Model View Controller (MVC)

Multi-window support

Benefits of MVC

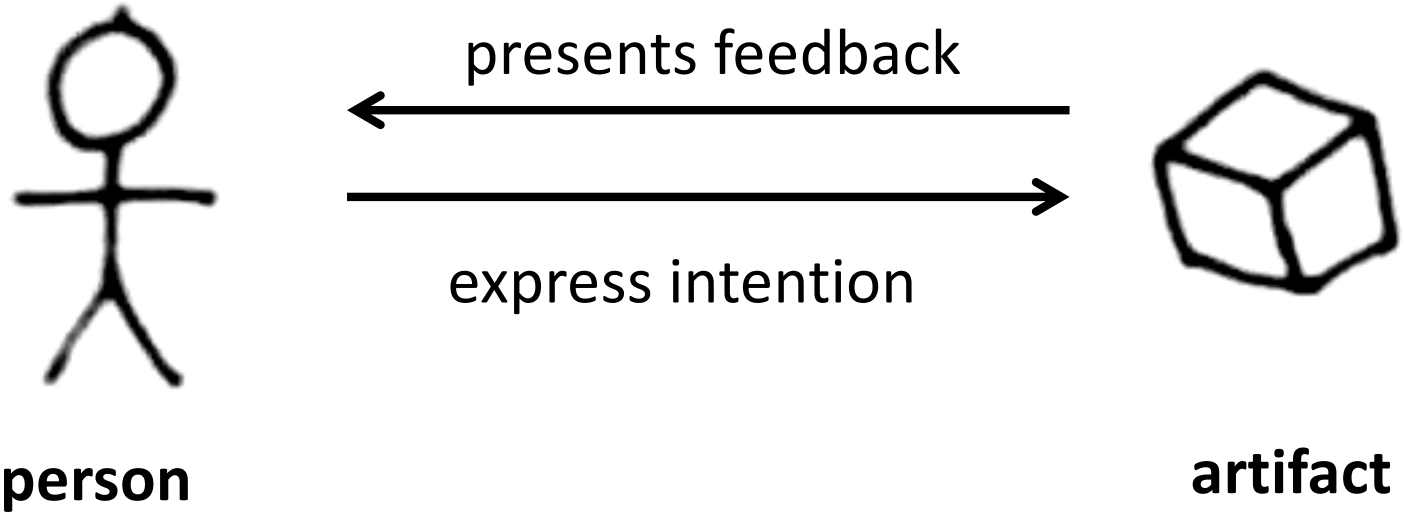
Java Implementation

Widgets

Recall: User Interaction

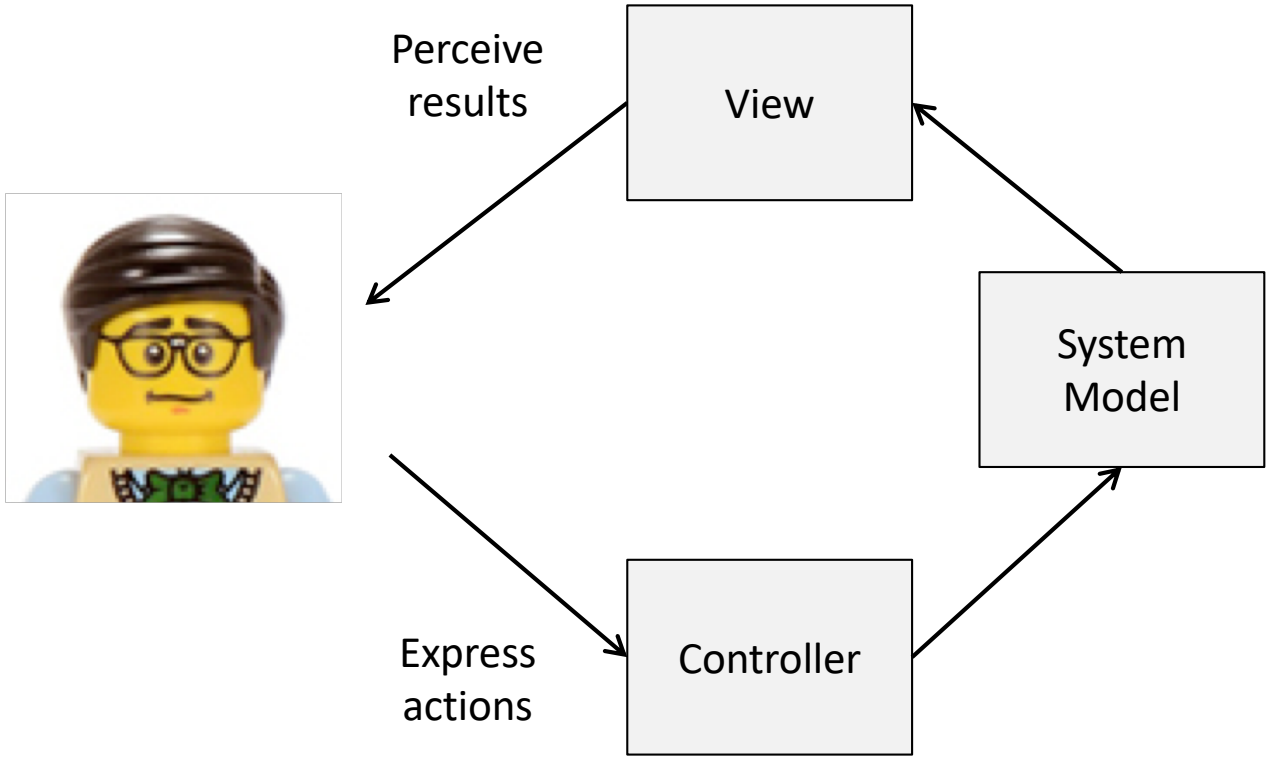
People typically interact with technology to perform a task.

They determine what they want to do, and provide guidance to the system, which gives them feedback.



User Interaction

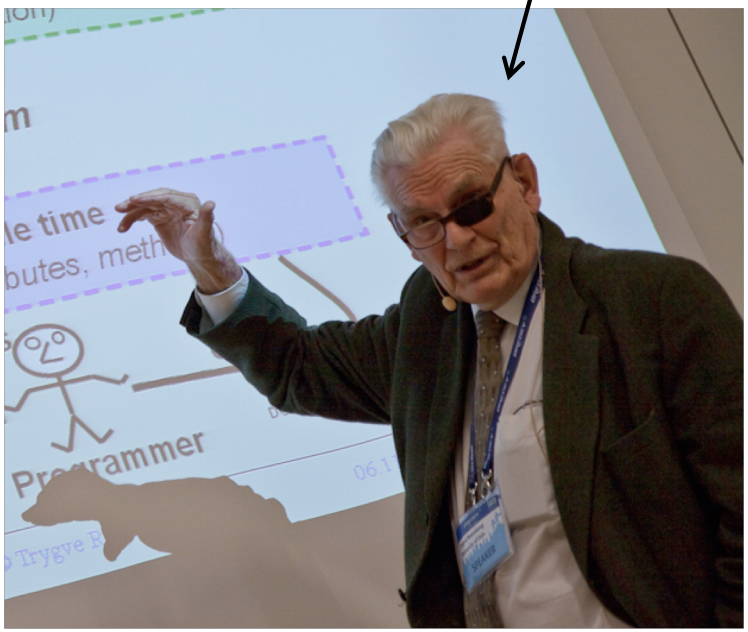
We often design our systems to directly support this style of interaction. This architectural pattern is called **Model-View-Controller**.



Model-View-Controller (MVC)

- Developed at Xerox PARC in 1979 by Trygve Reenskaug
  - for Smalltalk-80 language, the precursor to Java
- Standard design pattern for GUIs
- Used at many levels
  - Overall application design
  - Individual components
- Many variations of MVC idea:
  - Model-View-Presenter
  - Model-View-Adapter
  - Hierarchical Model-View-Controller

Trygve Reenskaug



Why use MVC?

1. Clear separation of “business logic” and the user-interface logic.

This means that the View (output) and Controller (input) can be changed without changing the underlying Model.

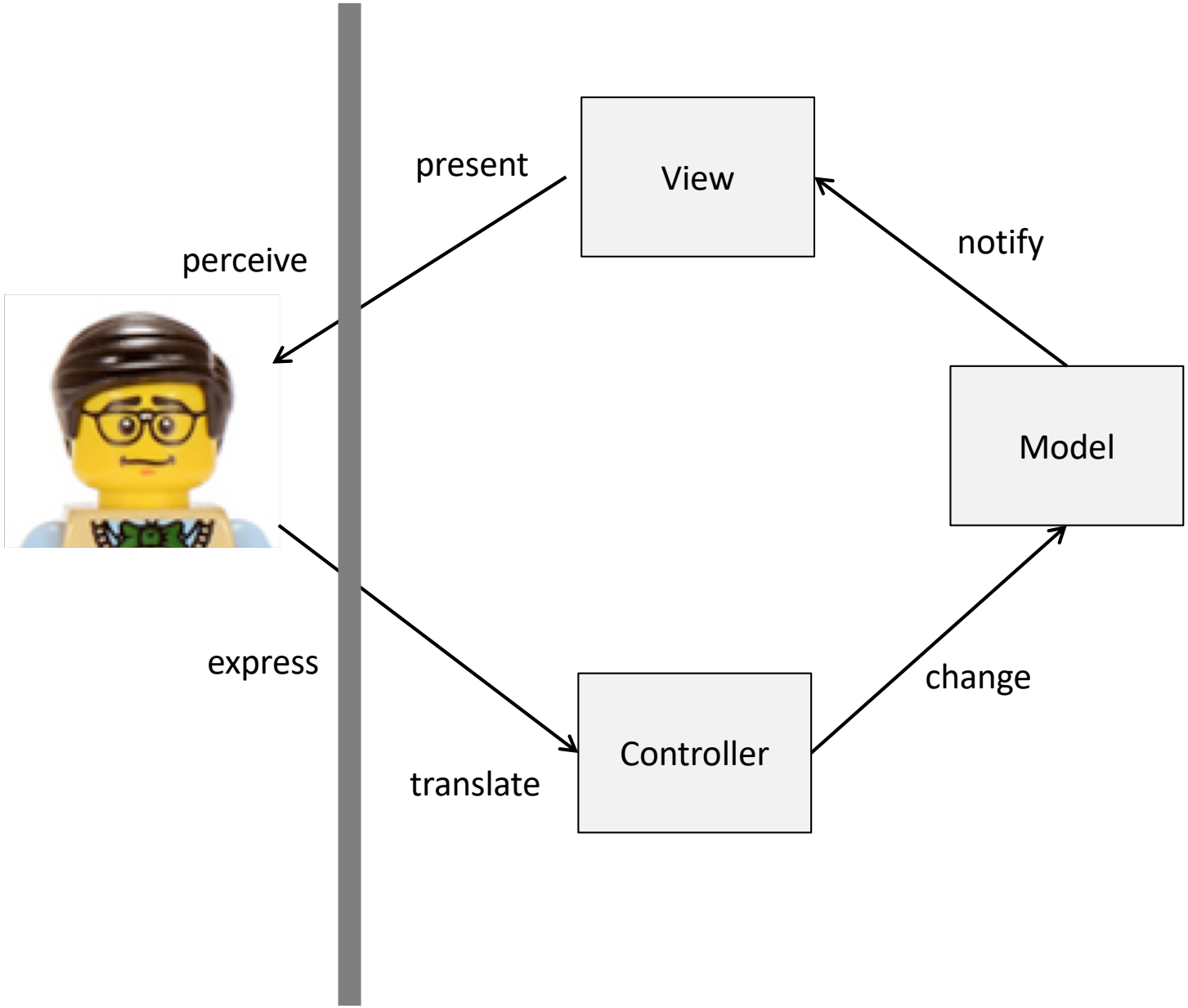
- When is this useful?
  - Adding support for a new input device (e.g. voice control, touchscreen)
  - Adding support for a new type of output device (e.g. different size screen)

2. Supports multiple views of the underlying data/model.

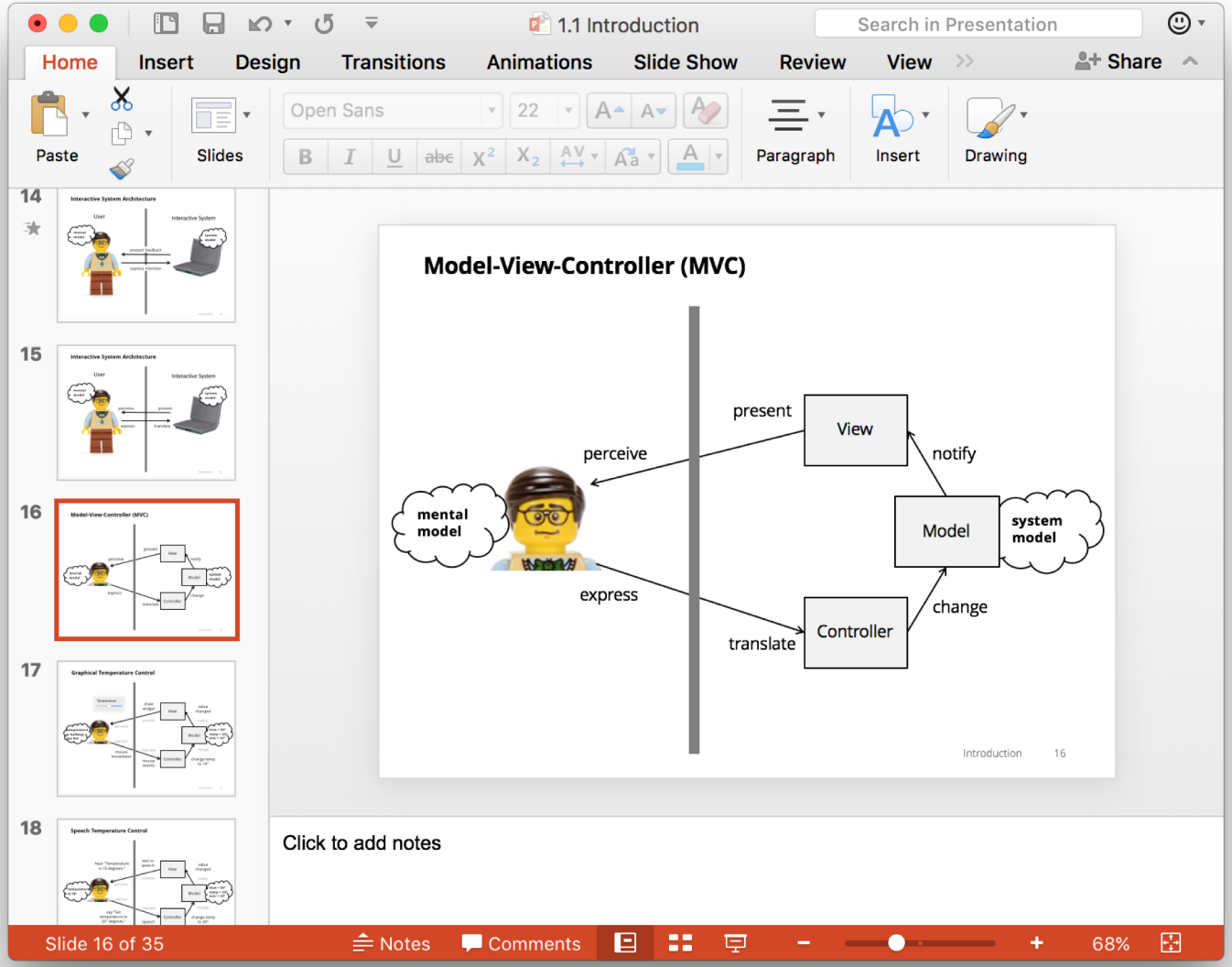
- When is this useful?
  - Viewing numeric data as a table, a line graph, a pie chart, …
  - Displaying simultaneous “overview” and “detail” views
  - Enabling “edit” and “preview” views

3. Separation of concerns in code (code reuse, ease of testing)

Model-View-Controller (MVC)

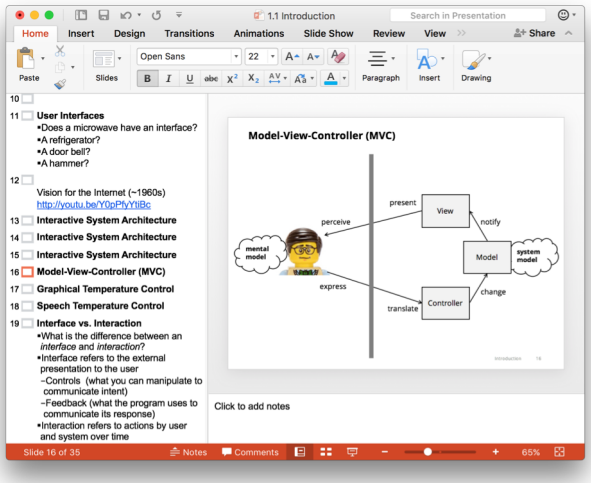


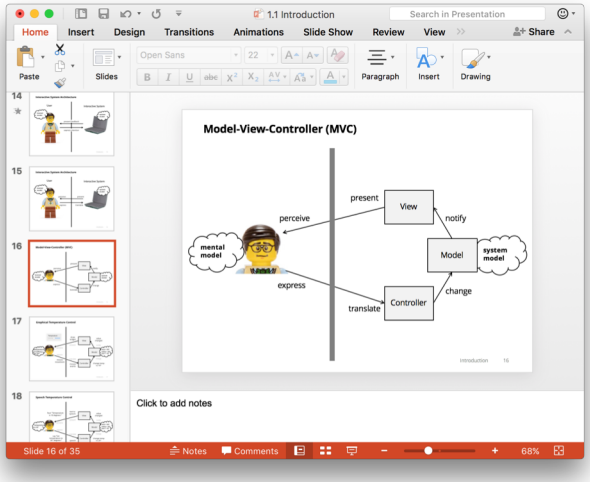
How can we design PowerPoint?

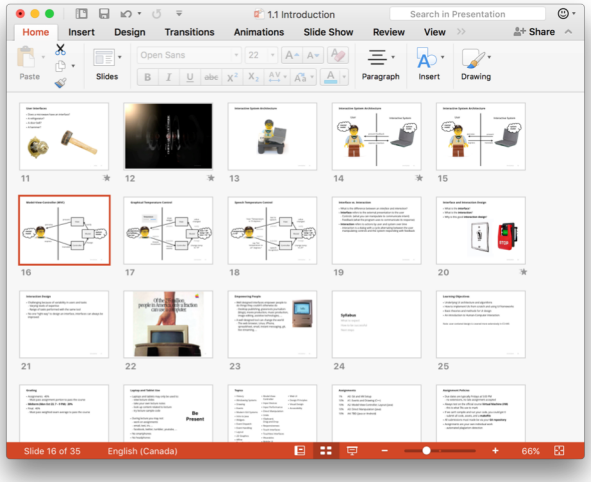


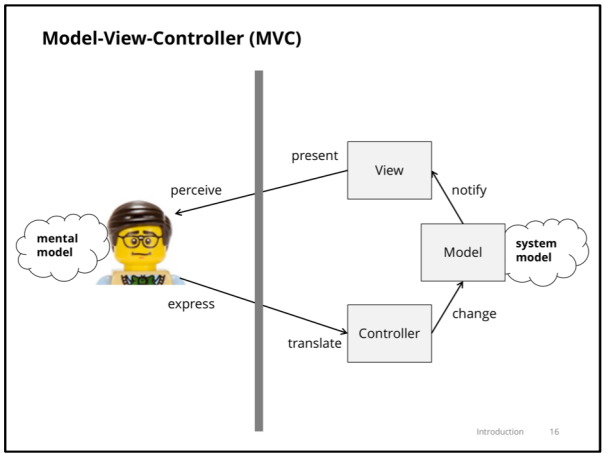
Multiple Views

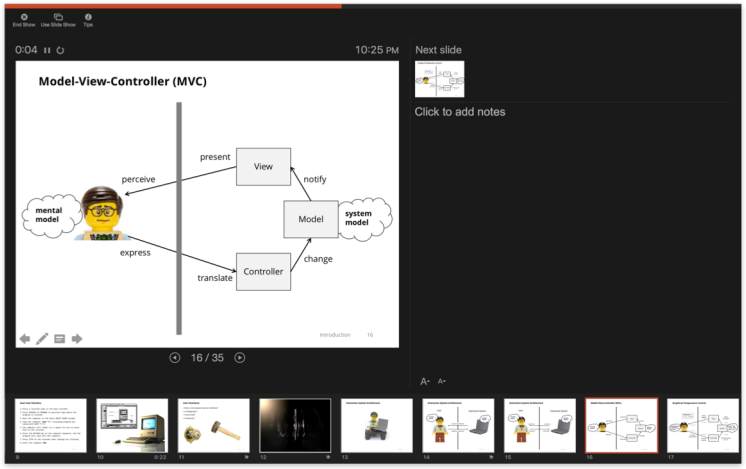
- Many applications have multiple views of one “document”





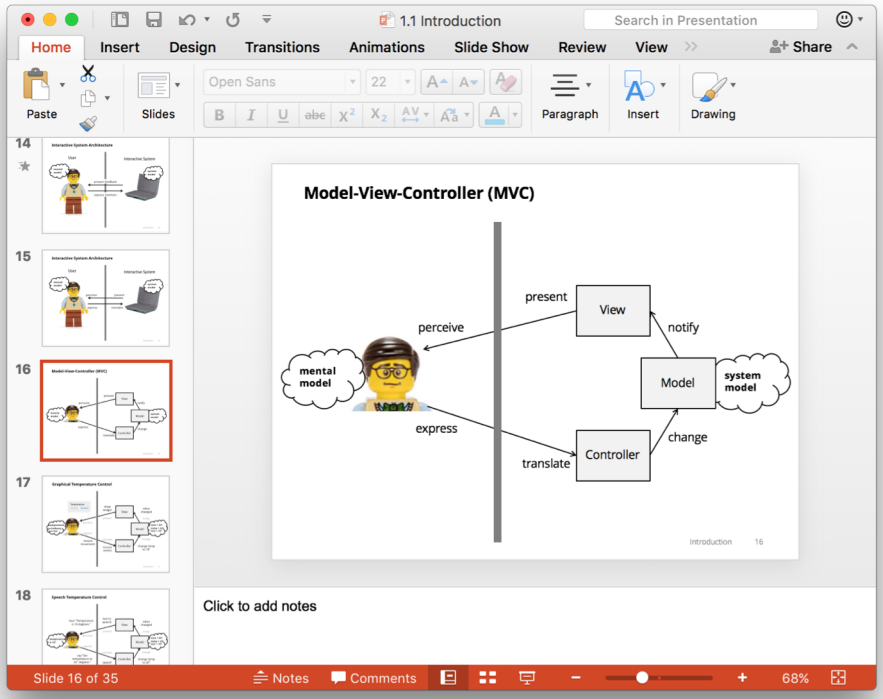






Multiple views observations

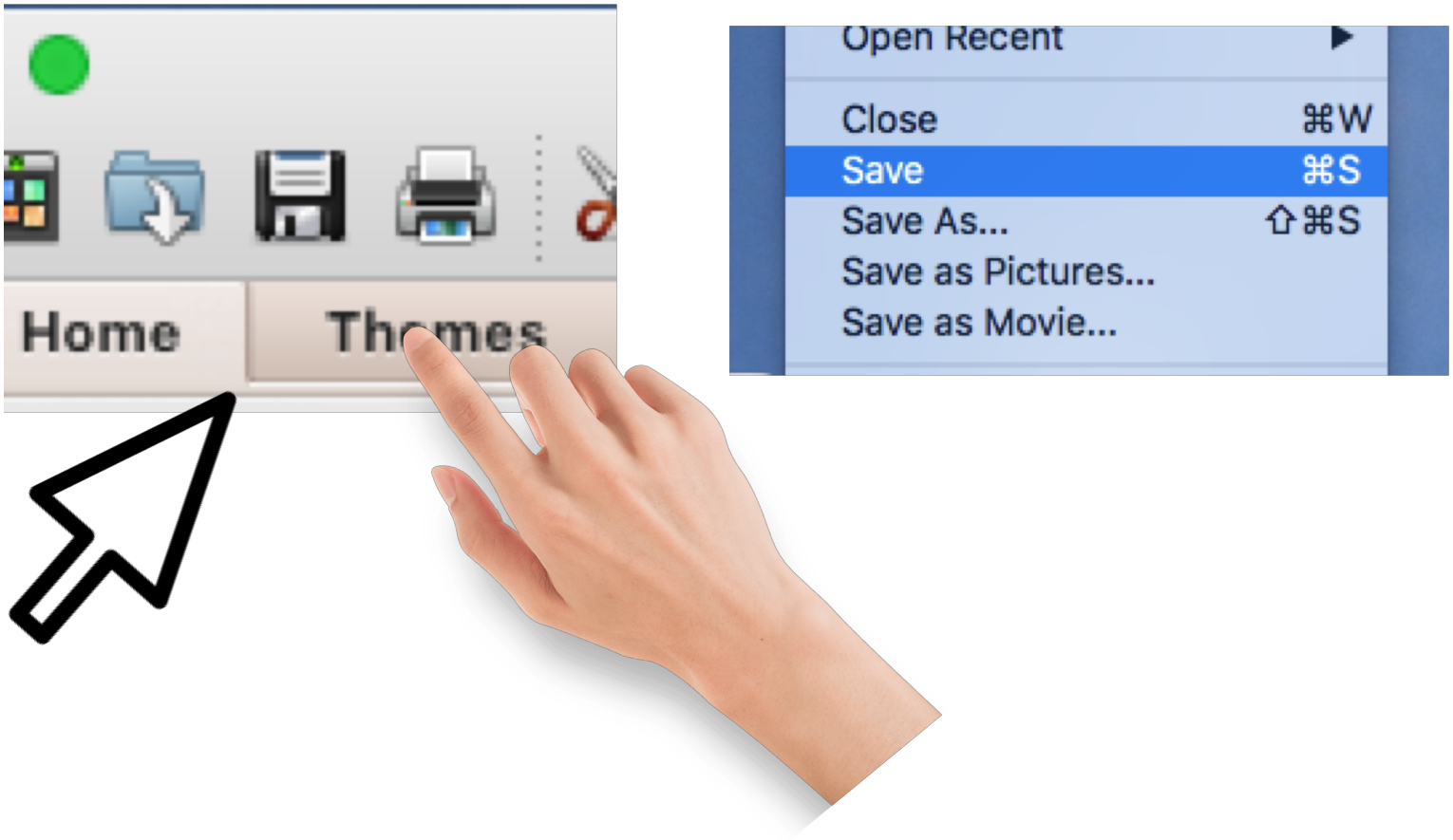
When one view changes, the others should change as well.



- How do we design software to support these observations?
  - We define a single model, that can send information to multiple views.

Multiple input mechanism for same functionality

- What if we want to add new input mechanism?
- Replaceable controllers make this possible.

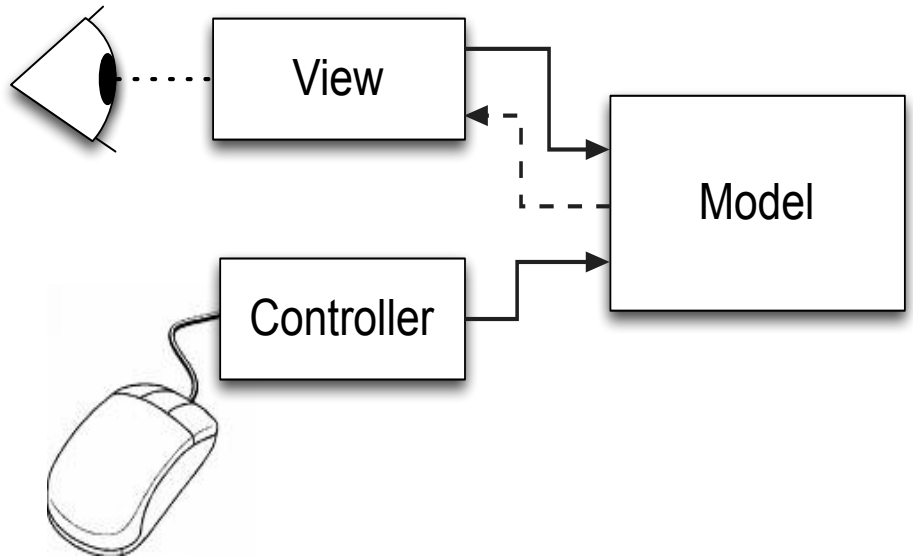


MVC Implementation

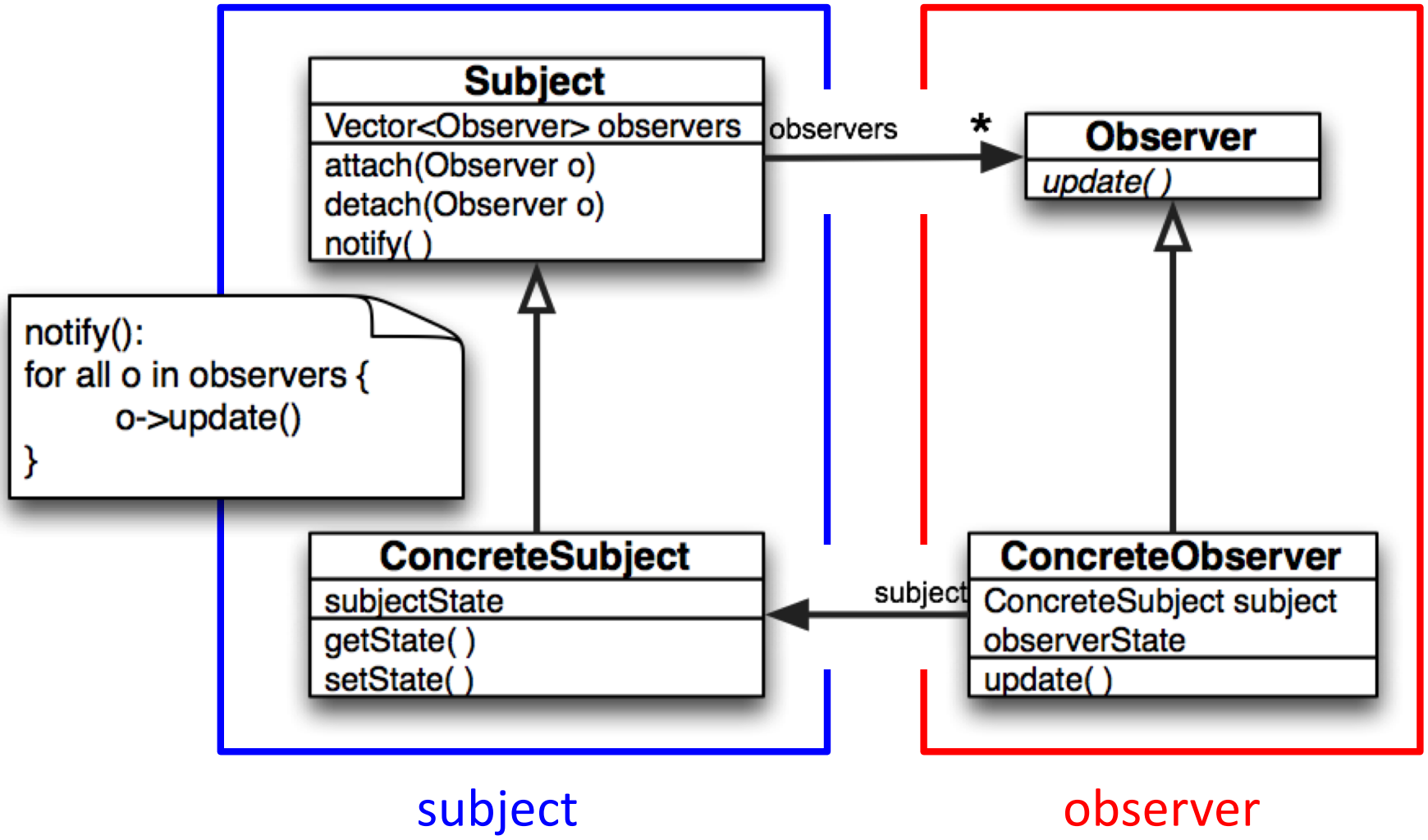
MVC is an instance of the Observer design pattern (sim. “publish-subscribe”)

In MVC, interface architecture is decomposed into three parts:

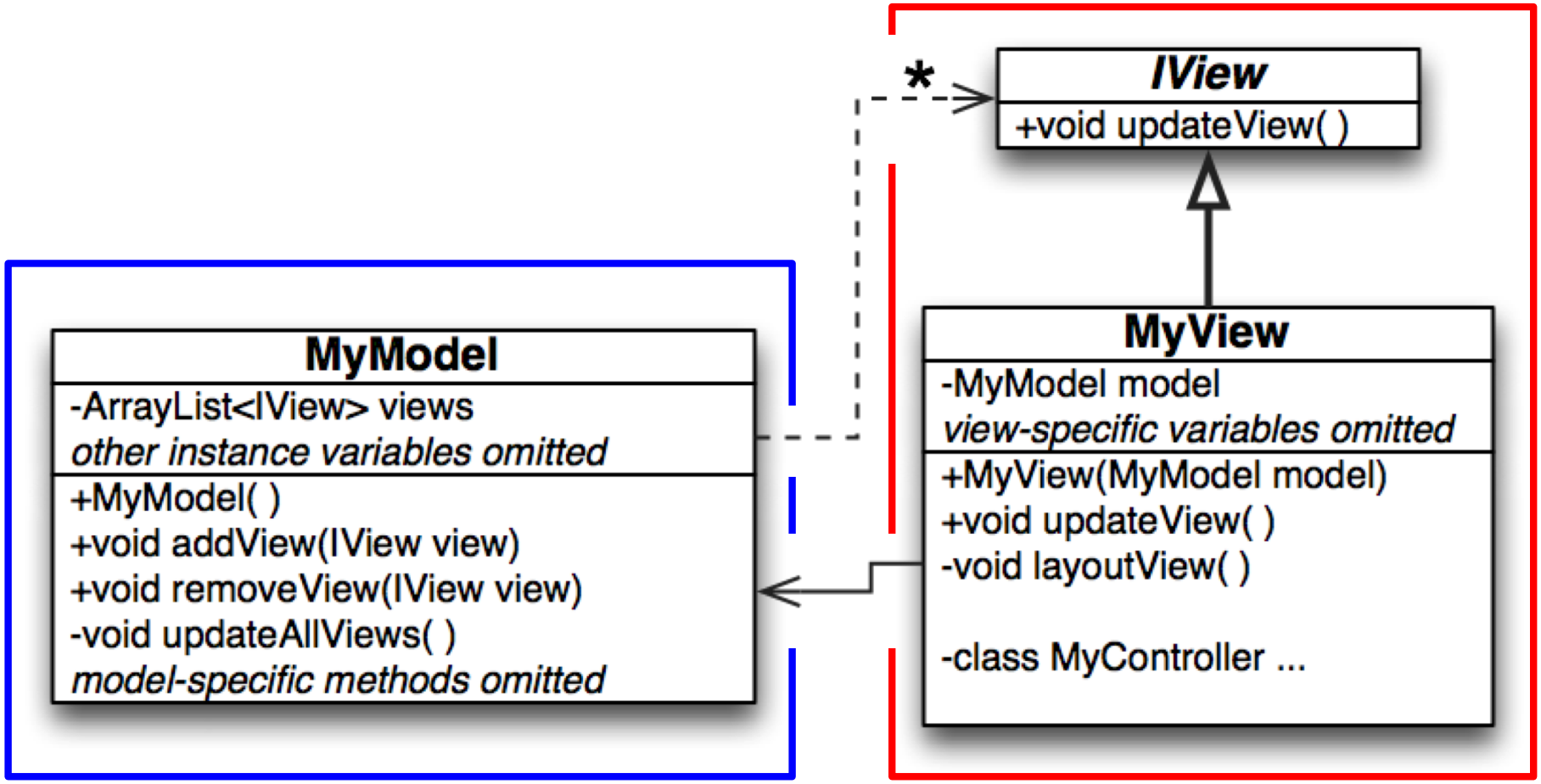
- **Model**: manages application data and its modification
- **View**: manages interface to present data
- **Controller**: manages interaction to modify data



Observer Design Pattern

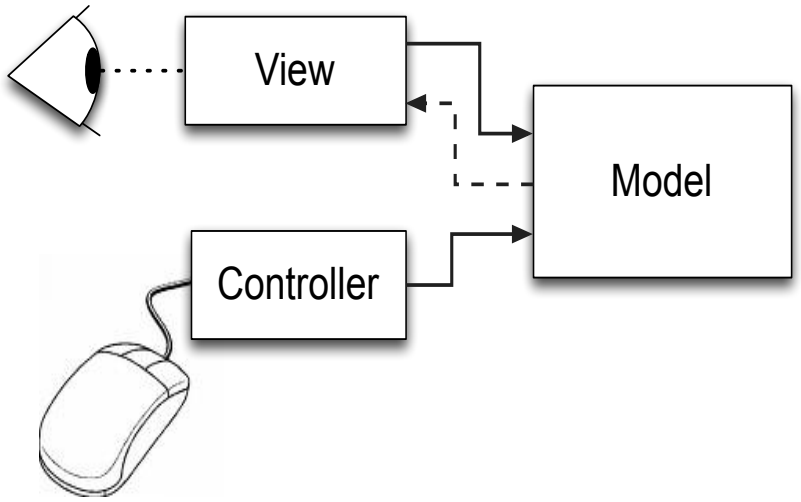


MVC as Observer Pattern

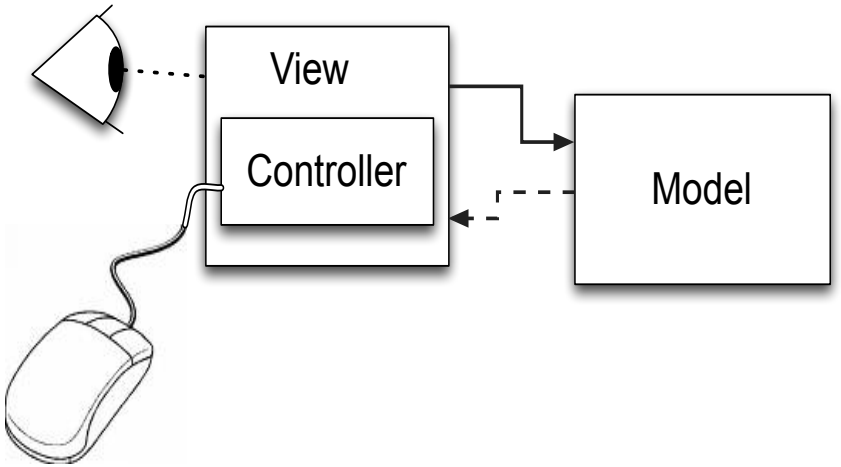


Theory and Practice

- **MVC in Theory**
  - View and Controller are separate and loosely uncoupled



- **MVC in Practice**
  - The View and Controller are tightly coupled. Why?



Problems with MVC

There have been issues identified with MVC since it was introduced.

1. The View should handle both input and output
   - We input and view data on the same screen, so a separate controller class makes little sense.
   - There is often view-level data manipulations that don't make sense to send to the Model. e.g. checking the format of a phone number, highlighting an invalid entry.

     e.g. Model-View, Model-View-Adapter eliminate Controller class
2. One common Model doesn't always make sense
   - We often have data/state that is specific to a View. e.g. different logic on a screen based on region or language.

     e.g. Model-View-Adapter, Model-View-Presenter mediate between Model and View, and provide additional logic.

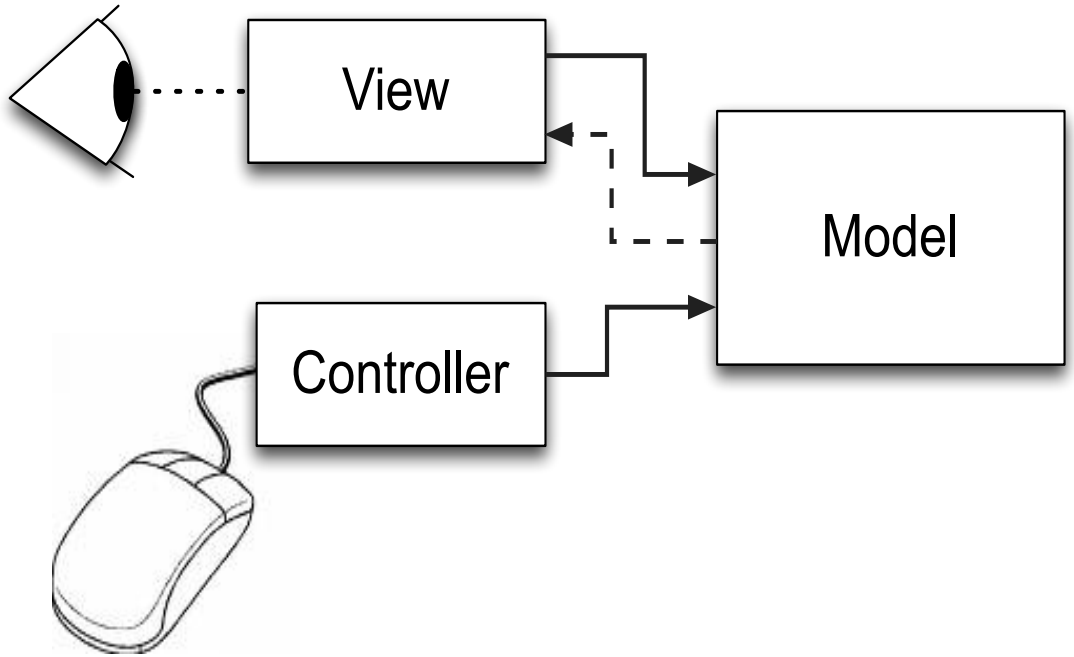
Implementing MVC in Java

Class design

Examples

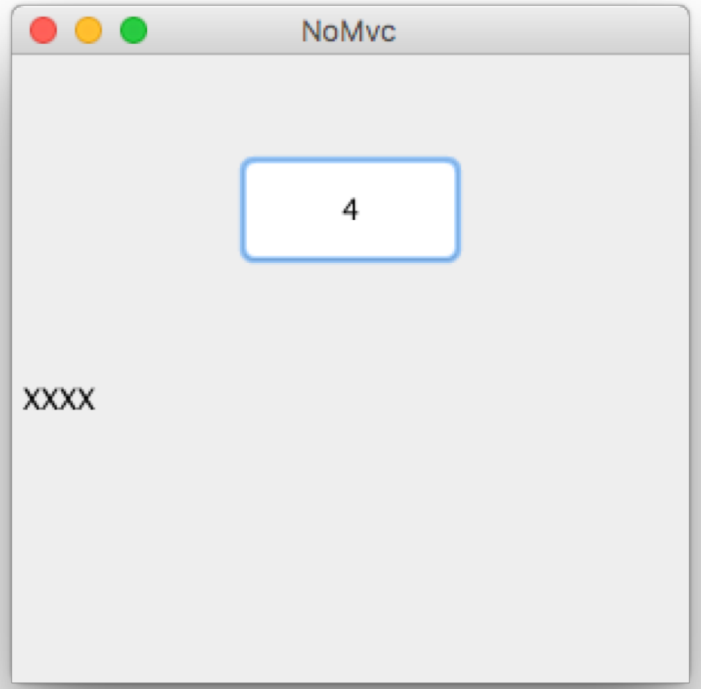
MVC Implementation

- Interface architecture decomposed into three parts:
  - **Model**: manages application data and its modification
  - **View**: manages interface to present data
  - **Controller**: manages interaction to modify data



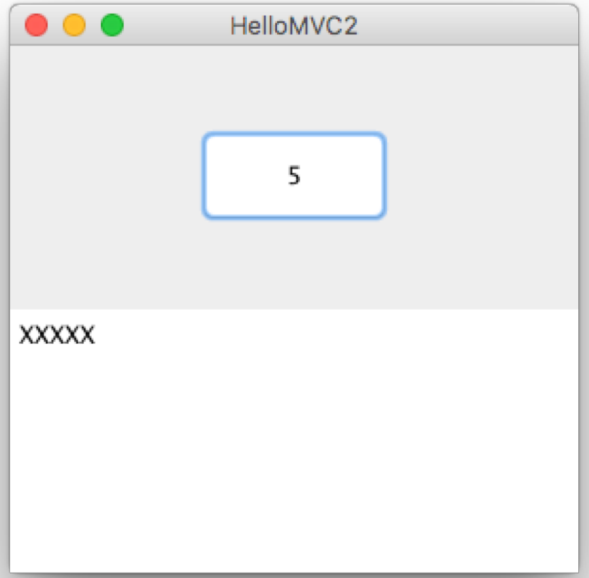
No MVC: Motivating Example

nomvc/



hellomvc1/
1 view

hellomvc2/
2 (or more) views



inspired by Joseph Mack: http://www.austintek.com/mvc/

- (also a good MVC explanation, shows how to use Java Observer class)

View Class Outline

```
class View implements IView {
   private Model model; // the model this view presents

   View(Model model, Controller controller) {

      ... create the view UI using widgets ...

      this.model = model; // set the model
      // setup the event to go to the controller
      widget1.addListener(controller);
      widget2.addListener(controller);
   }

   public void updateView() {
      // update view widgets using values from the model
      widget1.setProperty(model.getValue1());
      widget2.setProperty(model.getValue2());
      ...
   }
}
```

Controller Class Outline

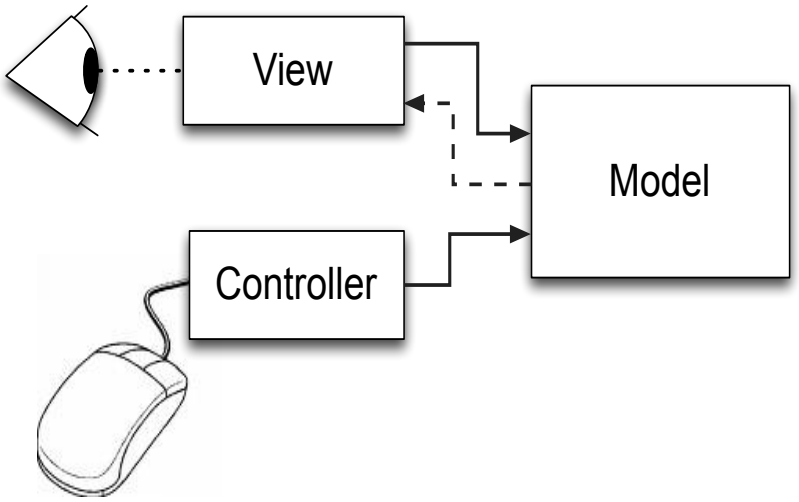
```
class Controller implements Listener {
   Model model; // the model this controller changes

   Controller(Model model) {
      this.model = model; // set the model
   }

   // events from the view's widgets
   // (often separated to 1 method per widget)
   public void action1Performed(Event e){
      // note the controller does need to know about view
      if (widget1 sent event)
         model.setValue1();
      else if (widget2 sent event)
         model.setValue2();
      ...
   }
}
```

Model Class Outline

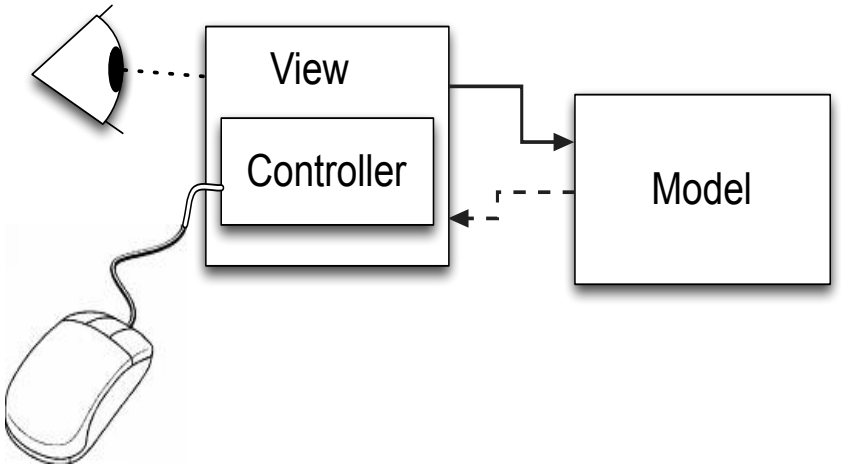
```
class Model {
   List<IView> views; // multiple views
   public void addView(IView view) {...} // add view observer

   // get model values
   public type getModelValue1() { return value1; }
   public type getModelValue2() { return value2; }
   ... more value getters ...

   // set model values
   public void setModelValue1(type value) {
      value1 = value; notifyObservers();
   }

   ... more setters, each calls notifyObservers() ...

   // notify all IView observers
   private void notifyObservers() {
      for (IView view: views) view.updateView();
   }
}
```

Theory and Practice

- **MVC in Theory**
  - View and Controller are separate and loosely uncoupled



- **MVC in Practice**
  - The View and Controller are tightly coupled. Why?



Why doesn't the Controller just directly tell the View to update?
Why "go through" the Model?

hellomvc3/

Controller code in View

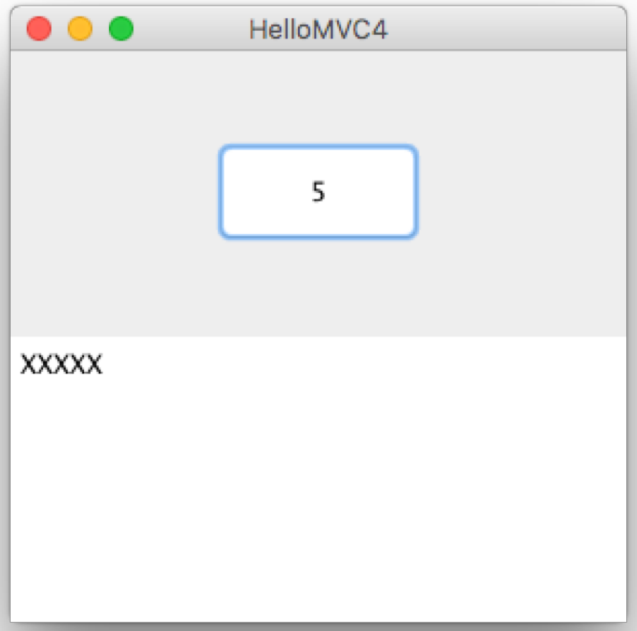
Model Updates Can be Considered an Event

- View can use an anonymous inner class of type IView to create a "ModelListener" for Model to register

hellomvc3b/
anonymous ModelListener

hellomvc4/

- java.util provides Observer interface and Observable class
  - Observer is like IView, i.e. the View implements Observer
  - Observable is the “Subject” being observed
    i.e. the Model extends Observable
  - base class has list of Observers and method to notify them

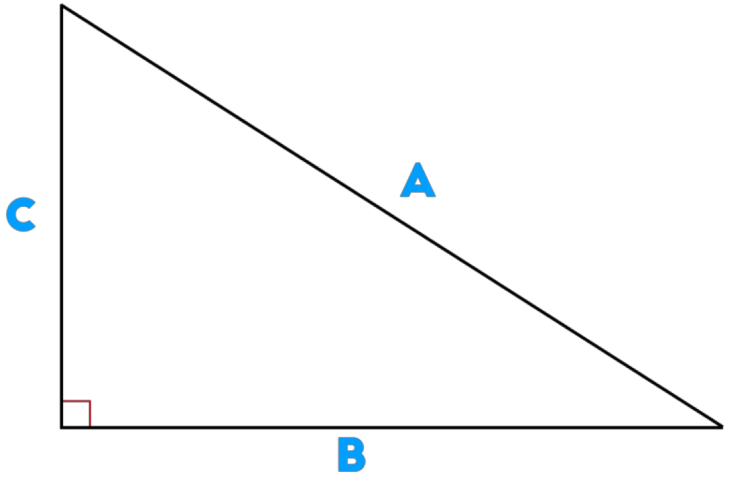


Optimizing View Updates

- Each viewUpdate, *everything* in *every view* is refreshed from model
- Could add parameters to viewUpdate to indicate *what* changed
  - if view knows it isn't affected by change, can ignore it
- But, **simpler is better**
  - early optimization only introduces extra complexity that causes bugs and adds development time
  - don't worry about efficiency until you have to:
    just update the entire interface

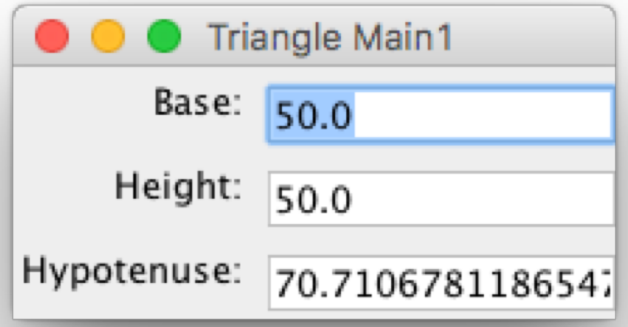
Triangle MVC Code Demos

- Program requirements:
  - vary base and height of right triangle, display hypotenuse
- TriangleModel.java
  - stores base and height, calculates hypotenuse
  - constrains base and height values to acceptable range

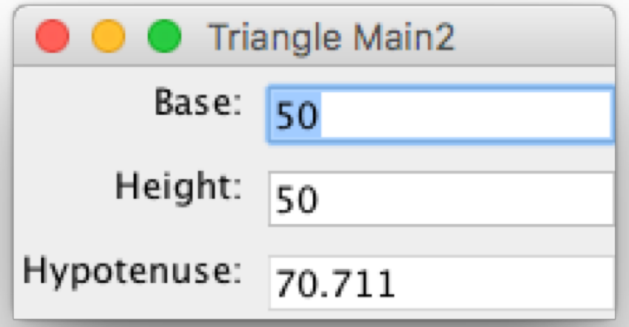


Triangle: Main1.java and Main2.java

`SimpleTextView`



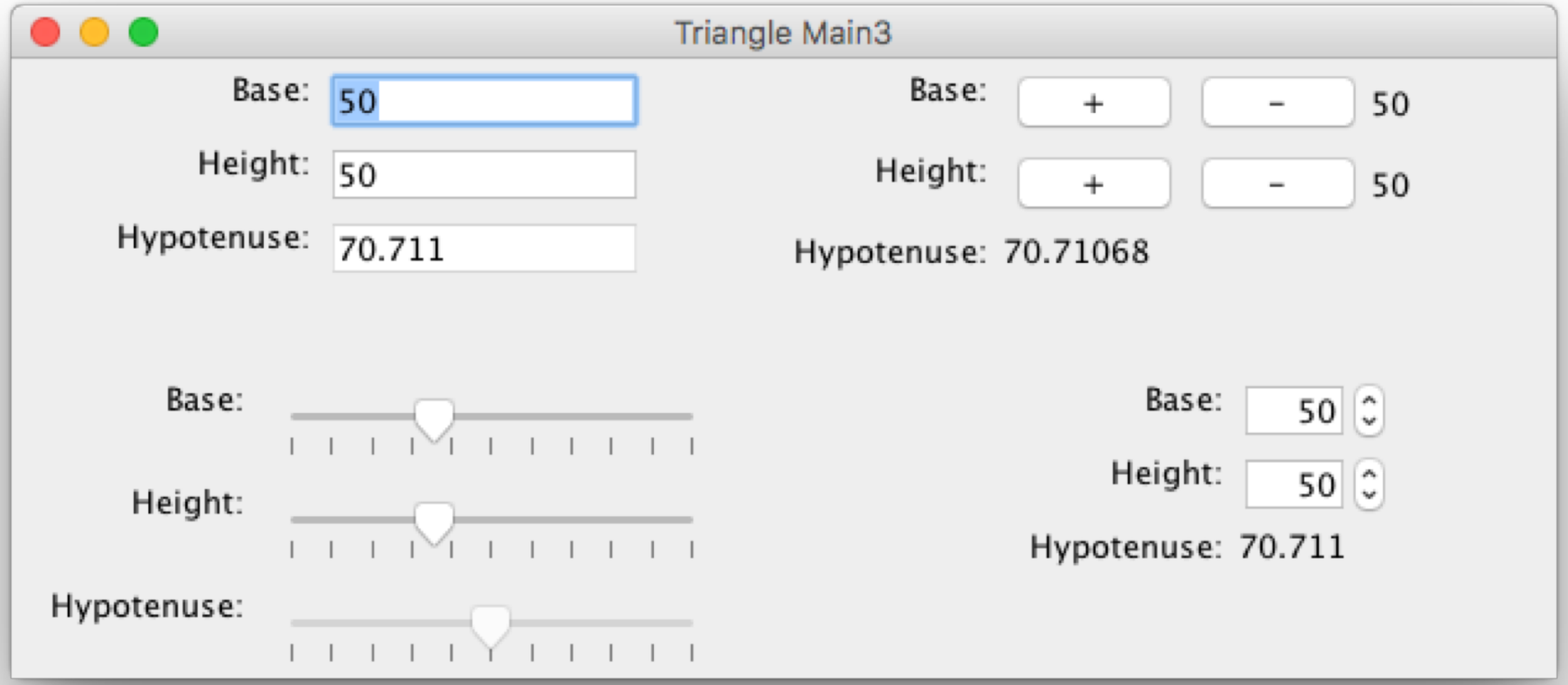
`TextView`



Triangle: Main3.java

Combines Multiple Views using `GridLayout`

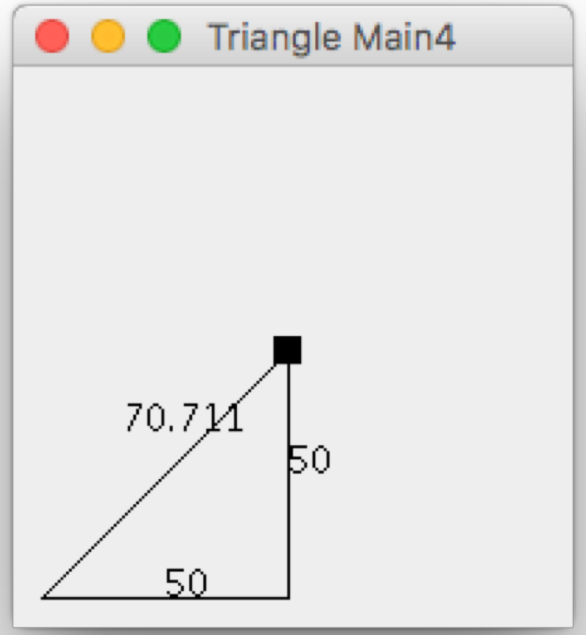
`TextView` `ButtonView`



`SliderView` `SpinnerView`

Triangle: Main4.java

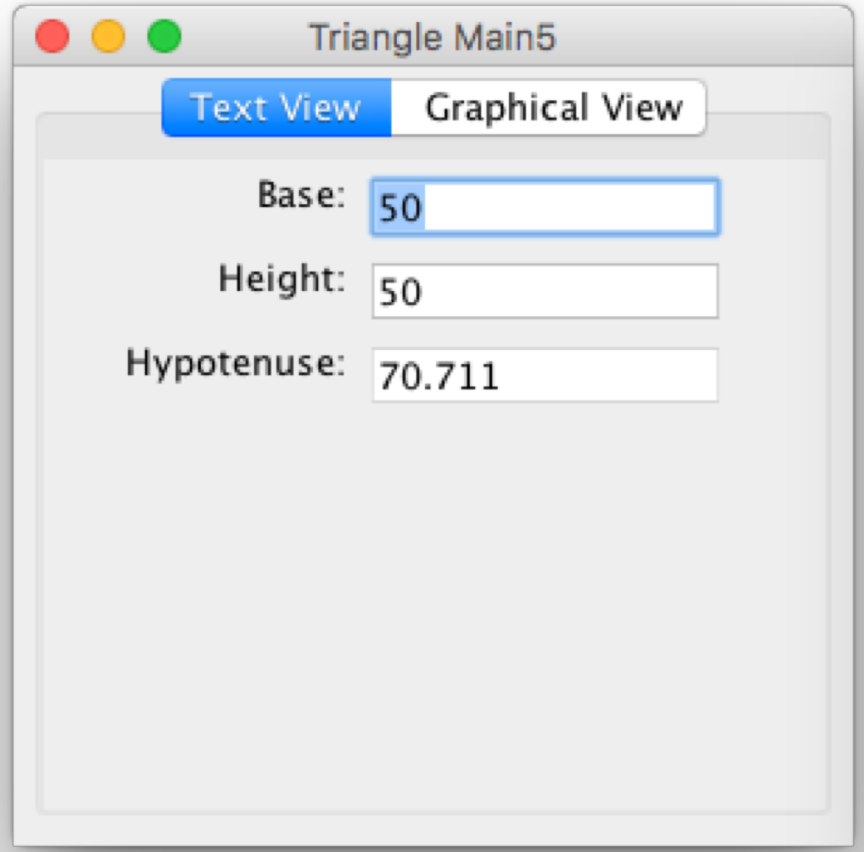
`GraphicalView`



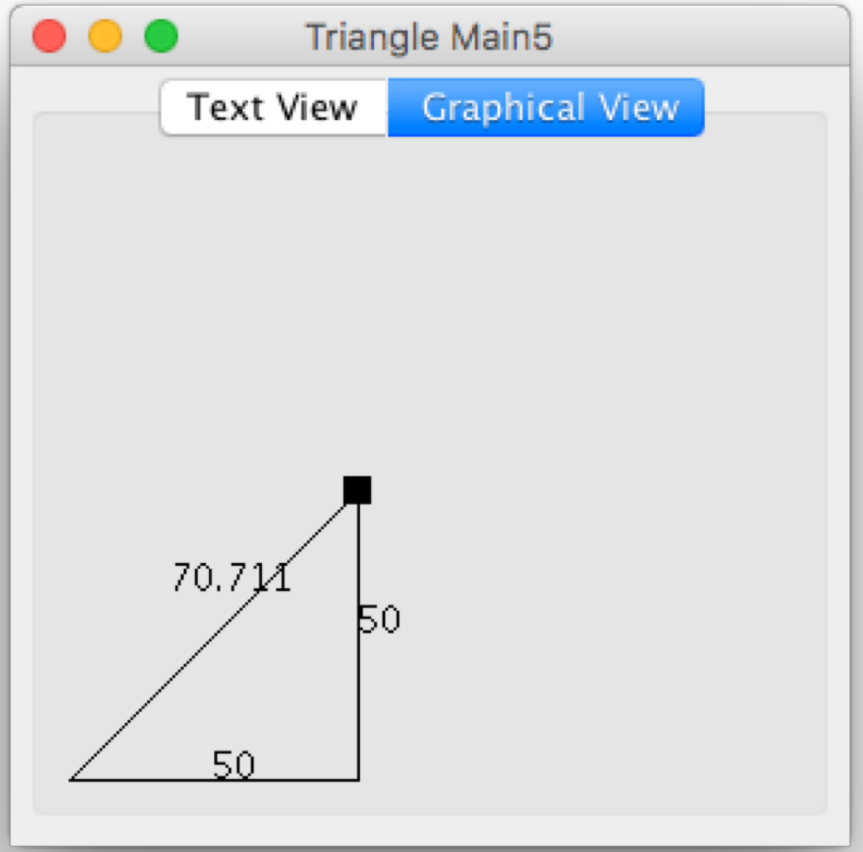
Triangle: Main5.java

Combines Multiple Views using Tab Panel

`TextView`



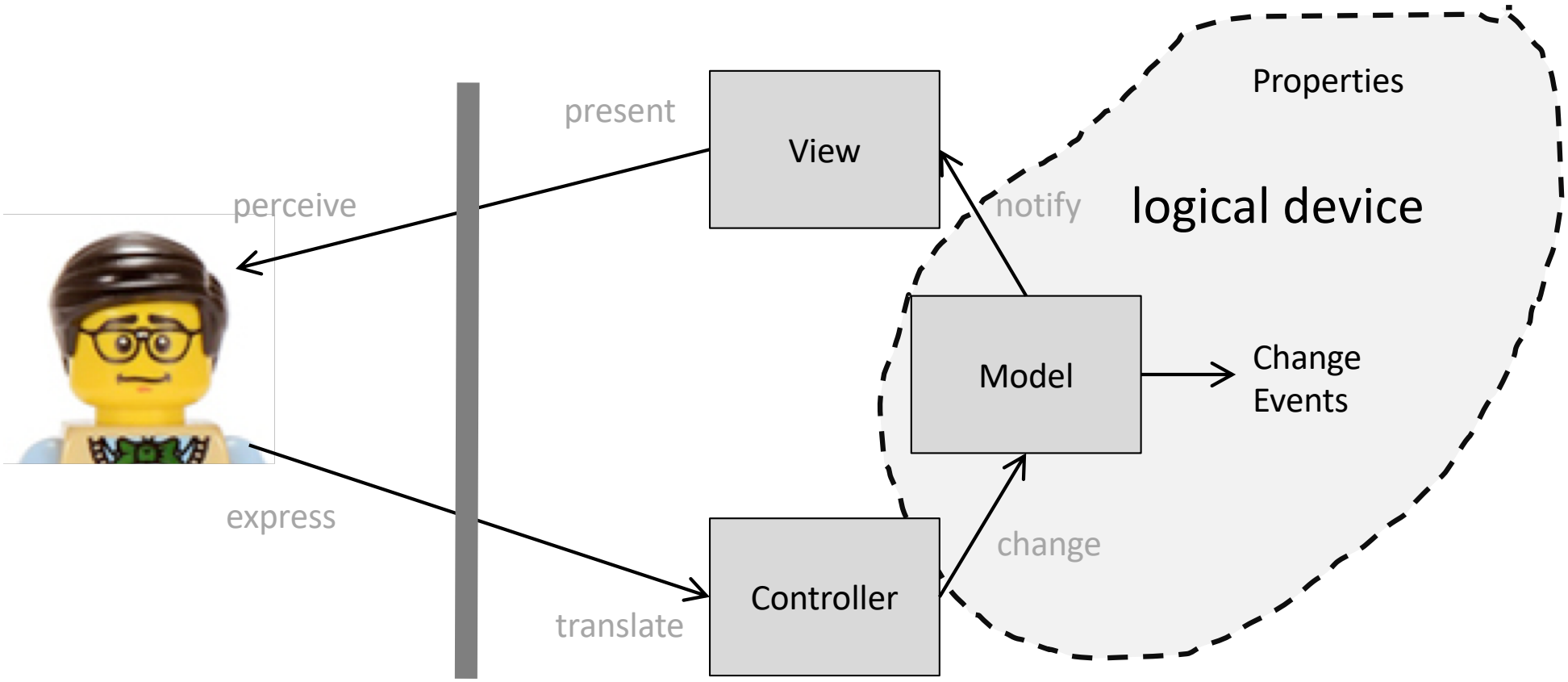
`GraphicalView`



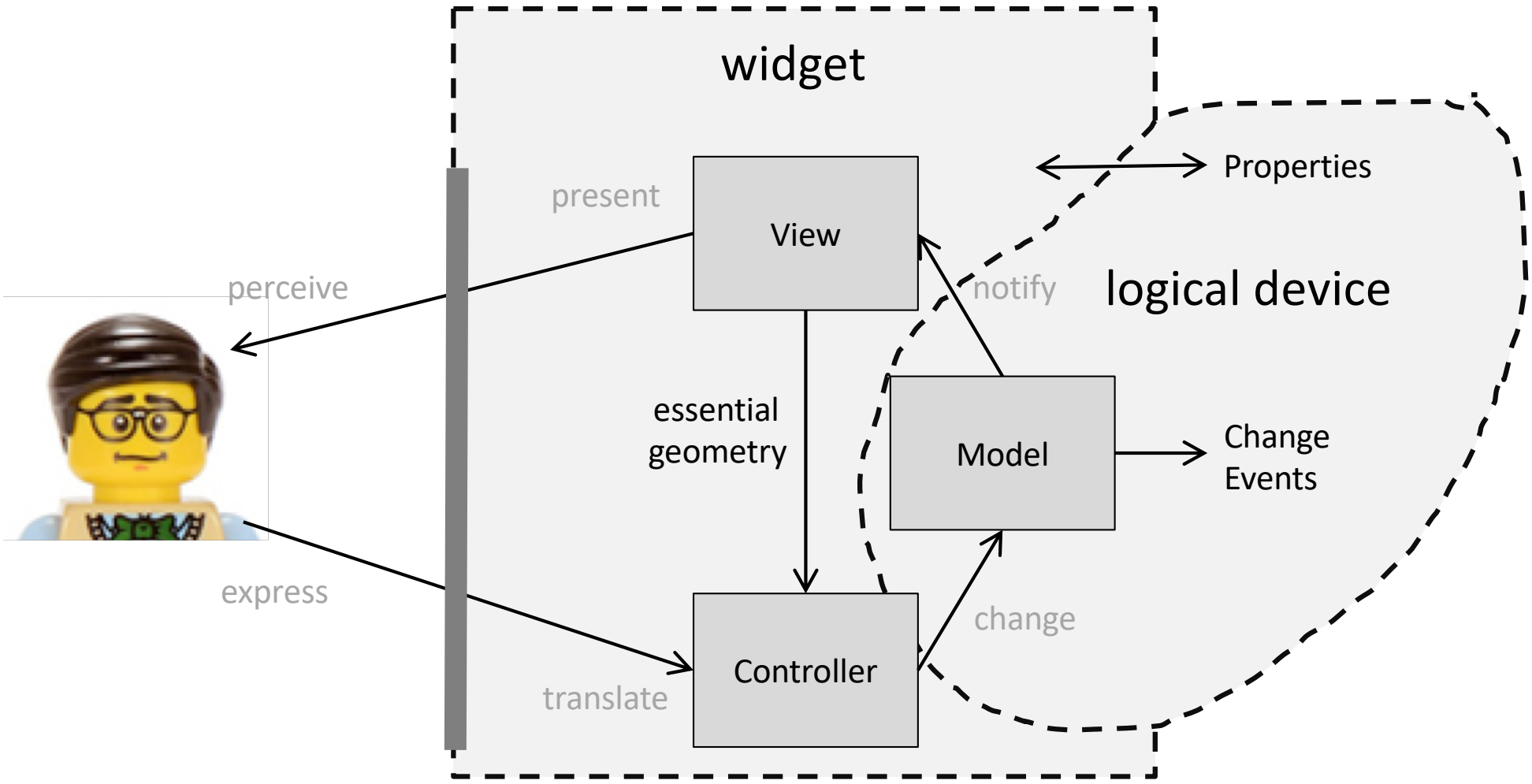
MVC Widget Architecture

Revisiting widgets

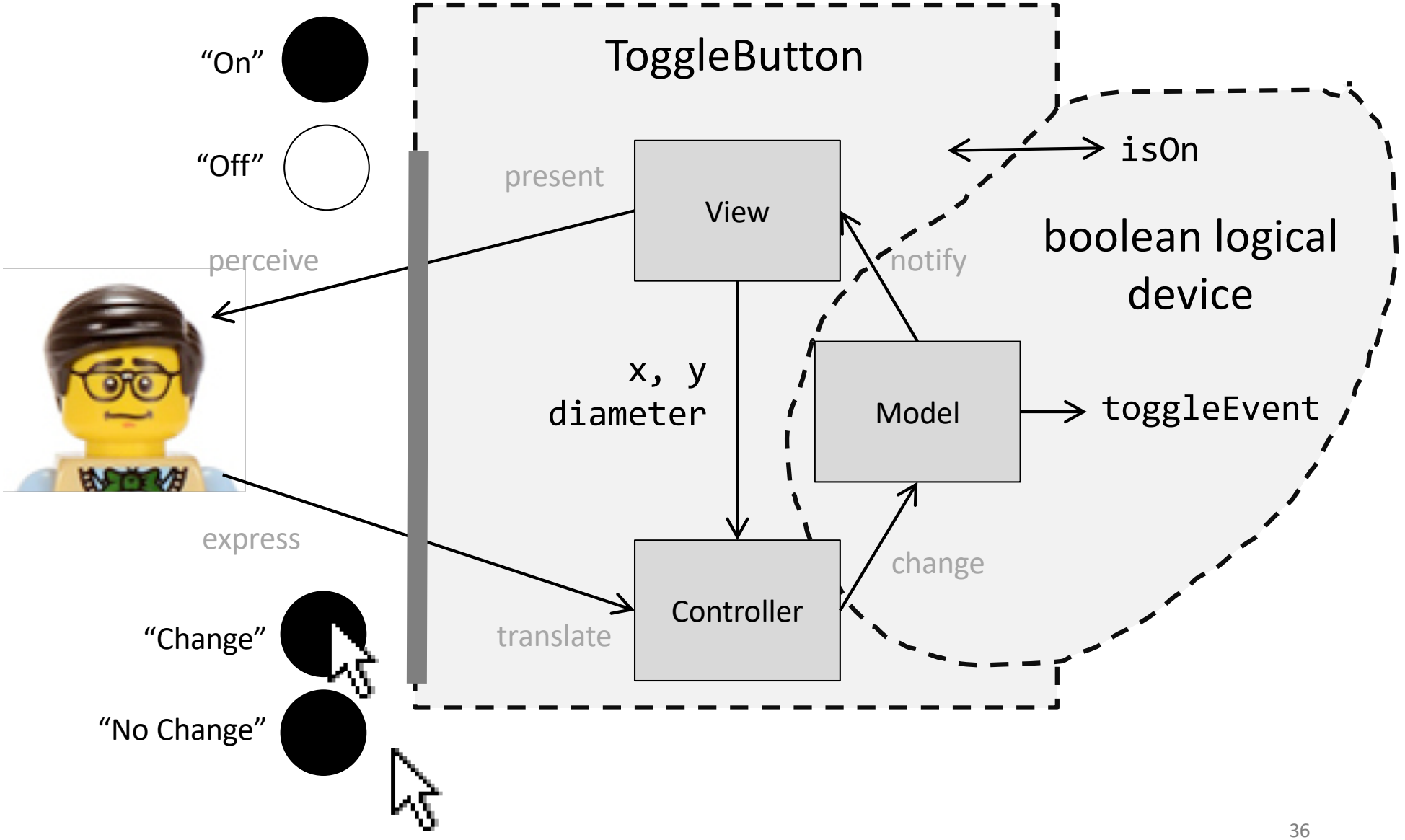
Widget Architecture as MVC



Widget Architecture as MVC



Custom Widgets: ToggleButton



ToggleButton.cpp

```
class ToggleButton {
   ToggleButton(int _x, int _y, void (*_toggleEvent)(bool)) {
      toggleEvent = _toggleEvent;
      isOn = false;
      ...
   }

   // the CONTROLLER
   void mouseClick(int mx, int my) {
      float dist = sqrt(pow(mx - x, 2) + pow(my - y, 2));
      if (dist < diameter) { toggle(); }
   }

   ...
```

ToggleButton.cpp (cont'd)

```
...

// the VIEW
void draw() {
    if (isOn) {
        setForeground(BLACK);
        XFillArc(...);
    } else {
        setForeground(WHITE);
        XFillArc(...);
    }
}

// VIEW "essential geometry"
int x;
int y;
int diameter;

...
```

ToggleButton.cpp (cont'd)

```
    ...

    // toggle event callback
    void (*toggleEvent)(bool);

    // the MODEL
    bool isOn;
    void toggle() {
        isOn = !isOn;
        toggleEvent(isOn); }
};
```

ToggleButton.cpp (cont'd)

```
bool isPaused = false;
// isPaused callback (a simple event handler)
void togglePause(bool isOn) {
   isPaused = isOn;
}

...

ToggleButton toggleButton(150, 100, &togglePause);

...

   case ButtonPress:
      toggleButton.mouseClick(event.xbutton.x, event.xbutton.y);
      break;

...

if (!isPaused) {
   // update ball position
}

toggleButton.draw();
```