# Report Final Assignment

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**Scenario 3, Interactive Navigation**

Orchestrational responsibility of the Composition Pattern



Approach

<*Geef aan hoe jullie de opdracht hebben aangepakt en wie wat heeft gedaan, maximaal 1 A-4. Geef expliciet aandacht aan de volgorde van activiteiten*>

|  |  |
| --- | --- |
|  | Assignment 1: Problem analysis Jabberpoint is a simple slideshow application that can read a slideshow from a source allows the user to navigate through the slides and can save the state of the running slideshow to the source again.  This problem analysis is split into two parts: The first part focuses on the identification of the concepts, the entities. The latter part will elaborate on the rules that can be extracted from the case description.  Assumptions are made when necessary. Concepts |

|  |  |
| --- | --- |
| *slideshow*  *title*  *theme*  *background color*  *slide*  *slide item*  *text item*  *level*  *bitmap item*  *action*  *style* | The main concept is the **slideshow**. A slideshow is a presentation of a series of slides (still images) on the screen, in a *prearranged sequence*. A slideshow consists of the following parts:   * A **title**. The title of the selected slideshow will be displayed in the frame of the application * A **theme**. A slide is configured with a certain theme. The theme determines the **background color** of the slideshow. All slides in a slideshow will have that same background color * A list of **slides**. Slides in a slideshow have a prearranged order (first slide will have sequence number 1 and the last slide sequence number n). It´s possible to have an empty slideshow, i.e. a slideshow with no slides   A slide contains a number of **slide items**, which are items that are displayed on the slide. Slide items are displayed one after the other in a predefined order. The user will not have control over when or how the slide items are displayed, except for the fact that slide items can be assigned a certain level, which determines the way slide items look (style) and the position on the screen. A slide can be empty.  A slide item can have two forms:   * A **text item**. An item that consists of a simple text (string) and has a certain **level** * A **bitmap item**. An item that represents an image. Also a bitmap item has a certain level   Slide items can have 0, 1 or more **actions** attached to them which can be activated by clicking on either the text or the bitmap. The actions are preconfigured and this configuration determines the order that the actions are performed upon activation. Actions are discussed in more details later.  As said, all items have an associated level, and this level determines the **style**. How a slide item is styled is solely dependent on the level of the slide item.  A text item is styled in a different way than a bitmap item. A style for a text item can for example have a certain color, while a color for a bitmap style is not appropriate, as the coloring aspect of a bitmap is inherently determined by the bitmap itself. The following table shows the characteristics of both type of styles: |

|  |  |
| --- | --- |
| **Type of style** | **Characteristics** |
| Common style | * X-padding (“indent”). Padding on the x-axis, amount of space that is taken into account from the beginning of the containing frame * Y-padding (“leading”). Padding on the y-axis, amount of space that is taken into account from the y-value + height of the previous item |
| Text style | * Common style characteristics (see above) * Font size * Font color |
| Bitmap style | * Common style characteristics (see above) |

*Table 1: Styles types*

The following constrains and additional functionalities are valid:

* X- and y-values are deduced, based on the containing frame, the level associated with the style, and the sequence number of the item
* When drawing items, the scale of the screen is also taken into account.
* Styles will be hard-coded in the application

The next figure can be used to put these characteristics in perspective.

Text item

Bitmap item

leading

indent

scale

font color

font size

*Figure 1: Style characteristics*

|  |  |
| --- | --- |
| *action*  *navigation action*  *current slide*  *absolute, relative navigation action*  *slideshow persistence action*  *source*  *auxiliary action* | An important aspect of this assignment is the concept of “action”. The first type of **action** is the **navigation** action. The result of this action is a change of the **current** slide. The current slide in a slideshow is the slide that is being displayed at a certain moment in time. The current slide is a feature that should be maintained throughout different slideshow sessions and as such (it is assumed), should be saved upon user request (By using the File | Save menu item). When a slideshow is retrieved from the source, the current slide is determined and the navigation action to go to the indicated slide is performed.  The following navigation actions should be supported by the application:   * Go to next slide * Go to previous slide * Go to first slide * Go to last slide * Go to slide i   Navigation actions can either be **absolute** or **relative**. A relative navigation action takes the current slide into account. An absolute navigation action does not take the current slide into account, but indicates directly the slide that should be navigated to.  A second type of action is an action that operates on the level of slideshows persistence. A slideshow can be **opened** or **saved**. On saving a slideshow, the current slide is recorded in the **source**. Slideshows can be saved to or retrieved from different types of sources, like an **XML format** or a predefined **Demo format** (hard coded in the application). Of course, adding a different source to the application, like a database format, should require minimal effort and not affect the design of application in a major way. Saving to a demo format will not be possible, as it does not add any value to the application.  Finally, the last type of action is an auxiliary action. An **auxiliary action** for example is a beep sound, or a graphical effect. |

### Rules

This paragraph focuses on the rules that must be enforced. These rules are extracted from the case description and, if not clear, assumed.

Persistence actions rules

The following rules impact the way how slideshows are read from and written to sources (demo format, xml format or database format):

* A “slideshow save” action can only be issued by the user by selecting the option “File|Save” from the menu
* When a slideshow is saved, the current slide number is stored in the source
* A “slideshow open” action can be issued by the user by selecting “File|Open” from the menu. In that case, the application will ask the user to navigate to the stored slideshow by means of a dialog. The system will read the stored slideshow from the file and will navigate to the saved “current slide number”. A slideshow can also be opened by a user by clicking on a slide item which has preconfigured actions attached to it. If one of those attached actions is a “slideshow open” action, the name of the file will have been configured and it will be used to read the slideshow from the file. After reading the slideshow from the file, the system will navigate to the saved “current slide number”
* When the application reads a slideshow from a source (file or other), and an “open slideshow” action is encountered in an action tag, subsequent action tags are ignored, as these additional action tags don’t operate on the same slideshow anymore
* When the application reads a slideshow from a source with name x, and an embedded action in one of the slide items instructs to open the same slideshow with name x, the system will raise an error and not load the slideshow in the embedded action, as this would result in recursive, cyclic “open slideshow ”actions

*Navigational rules*

The user will be able to navigate within the slideshow, browsing through the slides, going to the beginning or the end of the slideshow and navigate directly to a certain slide by providing the slide number in a dialog box. The following rules can be identified (or are assumed if not clearly stated in the u ser-case):

* An absolute navigation action is either a “go to first slide”, “go to last slide” or “go to slide i” navigation action. The first two don’t require extra parameters. The latter requires a user to provide the slide number in a dialog window or the system must provide the page number in the corresponding action tag
* A relative navigation action is either a “go to next slide” or a “go to previous slide” navigation action and both don’t require extra information, as the system can deduce the current slide number from the state of the active slideshow
* Any kind of navigation action can be issued by the user by using the menu, keyboard or clicking on the text item or bitmap item that has an associated navigation action attached to it.
* An auxiliary action can only be issued by the system (like a sound) when reading the slideshow from the source after the user has clicked on a slide item with an action attached to it. A user cannot issue such action directly

The above rules are summarized in the following CVA table:

|  |  |  |  |
| --- | --- | --- | --- |
| **Action** | **Type** | **Additional**  **action** | **Activation** |
| go to first, last slide | absolute  navigation |  | * keystroke * mouse-click on slide item * mouse-click in menu |
| go to slide i | absolute  navigation | ask for page through dialog / get page from action in xml | * keystroke * mouse-click on slide item * mouse-click in menu |
| go to next, previous slide | relative navigation |  | * keystroke * mouse-click on slide item * mouse-click in menu |
| open slide | slideshow persistence | ask for source selection by means of dialog | * mouse-click on slide item * mouse-click in menu |
| save slide | slideshow persistence | ask for source selection by means of dialog | * mouse-click in menu |
| auxiliary action | auxiliary action |  | * mouse-click on slide item |

*Table 1: Action rules*

*General constraints*

There are a set of rules that can be classified as more general constraints and don’t depend on user-interaction (like the previous groups of rules):

* A slideshow always has a theme
* The background color of a slideshow depends on the theme
* A slideshow has 0, 1, or more slides
* A slide has 0, 1 or more slide items
* Every slide item has a level and a level is mandatory
* Slide items are positioned on the screen according to their level
* Slide items are styled according to their level. The theme of a slideshow does not impact the way that slide items are styled or are positioned on the screen
* Bitmap items and text items are not styled in the same manner

## Assignment 2: Design

This design of the application will be split into the following sections:

* Identification of high-level activities. An activity diagram will be presented that shows the main, high-level activities that are present in the application
* Class diagram of the domain model. This class diagram will shed a light on the main entities in the domain model. Not all entities are presented, only essential entities (abstractions, not implementations in many cases) are depicted to get a good overview of the model
* Class diagram with focus on MVC Design Pattern. Main entities that are involved in the MVC Design Pattern will be included in a separate class diagram
* The concept of action is important in this use-case, and a separate class diagram is shown that depicts the hierarchical structure and other involved entities
* As a good practice, the creation of objects is separated from the usage of the objects. This is reflected in the design, by grouping this facet of the design in a separate sequence of class and interactions diagrams

### High-level activities

The high-level activities that are present in the system are presented in the figure on the next page by means of an activity diagram.

From that diagram, it can be observed that there are two paths that lead from a user action to either the loading of the slideshow (and the displaying of the “current” slide and its slide items) or the change of a slide (and the displaying of that slide and its slide items):

1. Wait for user input -> load slide show -> draw slide -> draw item (-> draw border)
2. Wait for user input -> draw slide -> draw item (-> draw border)

*In either of those paths, after the initial user input, there is no more user interaction involved. This will be a very important observation that will have its impact in further design decisions.*



*Figure x: High-level activities in the application*

### Domain model

The domain model of the *Model* part of the MVC Design Pattern is depicted in the following class diagram:



*Figure x: Domain model of the Model part*

|  |  |
| --- | --- |
| *MVC Design Pattern*  *Bridge Pattern*  *No Observer Pattern*  *Singleton Pattern*  *Composite Design Pattern*  *Decorator Pattern*  *Command Pattern* | The above domain model only contains entities that are part of Model part of the **MVC Design Pattern**.  The Slideshow will communicate with a DrawingDriver and orchestrate the drawing of a Slide. With respect to SlideItems, this entity functions as an abstraction in the Bridge Pattern. The DrawingDriver is the abstraction of a set of implementations that will take care of the physical drawing of the slides. This way, SlideItems and implementations of DrawingDrivers are loosely decoupled and can vary accordingly. Why this pattern is used, and not the Observer Pattern is explained in TODO …*It is strongly recommended* to first read this section, as this is the most interesting part regarding the decisions taken in the design.  Slideshow is a **singleton** and it’s the heart of the Model domain model. The Slideshow implements the interface CompositeSlideshowComponent, which is the contract for the **Composite Design Pattern**. A Slideshow is composed of 0, 1 or more Slides, where each slide is composed of 0, 1 or more SlideItems. The SlideItem entity is the leaf in this composition and will have empty implementations for the methods that participate in this pattern.  Every SlideItem is either a DisplayableItem or an ActionDecoratedItem. A DisplayableItem is a SlideItem that can be displayed, thus having a level, which will lead to a certain Style. A DisplayableItem can be a TextItem or a BitmapItem. An ActionDecoratedItem is not displayed directly, but is a **decorator** for the concrete implementations TextItem and BitmapItem. It decorates these concrete implementations with Actions. So an ActionDecoratedItem is an entity that has an attribute that is a concrete SlideItem (either a TextItem or a BitmapItem) and 1 or more actions attached to that SlideItem. This decorator is part of the Model domain model. It does not specify *how* the DisplayableItem should be painted. It merely *specifies* *that* the DisplayableItem is decorated with Actions. How things are painted, that’s the responsibility of the View part of the domain model.  DisplayableItems are styled a certain way. The driver behind this concept is the level of the DisplayableItem. When an instance of a DisplayableItem is created, its Style is also determined by invoking a method on the StyleFactory (more about this later in the design).  Because DisplayableItems are styled in different ways, there are also two different implementations of Styles. BitmapItems are styled according to a BitmapStyle and TextItems are styled according to a TextStyle. At the moment that a Slideshow is loaded, a StyleFactory is used to retrieve instances of the correct kind. This StyleFactory will be elaborated on in a different part of the design that discusses the usage of factories.  Actions are implemented through the **Command Pattern**. The Action, as modeled in the above domain model, is an interface and it’s implemented by all sorts of concrete implementations like SaveSlideShowAction or RelativeNavigationAction. These Actions group together smaller fine-grained steps into a more integral piece of functionality. Instances of these Actions can be assigned to ActionDecoratedItems instances during the loading of the Slideshow. When the user clicks for example on a TextItem which is wrapped in an ActionDecoratedItem, the available Actions are executed in a sequential manner. Actions are created on-the-fly by asking an ActionFactory for the desired action. This factory class is not depicted in the domain model of the Model part. It will be covered in a different part of the design. |

### The MVC Design Pattern

The MVC Design Pattern will be used to separate entities into Model, View and Controller entities. The figure on the next page illustrates the relationships between the various entities that are involved in grouping them into those three groups.

Upon starting the application, the controllers KeyController, MenuController and MouseController are registered with the frame SlideViewerFrame. Also the area where the painting takes place, the JComponent SlideViewerComponent will be added to the frame’s content pane.

When a user presses a key, for example a right-arrow key, or when the user selects “View | Next “, either the KeyController or the MenuController will ask the ActionFactory (not showed in the next class diagram) for an instance of the AbsoluteNavigationAction. This action encapsulates the logic that is involved with changing the current slide from a Slideshow’s point of perspective. After the action has finished, the involved controller will call the frame’s repaint method in order to trigger the repainting of the SlideViewerComponent, which in turn will invoke Slideshow’s draw method. The Slideshow then manages the drawing of the required slide and its slide items through the DrawingDriver on the screen. The reason for this approached has already been referred to in the TODO…

The following diagram can be consulted to determine which entities belong to what part of the MVC Design Patterns.



*Figure x: MVC Class diagram*

In order to preserve space, parameters and return values of methods are not displayed in the entities. These details can be retrieved from other diagrams that will be presented in other parts of the design.

The next diagram contains the flow of messages between objects in a use-case where the user presses the right-arrow key with the goal to advance to the next slide



*Figure x: Sequence diagram that depicts flow of messages during a change of slide by using the keyboard*

The following bullets add clarification to the above diagram:

* The KeyController instance calls the repaint() method on the SlideViewerFrame instance. This call causes the frame to internally call a repaint() method on all its registered components.
* The SlideViewerCompent’s method paintComponent() is called by Swing and this is the moment *to grab the Graphics object and store it in the SlideViewerComponent instance to be used later by subsequent calls to draw information on the screen*
* The KeyController instance asks the ActionFactory to create an instance of type RelativeNavigationAction
* The ActionFactory creates the RelativeNavigationAction and returns it to the KeyController instance
* The KeyController instance issues the execute() method on the Action instance
* The Action instance of type RelativeNavigationAction deals with fine-grained logic to determine the slide to go
* The Action instance will call the draw() method on the singleton Slideshow.
* Here the Composite Patterns comes into action and first the getCurrentSlideNumber() method of Slideshow is called to retrieve the current slide item
* Then the getComponent() method is called with the current slide number that was retrieved in the previous step. This method will retrieve an instance of type Slide
* On the retrieved Slide instance, the method draw() will be called
* First a method to draw slide number info is called that will call a method on the SwingDrawingDriver, *which is an instance of type DrawingDriver*. This is a loosely coupled method invocation, as the invocation is done on variable that is of type DrawingDriver, an interface. The Slide is not aware of the underlying implementation. In the sequence diagram, the SwingDrawingDriver is mentioned. This is an instance that is returned by the DrawingDriverFactory. But due to lack of space on the page, this factory instance is not displayed in the sequence diagram. It will be covered later during the design of the factories
* The draw() method in the slide will iterate over its SlideItems
* For every SlideItem instance a call is made to the SwingDrawingDriver through a variable of type DrawingDriver. This call will do the drawing of the SlideItem on the screen

Actions are attached here to the slide item. A slide item has 0, 1 or more actions attached to it. In case a slide item has an action attached to it, a border should be drawn to indicate to the user that clicking on the item will results in 1 or more actions.

BitMapItem and TextItems have different kind of Styles. A TextItem has a TextItemStyle, which includes a font color and a font size, which a BitMapStyle is lacking.

In the above domain model, a decorator pattern is used to decorate the bitmap or text item with a border. Actions are attached to the ActionItemDecorator abstract class.

An alternative to this could be the figure that is depicted in the following figure, where no Decorator Pattern is used. In this situation, A SlideItem has 0, 1 or more Actions attached to it by means of a composition.



*Figure x: Items and actions, second alternative*

Actually both are valid alternatives, and one of the options must be chosen. The other alternative will be moved to the section regarding design decisions later on, including an explanation why we have chosen the alternative.

As it looks like right, we will go for the Decorator Pattern.

The following figure depicts the action hierarchy:



*Figure x: Action hierarchy*

The following figure shows how slide items and slides in the domain model are separated from the drawing implementations. The idea is that in the future perhaps other implementations are introduced, like JavaFx, In that case, only an extra JavaFXDrawingDriver must be created that encapsulates that specific logic.



*Figure x: Slide/SlideItem Bridge to DrawingDriver*

Slide and SlideItem are entities that belong to the Model part of the MVC Pattern. Model entities should not have direct navigable references to Controller and View entities. That is additional reason to introduce the DrawingDriver.

## Assignment 3: Design decisions

This section discusses the decisions that were taken during the design.

### Bridge Pattern vs. Observer Pattern regarding View/Model decoupling

The most obvious choice for decoupling the Model and the View in the MVC Design Pattern is to use the Observer Pattern.

Using the Observer Pattern to decouple the View and Model

For example, at the moment a user goes to the next page by pressing the right-arrow key, the KeyController will receive an interrupt. The KeyController will call the Model (or use an event) to change the current slide. Usually, one or more Observers have been registered with certain entities in the Model. In this case, an Observer (A view component interested in the change of the current slide) would be registered with the Observable, the SlideShow (the entity that is being changed). So, when the Slideshow changes the current slide, it will call a notify method that in turn will cause an update method to be fired at the Observer side, in this case the component in the View, let’s say the SlideViewerComponent, the component responsible for physical painting pixels, lines and characters on the screen. Now this View component has the responsibility of repainting the slide. In order to repaint the slide, it needs to get the Slideshow from the Model.



*Figure x: Diagram showing order of messages between MVC objects using the Observer Pattern*

It needs to get all the information from the Slideshow, i.e. the current Slide, the total number of slides and the SlideItems within the current Slide. It will need to iterate through the SlideItems and decide how to paint them. It’s the View who is in the driver seat and determines the *orchestration* of handling the Slideshow, Slide and SlideItems.

Using the Bridge Pattern to decouple the View and Model

Another way of decoupling the View and the Model is by applying the Bridge Pattern. In this pattern, one or more abstractions are decoupled from one or more implementations by communicating with an abstraction of the concrete implementations. In this use-case, the abstraction is the SlideItem and the implementation is the DrawingDriver. A DrawingDriver is an interface that defines a contract of what an implementation of that interface should do. For example, one of the implementations is a SwingDrawingDriver. This component knows how to paint the SlideItems, the current slide number, the total number of slides, the colors and lines, using the Swing library. But another implementation might be the JavaFxDrawingDriver. It adheres to the same contract; it just manages other bolts, nuts and screws by using JavaFx. It needs to be noted that also Slideshow and Slide can use the DrawingDriver, but in these cases they both have only one concrete implementation of the abstraction. If the Bridge Pattern is applied, the class diagram will look like this:



*Figure x: Class diagram that depicts the Bridge Pattern used to decouple SlideItems and implementations of DrawingDrivers*

The accompanying diagram to show the sequence of messages between the objects is the following:



*Figure x: Diagram showing order of messages between MVC objects using the Bridge Pattern*

The Slideshow is the Information Expert, according to the GRASP-guideline (TODO Larman, 2005, pg. 283). The Slideshow knows about its own information, it knows about the Slides, the current Slide. The Slides knows about its SlideItems and the SlideItems know all about themselves. The Composition Pattern is the best example of how to implement the Information Expert Pattern. It knows how to orchestrate the whole thing. The slideshow is the conductor. The implementations of the DrawingDriver are just the brass and the woodwinds section of the orchestra. They don’t see the big picture, they implement what the conductor tells them, namely to take care of those bolts, nuts and screws.

---------- The verdict ----------

So what to do? Which pattern should be used?

Of course, best practices say we need to use the Observer Pattern in this case: The View has to react to a change in the model, and the View and Model must be loosely coupled and there is a standard solution for that. The Model shouldn’t drive the View anyway. No thinking needed: 0-1 for Observer Pattern.

But what case? So let’s examine our use-case, and not just follow some best practices blindly.

We have a use-case where we have the same kind of behavior in the following three cases:

* The user changes the slide by pressing a key and the next slide is drawn
* The user clicks a text item with a relative navigational action attached to it and the next slide is drawn
* The user opens a new slideshow from a file and the first slide is drawn

In all of the above situations, no user interaction is allowed during the drawing of the slide. Neither the View nor the Controller can intervene in this process:

**Neither the View, nor the Controller is in control here**

So if the View is not in control, why allow the View to orchestrate the drawing of the Slides by using the Observer Pattern? When the Observer Pattern is being used, there is a “pull” action from the View towards the Model: The View will ask the model for information, will get that information and act upon that.

When the Bridge Pattern is used, there is a clear predefined sequence of information “push” that is taking place. The Slideshow pushes its will on the View by telling it exactly what to do, not how to do it:

**There is a clear orchestrational responsibility of the**

**Composition Pattern that the Slideshow takes**

That equals the score: 1-1.

Now let’s go back to the orchestra: It’s the perfect example of a real-life Bridge Pattern taking place. The conductor as a concept is the abstraction. There might be many different kind of conductors; these are the implementations of the conductor abstraction. They all speak the same language; they know how to interpret the sheet music by body language, rhythm and moving the baton. There are several sections in the orchestra, the brass section, the percussion section and the woodwinds section. They each are implementations of an abstract orchestra section. These sections know how to interpret the language of the conductor.

What would happen if every section of the orchestra would have a copy of the sheet music and the main door to the hall would open and somebody would come in and shout: “Now play Beethoven’s Symphony no. 5!”. All the sections would start playing immediately and each section would have to interpret the sheet music, playing hopelessly out of tune with the other sections. Apart from that, as all the section need a copy of the sheet music, it’s an example of redundancy.

So how does this last remark regarding redundancy relate to our use-case? If the Bridge and the Composition Pattern is not used as a means to dictate (“push”) the orchestration of the drawing of the slide, then we will end up with possible many “pull” actions implemented in several parts of the application, thus introducing redundancy in our use-case. If we would use the Observer Pattern, the View would have to pull the data from the Model. We already identified that issue. But is there another part in the application where we might have the same construct? If we can identify that same construct in another part of the application, we will have identified redundancy in the design.

Actually, there is: The Accessor. Let’s take a look at the following class diagram which is part of the final design.



*Figure x: Class diagram showing relationship between Accessor and Slideshow*

The Accessor abstract class defines the contract for its implementations regarding the saving and loading of the Slideshow to and from a source (which can be a Demo, XML or maybe even a Database source). The Accessor class uses template methods that have the responsibility of inspecting the Slideshow. The Accessor, for every Slide, inspects the SlideItems and calls a template method to save or load the information to or from the source. So, there is the pattern again! Here is the redundancy. Wouldn’t it be much better to give that responsibility to the “Conductor” class Slideshow? That’s because the Slideshow already knows about the structure of its children, as enforced by the Composite Pattern. The next figure illustrates this proposal



*Figure x: Proposal for refactoring of CompositeSlideshowComponent, Accessor, Slideshow and its children*

Save and load methods have been added to the CompositeSlideshowComponent, Slideshow and its composition hierarchy. The Accessor and its implementations now take care of the finer-grained details of loading and saving Slideshow information, Slides and SlideItems on a per-component request basis.

So, we can come to the conclusion that using the Observer Pattern in this use-case, thus using a pull-mechanism to retrieve information of the model, introduces redundancy, because the View will have to find about the composition of the Slideshow, iterate through the SlideItems. The same construct exists in the Accessor. The Accessor must access the model in order to find out about the structure of the Slideshow.

**We therefore can say that using a Bridge Pattern to decouple the Slideshow, Slide and SlideItems on one side and the DrawingDriver implementations on the other side, reduces redundancy**

Final score: 2-1 for Bridge Pattern. We will let the Slideshow take the role as a conductor by letting the Composite Pattern to its work. So the model is driving the View, but in a decoupled manner.

Would be good if there is a text box that needs to be filled and depending on the text a certain other textbox must be filled or a calculation must be redone.

The model is loosely coupled with the View. No direct calling. Down the drain 1-1

In our use-case,

We see a pattern slide.. sliditems

Explain use references in slide to drawingdriver and accessor!

Nethods in slideitem should be abstract

## Assignment 4: Source code

Todo:

Flyweight pattern

Explain why parameters are not visible in MVC class diagram