Modeling and Reasoning about DOM Events

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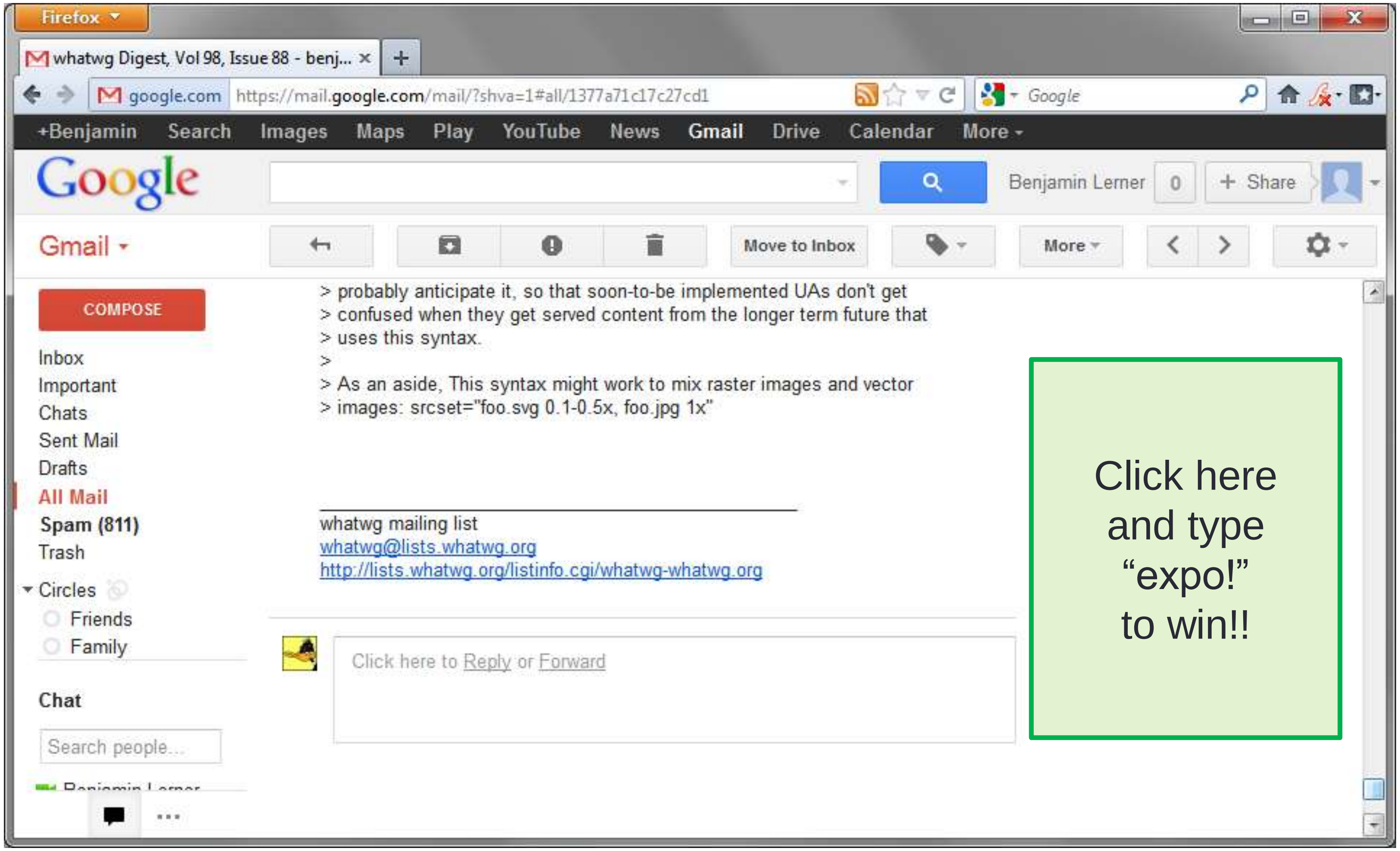
Brown University

WebApps 2012

Those pesky ads…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Chat
Search people...

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> confused when they get served content from the longer term future that
> uses this syntax.
>
> As an aside, This syntax might work to mix raster images and vector
> images: srcset="foo.svg 0.1-0.5x, foo.jpg 1x"

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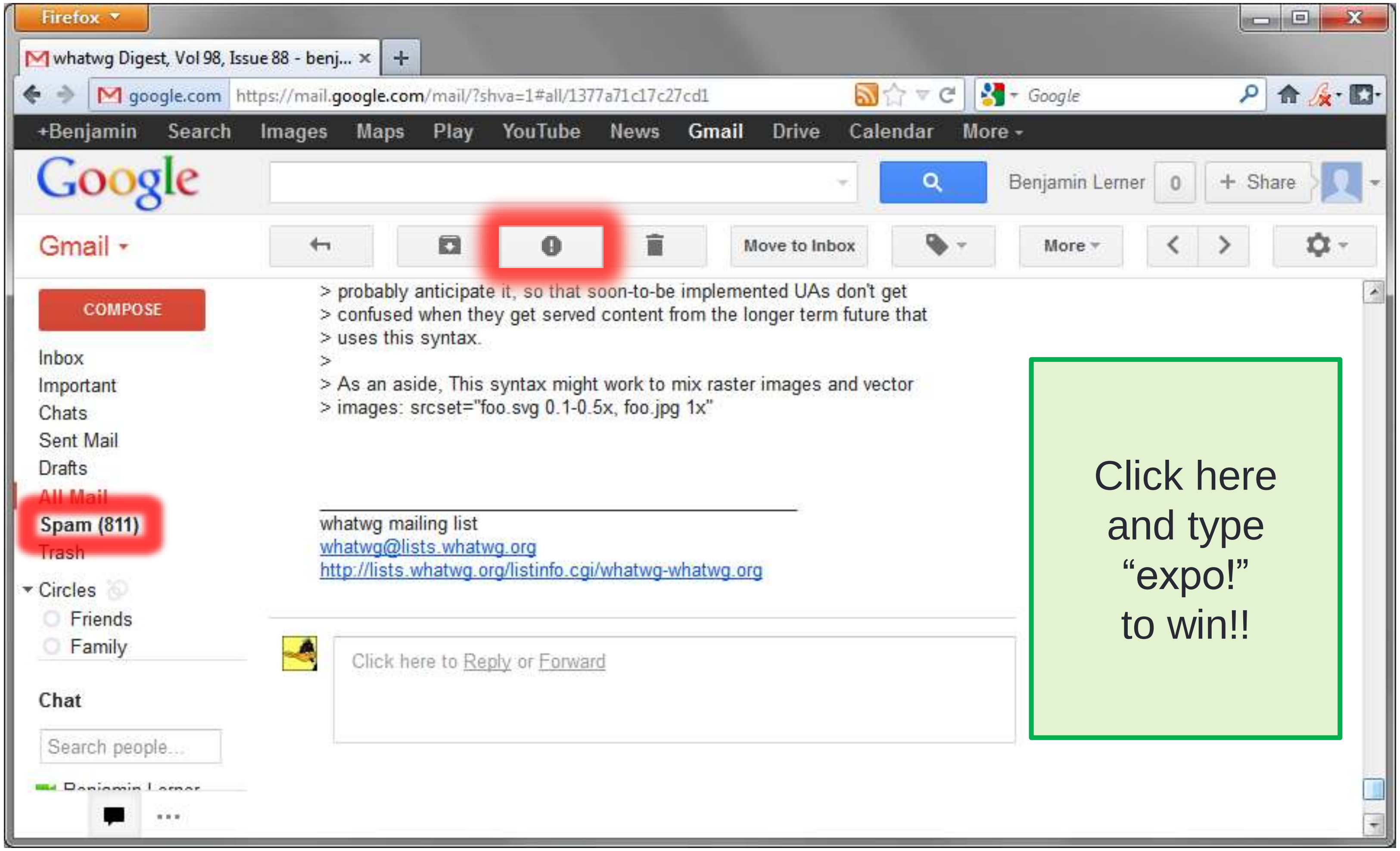

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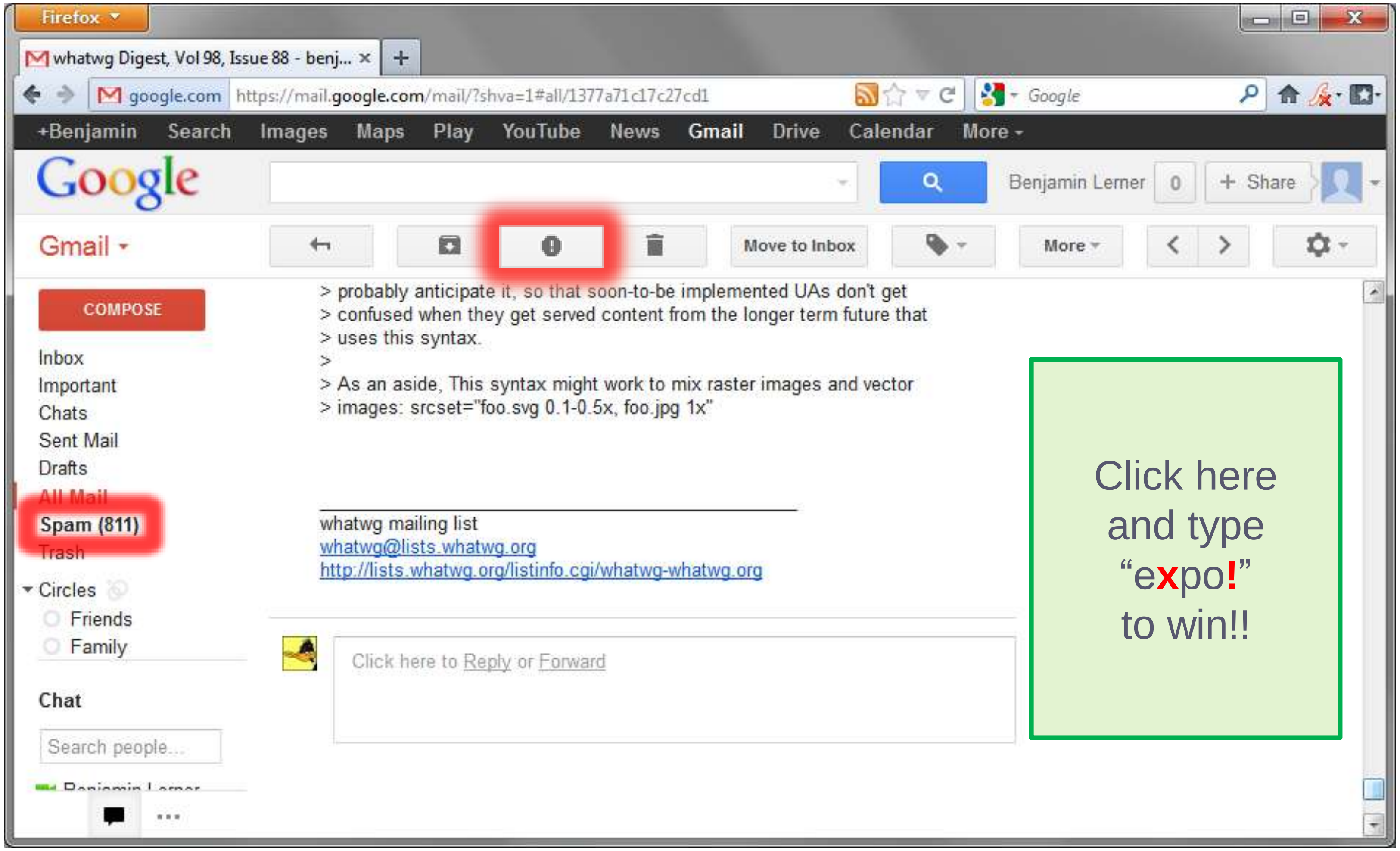
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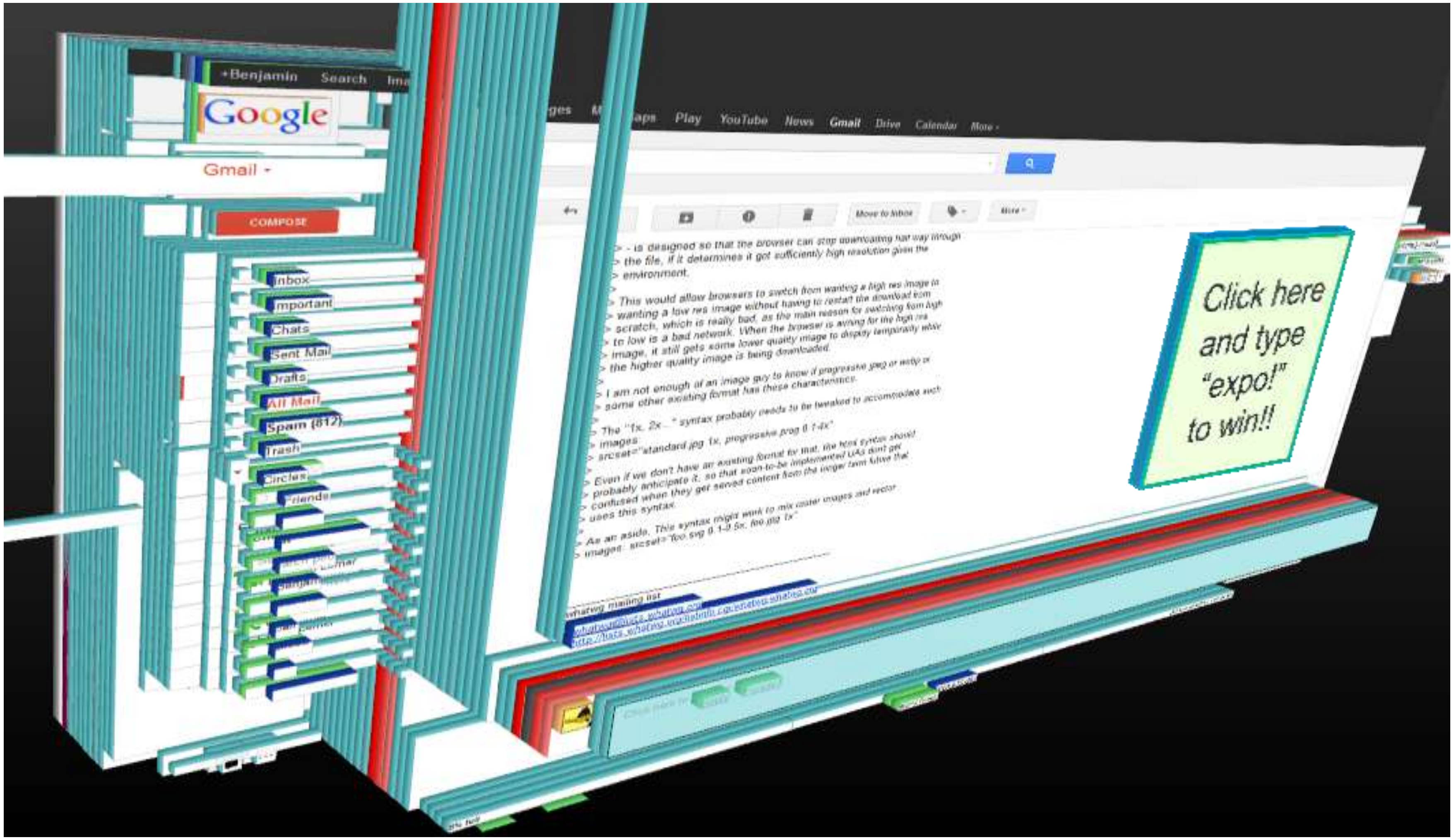
What’s really going on here?



> - is designed so that the browser can stop downloading half way through
> the file, if it determines it got sufficiently high resolution given the
> environment.
>
> This would allow browsers to switch from wanting a high res image to
> wanting a low res image without having to restart the download from
> scratch, which is really bad, as the main reason for switching from high
> to low is a bad network. When the browser is aiming for the high res
> image, it still gets some lower quality image to display temporarily while
> the higher quality image is being downloaded.
>
> I am not enough of an image guy to know if progressive jpeg or webp or
> some other existing format has these characteristics.
>
> The "1x, 2x..." syntax probably needs to be tweaked to accommodate such
> images:
> srcset="standard.jpg 1x, progressive.jpg 0.1-4x"
>
> Even if we don't have an existing format for that, the html syntax should
> probably anticipate it, so that soon-to-be implemented UAs don't get
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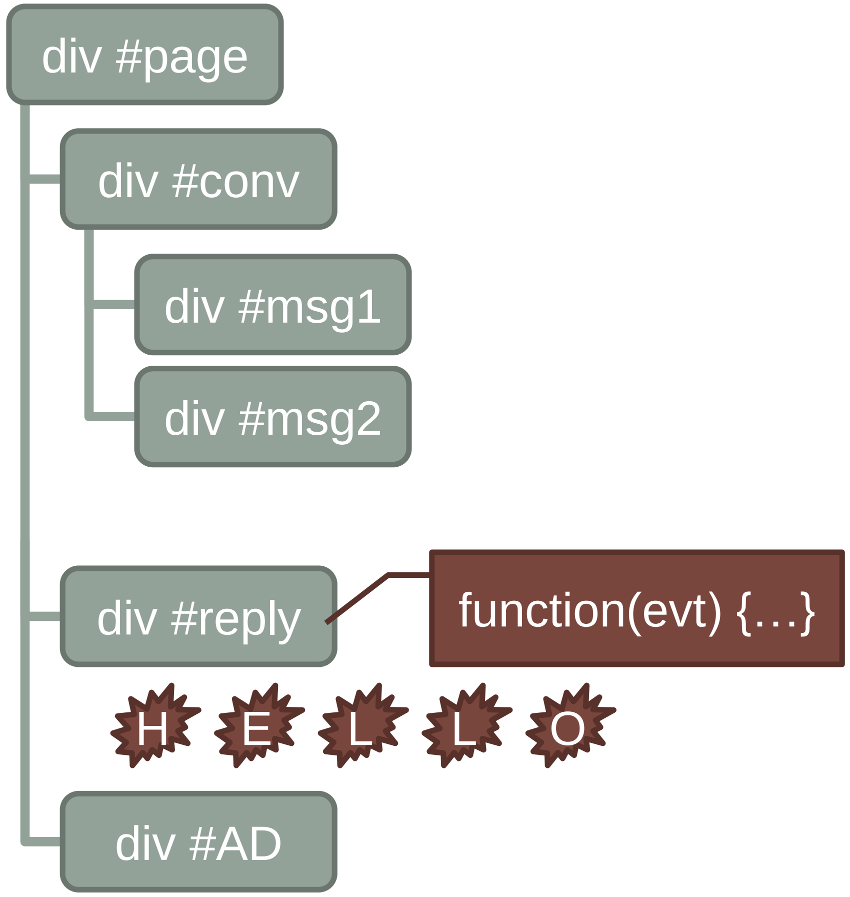
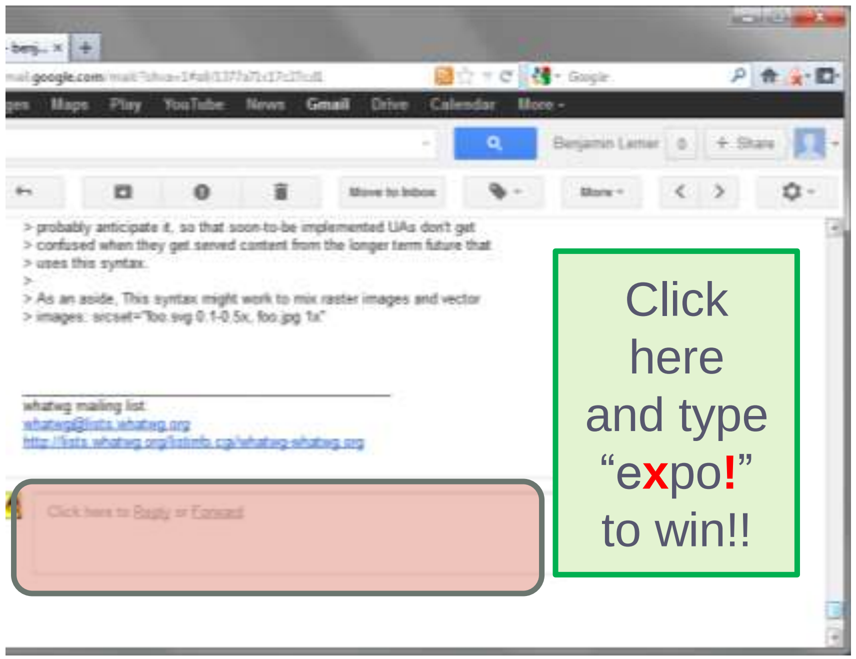
Event dispatch, informally





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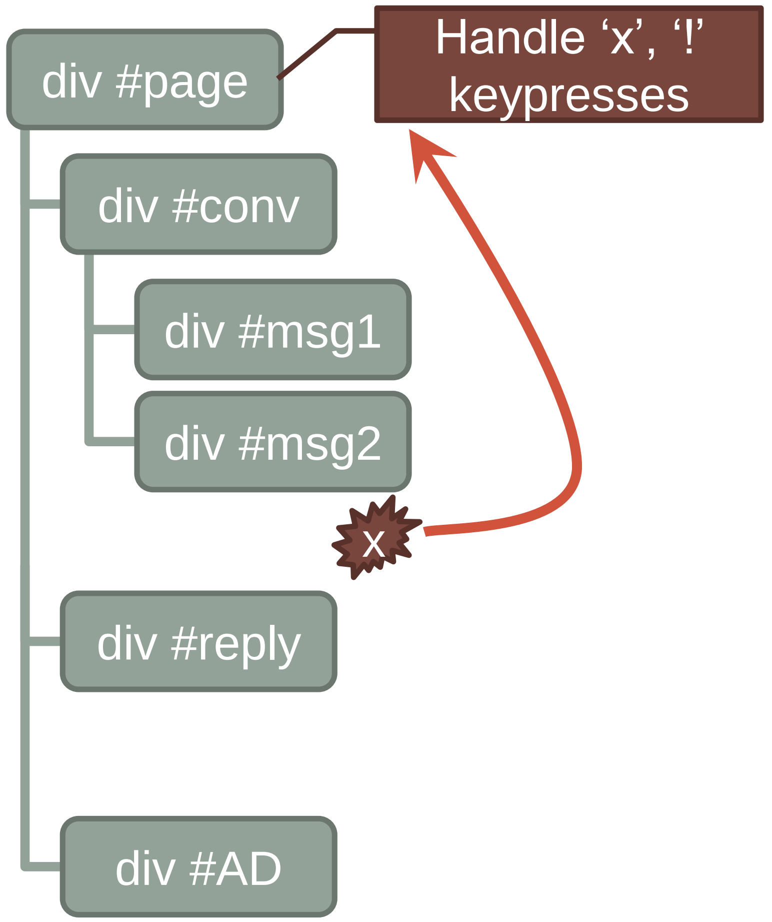

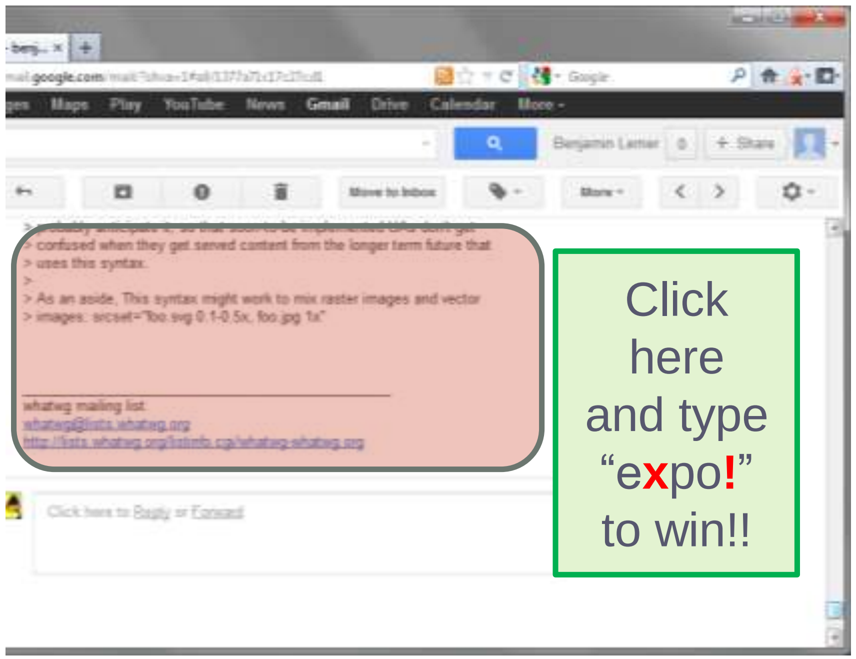

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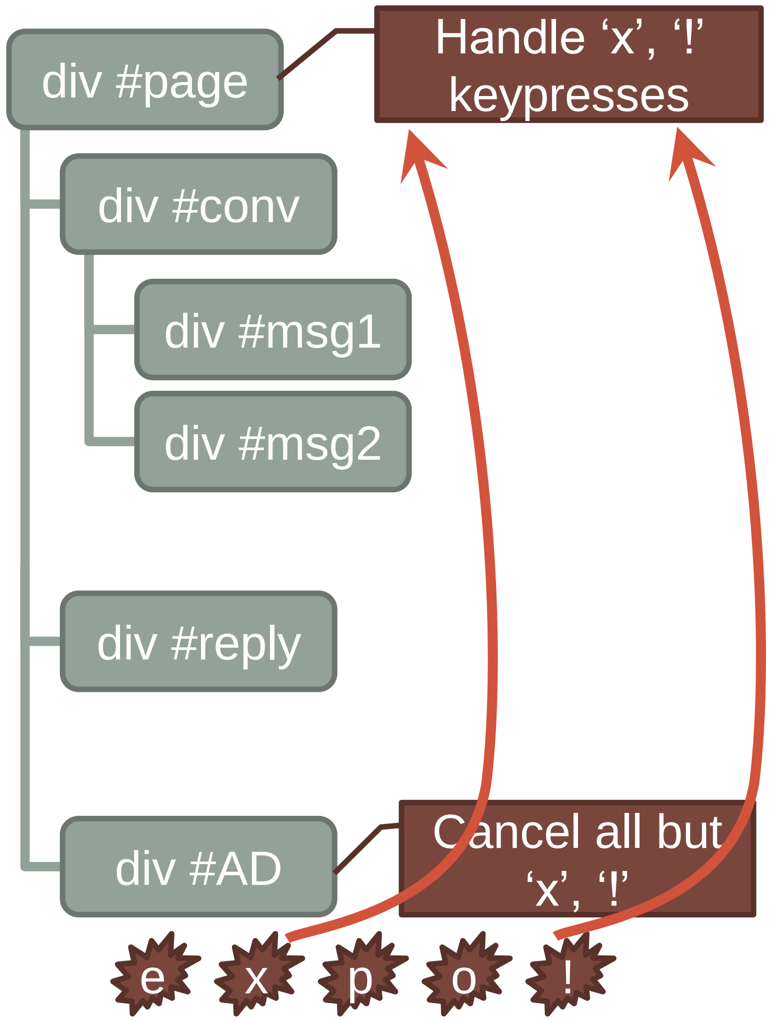

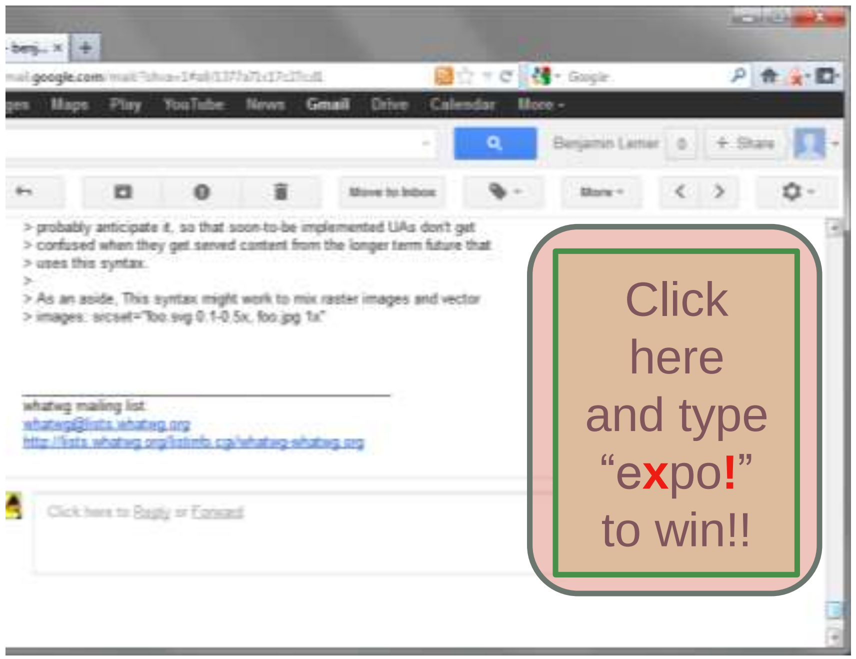

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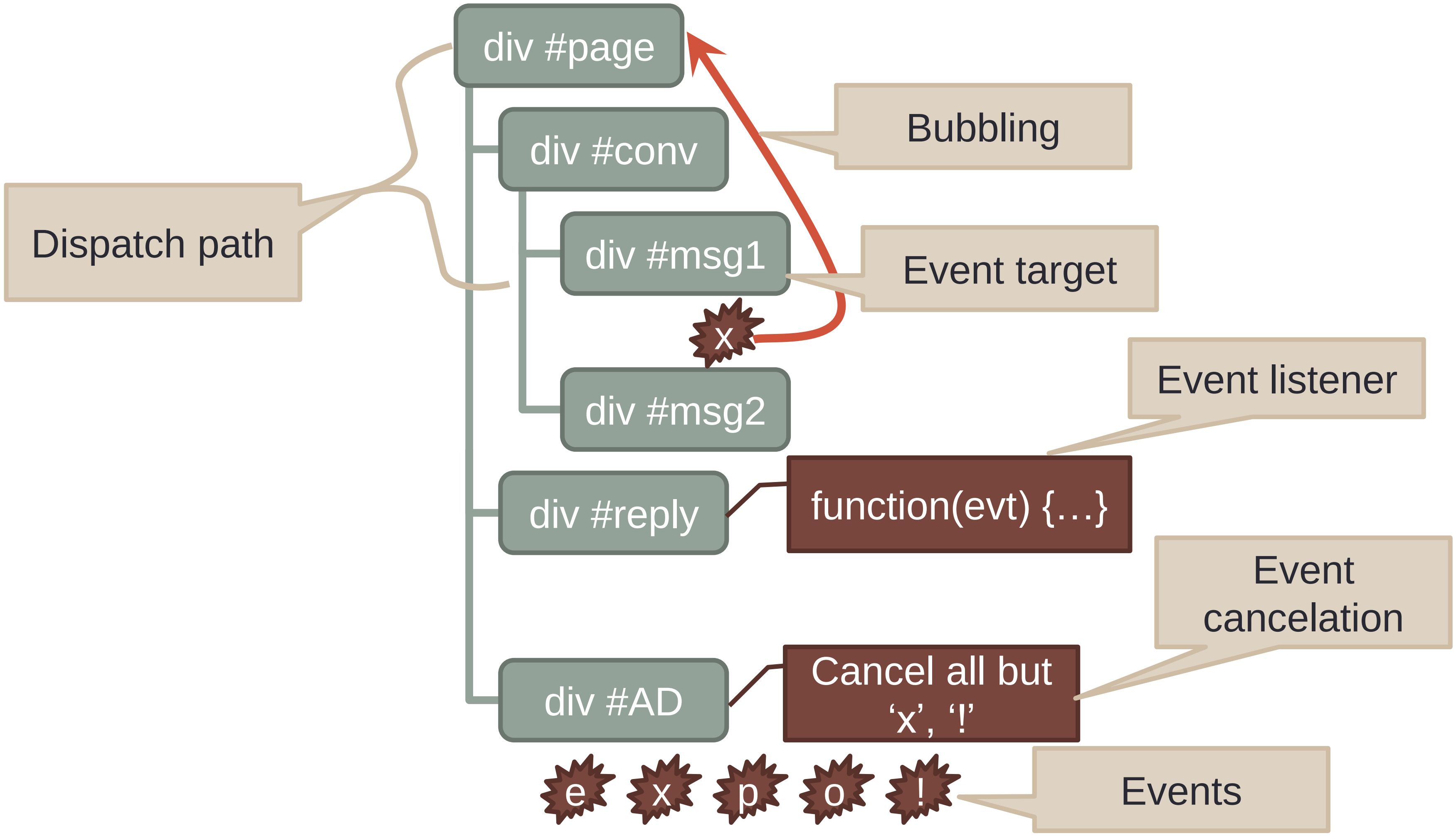
To understand the execution of any web page, we have to understand the model for event dispatch.

Event dispatch, informal summary

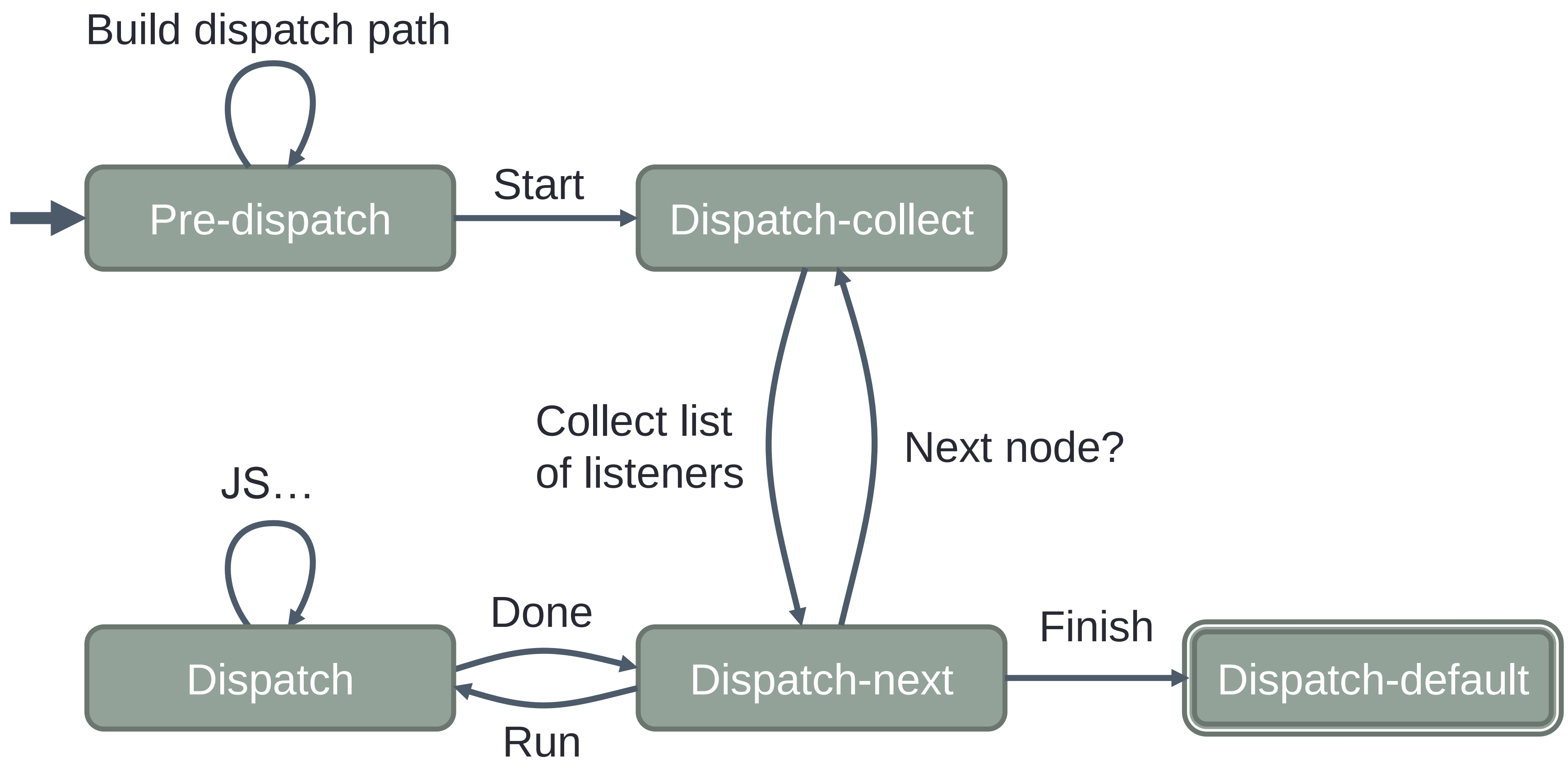


Event dispatch – the subtleties

Interactions between mutations and order of operations

- Multiple listeners per event per element
- Tree mutation
- Adding/removing listeners during dispatch
- Legacy “handlers”
- Default actions

Core dispatch algorithm



Surely this is all specified?

- Yes, but ☺
- Specification is 113 pages long
  - (Mostly definitions of specific event types)
- Core dispatch algorithm is 16 pages,
  - With side references to other specifications!
- Specification is not self-consistent

Example: addEventListener

addEventListener

Registers an event listener, depending on the useCapture parameter, **on the capture phase of the DOM event flow or its target and bubbling phases**.

Parameters

type : DOMString

Specifies the *Event.type* associated with the event for which the user is registering.

listener : EventListener

The *listener* parameter must be an object that implements the *EventListener* interface or a function. If *listener* is a function then it must be used as the callback for the event; otherwise, if *listener* implements *EventListener*, then its *handleEvent* method must be used as the callback.

useCapture : boolean

If true, *useCapture* indicates that the user wishes to **add the event listener for the capture and target phases only**, i.e., this event listener will not be triggered during the bubbling phase. If false, the event listener must **only be triggered during the target and bubbling phases**.

This parameter must be optional. If not provided, the *EventTarget.addEventListener* method must behave as if *useCapture* were specified to be false.

Modeling the event dispatch

We built a model in Redex of the event dispatch algorithm

- 1000 lines of commented code
- **Analyzable**
- **Testable**
- **Executable**
- **Composable**

Redex: what and why

- Redex is a framework designed for language engineers
- Makes it easy to:
  - Specify operational semantics
  - Simulate running of programs
  - Examine syntax and state of programs as they run
- *Particularly* convenient when trying to match web specs:
  - Mostly written in an idiomatic, step-by-step manner

addEventListener, revisited

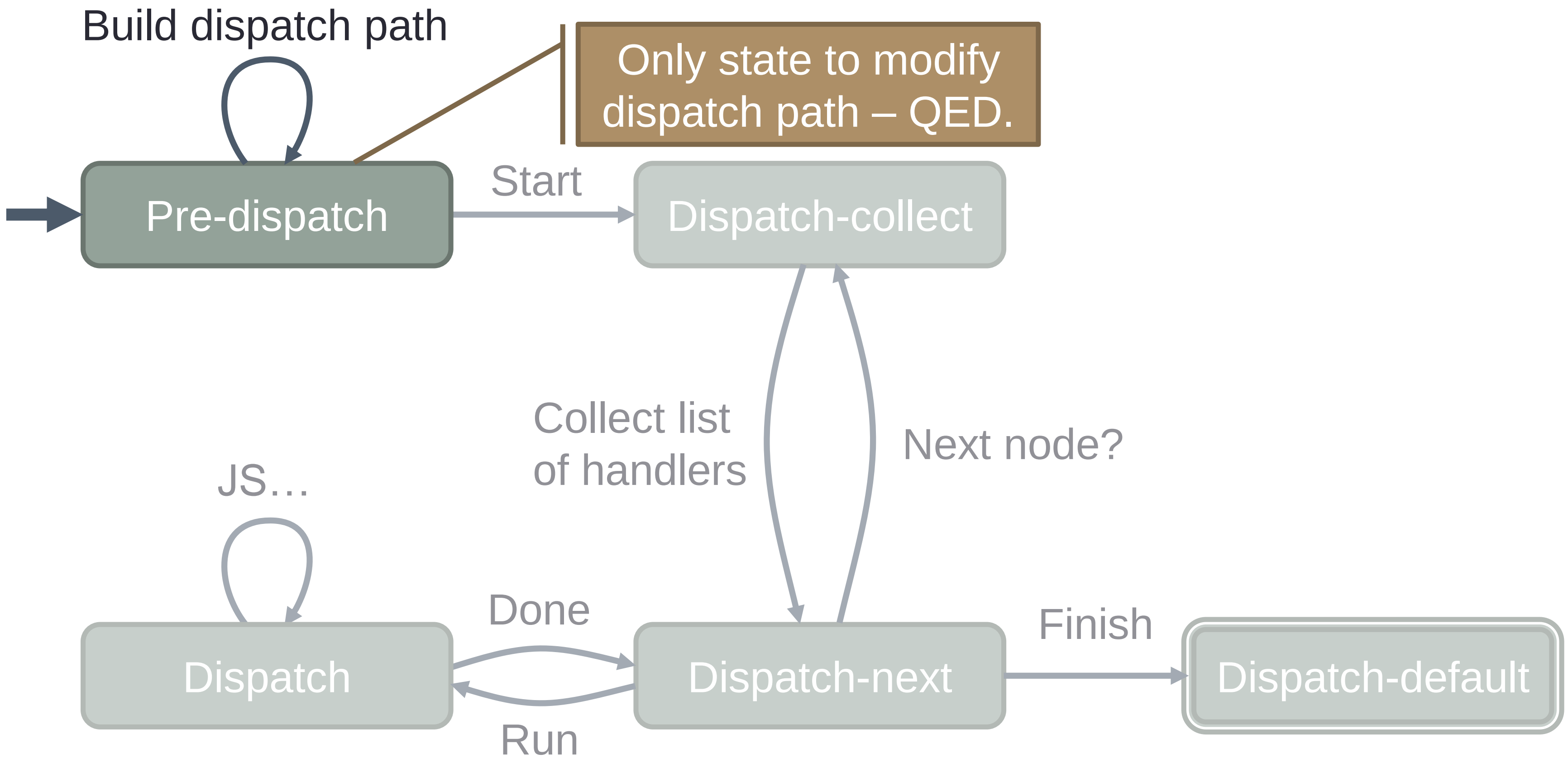
```
(define-metafunction DOM
  [(addListener LS string_type bool_useCapture loc_listener)
   (addListenerHelper
      (addListenerHelper
            LS string_type target bool_useCapture loc_listener)
      string_type
      ,(if (term bool_useCapture) (term capture) (term bubble))
      bool_useCapture
      loc_listener))))])
```

Using the model: formal **analysis**

- Common knowledge about event dispatch:
  - “Modifying the tree shouldn’t impact the current dispatch.”
  - “Every node gets visited twice (capture and bubble) except the target.”
  - “Event dispatch is deterministic.”
  - “Event dispatch terminates.”

- All of these are ***theorems*** that hold of our model
  - Good for user understanding.
  - Good for analyses that rely upon them.

Example: dispatch path is fixed



That’s nice, so? Model relevance

What assurance do we have that the model reflects reality?

Annotate the correspondence explicitly

Spec text ←annotations→ model rules

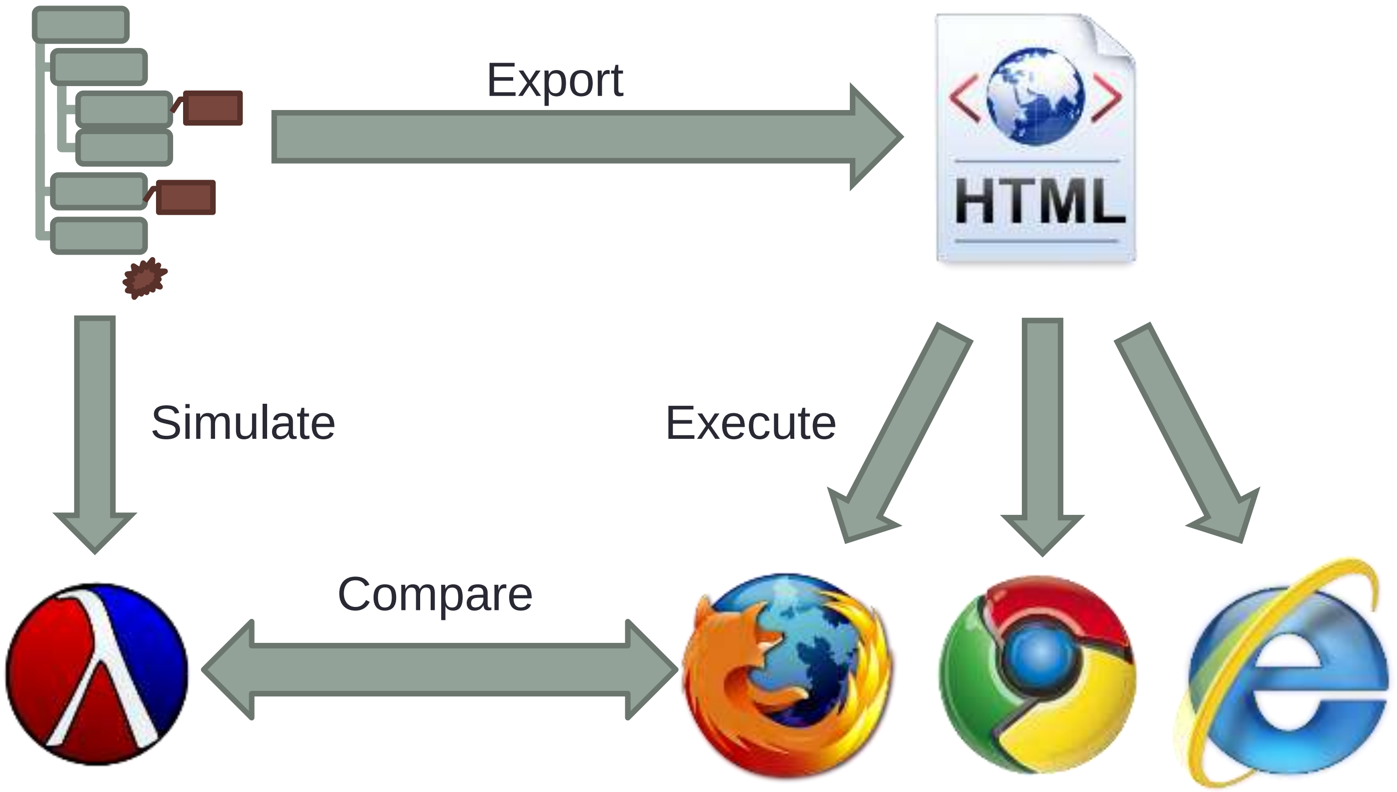
An informed reader could read both together and confirm they match.

(Compare the spec for addEventListener with our model)

Using the model: automatic **testing**

Can ***automatically*** construct test cases

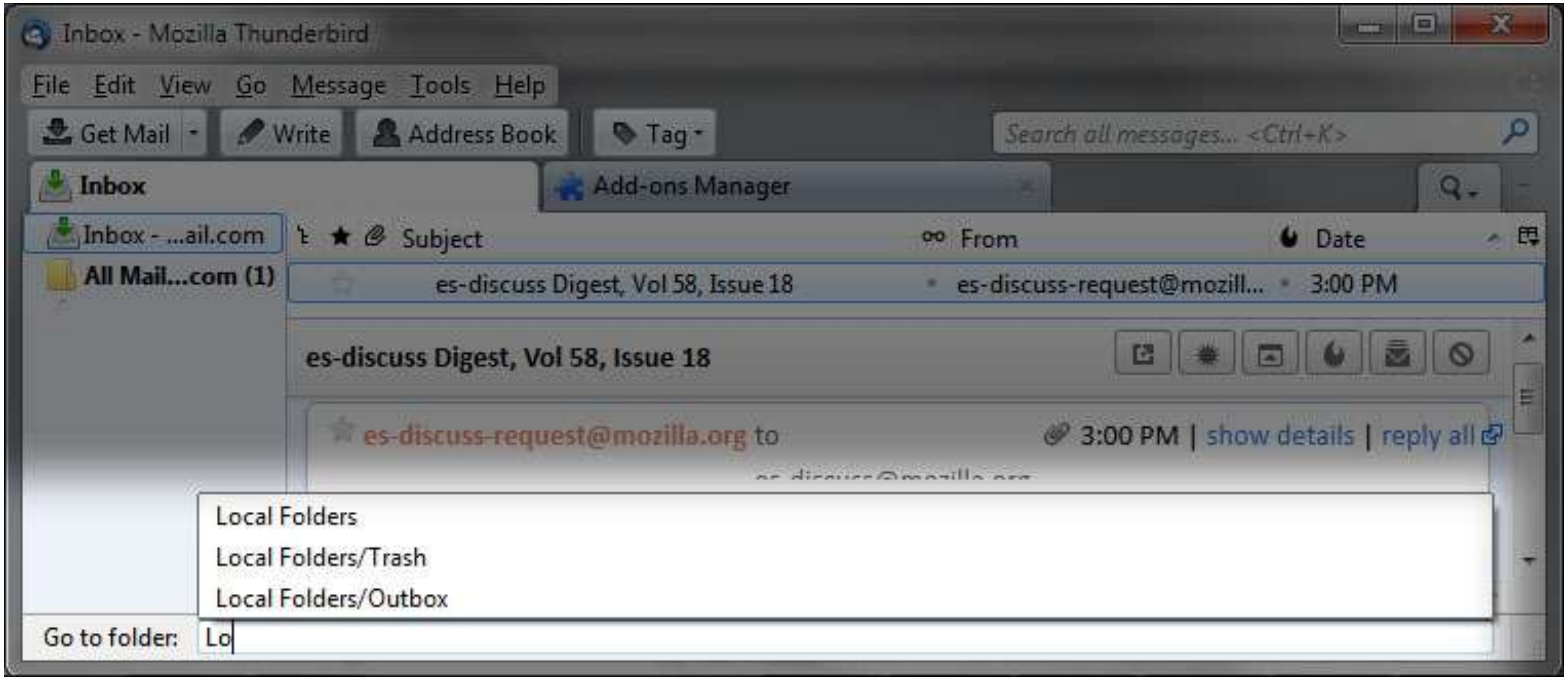
- All small trees, random larger ones…
- All pairs of 1-line listeners; random longer ones…



Using the model: debug **execution**

Two real-world Thunderbird extensions:

- Nostalgy



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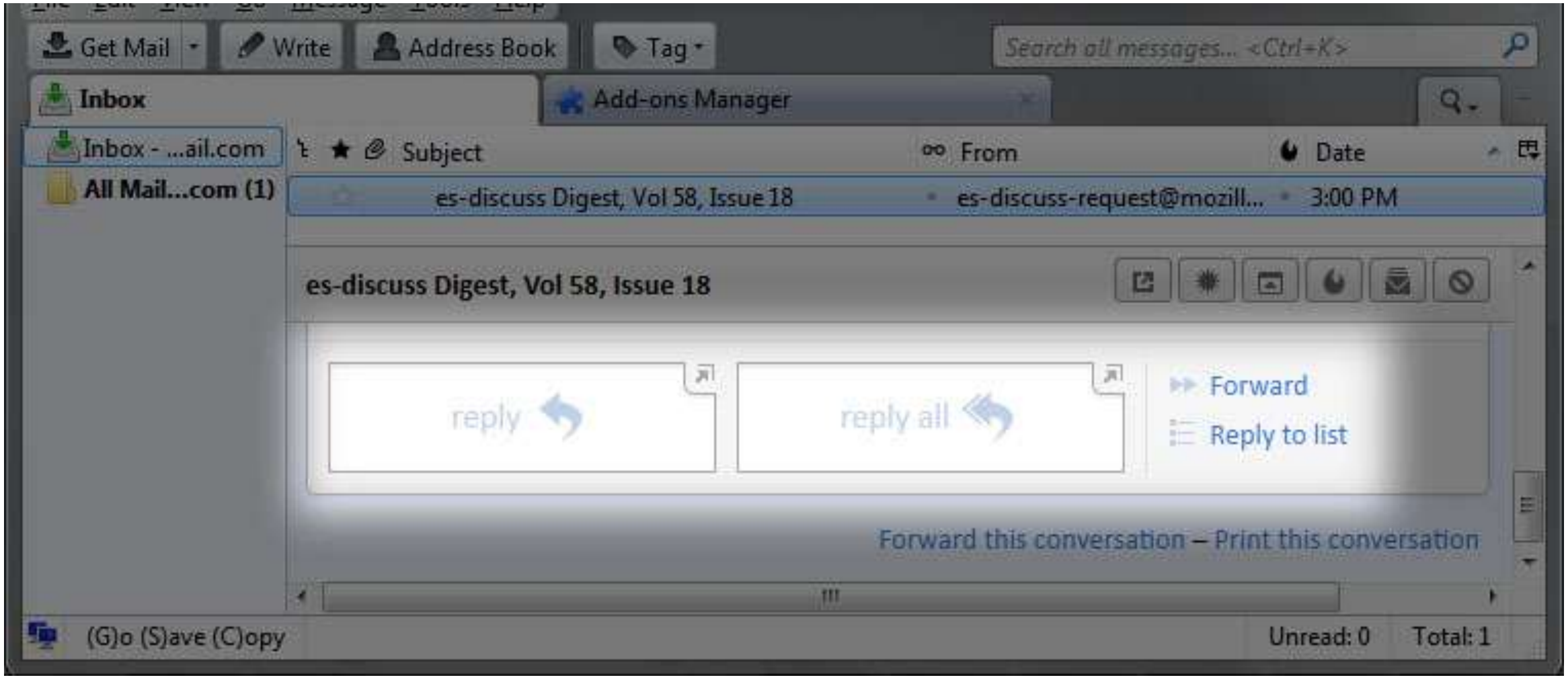
Local Folders
Local Folders/Trash
Local Folders/Outbox

Go to folder: Lo

Using the model: debug **execution**

Two real-world Thunderbird extensions:

- Thunderbird Conversations



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Using the model: debug **execution**

- Nostalgy: hot-keys for saving messages
  - Type ‘S’, then a folder name ➔ save message to folder
- Conversations: “Gmail-like” quick-reply box

- What should happen when you quick-reply with a word containing ‘s’?

- More importantly, when the “wrong thing” happens, why? And how should we fix it?

Future Uses

- A full account of dynamic web behavior:
  - Events (this work)
  - JavaScript
  - DOM
  - Network
  - Storage
- Testing and verification of larger web applications
- …

Recap: Contributions

- A **tractable**, **formal** model of web event dispatch
- **Analyzable**
  - Amenable to traditional PL techniques
- **Testable**
  - Has found actual bugs in current browsers
- **Executable**
  - Can help explain odd app behaviors or debug broken extensions
- **Composable**
  - Can be combined with other models for increased precision