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Modeling user interfaces with Cal and Ptolemy

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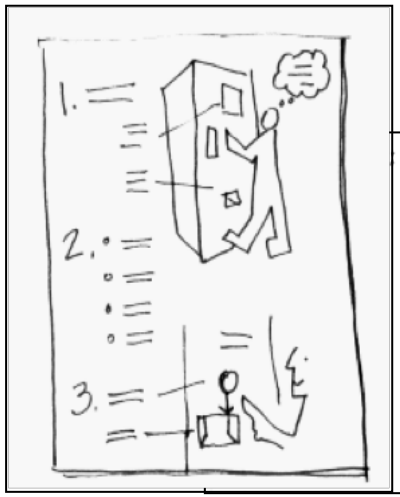
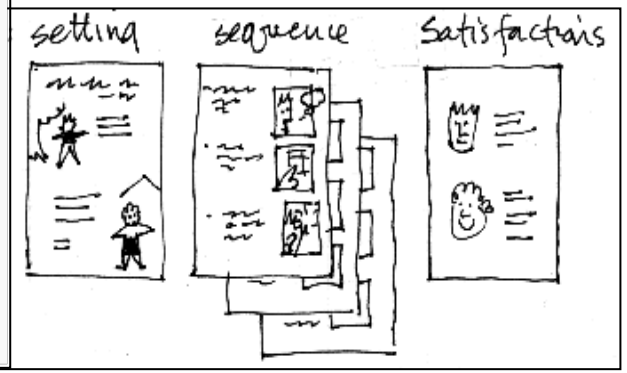
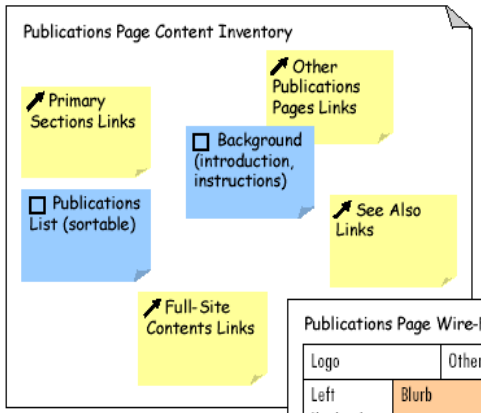
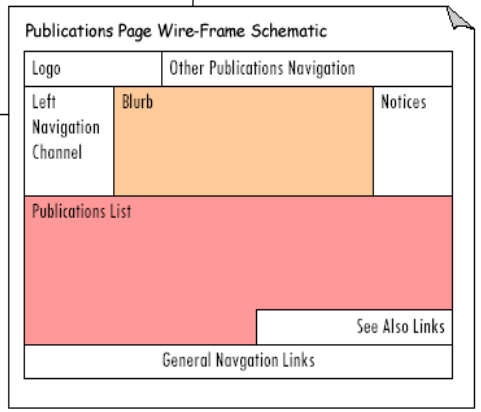
Designers use informal representations...

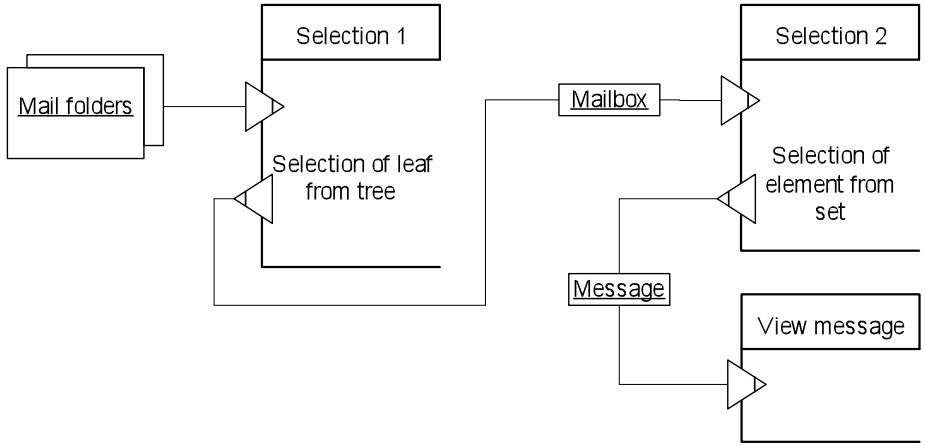




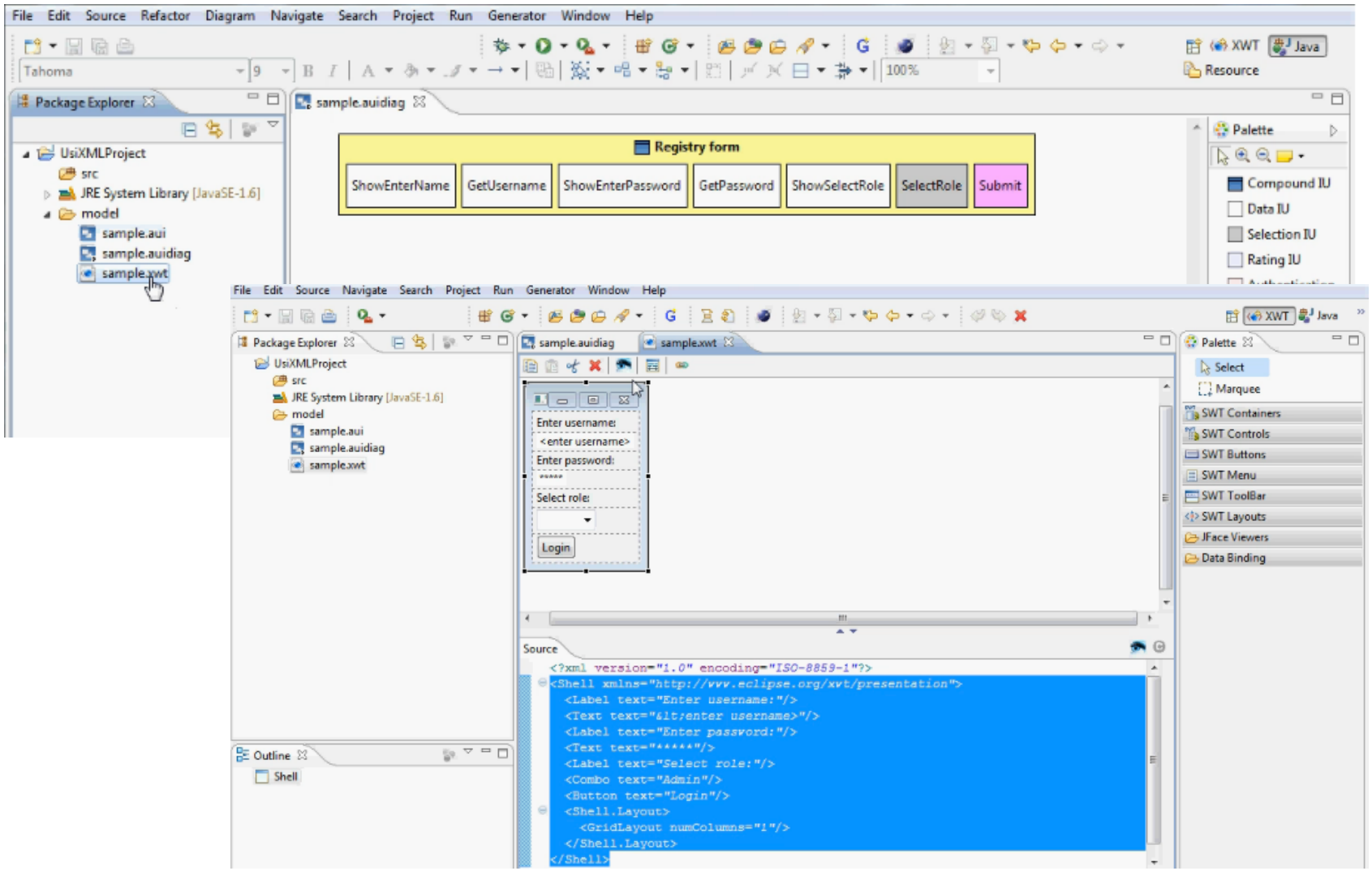




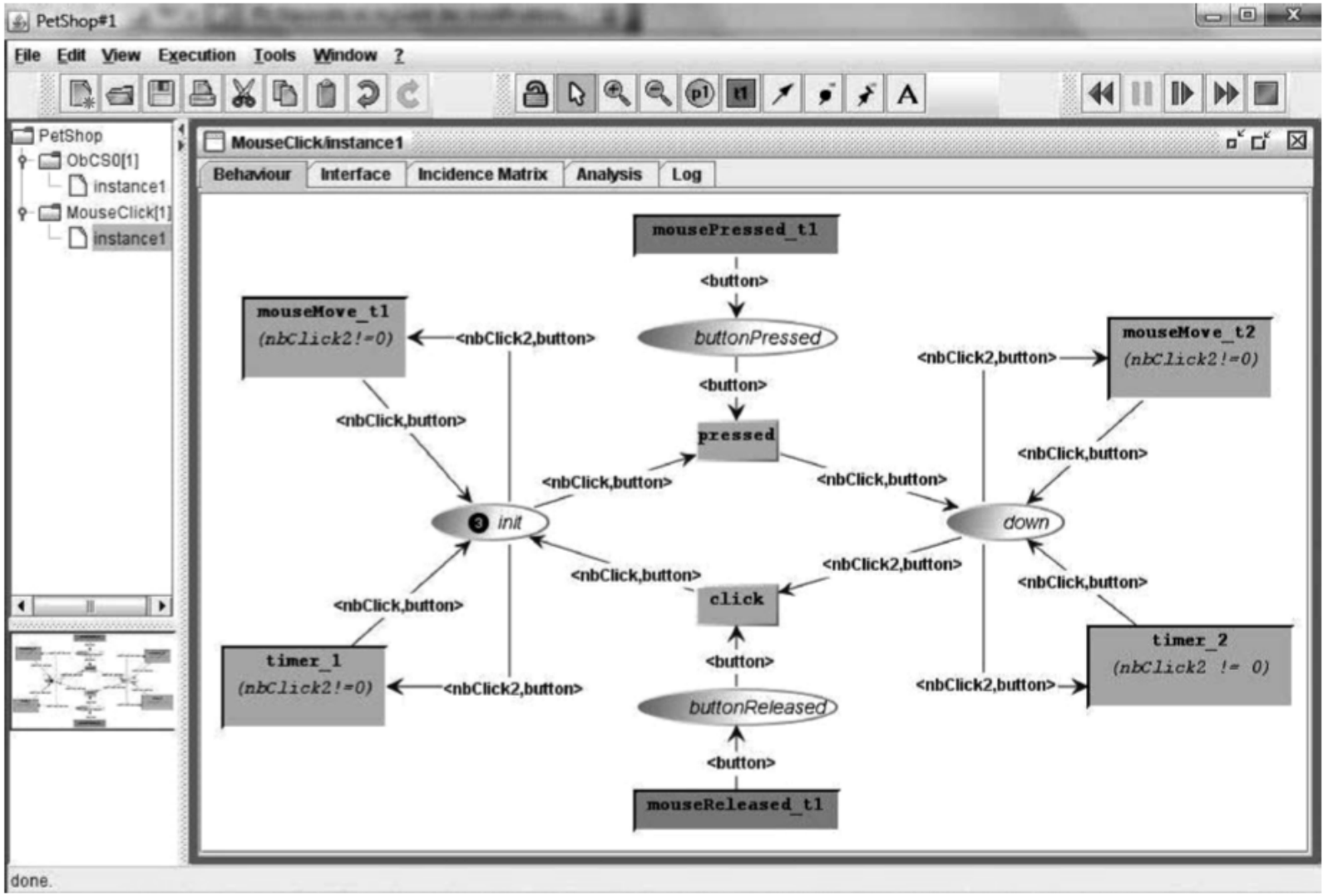
Engineers use models



UsiXML [Vanderdonckt] – A family of XML-based notations for UI elements



Pet shop [Palanque] – Modeling safety critical UIs with ICO PetriNets

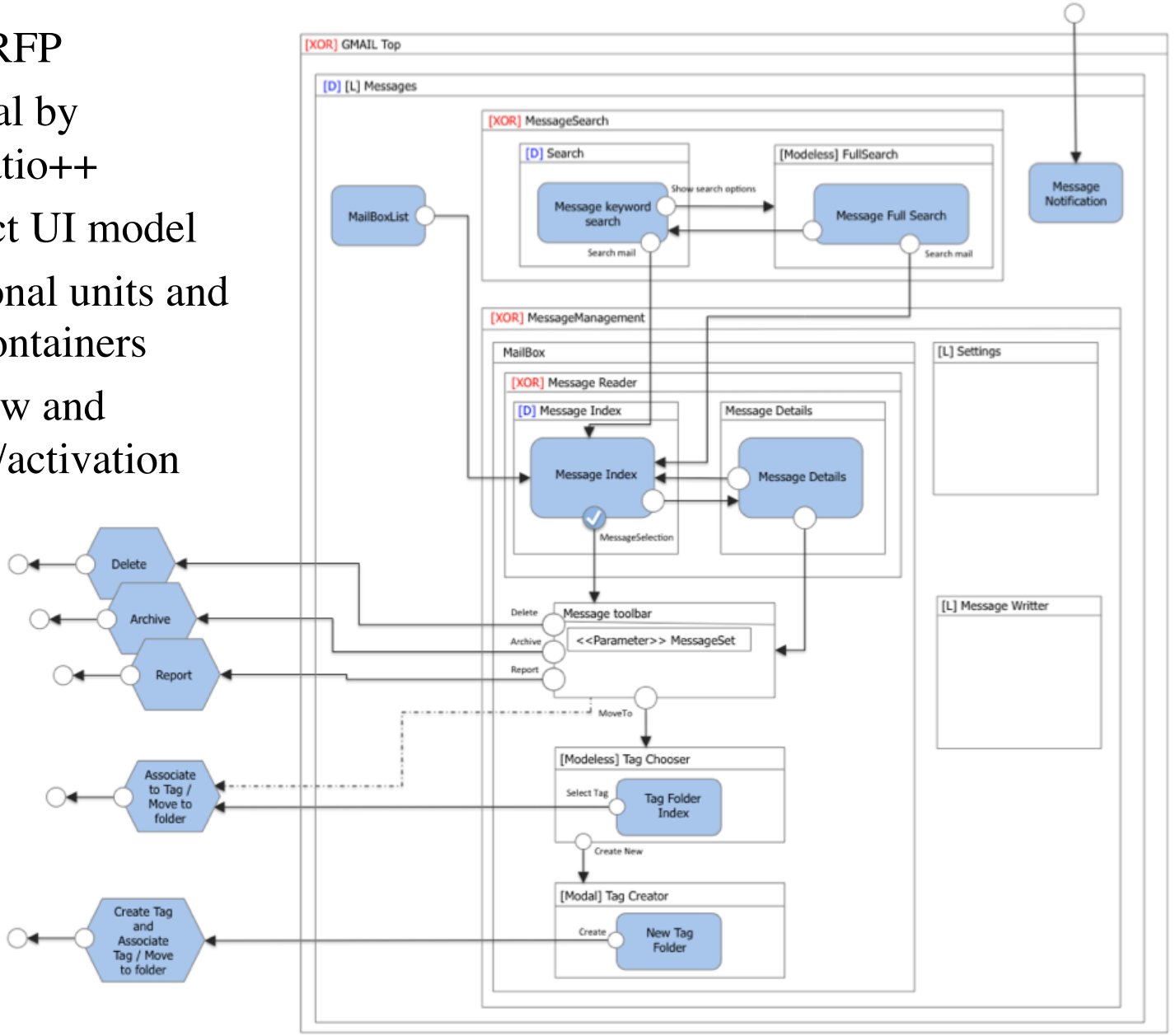


Lots of pragmatic approaches (read: non-academic and useful)

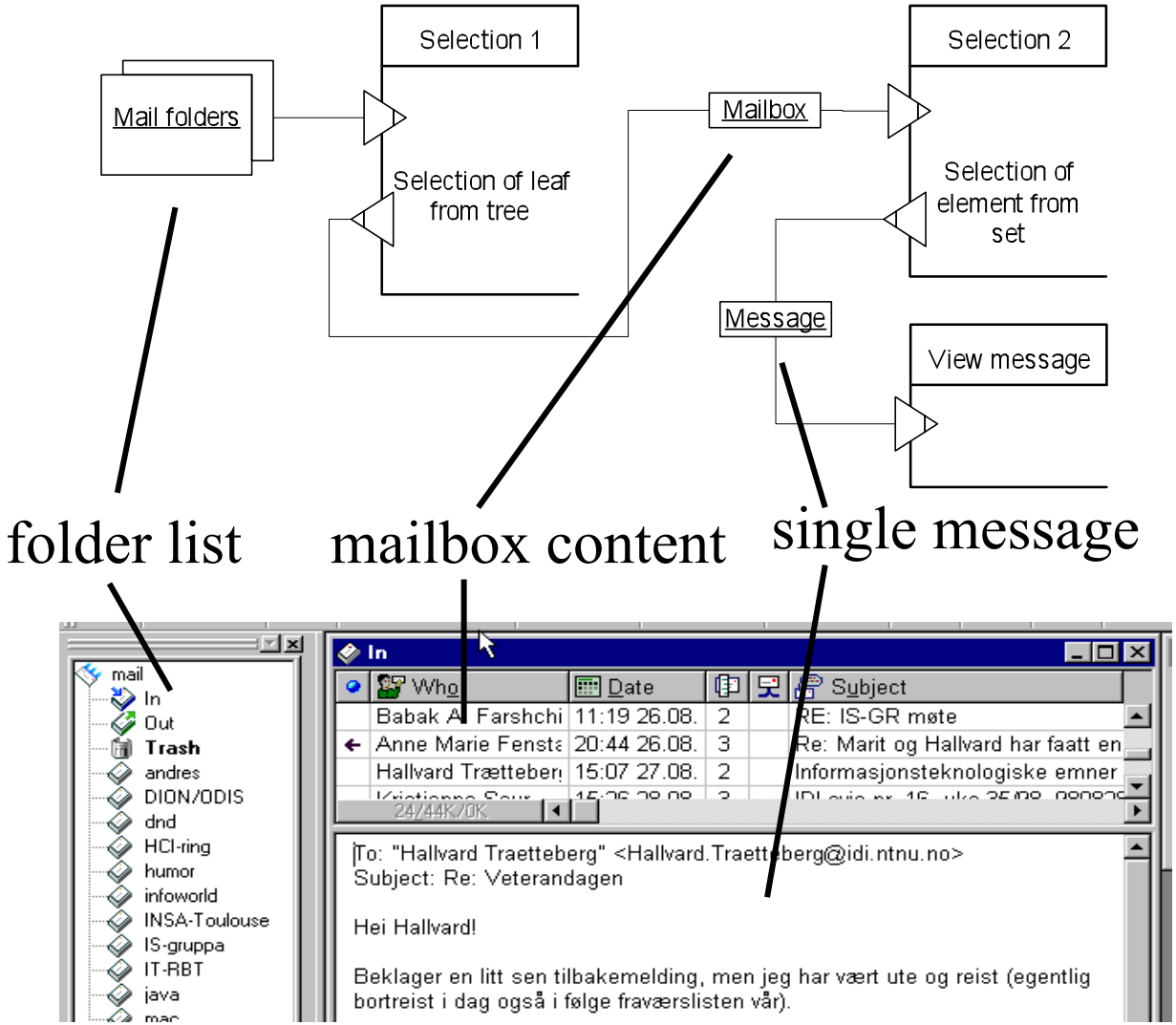
- XML-based formats for describing user interface layout and style
  - XHTML (W3C) , XAML (Microsoft), JavaFX (Oracle), XUL (Mozilla)
  - template languages for web pages
- DSLs
  - Ecore-based: Eclipse 4's workbench model, Wazaabi
  - Xtext-based: APPlause, MOBL, Agentry
- Application modeling
  - Esito's Genova – business applications for the desktop and web
  - WebRatio - business applications for the web
- Standardization
  - WebML
  - IFML (in progress)
  - Model-Based User Interfaces (MBUI) Working Group

IFML – Interaction Flow Modeling Language

- OMG RFP
- Proposal by WebRatio++
- Abstract UI model
- Functional units and view containers
- Dataflow and control/activation signals



Diamodl


Selection 1
Selection 2
Mail folders
Mailbox
Selection of leaf from tree
Selection of element from set
Message
View message
folder list
mailbox content
single message
mail
In
Out
Trash
andres
DION/ODIS
dnd
HCI-ring
humor
infoworld
INSA-Toulouse
IS-gruppa
IT-RBT
java
In
Who
Date
Subject
Babak A Farshchi 11:19 26.08. 2
RE: IS-GR møte
Anne Marie Fenst 20:44 26.08. 3
Re: Marit og Hallvard har faatt en
Hallvard Trætteber 15:07 27.08. 2
Informasjonsteknologiske emner
24/44K/0K
To: "Hallvard Traetteberg" <Hallvard.Traetteberg@idi.ntnu.no>
Subject: Re: Veterandagen
Hei Hallvard!
Beklager en litt sen tilbakemelding, men jeg har vært ute og reist (egentlig bortreist i dag også i følge fraværslisten vår).

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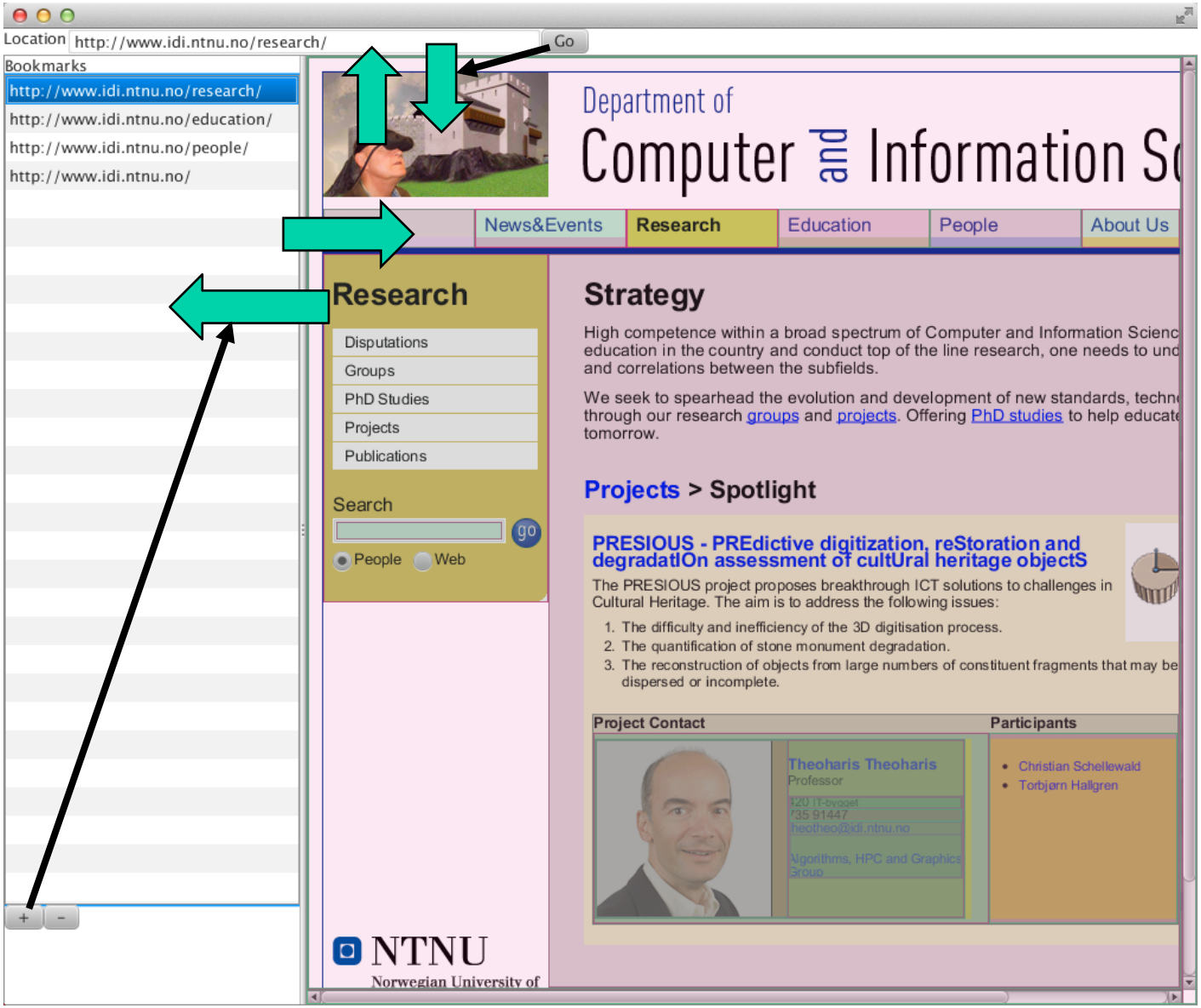
But what is

- the *semantics* of the model (runtime behavior)?
- the *role* of the model (scope/interoperability)?

Example – web browser

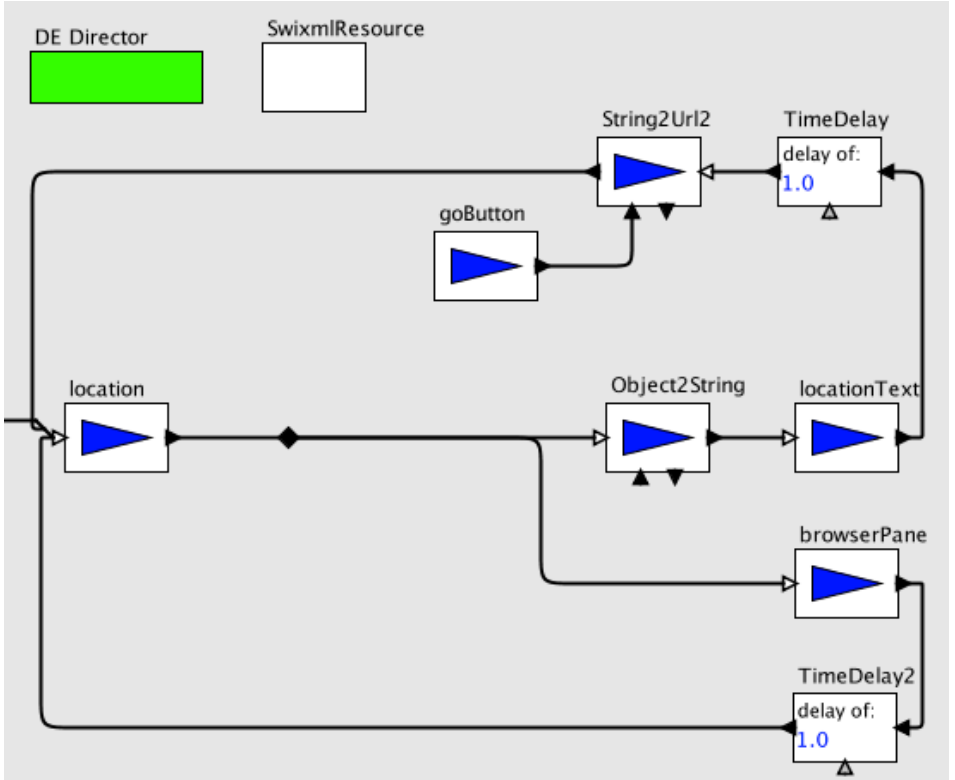


Three iterations

- Take 1 – hand-code Ptolemy actors and Java Swing toolkit
  - showed the feasibility of using Ptolemy
  - lot of work writing generic and configurable actors
  - a specialized actor language would be nice, e.g. Cal
- Take 2 – Cal implementation for Ptolemy runtime library
  - thin layer on top of atomic actors to support Cal implementation
  - extra Cal constructs for event handling, as an actor can be triggered by data and widget events, in addition to input on ports
- Take 3 – moved to Javafx toolkit
  - more Cal constructs for UI state update
  - improved thread handling

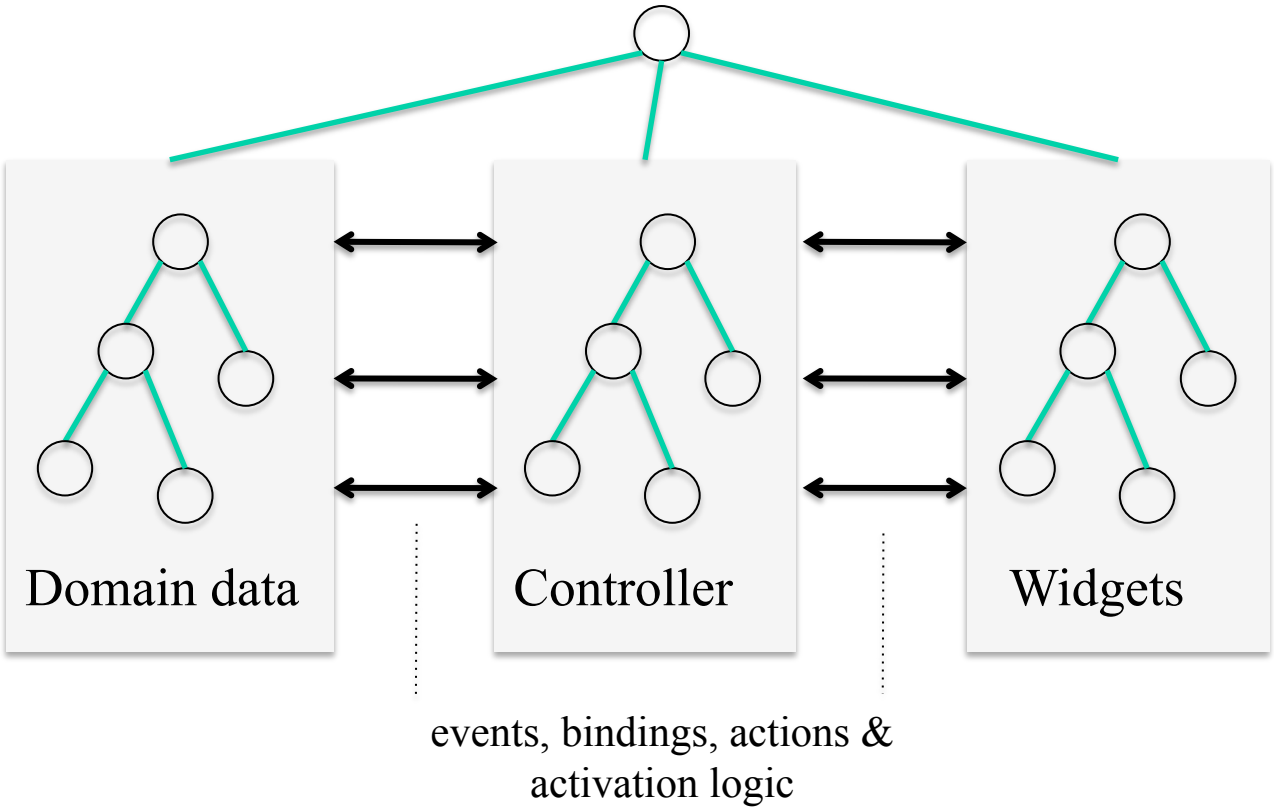
Take 1

- Event-driven, use DE Director
- Load UI with SwixmlResource
- Break cycles with TimeDelay



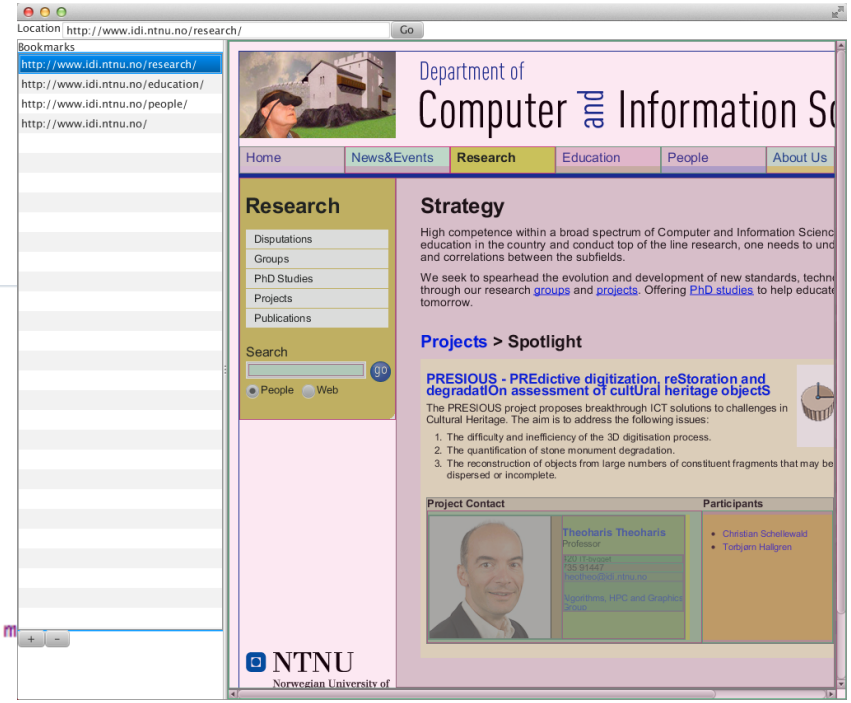
- Issues
  - hand-coding actors is difficult and tedious
  - Swing is being replaced by Javafx

Application architecture



- The whole runtime state is captured as coordinated graphs of data
- The widget hierarchy is continuously rendered on a device

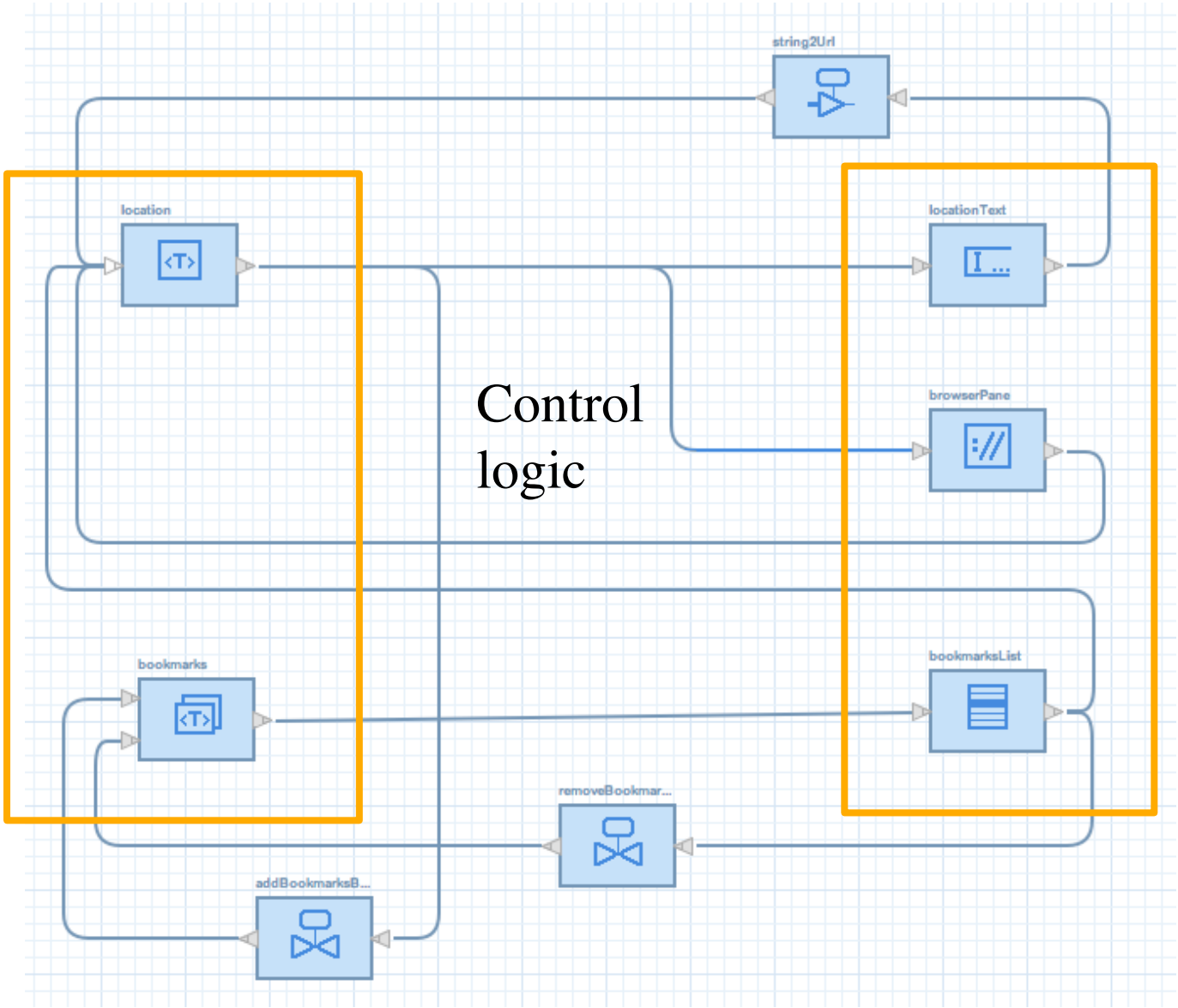
Javafx widgets with fxml



browser.fxml | PTextField.java

```
<?xml version="1.0" encoding="UTF-8"?>

<?import java.lang.*?>
<?import java.util.*?>
<?import javafx.scene.control.*?>
<?import javafx.scene.layout.*?>
<?import javafx.scene.paint.*?>
<?import javafx.scene.web.*?>

<BorderPane maxHeight="-Infinity" maxWidth="-Infinity" m
  <top>
    <HBox>
       <Label text="Location" />
       <TextField id="browser_location_text" prefWidth="400.0" text="http://www.idi.ntn
       <Button id="browser_location_goButton" mnemonicParsing="false" text="Go" />
    </HBox>
  </top>
  <center>
    <SplitPane dividerPositions="0.25" focusTraversable="true">
      <items>
         <VBox>
            <Label text="Bookmarks" />
            <ListView id="browser_bookmarks_list" prefHeight="700.0"  prefWidth="200.0"
            <HBox>
                <Button id="browser_bookmarks_addButton" text="+" />
                <Button id="browser_bookmarks_removeButton" text="-" />
            </HBox>
         </VBox>
         <WebView id="browser_viewer" prefHeight="800.0" prefWidth="800.0" />
      </items>
    </SplitPane>
  </center>
</BorderPane>
```

Model of the controller



Data

Control logic

Widgets

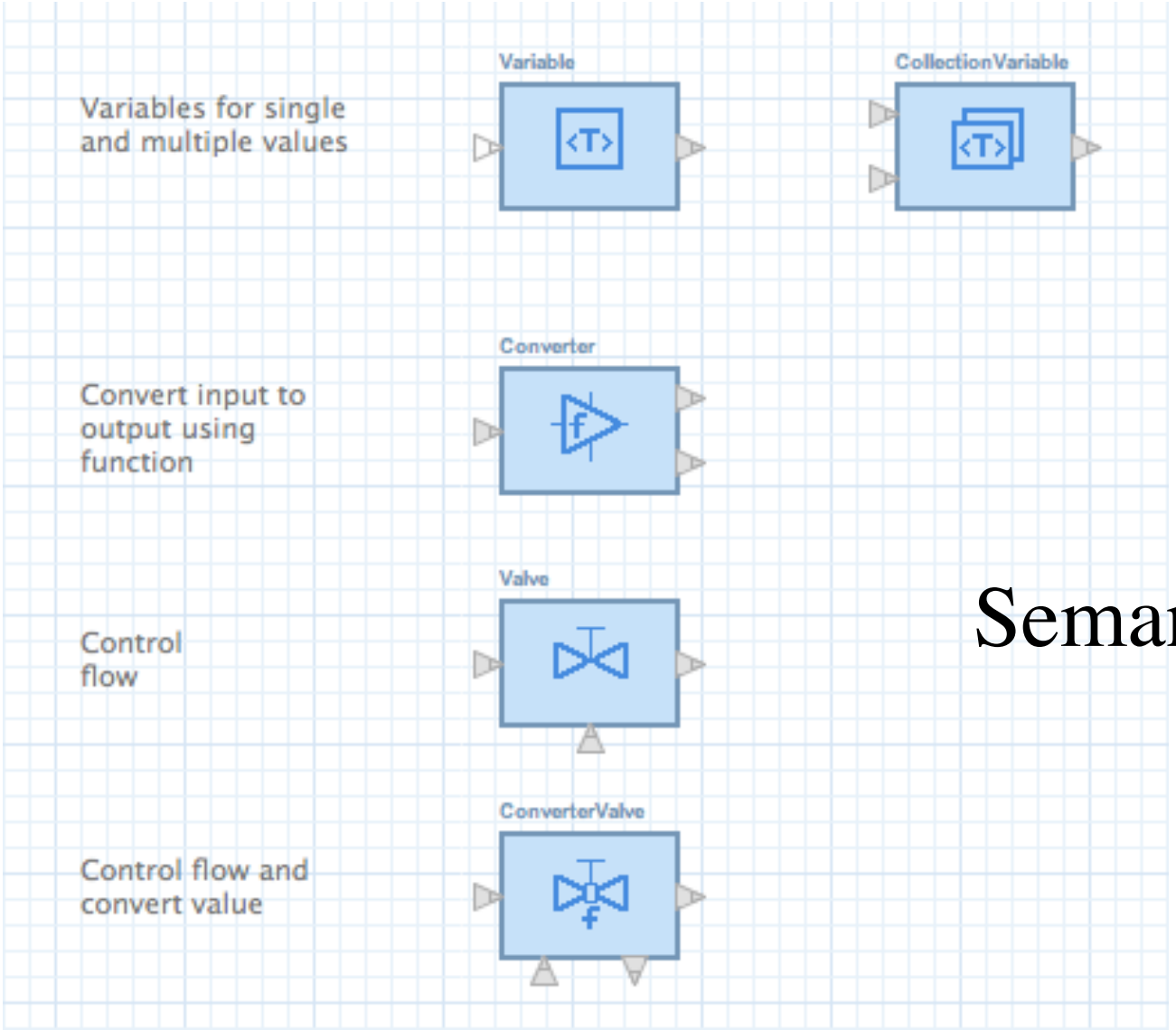
Model of the controller

browser.xactor | ui.xactor | swing.xactor | browser.swixml. | AbstractCaltrop | javafx.xa

```
network browser :
    entities
        location = Variable<URL>(allowNull=false)

        locationText = PTextField(id="browser_location_text")
        string2Url = PButtonEagerConverter<String, URL>(id="browser_location_goButton",
            fun=[String s|try { new URL(s) } catch (Exception e) { throw new RuntimeException(e)}]
        )
        browserPane = PBrowser(id="browser_viewer")

        bookmarks = CollectionVariable<URL>
        bookmarksList = PCollection<URL>(id="browser_bookmarks_list")
        addBookmarksButtonValve = PButtonValve<URL>(id="browser_bookmarks_addButton")
        removeBookmarksButtonValve = PButtonValve<URL>(id="browser_bookmarks_removeButton")

    structure
        location.value -- toString() when it != null --> locationText.systemOutput
        location.value          --> browserPane.systemOutput
        string2Url.output       --> location.setValue
        locationText.userInput  --> string2Url.input
        browserPane.userInput   --> location.setValue

        bookmarks.value --> bookmarksList.systemOutput
        bookmarksList.userInput --> location.setValue

        location.value --> addBookmarksButtonValve.input
        addBookmarksButtonValve.output --> bookmarks.add

        bookmarksList.userInput --> removeBookmarksButtonValve.input
        removeBookmarksButtonValve.output --> bookmarks.remove
end
```

Network of (instances of) reusable actors

Generic actors, based on Diamodl



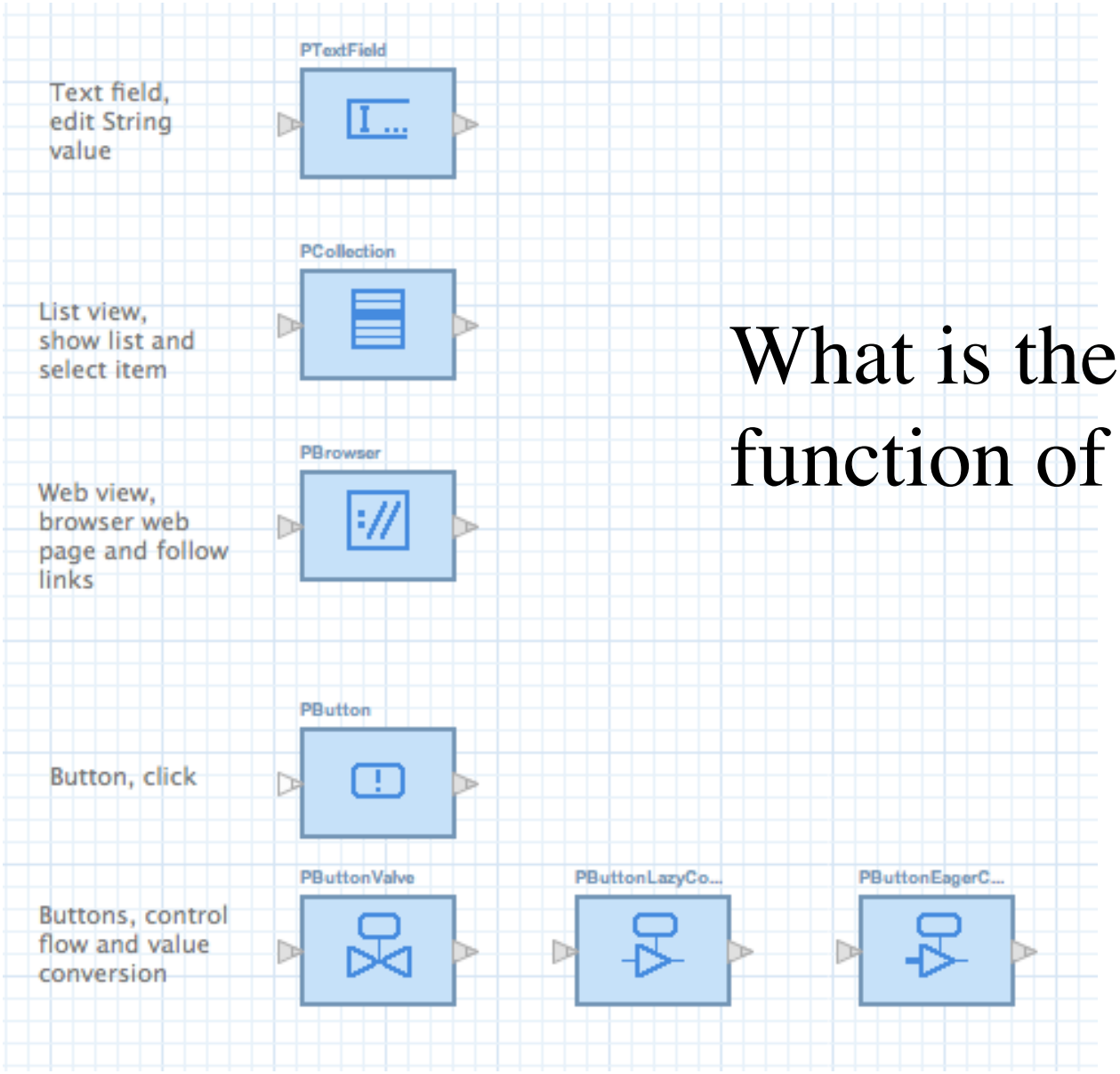
Semantics!

Cal – generic actors

browser.xactor | ui.xactor | swing.xactor | browser.swixml. | AbstractCaltrop

```
namespace org.ptolemy.xtext.examples.ui :

import java.util.Collection
import java.util.ArrayList

actor Variable<T>(T initialValue=null, boolean allowNull=true, (T) => boolean validator)
T* setValue ==> T value :
    var T current = initialValue;
    function diff(T oldValue, T newValue) --> boolean :
        (oldValue != newValue && (oldValue == null || (! oldValue.equals(newValue))))
    end
    function isValid(T value) --> boolean :
        (allowNull || value != null) && (validator == null || validator.apply(value))
    end
    action [newValue] any ==> [current] when current != old_current do
        val T value = newValue.values.head
        if (diff(current, value) && isValid(value)) {
            current = value
        }
    end
end
```

Widget actors, wrappers/abstractions



What is the essential function of widget?

Cal – widget actors

javafx.xactor | browser.xactor | ui.xactor | swing.xactor | browser.swi

```
actor PTextField(String id)
String systemOutput ==> String userInput :
    val @javafx TextField textField = get(id, TextField);
    var @javafx String text := textField.text update textField.text = text;
    initialize ==> [text] end
    action [string] ==> do
        text = string
    end
    event textField.text [propertyEvent] ==> [text] end
    event textField!^action [actionEvent] ==> [text] end
end
```

Widgets

Cal implementation

- Xtext and Xbase provide tight integration with Eclipse platform
  - editor with syntax highlighting, code completion, navigation, ...
  - can refer to and use Java APIs (standard, third-party, custom)

- Implementation liberties
  - expressions – Java-like, closures, syntactic sugar, due to Xbase
  - atomic actors – event specifications
  - network – inline atomic actors, data transforming relations

- Runtime state
  - referring to contextual data
  - updating contextual data
  - threads

Summary

- Ptolemy as a platform for exploring and experimenting with semantics for domain-specific languages

- Utilize Ptolemy and Cal for developing apps
  - language, architecture and tooling issues