# MVC / Tables

# Model / View / Controller

Design
- A decomposition strategy where "presentation" is separated from data maintenance
- Smalltalk idea
- Controller is often combined with View, so have Model and View/Controller

Web Version
- Shopping cart model is on the server
- The view is the HTML in front of you
- Form submit = send transaction to the model, it computes the new state, sends you back a new view

## Modularity

Writing larger programs in teams, we're always on the lookup for a natural dividing line to help use separate our 1000 into two 500 line parts that are as independent as possible.

Separating the "Data Model" and "View" ideas is works well and is a common modularity strategy.

## Model -- aka Data Model

"data model"

Storage, not presentation

Knows data, not pixels

Support data model operations
- cut/copy/paste, File Saving, undo, networked data -- these can be expressed just on the model which simplifies things
- e.g. can get the logic for file save or undo working, without worrying about pixels.

## View

Presentation

Gets all data from model and draws or otherwise renders it for the user

## Controller

The logic that glues things together.

Manage the relationship between the model and view

1. Most data changes are initiated by user events (keyboard, mouse gestures) that tend to happen on the view side. These are translated to messages to the model which does the actual data maintenance

2. Going the other direction, the view needs to hear about changes in the model. In Java, this is done with a Listener paradigm in Swing.

Usually, the controller is implemented in the view.

## Model Role

Respond to getters methods to provide data
Respond to setters to change data
Manage a list of listeners
    Java uses the Model/Listener structure, and it's a good design, although there are other ways to do it. Alternately, the model could not know anything about the views (dumb), and instead there is some Controller that is smart about keeping the view and model in synch both ways.
When receiving a setData() to change the data, notify the listeners of the change (fireXXXChanged)
    Change notifications express the different changes possible on the model. (cell edited, row deleted, ...)
    Iterate through the listeners and notify each about the change.

## View Role

Have pointer to model
Don't store any data
Send getData() to model to get data as needed
User edit operations (clicking, typing) in the UI map to setData() messages sent to model
Register as a listener to the model and respond to change notifications
On change notification, consider doing a getData() to get the new values to make the pixels up-to-date with the real data.

# Swing Table Classes

## JTable -- view

Uses a TableModel for storage
Has all sorts of built-in features to display tabular data.

## TableModel -- Interface

The messages that define a table model -- the abstraction is a rectangular area of cells.
getValueAt(), setValueAt(), getRowCount(), getColumnCount(), ...
The table model establishes a co-ordinate system: 0..getRowCount()-1, 0..getColumnCount()-1. The model and the view(s) all use the model coordinate system to identify rows and columns.

## TableModelListener -- Interface

Defines the one method tableChanged()
If you want to listen to a TableModel to hear about its changes, implement this interface.

```
public interface TableModelListener extends java.util.EventListener
{
```

```
    /**
     * This fine grain notification tells listeners the exact range
     * of cells, rows, or columns that changed.
     */
    public void tableChanged(TableModelEvent e);
}
```

# AbstractTableModel

Implements some TableModel utility behavior.
Provides helper utilities for things not directly related to storage
    addTableModelListener(), removeTableModelListener(), ...
fireXXXChanged() convenience methods
    These iterate over the listeners and send the appropriate notification
    fireTableCellUpdated(row, col)
    fireTableRowDeleted(row)
    etc.
getRowCount(), getColumnCount(), and getValueAt() are **abstract** -- they must be provided by a subclass model that actually stores data.
This is similar to the situation we had subclassing ChunkList off AbstractCollection.

# DefaultTableModel

extends AbstractTableModel
Complete implementation with Vector

# BasicTableModel Code Points

A complete implementation of TableModel using ArrayList
getValueAt()
    Pulls data out of the ArrayList of ArrayList implementation
setValueAt()
    Changes the data model and uses fireTableXXX (below) to notify the listeners
AbstractTableModel
    Has routine code in it to manage listeners -- add and remove.
    Has fireTableXXX() methods that notify the listeners -- BasicTableModel uses these to tell the listeners about changes.

# 1. Passive Example

1. Table View points to model
2. View does model.getXXX to get data to display

# 2. Row Add Example

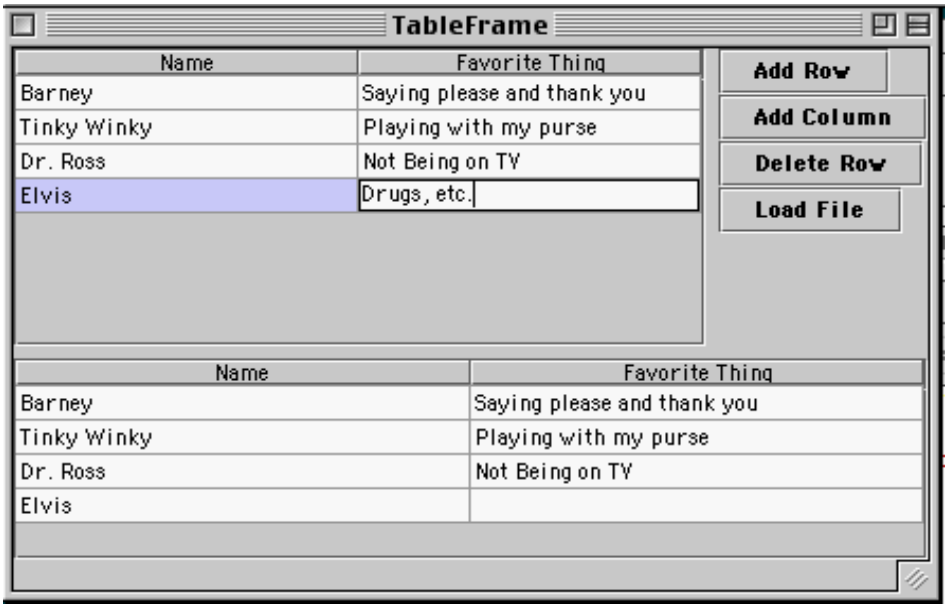
1. Add row button wired to the model
2. Model changes its state
3. Model does fireRowAdded() which sends notification to each listener
4. Listeners get the notification, call getData() as needed

# 3. Edit Example

1. Table View1 points to model for its data and listens for changes

2. Table View2 also points to the model and listens for changes
3. User clicks/edits data in View1
4. View1 does a model.setXXX to make the change
5. Model does a fireDataChanged() -- notifies both listeners
6. Both views get the notification of change, update their display (getXXX) if necessary

View2 can be smart if View1 changes a row that View2 is not currently scrolled to see.




In this case, "Elvis" has been entered, but the return key has not yet been hit for the "Sex, drugs, etc." entry

# BasicTableModel.java

Demonstrates a complete implementation of TableModel -- stores the data and generates fireXXXChanged() notifications where necessary.

```
// BasicTableModel.java

/*
 Demonstrate a basic table model implementation
 using ArrayList.

 A row may be shorter than the number of columns
 which complicates the data handling a bit.
*/
import java.awt.*;
import javax.swing.*;

import javax.swing.table.*;

import java.util.*;
import java.io.*;


class BasicTableModel extends AbstractTableModel {
```

```
private ArrayList names;   // the label strings
private ArrayList data;    // arraylist of arraylists


public BasicTableModel() {
   super();

   names = new ArrayList();
   data = new ArrayList();
}


// Basic Model overrides
public String getColumnName(int col) {
   return (String) names.get(col);
}
public int getColumnCount() { return(names.size()); }
public int getRowCount() { return(data.size()); }
public Object getValueAt(int row, int col) {
   ArrayList rowList = (ArrayList) data.get(row);
   String result = null;
   if (col<rowList.size()) {
      result = (String)rowList.get(col);
   }

   // _apparently_ it's ok to return null for a "blank" cell
   return(result);
}


// Support writing
public boolean isCellEditable(int row, int col) { return true; }
public void setValueAt(Object value, int row, int col) {
   ArrayList rowList = (ArrayList) data.get(row);

   // make this row long enough
   if (col>=rowList.size()) {
      while (col>=rowList.size()) rowList.add(null);
   }

   rowList.set(col, value);

   // notify model listeners of cell change
   fireTableCellUpdated(row, col);
}

// Adds the given column to the right hand side of the model
public void addColumn(String name) {
   names.add(name);
   fireTableStructureChanged();
   /*
    At present, TableModelListener does not have a more specific
    notification for changing the number of columns.
   */
}

// Adds an empty row, returns the new row index
public int addRow() {
   // Create a new row with nothing in it
   ArrayList row = new ArrayList();
   return(addRow(row));
}

// Adds the given row, returns the new row index
```

```
   public int addRow(ArrayList row) {
      data.add(row);
      fireTableRowsInserted(data.size()-1, data.size()-1);
      return(data.size() -1);
   }

   // Deletes the given row
   public void deleteRow(int row) {
      if (row == -1) return;

      data.remove(row);
      fireTableRowsDeleted(row, row);
   }


   /*
    Utility.
    Given a text line of tab-delimited strings, build
    an ArrayList of the strings.
   */
   private static ArrayList stringToList(String string) {
       // Create a tokenize that uses \t as the delim, and reports
       // both the words and the delimeters.
      StringTokenizer tokenizer = new StringTokenizer(string, "\t", true);
      ArrayList row = new ArrayList();
      String elem = null;
      String last = null;
      while(tokenizer.hasMoreTokens()) {
         last = elem;
         elem = tokenizer.nextToken();
         if (!elem.equals("\t")) row.add(elem);
         else if (last.equals("\t")) row.add("");
         // We need to track the 'last' state so we can treat
         // two tabs in a row as an empty string column.
      }
      if (elem.equals("\t")) row.add(""); // tricky: notice final element

      return(row);
   }

   /*
    Utility
    Given a collection of strings, writes them out as a line of text, separated by
tabs.
    Null strings are interpreted as a zero-length strings.
   */
   private static void writeStrings(BufferedWriter out, Collection strings
     throws IOException {
      Iterator it = strings.iterator();

      while (it.hasNext()) {
         String string = (String)it.next();
         if (string!=null) out.write(string);
         if (it.hasNext()) out.write('\t');
      }
      out.newLine();
   }



   /*
    Loads the whole model from a file.
   */
```

```
   public void loadFile(File file) {
      try {
         FileReader fileReader = new FileReader(file);
         BufferedReader bufferedReader = new BufferedReader(fileReader);

         // read the column names
         ArrayList first = stringToList(bufferedReader.readLine());
         names = first;

         // each line makes a row in the data model
         String line;
         data = new ArrayList();
         while ((line = bufferedReader.readLine()) != null) {
            data.add(stringToList(line));
         }

         // Send notifications that the whole table is now different
         fireTableStructureChanged();
      }
      catch (IOException e) {
         e.printStackTrace();
      }
   }


   /*
    Saves the model to the given file as tab-delimited text.
   */
   public void saveToFile(File file) {
      try {
         BufferedWriter out = new BufferedWriter(new FileWriter(file));

         // write the column names
         writeStrings(out, names);

         // write all the data
         for (int i=0; i<data.size(); i++) {
            writeStrings(out, (ArrayList) data.get(i));
         }

         out.close();
       }
       catch (IOException e) {
         e.printStackTrace();
       }
   }

}
```

# TableFrame.java

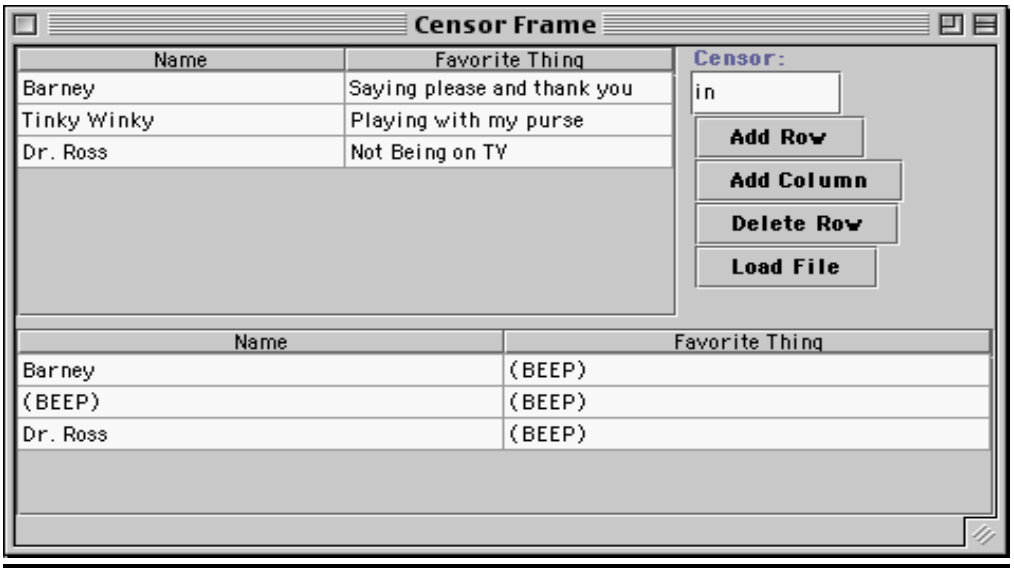
```
// TableFrame.java
/*
 Demonstrate a couple tables using one table model.
*/

import java.awt.*;
import javax.swing.*;
import java.util.*;

import java.awt.event.*;
import javax.swing.event.*;
import javax.swing.filechooser.*;
```

```
class TableFrame extends JFrame {
   private BasicTableModel model;

   private JTable table;
   private JTable table2;

   JButton columnButton;
   JButton rowButton;
   JButton deleteButton;
   JButton loadButton;
   JButton saveButton;
   JComponent content;

   public TableFrame(String title) {
      super(title);
      content = (JComponent)getContentPane();
      content.setLayout(new BorderLayout(6,6));

      // Create a table model
      model = new BasicTableModel();

      // Create a table using that model
      table = new JTable(model);

      // there are many options for col resize strategy
      //table.setAutoResizeMode(JTable.AUTO_RESIZE_ALL_COLUMNS);
      // JTable.AUTO_RESIZE_OFF

      // Create a scroll pane in the center, and put
      // the table in it
      JScrollPane scrollpane = new JScrollPane(table);
      scrollpane.setPreferredSize(new Dimension(300,200));
      content.add(scrollpane, BorderLayout.CENTER);

      // Create a second table using the same model, and put in the south
      JTable table2 = new JTable(model);
      scrollpane = new JScrollPane(table2);
      scrollpane.setPreferredSize(new Dimension(300,200));
      content.add(scrollpane, BorderLayout.SOUTH);

      // Create a bunch of controls in a box
      JPanel panel = new JPanel();
      panel.setLayout(new BoxLayout(panel, BoxLayout.Y_AXIS));
      content.add(panel, BorderLayout.EAST);

      rowButton = new JButton("Add Row");
      panel.add(rowButton);
      rowButton.addActionListener(
         new ActionListener() {
            public void actionPerformed(ActionEvent e) {
               int i = model.addRow();
               table.clearSelection();
               table.addRowSelectionInterval(i, i);
            }
         }
      );

      columnButton = new JButton("Add Column");
      panel.add(columnButton);
      columnButton.addActionListener(
         new ActionListener() {
            public void actionPerformed(ActionEvent e) {
```

```
                String result = JOptionPane.showInputDialog("What name for the new
column?");
                if (result != null) {
                   model.addColumn(result);
                }
             }
          }
       );

       deleteButton = new JButton("Delete Row");
       panel.add(deleteButton);
       deleteButton.addActionListener(
          new ActionListener() {
             public void actionPerformed(ActionEvent e) {
                int row = table.getSelectedRow();
                if (row!=-1) model.deleteRow(row);
             }
          }
       );

       loadButton = new JButton("Load File");
       panel.add(loadButton);
       loadButton.addActionListener(
          new ActionListener() {
             public void actionPerformed(ActionEvent e) {
                 //FileSystemView fsv = FileSystemView.getFileSystemView();
                JFileChooser chooser = new JFileChooser(".");
                int status = chooser.showOpenDialog(TableFrame.this);
                if (status == JFileChooser.APPROVE_OPTION) {
                   model.loadFile(chooser.getSelectedFile());
                }
             }
          }
       );

       saveButton = new JButton("Save File");
       panel.add(saveButton);
       saveButton.addActionListener(
          new ActionListener() {
             public void actionPerformed(ActionEvent e) {
                JFileChooser chooser = new JFileChooser(".");
                int status = chooser.showSaveDialog(TableFrame.this);
                if (status == JFileChooser.APPROVE_OPTION) {
                   model.saveToFile(chooser.getSelectedFile());
                }
             }
          }
       );

       setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
       pack();
       setVisible(true);
    }


    static public void main(String[] args)
    {
       new TableFrame("TableFrame");
    }
}
```

# Complex Censor Example

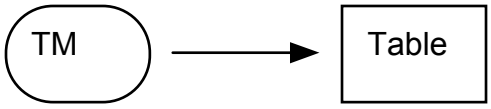
Uses the delegate strategy to build a variant table model
Uses table model listener logic in a complex way




## Censor Table Example

Implement a TableModel that censors cells
Use a BasicTableModel delegate to take care of the storage

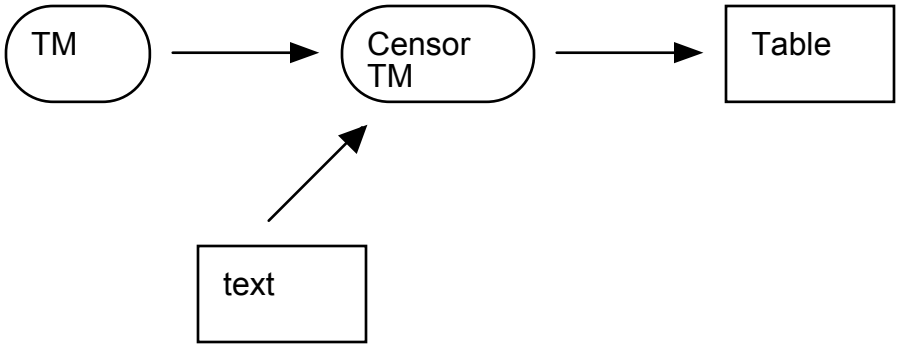
## 1. Plain




Listening
Data

## 2. "Layered" or "Delegate" Solution

Censor TableModel (TM)
"Delegate" to real TM
Listen to real TM
Listen to text field




# Censor Strategy

"delegate" strategy
- ISA vs. HASA
- Do not store any data -- let the delegate do that
- "Pass back" requests you get to the delegate (with a little adjustment)

Real model
- Have a pointer to the "real" TableModel that has the real data -- the delegate

getValueAt
- Pass back to the real model, taking the censoring into account

listen to real model
- If it says something is changed, pass that notification forward.
- e.g.. if the real model says that (0,1) has changed, tell your client that (0,1) has changed

text field change -> fireTableCellUpdated(r, c)
- Register as a listener to the text field
- When it changes, iterate over the whole model, and generate cellUpdated(r,c) notifications for cells that are now different

Decomposition
- The code has nice examples of factoring out common code into utility methods -- censorUpdate() and isCensored(). 106a students sometimes complain that the decomposition examples are unrealistic. Well here's a realistic example.

# CensorTableModel Code Points

1. ctor() -- register as listener to the real TM and the text field
2. getRowCount(), getValueAt() -- pass back to the real TM, do the filtering on the results
3. tableChanged() (notification from the real TM) -- pass the notification forward to our view
4. insertUpdate() (notification from the text), calls censorUpdate() to refigure what's censored and notify the view

# CensorTableModel.java

```
// CensorTableModel
import java.awt.*;
import javax.swing.*;
import javax.swing.table.*;
import java.util.*;
```

```
import java.io.*;
import javax.swing.event.*;
/*
 Presents a table model that censors out table cells based
 on the "censor" text in a text field.

 This is a "layered" or "delegate" solution.
 We do not store any cell data at all --
 we store a pointer to delegate "real" table model that has the real data.
 Messages we receive, we pass through to the delegate for processing.
 We pass the data forward, but do the censoring on it.
 We listen to the delegate to hear about table model changes from it.
 We also listen to the text field for changes, so we can update the censoring.
 This is a pretty complex use of model-listener logic.

 Note: another solution would be to subclass off TableModel to create a censoring
 variant. The delegate strategy shown here is probably easier to get right.
*/
class CensorTableModel extends AbstractTableModel implements TableModelListener,
DocumentListener {
   private TableModel model;     // the "real" model
   private String censor;        // current censor string
   private String oldCensor;     // previous censor string
   private JTextField field;     // censor string text field


   /*
    Stores the real model and text field, and registers
    as a listener for changes to both.
   */
   public CensorTableModel(TableModel model, JTextField textField) {
      super();

      this.model = model;
      this.field = textField;
      censor = "";

      model.addTableModelListener(this);
      field.getDocument().addDocumentListener(this);
      fetchCensor();
   }

   /*
    Retrieves the string from the text field
    and recomputes what we are presenting to the table.
   */
   private void fetchCensor() {
      oldCensor = censor;
      censor = field.getText().toLowerCase();
      censorUpdate();
   }

   /*
    Tests a table cell against a censor string to
    see if it should be censored.
    For censoring to happen, the censor string must
    not be the empty string.

    note: example of "bottlneck" strategy -- in this way,
    getValueAt() and censorUpdate() have exactly the same
    notion of censoring.
   */
   private boolean isCensored(String cell, String censorString) {
      return(cell!=null && !"".equals(censorString) &&
```

```
      cell.toLowerCase().indexOf(censorString) != -1);
}


/*
 The censor string has changed, so we need to
 check if any of the cells are now different
 after censoring. fireTableCellUpdated() to notify
 the table of any cells that are changed.
 Compares what each cell looked like with the
 old censor string vs. the new censor string to
 decide if we need to tell our table to change or not.
*/
private void censorUpdate() {
   // if the strings are the same, just forget it
   if (censor.equals(oldCensor)) return;

   for (int row = 0; row<model.getRowCount(); row++) {
      for (int col = 0; col<model.getColumnCount(); col++) {
         String elem = (String) model.getValueAt(row, col);
         if (elem != null) {
            boolean old = isCensored(elem, oldCensor);
            boolean now = isCensored(elem, censor);

            // tell the table the cell changed if the
            // new state is different from the old state.
            if (old != now) fireTableCellUpdated(row, col);
         }
      }
   }
}


/*
 We get this notification when the real table model
 changes: column added, cell updated, etc.
 We just pass it along to our table, and it
 will generate getData() requests as it sees fit.
*/
public void tableChanged(TableModelEvent e) {
   fireTableChanged(e);
}

/*
 We get these three notifications on changes
 in the text field.
*/
public void insertUpdate(DocumentEvent e) {
   fetchCensor();
}
public void changedUpdate(DocumentEvent e) {
   fetchCensor();
}
public void removeUpdate(DocumentEvent e) {
   fetchCensor();
}


/*
 Standard table model messages -- we pipe them through
 to the real table model (our "delegate" in this case).
 Except, getData, which does the censoring.
*/
public String getColumnName(int col) { return model.getColumnName(col); }
```

```
   public int getColumnCount() { return model.getColumnCount(); }
   public int getRowCount() { return model.getRowCount(); }
   public Object getValueAt(int row, int col) {
      String elem = (String) model.getValueAt(row, col);
      if (isCensored(elem, censor)) return("(BEEP)");
      else return(elem);
   }

   // We don't allow a censored cell to be edited
   public boolean isCellEditable(int row, int col) { return false; }
   // So we don't have to respond to the following...
   //public void setValueAt(Object value, int row, int col) {
   // model.setValueAt(value, row, col);
   //}

}
```

# MVC Summary

MVC is used in Swing in many places, and it is also a pattern you will see in other systems.

1. Data model -- storage
   Deals with storage. Algorithmic code can send messages to the model to get, modify, and write back the data
2. View -- presentation
   Gets data from the model and presents it. Translates user actions in the view into getters/setters sent to model. Presentation could be pixels, HTML, PDF, ...
3. Listener logic
   A design used in Swing: Model/view use a listener system to update the view(s) about changes in the model.

# Advantage: Modularity

2 small problems vs. 1 big problem

Provides a natural decomposition "pattern"
   You will get used to the MVC decomposition. Other Java programmers will also. It ends up providing a common, understood language.

Isolate coding problems in a smaller domain
   Can solve GUI problems just in the GUI domain, the storage etc. is all quite separate. e.g. don't worry about file saving when implementing scrolling and visa-versa.

# Networking / Mult Views

The abstraction between the model and view works well for a networked version: the model is on the central machine, the view is on the client machine.

The abstraction between the model and view can support multiple views all looking at one model (on one machine, or with some views over the network).

# Use 50% Off The Shelf

The Model and View are both already written -- can customize one or the other
e.g. Substitute, say, your own Model, but use the off the shelf View.

# e.g. File Save, or Undo

File save can be implemented/debugged just against the model. If the view worked before, it should still work.

undo() can just be implemented on the model -- it has to interact with far fewer lines of code than if it were implemented on top of some sort of combined model+view system

# e.g. Web Site

Suppose you are implementing a calendaring web site.

model -- complex data relationships of people, times, events

view -- web pages, javascript, etc. that present parts of the model

Need to support multiple views simultaneously, and perhaps different types of view -- web page, PDF, IM message, ...

MVC: the data model team and the view team should be separate as much as possible -- don't want choices about pixels to interfere which choices of whether to store events in a hash map vs. a binary tree.

This is what the modern Servlet/JSP style does. The servlet does the data model "business logic", and the JSP just sends getter messages and formulates the results in to HTML or whatever (take CS193i).

# e.g. Model Substitution

Have some 2-d data. Want to present it in a 2-d GUI. Wrap your data up so that it responds to getColumnCount(), getDataAt(), etc....

Build a JTable, passing it pointer to your object as the data model and voila. The scrolling, the GUI, etc. etc. is all done by JTable.

# e.g. Wrap Database

Similar example -- suppose you have a table in an SQL database. Wrap it in TableModel class that makes the data appear to be in row/col format. getValueAt() requests are translated into queries on the database. Note that the JTable is insulated from knowing how you get the data, so long as you respond to the TableModel messages -- that's a nice use of OOP modularity.

# Danger: Listener Storm

Suppose you have objects A, B, and C

Suppose they are listening to each other

Can get a sort of infinite loop where A changes and notifies B, which changes as a result and notifies C, which changes as a result, and notifies A, which ...

Solution #1: on change notification, do the data = model.getData(), but then check if the data value is actually different from the old value. Only notify if the value is actually different. This solves some cases.

Solution #2: have a "isupdating" boolean. Set it to true while making a change and doing notifications. Ignore notifications that come in while isupdating==true.