2005]

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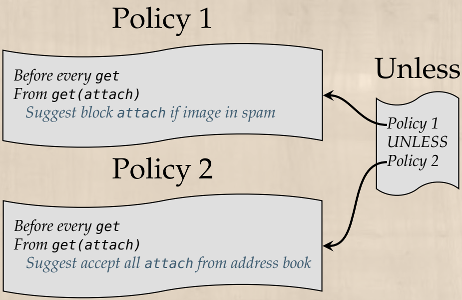

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- by requiring cooperation from *extension authors*
  - needed for extensions to extend each other

$$\mathtt{ALWAYS}(calls(a, b) \rightarrow \mathtt{EVENTUALLY}(forward(a, b, c) \vee hangup(a)))$$

[Li et al. 2005]

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- by requiring cooperation from *extension authors*
  - needed for extensions to extend each other

$$\texttt{ALWAYS}(\mathit{calls}(a,b) \rightarrow \texttt{EVENTUALLY}(\mathit{talk}(a,b) \vee \mathit{hangup}(a))\texttt{UNLESS}\ X)$$

$$\texttt{ALWAYS}(\mathit{calls}(a,b) \rightarrow \texttt{EVENTUALLY}(\mathit{forward}(a,b,c) \vee \mathit{hangup}(a))\texttt{UNLESS}\ Y)$$

Add an axiom $\mathit{talk}(a,b) \neq \mathit{forward}(a,b,c)$

[Li et al. 2005]

TabMix Plus + others

Key problem: no declarative manifest

- Use *declarative manifests* to claim resources
- …convenient: with XPath to name XUL nodes

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Key problem: code composition

- Detect weaving conflicts with *AOP techniques*
- …need namespaced, typed DOM APIs

FoxyTunes + FlashBlock

Key problem: no declarative manifest

- Use *Singularity manifests* as before

FoxyTunes + FlashBlock

Key problem: no declarative manifest

- Use *Singularity manifests* as before

Key problem: no clear policy for FlashBlock

- Define an *explicit security policy*
- Detect conflict with FoxyTune's actions
- Define *higher-order policies* to revise one or both extension

Linkify + Printify

Key problem: no temporal dependencies

- Define Printify *feature* connecting <a> to text
- Define Linkify *feature* connecting text to <a>
- Make *extensions cooperate* to break the cycle

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- Make *extensions cooperate* to break the cycle

Key problem: aspect ordering

- Use *AOP techniques* to detect weaving conflicts

Conclusion

- The browser is a system deserving extensions
- Extensions can interact and conflict in odd ways

- We defined a classification scheme for extension models
- …and specialized it to the browser
- …and used other systems' extension models to address problems in the browser