Isolating Programs in Modern Browser Architectures

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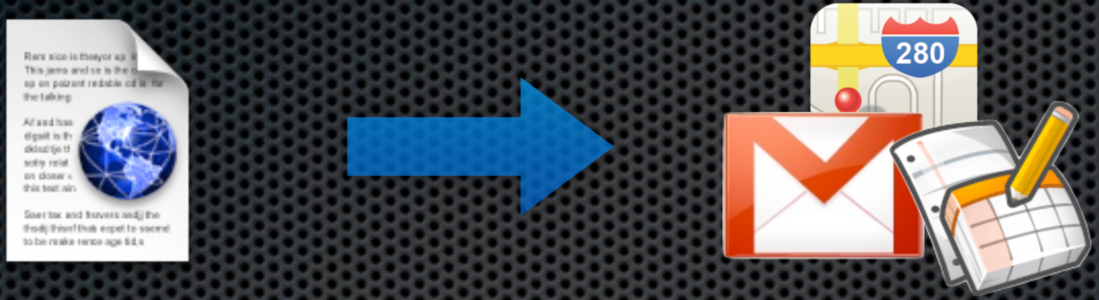
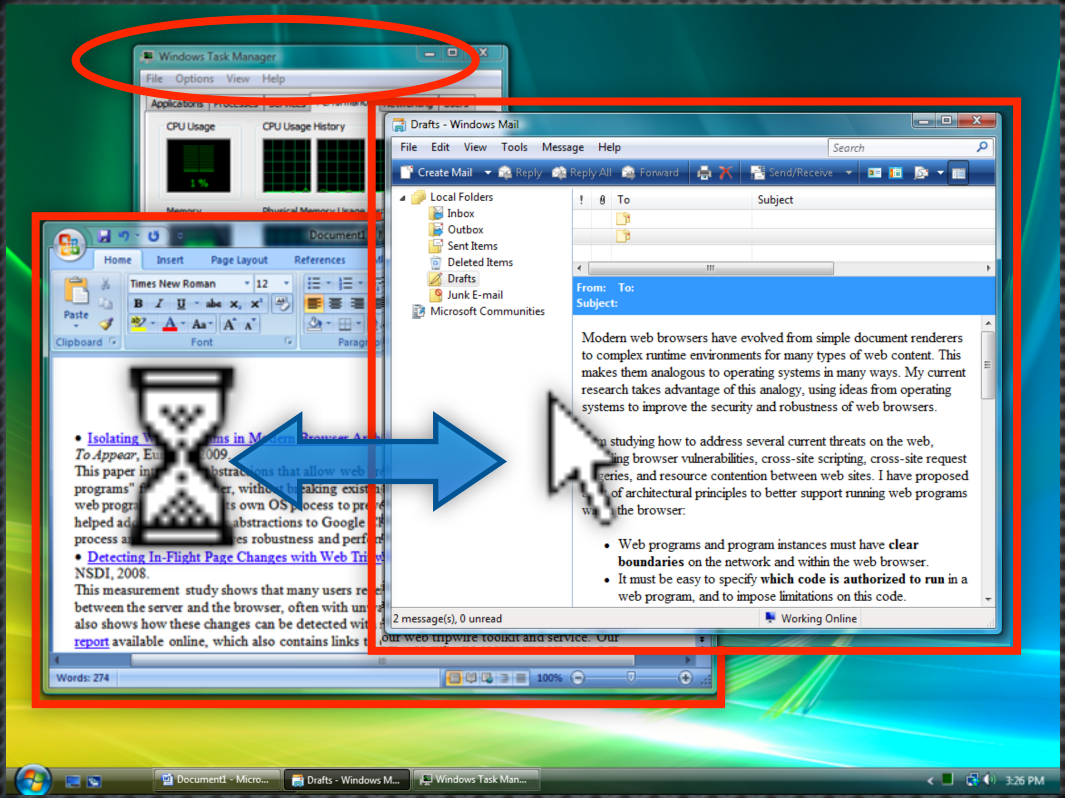
Web is Evolving



Pages *Programs*

- **More complex, active content**
- **Browser now in role of OS, but not designed for it**
  - Robustness and performance problems

Consider OS Landscape



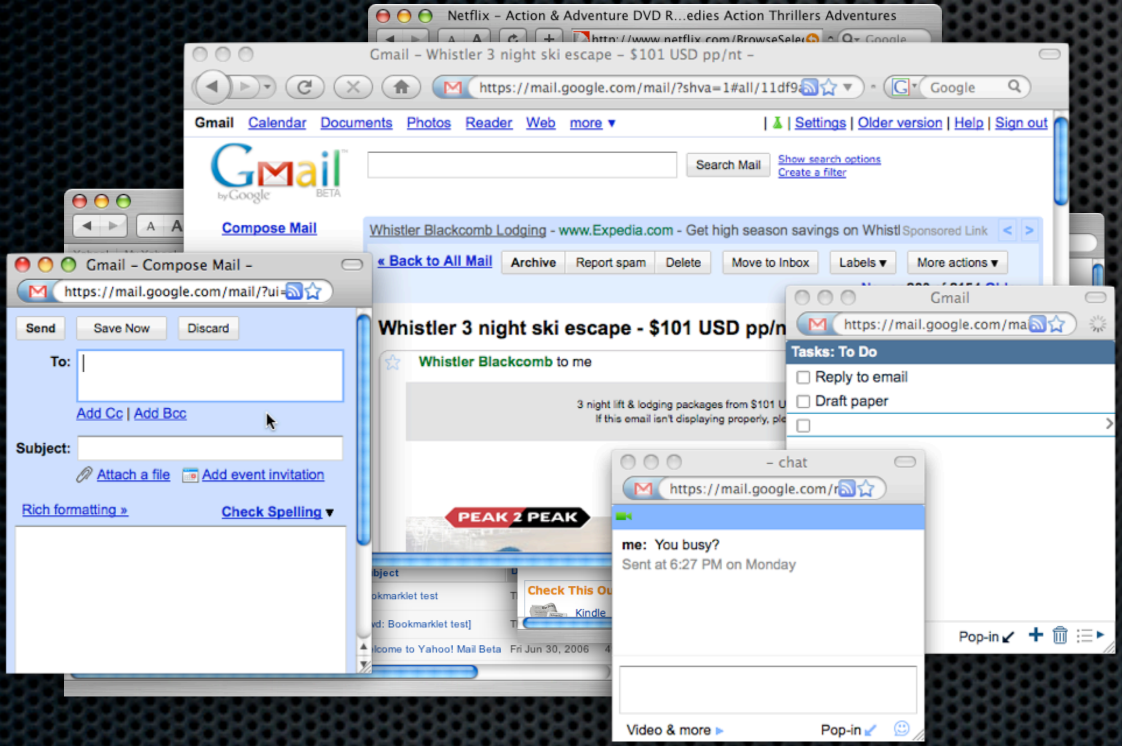
Modern web browsers have evolved from simple document renderers to complex runtime environments for many types of web content. This makes them analogous to operating systems in many ways. My current research takes advantage of this analogy, using ideas from operating systems to improve the security and robustness of web browsers.

n studying how to address several current threats on the web, ing browser vulnerabilities, cross-site scripting, cross-site request eries, and resource contention between web sites. I have proposed of architectural principles to better support running web programs wi the browser:

- Web programs and program instances must have **clear boundaries** on the network and within the web browser.
- It must be easy to specify **which code is authorized to run** in a web program, and to impose limitations on this code.

- Performance isolation
- Resource management
- Failure isolation
- **Clear program abstraction**

Browsers Fall Short


Netflix – Action & Adventure DVD R...edies Action Thrillers Adventures
Gmail – Whistler 3 night ski escape – $101 USD pp/nt –
https://mail.google.com/mail/?shva=1#all/11df9
Gmail Calendar Documents Photos Reader Web more ▾
Settings | Older version | Help | Sign out
Search Mail
Show search options
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Compose Mail
Whistler Blackcomb Lodging - www.Expedia.com - Get high season savings on Whistl Sponsored Link
« Back to All Mail
Archive
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Draft paper
Pop-in
– chat
https://mail.google.com/r
Video & more ▸
Pop-in

me: You busy?
Sent at 6:27 PM on Monday

- Unresponsiveness
- Jumbled accounting
- Browser crashes
- **Unclear what a program is!**

Outline

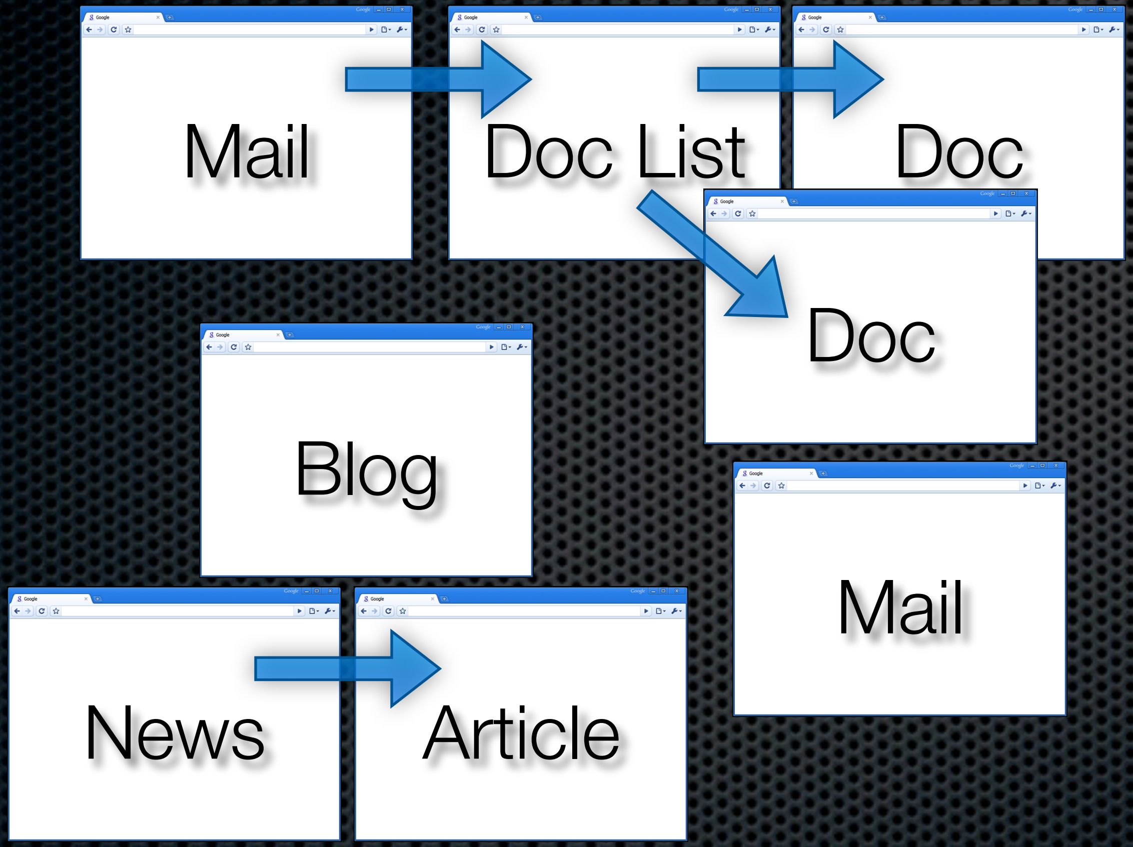
Looking for Programs

New Abstractions

Isolation in Chromium

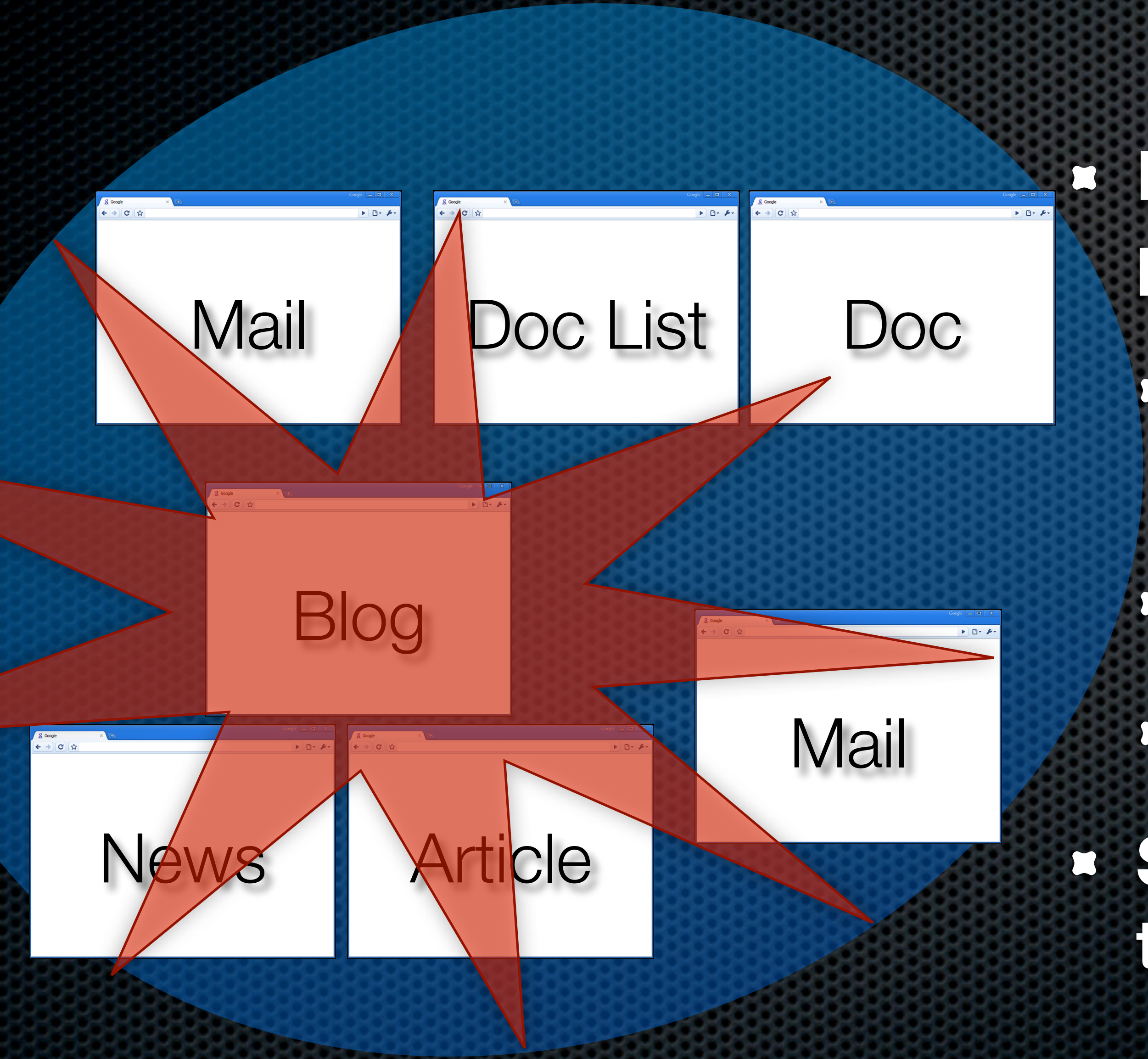
Evaluation

Programs in the Browser



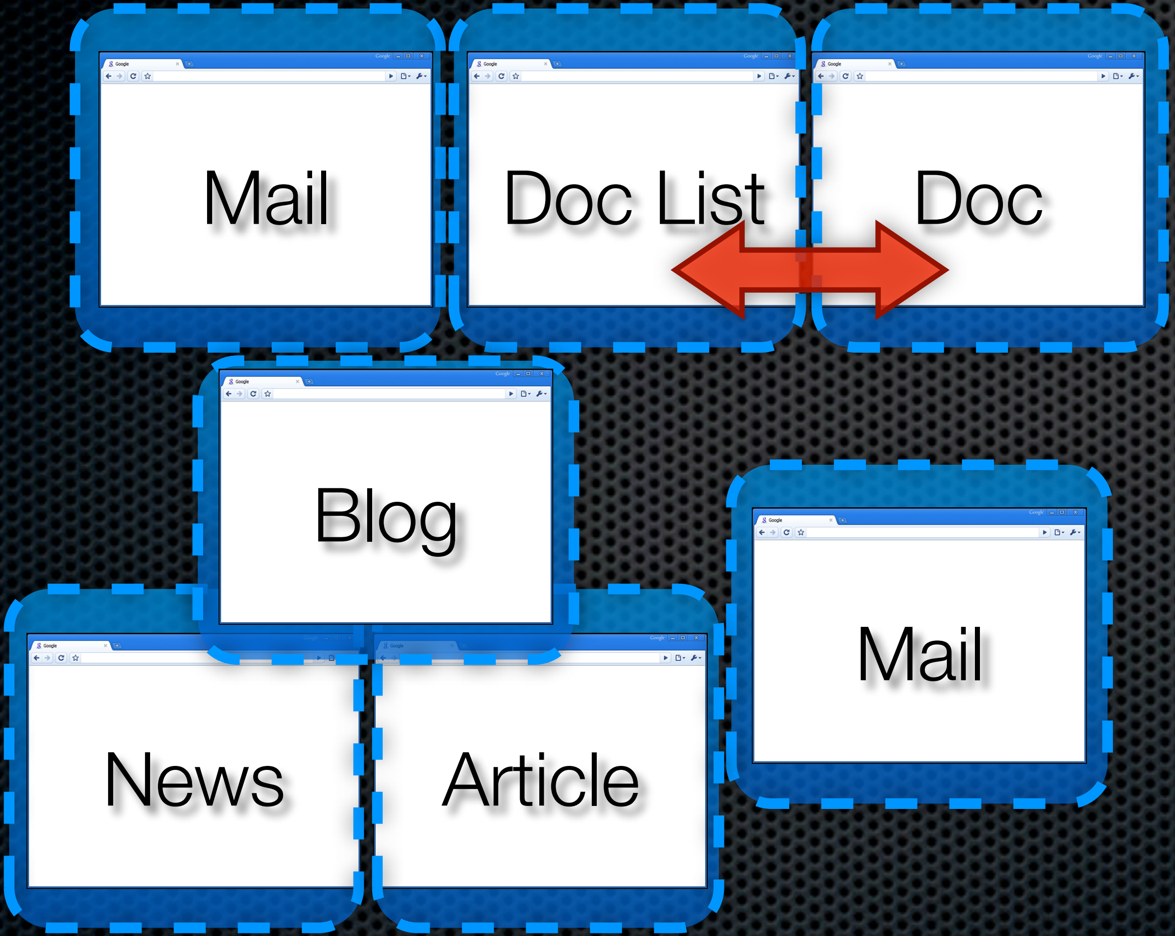
- Consider an example browsing session
  - Several independent programs

Monolithic Browsers



- **Most browsers put all pages in one process**
  - Poor performance isolation
  - Poor failure isolation
  - Poor security
- **Should re-architect the browser**

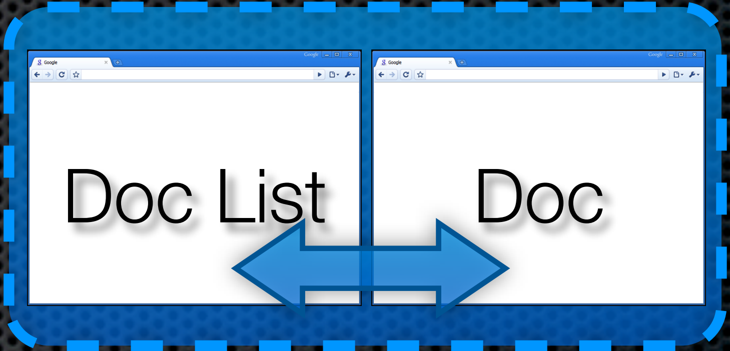
Process per Window?



- **Breaks pages** that directly communicate
  - Shared access to data structures, etc.
- **Fails as a program abstraction**

Need a Program Abstraction

- Aim for **new groupings** that:
  - **Match our intuitions**
  - **Preserve compatibility**
- Take cues from browser's existing rules
- Isolate each grouping in an OS process
- Will get **performance and failure isolation**, but not security between sites



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Ideal Abstractions

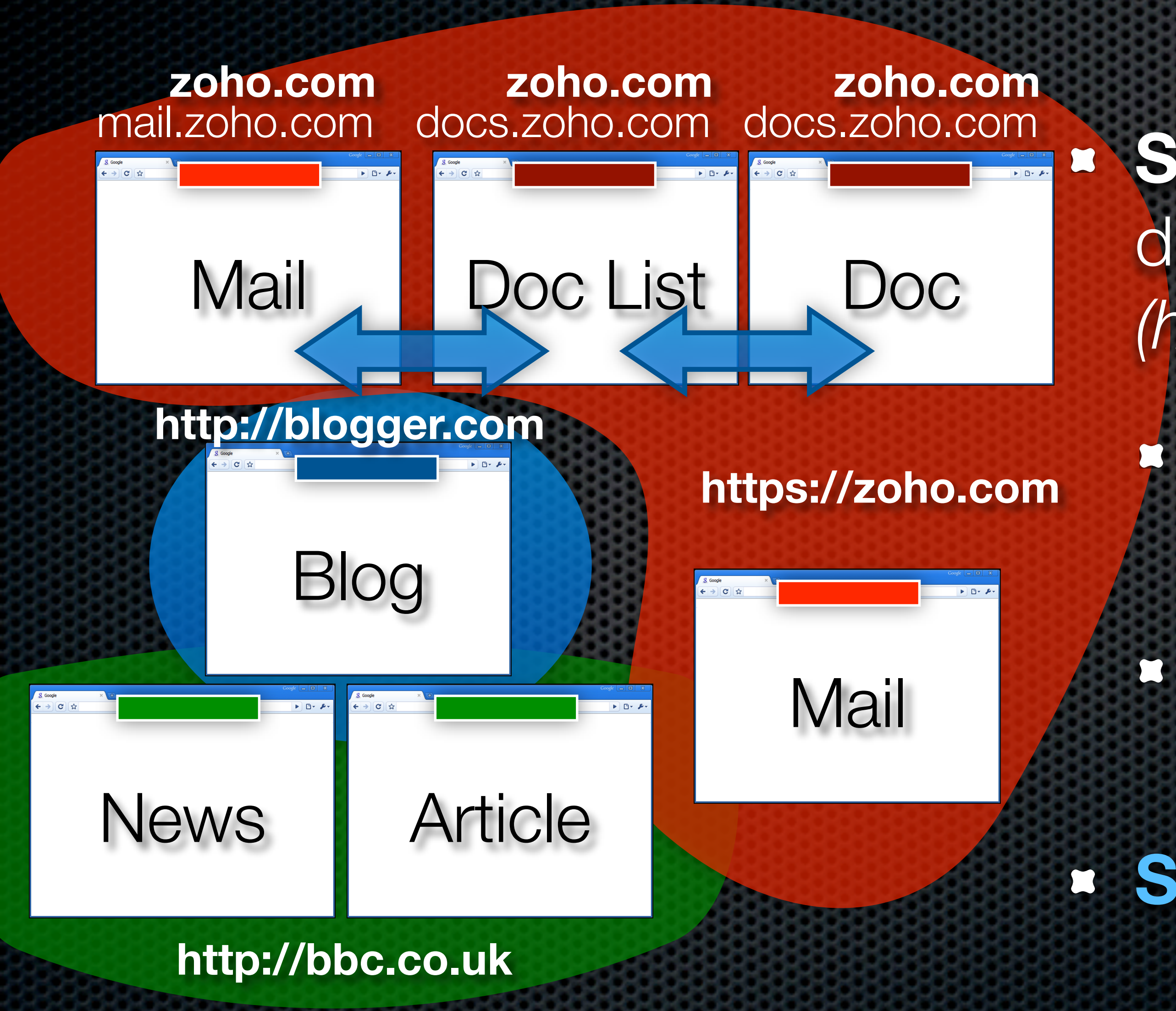
- **Web Program**
  - Set of pages and sub-resources providing a service
- **Web Program Instance**
  - Live copy of a web program in the browser
  - Will be isolated in the browser's architecture

Intuitive, but how to define concretely?

Compatible Abstractions

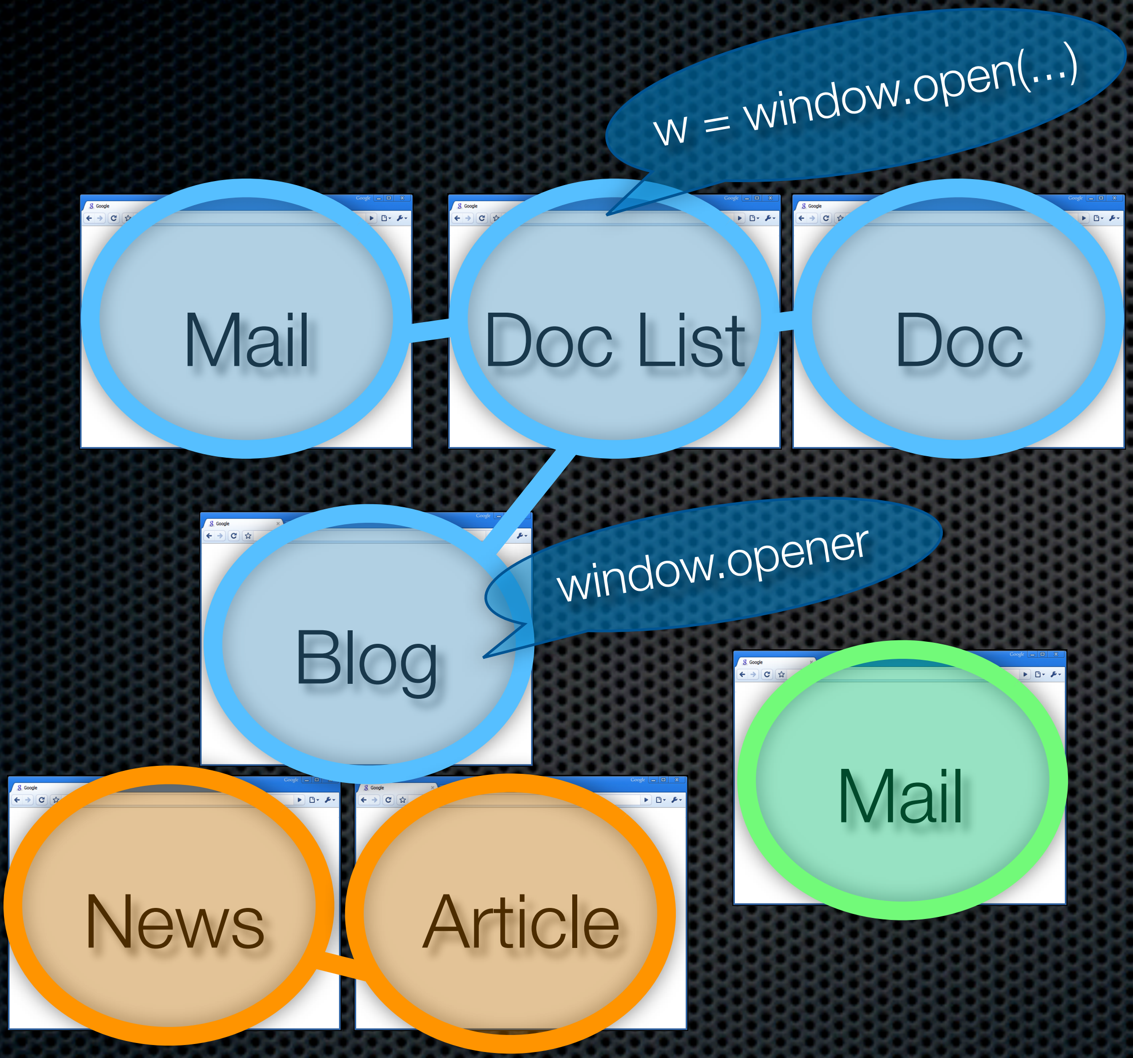
- Three ways to group pages into processes:
  1. **Site:** based on browser's *access control policies*
  2. **Browsing Instance:** *communication channels* between pages
  3. **Site Instance:** intersection of the first two

1. Sites



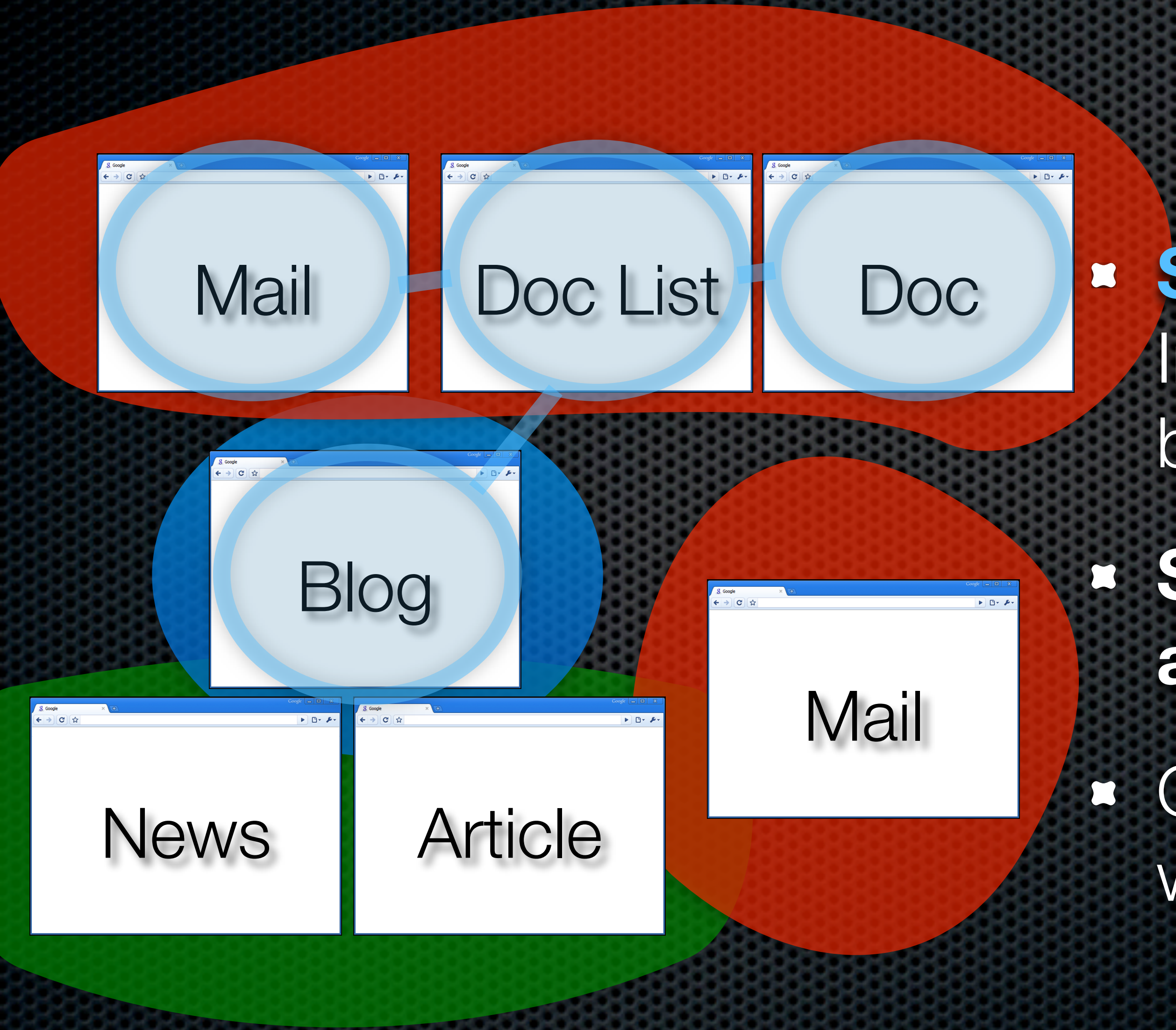
- **Same Origin Policy** dictates some isolation *(host+protocol+port)*
  - Pages can change document.domain
  - *Registry-controlled domain name* limit
- **Site:** RCDN + protocol

2. Browsing Instances



- Not all pages can talk
- References between "related" windows
    - Parents and children
    - Lifetime of window
- **Browsing Instance:** connected windows, regardless of site

3. Site Instances



- **Site Instance:** Intersection of site & browsing instance
- **Safe to isolate from any other pages**
- Compatible notion of a web program instance

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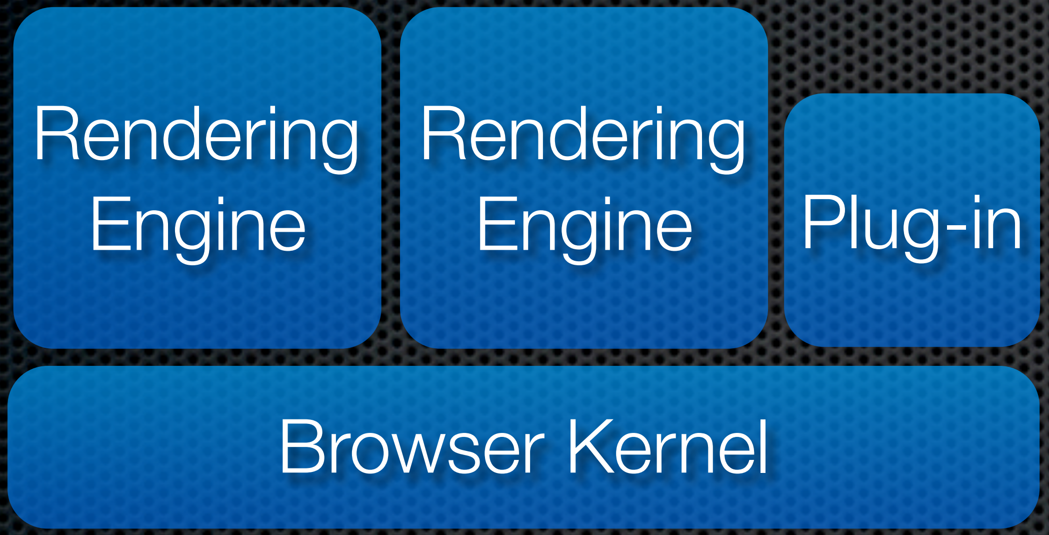
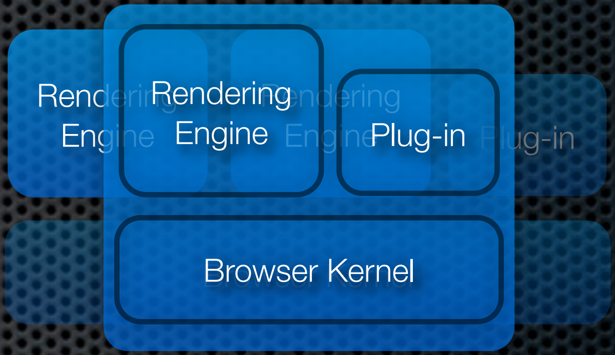
Multi-Process Browser



- **Browser Kernel**
  - Storage, network, UI
- **Rendering Engines**
  - Web program and runtime environment
- **Plug-ins**

- **Implemented in Chromium**

Chromium Process Models



1. **Monolithic**
2. **Process-per-Browsing-Instance**
   - New window = new renderer process
3. **Process-per-Site-Instance** *(default)*
   - Create renderer process when navigating cross-site
4. **Process-per-Site**
   - Combine instances: fewer processes, less isolation

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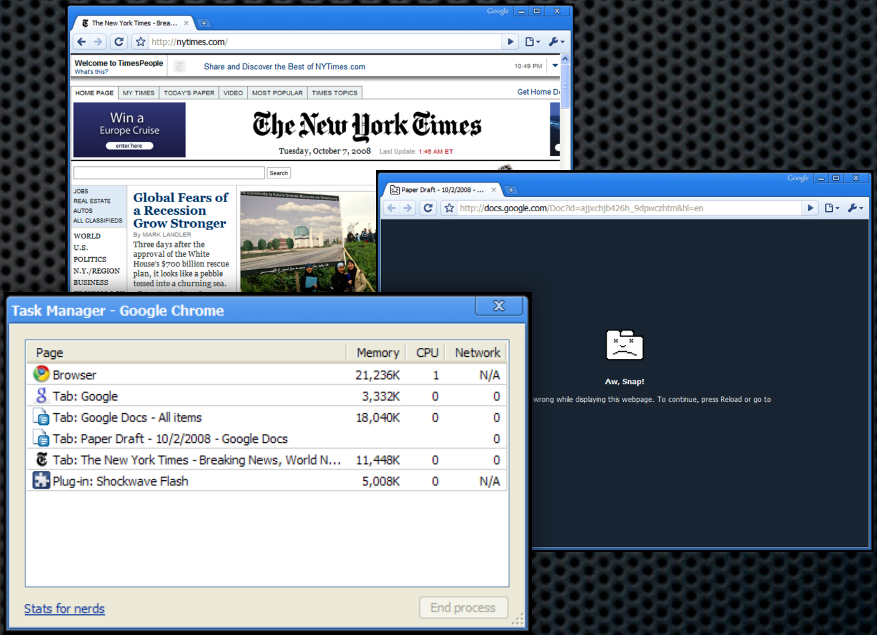
Robustness Benefits

- Failure Isolation
- Accountability
- Memory Management

- Some additional security (e.g., Chromium's sandbox)



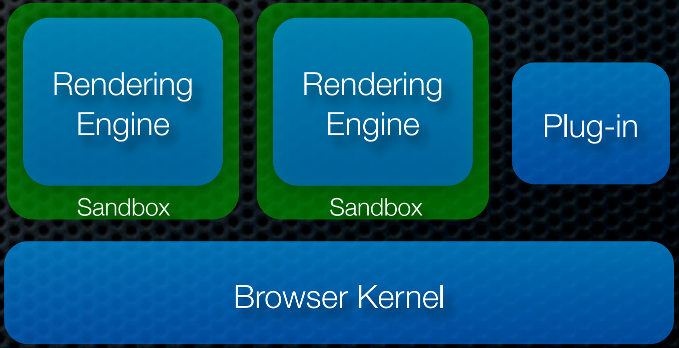
Task Manager - Google Chrome

Page	Memory	CPU	Network
Browser	21,236K	1	N/A
Tab: Google	3,332K	0	0
Tab: Google Docs - All items	18,040K	0	0
Tab: Paper Draft - 10/2/2008 - Google Docs			0
Tab: The New York Times - Breaking News, World N...	11,448K	0	0
Plug-in: Shockwave Flash	5,008K	0	N/A

Stats for nerds   End process

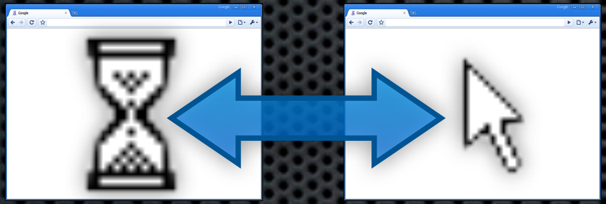
Aw, Snap!

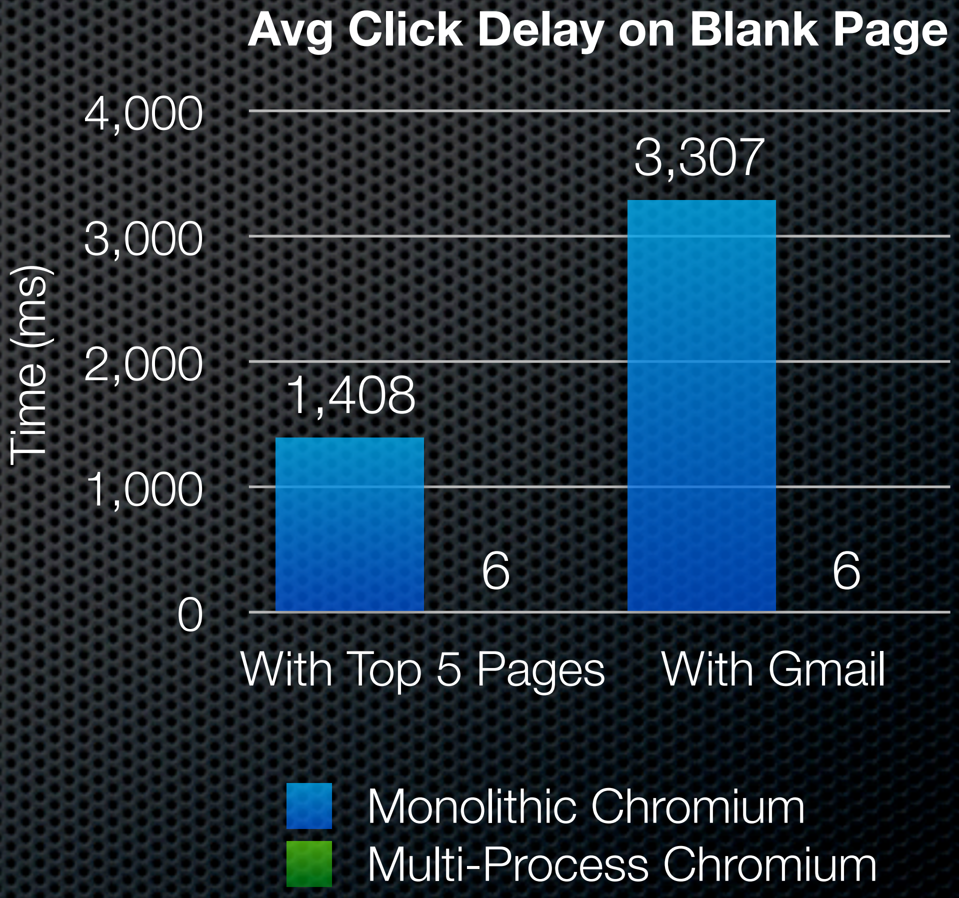
wrong while displaying this webpage. To continue, press Reload or go to



Performance Isolation

- **Responsive** while other web programs working



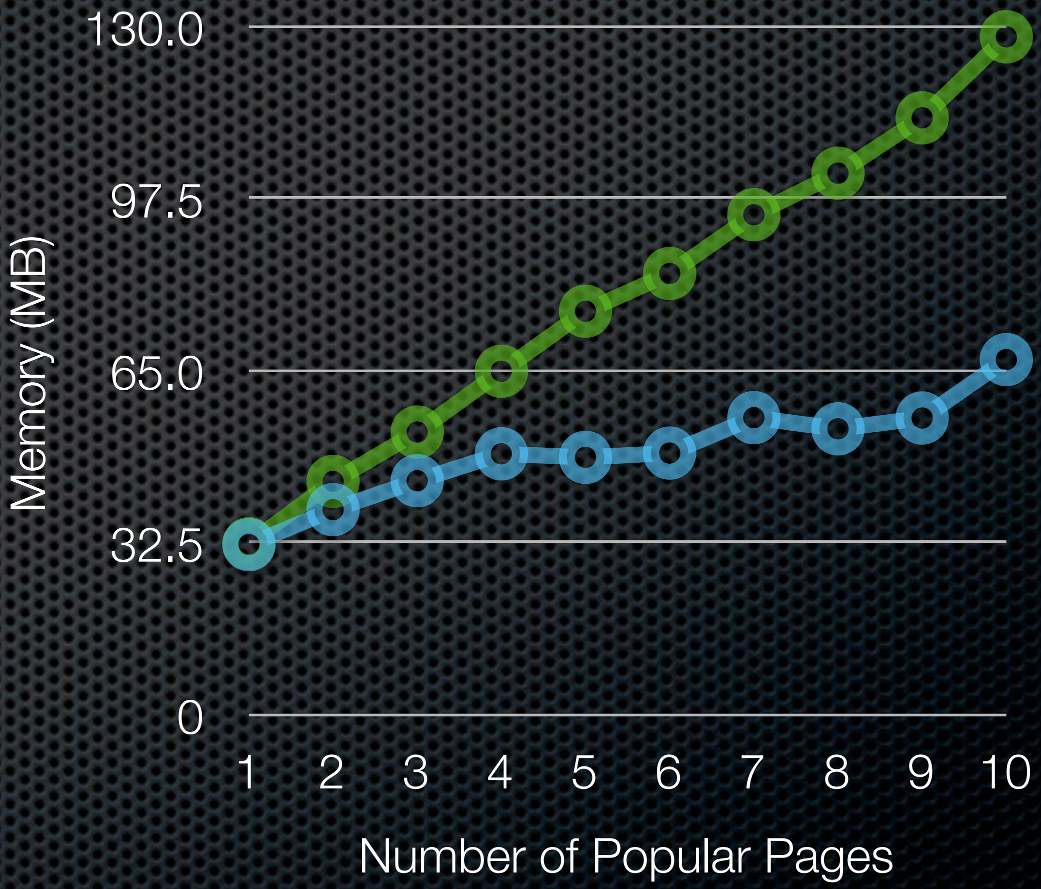


Other Performance Impact

- **Speedups**
  - More work done concurrently, leveraging cores
  - e.g., Session restore of several windows
- **Process Latency**
  - 100 ms, but masked by other speedups in practice

Memory Overhead

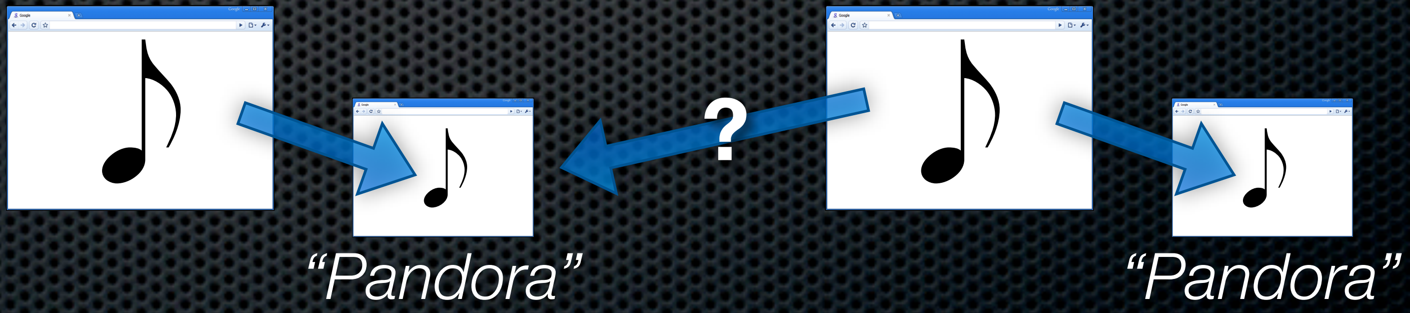
- Robustness benefits do have a cost
  - Reasonable for many real users



● Monolithic Chromium ● Multi-Process Chromium

Compatibility Evaluation

- No known compat bugs due to architecture
- Some minor behavior changes
  - e.g., **Narrower scope of window names:** browsing instance, not global



Related Architecture Work

- **Internet Explorer 8**
  - Multi-process architecture, no program abstractions
- **Gazelle**
  - Like Chromium, but values security over compatibility
- **Other research: OP, Tahoma, SubOS**
  - Break compatibility (isolation too fine-grained)

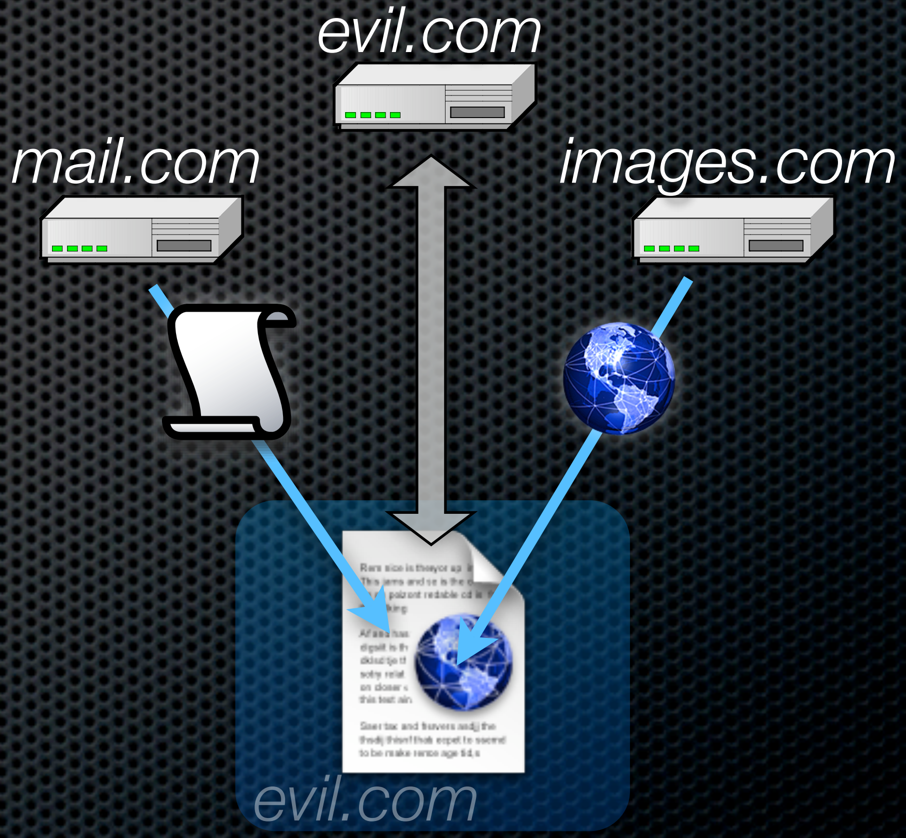
Conclusion

- Browsers must recognize programs to support them
  - **Site Instances** capture this
  - **Compatible** with existing web content
  - Can prevent interference with **process isolation**

Implemented in Chromium

Relevant for security?

- **Pages are free to embed objects from any site**
  - Scripts, images, plugins
  - Carry user's credentials
  - *Inaccessible info within each Site Instance*
- **Compatibility makes us rely on internal logic**



Compatibility Compromises

- **Coarse granularity**
  - Some logical apps grouped together (instances help)
- **Imperfect isolation**
  - Shared cookies, some window-level JS calls
- **Not a secure boundary**
  - Must still rely on renderer to prevent certain leaks

Implementation Caveats

- **Sites may sometimes share processes**
  - Frames still in parent process
  - Not all cross-site navigations fork processes
  - Process limit (20), then randomly re-used