




Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

	
IBM Software Group	
<p>Mastering Object-Oriented Analysis and Design with UML 2.0 Module 8: Identify Design Mechanisms</p>	
	
	

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Instructor Notes:

In the discussion and the exercise, we will give the students the architectural mechanism map.

Objectives: Identify Design Mechanisms

- ♦ Define the purpose of the Identify Design Mechanisms activity and explain when in the lifecycle it is performed
- ♦ Explain what design and implementation mechanisms are and how they map from Analysis mechanisms
- ♦ Describe some key mechanisms that will be utilized in the case study

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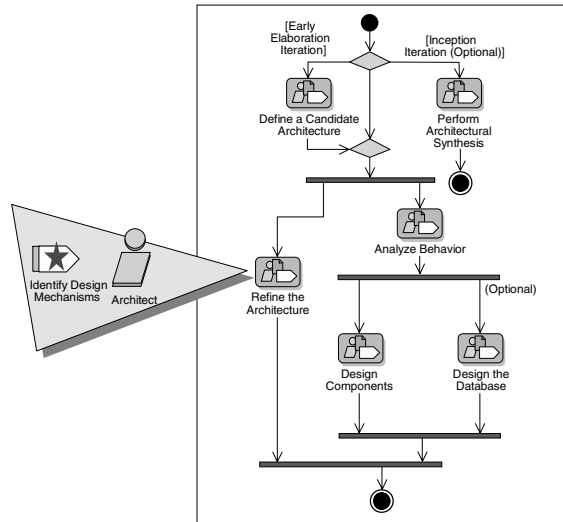
In this module, we will describe WHAT is performed in **Identify Design Mechanisms**, but will not describe *how* to do it. Such a discussion is the purpose of an architecture course, which this course is not.

Understanding the rationale and considerations that support the architectural decisions is needed in order to understand the architecture, which is the framework in which designs must be developed.

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Instructor Notes:

Identify Design Mechanisms in Context



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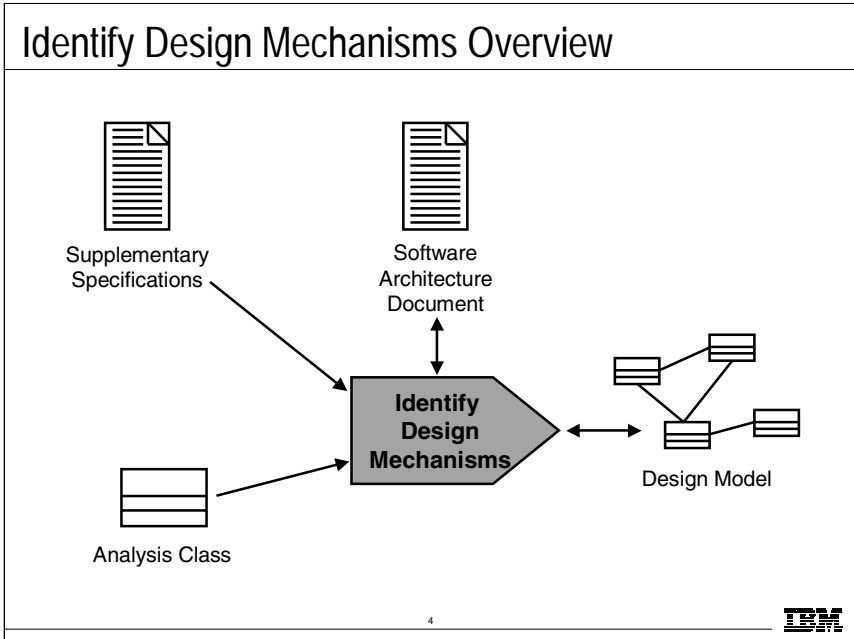


As you may recall, the above diagram illustrates the workflow that we are using in this course. It is a tailored version of the Analysis and Design core workflow of the Rational Unified Process. **Identify Design Mechanisms** is an activity in the Refine the Architecture workflow detail.

Identify Design Mechanisms is where we refine the analysis mechanisms into design mechanisms based on the constraints imposed by the implementation environment.

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Instructor Notes:



Identify Design Mechanisms is performed by the architect, once per iteration.

Purpose

- To refine the analysis mechanisms into design mechanisms based on the constraints imposed by the implementation environment.

Input Artifacts

- Supplementary Specifications
- Software Architecture Document
- Analysis Class
- Design Model

Resulting Artifacts

- Design Model elements
 - Classes
 - Packages
 - Subsystems
- Software Architecture Document

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Instructor Notes:

This slide will preview what is coming up in this module.

This module skips some of the steps in this activity. These steps were left out because of scope.

Identify Design Mechanisms: Steps

- ◆ Categorize clients of analysis mechanisms
- ◆ Document architectural mechanisms

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The above are the topics we will be discussing within the Identify Design Elements module. Unlike the Designer activity modules, we will not be discussing each step of the activity, as the objective of this module is to understand the important architectural concepts and not to learn *how* to create an architecture.

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Instructor Notes:

Analysis mechanisms provide conceptual sets of services which are used by analysis objects. They offer a convenient short-hand for fairly complex behaviors which will ultimately concern us, but which are out of scope for the analysis effort. Their main purpose is to allow the students to capture the requirements on these yet-to-be designed services of the system without having to be concerned about the details of the service provider itself.

Now you must begin to refine the information gathered on the analysis mechanisms.

You discussed analysis mechanisms in Architectural Analysis. Now you will look at design and implementation mechanisms.

In this section, define what design and implementation mechanisms are and how they map from analysis mechanisms. Provide abstract patterns of behavior for the mechanisms which are utilized in the later design activities.

The goal is NOT to teach the students how to identify and design the presented mechanisms, but to be able to produce designs which incorporate the mechanisms.

Identify Design Mechanisms: Steps

- ☆ ♦ Categorize clients of analysis mechanisms
- ♦ Documenting architectural mechanisms

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Analysis mechanisms provide conceptual sets of services that are used by analysis objects. They offer a convenient shorthand for fairly complex behaviors that will ultimately have to be worried about, but that are out of scope for the analysis effort. Their main purpose is to allow us to capture the requirements of these yet-to-be designed services of the system without having to be concerned about the details of the service provider itself.

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In this section, we will define what design and implementation mechanisms are and how they map from analysis mechanisms. We will provide abstract patterns of behavior for the mechanisms that we will utilize in the later Design activities.

The goal is *not* to teach you how to identify and design the presented mechanisms, but to be able to produce designs that incorporate those mechanisms.

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Instructor Notes:

This slide was originally discussed in Architectural Analysis.

Frameworks enable scalability of development: the ability to develop and deliver systems as quickly as the market requires by using a leveraged solution. An analogy in bridge-building may help clarify this. Examples of frameworks are suspension bridge, piling-and-trestle bridge, and cantilever bridge. Examples of design patterns are rivet fastener, bolt, and weld. In building a bridge, each is substitutable in some cases, and each is uniquely superior in other cases. (Both a weld and a bolt can be used to join two materials; the weld can be stronger if done correctly, but cannot be undone, repaired, or replaced as the bolt can.)

Taking the analogy a bit further, a suspension bridge can be a footbridge or the Golden Gate bridge. Both represent the same basic design approach and principles, so that one could readily say “that is a suspension bridge,” but the extensions and localizations cause the end result to be quite different.

Review: Patterns and Frameworks

- ♦ **Pattern**
 - Provides a common solution to a common problem in a context
- ♦ **Analysis/Design Pattern**
 - Provides a solution to a narrowly scoped technical problem
 - Provides a fragment of a solution, or a piece of the puzzle
- ♦ **Framework**
 - Defines the general approach to solving the problem
 - Provides a skeletal solution, whose details may be analysis/design patterns

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A **pattern** codifies specific knowledge collected from experience. Patterns provide examples of how good modeling solves real problems, whether you come up with the patterns yourself or you reuse someone else's. Design patterns are discussed in more detail on the next slide.

Frameworks differ from analysis and design patterns in their scale and scope. Frameworks describe a skeletal solution to a particular problem that may lack many of the details. These details can be filled in by applying various analysis and design patterns.

A framework is a micro-architecture that provides an incomplete template for applications within a specific domain. Architectural frameworks provide the context in which the components run. They provide the infrastructure (plumbing, if you will) that allows the components to co-exist and perform in predictable ways. These frameworks can provide communication mechanisms, distribution mechanisms, error processing capabilities, transaction support, and so forth.

Frameworks can range in scope from persistence frameworks that describe the workings of a fairly complex but fragmentary part of an application, to domain-specific frameworks that are intended to be customized (such as Peoplesoft, SanFrancisco, Infinity, and SAP). SAP is a framework for manufacturing and finance.

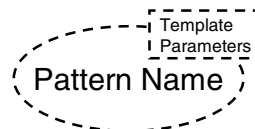
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Instructor Notes:

What Is a Design Pattern?

- ♦ A design pattern provides a scheme for refining the subsystems or components of a software system, or the relationships between them. It describes a commonly-recurring structure of communicating components that solves a general design problem within a particular context.

Erich Gamma et al. 1994. *Design Patterns—Elements of Reusable Object-Oriented Software*



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Design patterns are medium-to-small-scale patterns, smaller in scale than architectural patterns but typically independent of programming language. When a design pattern is bound, it forms a portion of a concrete design model (perhaps a portion of a design mechanism). Design patterns tend, because of their level, to be applicable across domains.

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Instructor Notes:

In the Architectural Analysis module, we brought up architectural patterns when we had to define the architectural layout. (We chose the Layers pattern.) Now, we are beginning to narrow things down with design mechanisms. Design mechanisms are frequently made up of one or more design patterns.

Examples of Pattern Usage

Pattern	Example
Command (behavioral pattern)	Issue a request to an object without knowing anything about the operation requested or the receiver of the request: for example, the response to a menu item, an undo request, the processing of a time-out
Abstract factory (creational pattern)	Create GUI objects (buttons, scrollbars, windows, etc.) independent of the underlying OS: the application can be easily ported to different environments
Proxy (structural pattern)	Handle distributed objects in a way that is transparent to the client objects (<i>remote proxy</i>) Load a large graphical object or any entity object “costly” to create/initialize only when needed (<i>on demand</i>) and in a transparent way (<i>virtual proxy</i>)
Observer (behavioral pattern)	When the state of an object changes, the dependent objects are notified. The changed object is independent of the observers. Note: The MVC architectural pattern is an extension of the Observer design pattern

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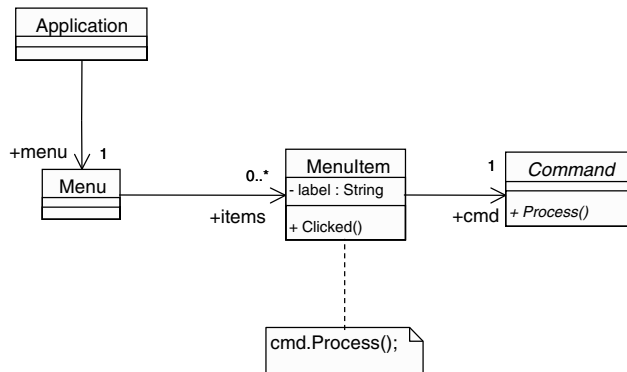


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Instructor Notes:

See the Appendix for more information on Command Patterns.

Detailing the Command Pattern



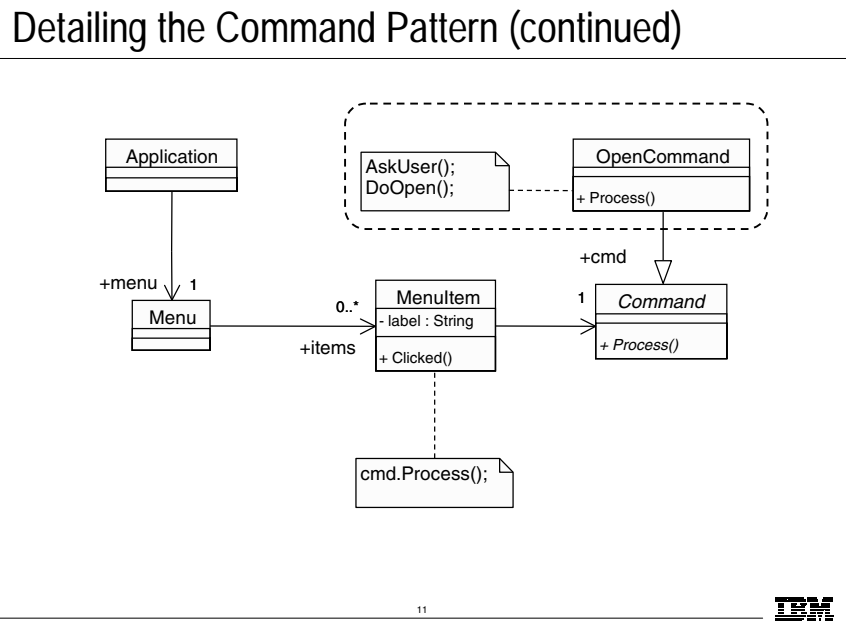
The problem — imagine we want to build a reusable GUI component. To keep it simple, we will limit ourselves to the implementation of generic menus in a windowing system (in such a way that it will be possible to add new menus without having to modify the GUI component).

- *Application*: it is the client class, it “simulates” the application.
- *Menu*: to simplify, we will make the assumption that our “application” has only one menu represented by an association with a multiplicity of 1 and a role name *menu*.
- *MenuItem*: a menu is composed of menu items.
- *Command*: this is an abstract class. It has one operation called *Process*. It is an abstract operation, which means it must be overridden by subclasses of *Command*.
- We will now make the assumption that the underlying windowing system requires that we define in *MenuItem* an operation called *Clicked* that will be automatically invoked when the user selects the corresponding menu during execution time. The code for *Clicked* is (using a Java-like pseudo-code):

```
cmd.Process();
```

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Instructor Notes:



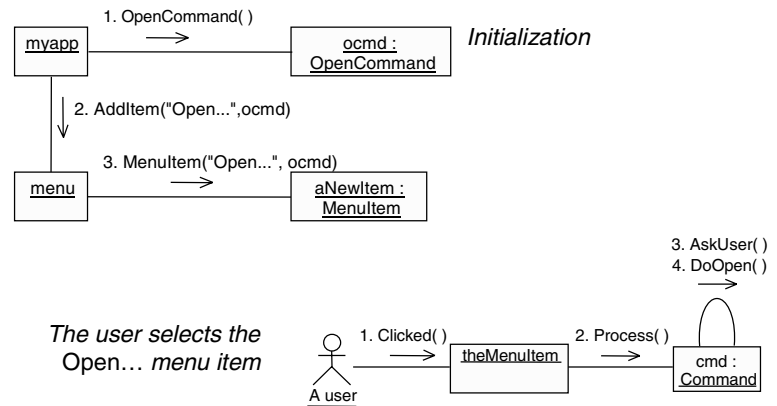
Suppose now that you want to implement the menu command *Open...*. Create a new class called *OpenCommand* that inherits from *Command*. This class overrides the operation *Process* to prompt the user to for the file to open and to open it:

```
AskUser () ;  
DoOpen () ;
```

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Instructor Notes:

Detailing the Command Pattern (continued)



- Look at the dynamic behavior of the system: first, create an interaction diagram showing the initialization of the system. When the system started up, the objects `myapp:Application` and `menu:Menu` were created. Then `myapp` creates the object `ocmd:OpenCommand` (message 1). Then it invokes a new operation from `menu` called `AddItem` that takes two arguments: `s` of type `String` (the label of the menu item to create) and `c` of type `Command`. Note that `myapp` passes to `AddItem`, a subclass of `Command` (message 2).
- `Menu` creates a new menu item (message 3). The arguments of the constructor for `MenuItem` are the same as `AddItem`. The code of the constructor is straightforward:

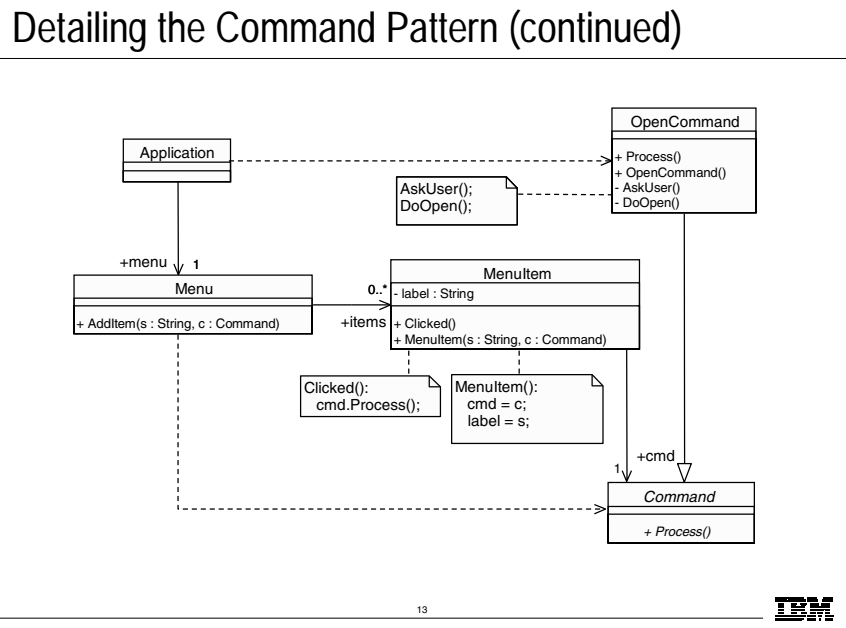
```
label = s;  
cmd = c;
```

It is very important to note that `cmd` is initialized with a subclass of `Command` but that `MenuItem` "thinks" it is a `Command` object! This is all the magic of polymorphism!

Now, draw a second interaction diagram that will show what happens when the user selects the menu item "Open...". The `Clicked` operation is invoked (message 1). `Clicked` simply executes the `Process` operation of the associated `cmd` object. In this case, the `cmd` object is actually the `OpenCommand` object (although this is transparent to the `MenuItem` object).

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Instructor Notes:

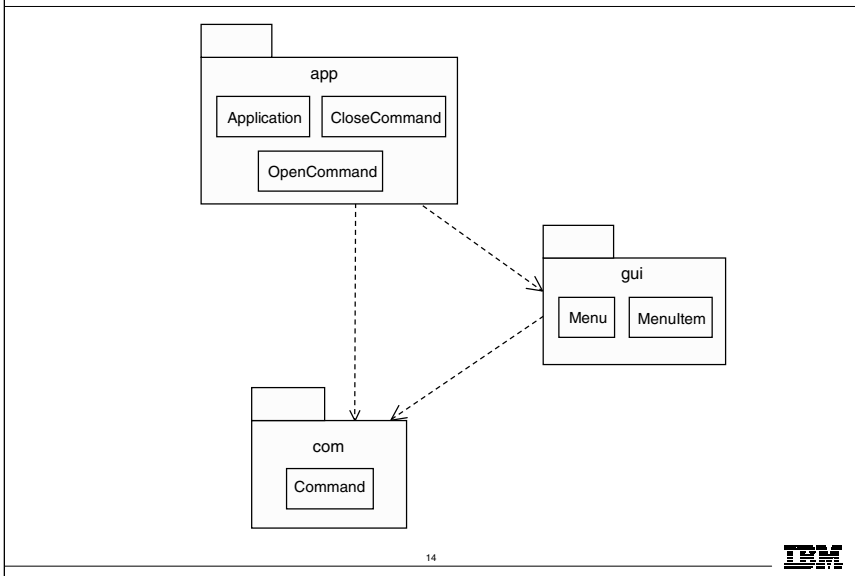


To complete the class diagram, there should be a *Uses* relationship from *Application* to *OpenCommand* to account for the fact that the former creates the latter, and there should be another *Uses* relationship from *Menu* to *Command* as the *AddItem* operation takes one argument of type *Command*.

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Instructor Notes:

Detailing the Command Pattern (continued)



So what about reuse? Assign the classes to packages: *OpenCommand* and *Application* to *app* (you have also added a new class, *CloseCommand*), *Menu* and *MenuItem* to *gui* and *Command* to *com*, now add the appropriate dependencies. You have created a reusable set of components (*gui* and *com*) independent of the application packages using them! *MenuItem* can be made an Implementation class only! Only *Menu* is exported.

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Instructor Notes:

Analysis mechanisms were originally presented in the Architectural Analysis module. Remind the students about the analysis mechanisms that they have been working with. In this module, we will clearly define how we are going to handle these issues (specifically persistence and distribution).

Describing Analysis Mechanisms

- ♦ Collect all analysis mechanisms in a list
- ♦ Draw a map of the client classes to the analysis mechanisms

Analysis Class	Analysis Mechanism(s)
Student	Persistence, Security
Schedule	Persistence, Security
CourseOffering	Persistence, Legacy Interface
Course	Persistence, Legacy Interface
RegistrationController	Distribution

- ♦ Identify characteristics of the Analysis mechanisms

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As we discussed in module 5, analysis mechanisms represent a pattern that constitutes a common solution to a common problem. They can show patterns of structure, patterns of behavior, or both.

These mechanisms might show patterns of structure, patterns of behavior, or both. They are used during analysis to reduce the complexity of analysis, and to improve its consistency by providing designers with a shorthand representation for complex behavior. By using mechanisms as “placeholders” in the architecture, the architecting effort is less likely to become distracted by the details of mechanism behavior.

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Instructor Notes:

This is a step that only the architect performs. It is included in this course as information on how the architect decides on the mechanisms to use.

Categorize Analysis Mechanisms

- ◆ **Purpose**
 - To refine the information gathered on the analysis mechanisms
- ◆ **Steps**
 - Identify the clients of each analysis mechanism
 - Identify characteristic profiles for each analysis mechanism
 - Group clients according to their use of characteristic profiles
 - Proceed bottom up and make an inventory of the implementation mechanisms that you have at your disposal

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Identify the clients of each analysis mechanism. Scan all clients of a given analysis mechanism, looking at the characteristics they require for that mechanism. For example, a number of analysis objects might make use of a persistence mechanism, but their requirements on this can widely vary: A class that has one thousand persistent instances has significantly different persistence requirements than a class that has four million persistent instances. Similarly, a class whose instances must provide sub-millisecond response to instance data requires a different approach than a class whose instance data is accessed through batch applications.

Identify characteristic profiles for each analysis mechanism. There may be widely varying characteristics profiles, providing varying degrees of performance, footprint, security, economic cost, and so forth. Each analysis mechanism is different – so different characteristics will apply to each. Many mechanisms require estimates of the number and size of instances to be managed. The movement of large amounts of data through any system creates tremendous performance issues that must be dealt with.

Group clients according to their use of characteristic profiles. Identify a design mechanism for groups of clients that seem to share a need for an analysis mechanism with a similar characteristics profile. These groupings provide an initial cut at the design mechanisms. An example analysis mechanism, "inter-process communication," might map onto a design mechanism "object request broker." Different characteristic profiles will lead to different design mechanisms that emerge from the same analysis mechanism. The simple persistence mechanism in analysis will give rise to a number of persistence mechanisms in design: in-memory persistence, file-based, database-based, distributed, and so forth.

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Instructor Notes:

Design mechanisms provide an abstraction of the implementation mechanisms, bridging the gap between analysis mechanisms and implementation mechanisms. The use of abstract architectural mechanisms during Design allows you to consider how you are going to provide architectural mechanisms without obscuring the problem-at-hand with the details of a particular mechanism. It also allows you to potentially substitute one specific implementation mechanism for another without adversely affecting the Design.

Identify Design Mechanisms: Steps

- ◆ Categorize clients of analysis mechanisms
- ☆◆ Documenting architectural mechanisms



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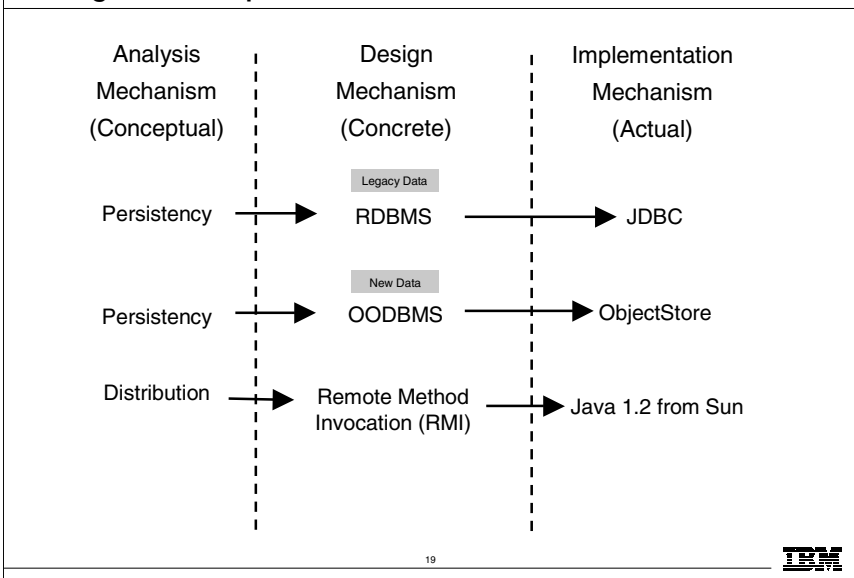
Instructor Notes:

Analysis mechanisms were identified in the Architectural Analysis module. In a design mechanism, some specific technology is chosen, whereas with implementation mechanisms, a very specific technology is chosen. The design mechanisms emerge from analysis mechanisms, and are constrained based on what is possible to achieve in the implementation environment. One can think of design mechanisms as refined in a bottom up manner, although they are initially derived from the need for analysis mechanisms (which are found top down).

More than one design mechanism can be associated with a client class as a compromise between different characteristics (for example, the need for fast access during application execution, and the requirements to be persistent). The mechanism map must be navigable in both directions, so that it is easy to determine client classes when changing implementation mechanisms.

In Identify Design Mechanisms, the design and implementation mechanisms are not only defined but patterns for use are also provided. We will look at some specific examples on the following slides.

Design and Implementation Mechanisms



During Architecture Analysis, you identified the key architectural mechanisms that might be required to solve the problem. Now it is time to refine these and incorporate the decisions made about our implementation.

Design mechanism assumes some details of the implementation environment, but it is not tied to a specific implementation (as is an implementation mechanism). Examples of design mechanisms include:

- **Persistency:** RDBMS, OODBMS, flash card, in-memory storage.
- **Inter-process communication (IPC):** Shared memory, function-call-like IPC, semaphore-based IPC.

Implementation mechanisms are used during the Implementation process. They are refinements of design mechanisms, and they specify the exact implementation of the mechanism. They are bound to a certain technology, implementation language, vendor, etc. Some examples of implementation mechanisms include the actual programming language, COTS products, database (Oracle, Sybase), and the inter-process communication/distribution technology in use (COM/DCOM, CORBA).

The above slide shows the architectural mechanism decisions that have been made for each example. For RDBMS persistency (that is, legacy data access), JDBC was chosen. For OODBMS persistency, ObjectStore was chosen, and for Distribution, RMI was chosen. The JDBC mechanism is discussed later in this module. Information on the ObjectStore and RMI mechanisms are provided in the *Additional Information Appendix*.

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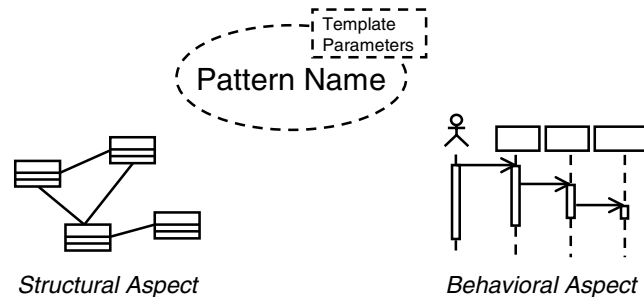
Instructor Notes:

One way to document the mechanisms is to create an Architectural Mechanisms package in the Design Model package in the Logical View. Each mechanism can be represented by a <<mechanism>> stereotyped use case. The class and interaction diagrams for the mechanism can then be attached to the <<mechanism>> use case.

There is also a need to define which elements are concrete and which are roles that should be filled by the designer as they apply the mechanism. One way to model this is to use the <<role>> stereotype on anything (class, operation, relationship, attribute) that should be regarded as a placeholder for the actual design element. Such a convention makes it easier to apply the mechanism because it is easier to recognize what the designer must supply. The concrete classes supporting the mechanisms reside in the actual Design Model layers. The <<role>> classes reside within the Architectural Mechanisms package (or subpackages). This is the approach that we have taken in the course models.

Review: Documenting Architectural Mechanisms

- ♦ Architectural mechanisms can be treated as patterns (i.e., parameterized collaboration)



Documented in Design Guidelines

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Design patterns as parameterized collaborations were discussed in the Architectural Analysis module. Architectural mechanisms can be treated as patterns and documented the same way (that is, as parameterized collaborations).

Like the patterns discussed in Architectural Analysis, an architectural mechanism parameterized collaboration has a structural aspect and a behavioral aspect. The structural part consists of the classes whose instances implement the mechanism and their relationships (the static view). The behavioral aspect describes how the instances collaborate (that is, send messages to each other) to implement the mechanism (the dynamic view).

The role of the architect is to decide upon and validate mechanisms by building or integrating them, as well as by verifying that they do the job. The architect must then consistently impose the mechanisms upon the rest of the system design. Thus, for each architectural mechanism the architect must provide a static and a dynamic view, accompanied by rules of use.

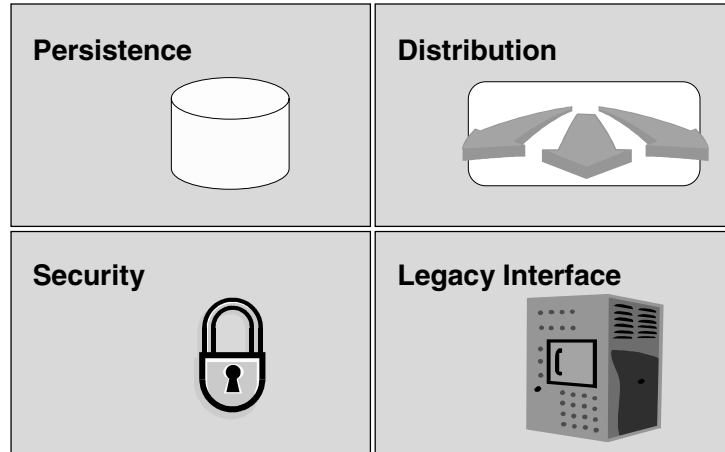
The mechanisms, the mapping between them, and details regarding their use, must be documented in the Design Guidelines specific to the project, not in the Software Architecture Document (SAD). The SAD captures actual architectural choices made for a system on the basis of nonfunctional requirements and functional requirements. The Design Guidelines document provides for design not yet done. In many organizations, the design guidelines exist as an organizational asset independent of particular projects. It represents the collected reusable design wisdom for that organization in a particular domain. It might then require refinement to suit a project. Therefore, the SAD is the architectural representation (or at least the most significant parts of it). The Design Guidelines cover how to do design, in a very specific, not just conceptual, way.

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Instructor Notes:

This slide is meant to remind the students what mechanisms are being discussed in this course. These mechanisms are important because the students will be using them during Use-Case Design and Subsystem Design.

Review: Course Registration Analysis Mechanisms



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The above slide lists the selected analysis mechanisms for the Course Registration System.

Persistency: A means to make an element persistent (that is, exist after the application that created it ceases to exist).

Distribution: A means to distribute an element across existing nodes of the system.

Security: A means to control access to an element.

Legacy Interface: A means to access a legacy system with an existing interface.

These mechanisms are also documented in the Payroll Architecture Handbook, Architectural Mechanisms section.

Next, we will discuss the design mechanisms for persistence, distribution, and security.

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Instructor Notes:

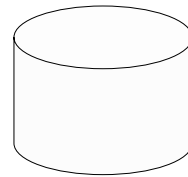
Take a moment to set the context for the students before getting into the next series of slides that will demonstrate the design mechanism for incorporating JDBC in the Course Registration System.

If you have a class that does not use a RDBMS and is interested in an OODBMS implementation, then you can replace these slides with the ones from the ObjectStore Mechanism section in the *Additional Information Appendix*.

Mechanism: Persistency: RDBMS: JDBC

◆ Persistence characteristics:

- Granularity
- Volume
- Duration
- Access mechanism
- Access frequency (creation/deletion, update, read)
- Reliability



Note: JDBC is the standard Java API for talking to a SQL database.

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These characteristics were first introduced in Architectural Analysis. When we described the persistency architectural mechanism, we used the following characteristics;

Persistency: For all classes whose instances might become persistent, we need to identify:

- **Granularity:** What is the range of the persistent objects?
- **Volume:** How many objects must be kept persistent?
- **Duration:** How long must the persistent objects be kept?
- **Access mechanism:** How is a given object uniquely identified and retrieved?
- **Access frequency:** Are the objects more or less constant? Are they permanently updated?
- **Reliability:** Can the objects survive a crash of the process, the processor, or the whole system?

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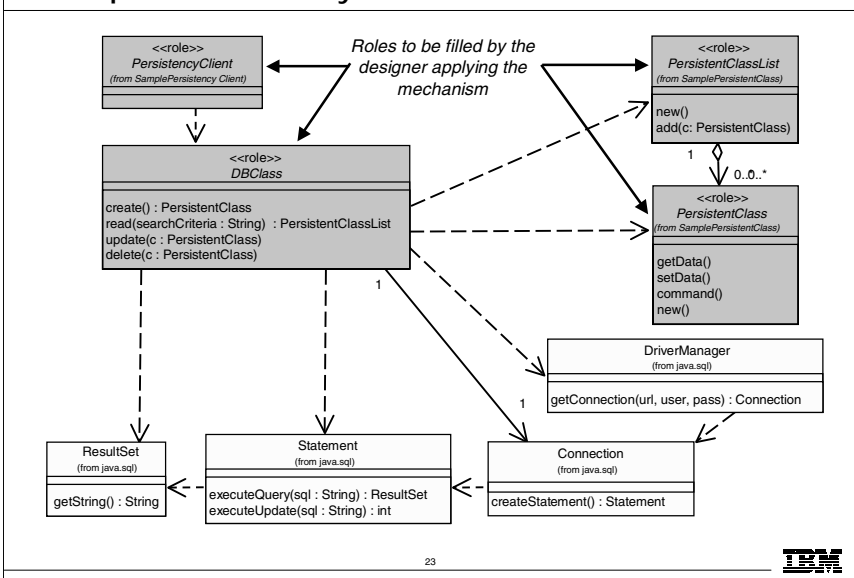
The classes to be replaced with concrete classes by the designer applying the mechanism are shaded in blue and have italicized class names.

With this approach, the OO model is separable from the DBMS model, and the class does not know it is persistent. (It can be reused in applications where its objects are not persistent.)

For performance optimization, there is also the notion of PreparedStatements (which inherit from Statement). The basic advantage of a PreparedStatement is that most of the SQL can be precompiled, and then only the small amount of changing data must be passed in for each call. This is a performance optimization that is not that important from a mechanism's point of view. Thus, for this model, we did not use PreparedStatements at all. For more information, see the JDBC specifications.

Walk the students through the mechanism diagrams at a high level. Do not let them get hung up on the mechanism details. We'll cover how the RDBMS mechanism is applied in Subsystem Design.

Example: Persistency: RDBMS: JDBC



The next few slides demonstrate the pattern of use of the persistent mechanism chosen for the RDBMS classes in our example: JDBC. The above diagram is the static view.

For JDBC, a client works with a **DBClass** to read and write persistent data. The **DBClass** is responsible for accessing the JDBC database using the **DriverManager** class. Once a database **Connection** is opened, the **DBClass** can then create SQL statements that will be sent to the underlying RDBMS and executed using the **Statement** class. The **Statement** is what “talks” to the database. The result of the SQL query is returned in a **ResultSet** object.

The **DBClass** is the one responsible for making another class instance persistent. It understands the OO-to-RDBMS mapping and has the behavior to interface with the RDBMS. The **DBClass** flattens the object, writes it to the RDBMS, reads the object data from the RDBMS, and builds the object. Every class that is persistent has a corresponding **DBClass**.

The **PersistentClassList** is used to return a set of persistent objects as a result of a database query (for example, **DBClass.read()**).

The <<role>> stereotype was used for anything that should be regarded as a placeholder for the actual design element to be supplied by the developer. This convention makes it easier to apply the mechanism, because it is easier to recognize what the designer must supply.

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Instructor Notes:

This diagram is one of the dynamic representations of JDBC, the chosen RDBMS persistency mechanism. The classes to be replaced with concrete classes by the designer applying the mechanism are shaded in blue and have italicized class names.

Possible question from the students:

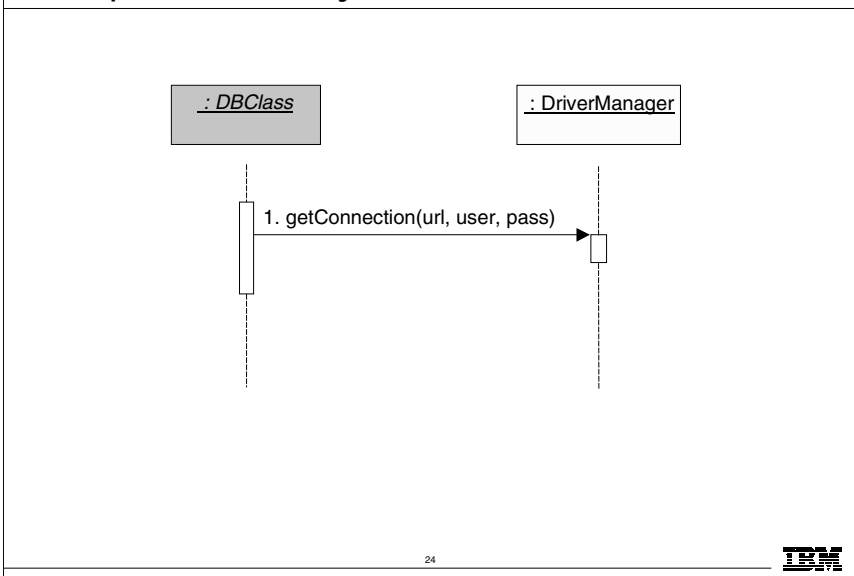
Every DBClass must establish a separate Connection? Since there's one DBClass per persistent class, that's a lot of connections. I would have expected one connection that everyone shares.

Answer: This depends on how many persistent classes you have to access. Each DBClass could create its own connection (as is done in this example) or a connection could be passed in.

Don't spend too much time on this diagram, since it will not be applied in later modules. However, it is needed in order to better understand the persistency mechanism.

Note: Explicit shutdown of the database is not required with the RDBMS mechanism.

Example: Persistency: RDBMS: JDBC: Initialize



Initialization must occur before any persistent class can be accessed.

To initialize the connection to the database, the DBClass must load the appropriate driver by calling the DriverManager getConnection() operation with a URL, user, and password.

getConnection() attempts to establish a connection to the given database URL. The DriverManager attempts to select an appropriate driver from the set of registered JDBC drivers.

Parameters:

url: A database url of the form jdbc:subprotocol:subname. This URL is used to locate the actual database server. It is not Web-related in this instance.

user: The database user on whose behalf the connection is being made.

password: The user's password. It returns a connection to the URL.

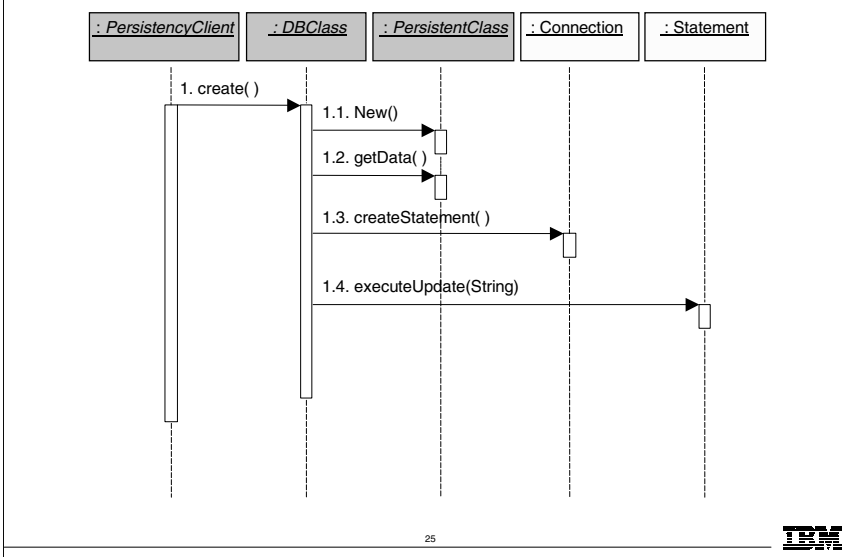
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Instructor Notes:

Do not spend too much time on this diagram since it will not be applied in later modules. However, it is needed in order to help the students better understand the persistency mechanism.

The classes to be replaced with concrete classes by the designer applying the mechanism are shaded in blue and have italicized class names.

Example: Persistency: RDBMS: JDBC: Create



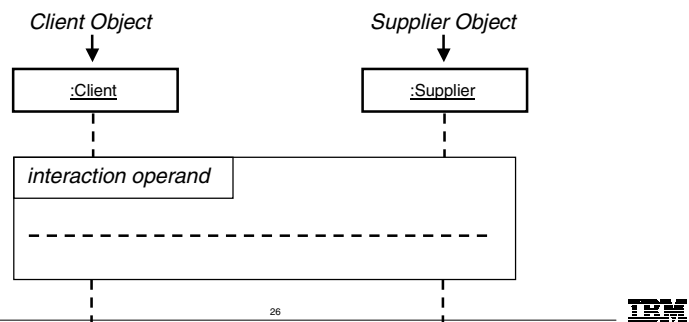
To create a new class, the persistency client asks the DBClass to create the new class. The DBClass creates a new instance of PersistentClass with default values. The DBClass then creates a new Statement using the Connection class createStateiment() operation. The Statement is executed, and the data is inserted into the database.

Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

What Is a Combined Fragment?

- ♦ A construct within an interaction that comprises an operator keyword and one or more interaction operands, each of which is a fragment of an interaction.
 - It is shown as a nested region within a sequence diagram.



The general notation for a combined fragment is a rectangle with a small pentagon in the upper left corner containing the interaction operand. The rectangle is nested within its containing fragment or within the sequence diagram as a whole.

Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

What is an Interaction Operand?

- ♦ Each fragment comprises one or more interaction operands, each a subfragment of the interaction.
 - The number of operands depends on the type of combined fragment.
 - For example, a loop has one operand (the loop body) and a conditional has one or more operands (the branches of the conditional).
 - An operand is a nested fragment of an interaction.
 - Each operand covers the lifelines covered by the combined fragment or a subset of them.

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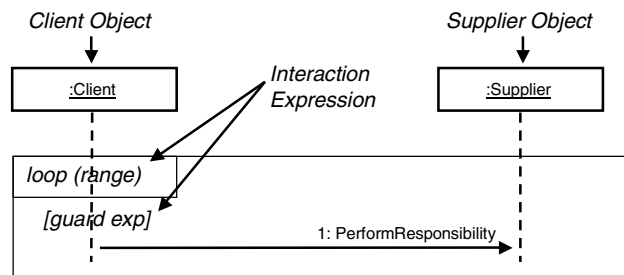
The value of the Interaction Operand is given as text in a small compartment in the upper left corner of the Combined Fragment frame (alt, assert, break, consider, critical, ignore, loop, neg, opt, par, seq, strict). Multiple interaction operands will be separated by a dashed horizontal line and together make up the framed Combined Fragment.

Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

What is an Interaction Expression?

- ♦ A specification of the range of number of iterations of a loop.
 - Range can be specified with minimum and maximum values
 - A guard condition, enclosed in square brackets, can be included on a lifeline.



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The range on the number of iterations of a loop are included in parentheses as part of the tag after the keyword loop:

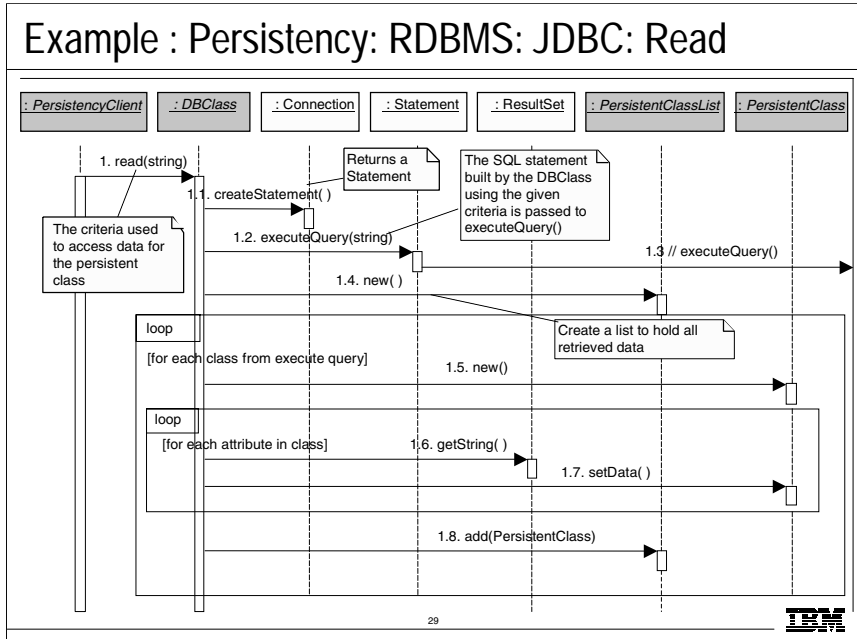
- loop Minimum = 0, unlimited maximum
- loop (repeat) Minimum = maximum = repeat
- loop (minimum, maximum) Explicit minimum and maximum bounds

In addition to the bounds, a Boolean expression can be included as a guard on a lifeline. As long as the expression is true, the loop will continue to iterate.

Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

This is a review slide from the *Identify Design Mechanisms* module.



To read a persistent class, the persistency client asks the DBClass to read. The DBClass creates a new Statement using the Connection class createStatement() operation. The Statement is executed, and the data is returned in a ResultSet object. The DBClass then creates a new instance of the PersistentClass and populates it with the retrieved data. The data is returned in a collection object, an instance of the PersistentClassList class.

Note: The string passed to executeQuery() is *not* the exact same string as the one passed into the read(). The DBClass builds the SQL query to retrieve the persistent data from the database, using the criteria passed into the read(). This is because we do not want the client of the DBClass to have the knowledge of the internals of the database to create a valid query. This knowledge is encapsulated within DBClass.

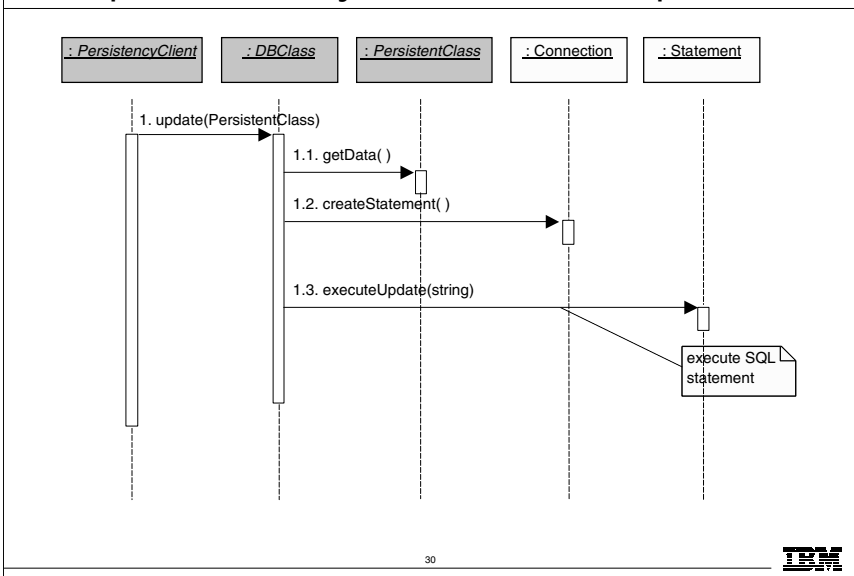
Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

Don't spend too much time on this diagram since it will not be applied in later modules. However, it is needed in order to help the students better understand the persistency mechanism.

The classes to be replaced with concrete classes by the designer applying the mechanism are shaded in blue and have italicized class names.

Example: Persistency: RDBMS: JDBC: Update



To update a class, the persistency client asks the DBClass to update. The DBClass retrieves the data from the given PersistentClass object, and creates a new Statement using the Connection class createStatement() operation. Once the Statement is built the update is executed and the database is updated with the new data from the class.

Remember — that it is the DBClass's job to "flatten" the PersistentClass and write it to the database. That is why it must be retrieved from the given PersistentClass before creating the SQL Statement.

Note: In the above mechanism, the PersistentClass must provide access routines for all persistent data so that DBClass can access them. This provides external access to certain persistent attributes that would have otherwise have been private. This is a price you have to pay to pull the persistence knowledge out of the class that encapsulates the data.

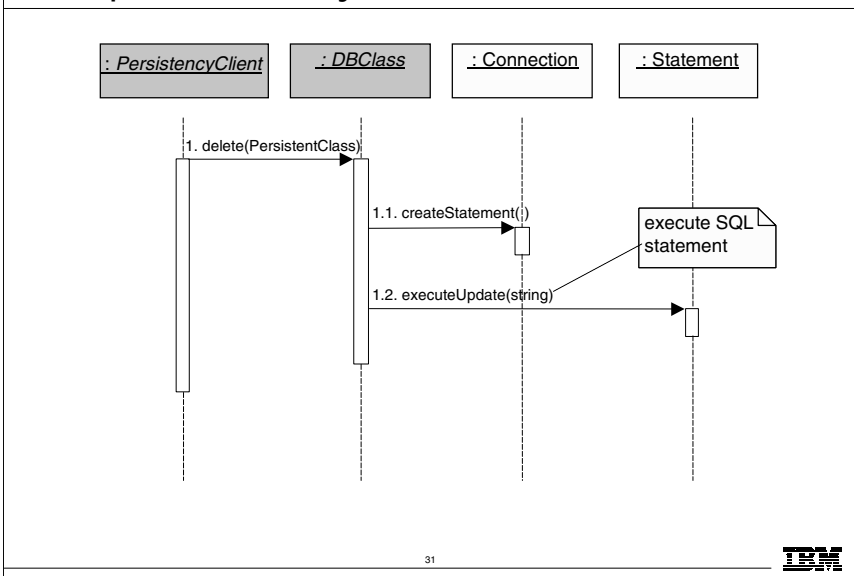
Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

Don't spend too much time on this diagram since it will not be applied in later modules. However, it is needed in order to help the students better understand the persistency mechanism.

The classes to be replaced with concrete classes by the designer applying the mechanism are shaded in blue and have italicized class names.

Example: Persistency: RDBMS: JDBC: Delete



To delete a class, the persistency client asks the DBClass to delete the PersistentClass. The DBClass creates a new Statement using the Connection class createStatement() operation. The Statement is executed, and the data is removed from the database.

Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

The italicized blue text reflects the RDBMS incorporation design decisions made for the current design.

Note: On the presented slide, the italicized text is also blue, but this does not show up in the back-and-white manuals.

Incorporating JDBC: Steps

1. Provide access to the class libraries needed to implement JDBC
 - *Provide java.sql package*
2. Create the necessary DBClasses
 - Assign one DBClass per persistent class
3. Incorporate DBClasses into the design
 - Allocate to package/layer
 - Add relationships from persistency clients
4. Create/Update interaction diagrams that describe:
 - Database initialization
 - Persistent class access: Create, Read, Update, Delete

Deferred

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The above is a summary of the steps that can be used to implement the RDBMS persistency mechanism (JDBC). The italicized text on the slide describes the architectural decisions made in regards to JDBC for our Course Registration example. Here are some explanations:

- The *java.sql* package contains the design elements that support the RDBMS persistency mechanism. It will be depended on by the package(s) in which the DBClasses are placed.
- There is one DBClass per persistent class.
- Once created, the DBClasses must be incorporated into the existing design. They must be allocated to a package/layer.
- Once the DBClasses have been allocated to packages/layers, the relationships to the DBClasses from all classes requiring persistence support will need to be added.

The interaction diagrams provide a means to verify that all required database functionality is supported by the design elements. The sample interaction diagrams provided for the persistency architectural mechanisms during **Identify Design Mechanisms** should serve as starting points for the specific interaction diagrams defined in detailed design.

In **Identify Design Mechanisms**, make sure that the architecture has the necessary infrastructure (that is, that we have access to the class libraries that are needed to implement JDBC). The definition of the actual DBClasses and the development of the detailed interaction diagrams is deferred until detailed design.

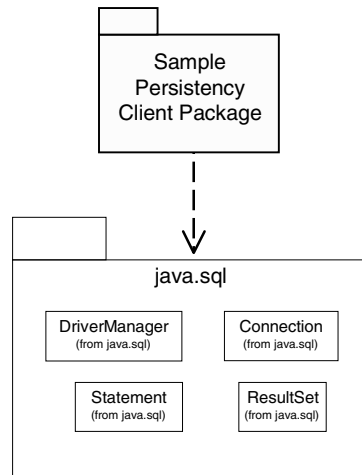
Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

The changes made to support the mechanism are shown in blue (but this does not show up in the black and white manuals).

Note: If your students are interested in the OODBMS (ObjectStore) mechanism, the slides found in the Additional Information appendix, ObjectStore section, first part, should be inserted after this slide.

Example: Incorporating JDBC



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The following changes must be made to the Course Registration Model to incorporate the JDBC persistency mechanisms:

- Access must be provided to the java.sql package that contains the design elements that support the RDBMS persistency mechanism. The packages where the created DBClasses reside must have a dependency on the java.sql package. Remember, there will be a DBClass for every RDBMS persistent class.
- The creation of the DB classes and the decision as to where they reside in the architecture will be determined during detailed design (for example, Use-Case and Subsystem Design).

Mastering OOAD w/ UML 2.0 – Instructor Notes

Instructor Notes:

1. Analysis mechanisms provide conceptual sets of services that are used by analysis objects. They offer a convenient shorthand for fairly complex behaviors that will ultimately have to be worried about, but that are out of scope for the analysis effort.

2. A **pattern** codifies specific knowledge collected from experience. Patterns provide examples of how good modeling solves real problems.

Frameworks differ from analysis and design patterns in their scale and scope. Frameworks describe a skeletal solution to a particular problem that may lack many of the details.

3. The purpose of categorizing the analysis mechanisms is to refine the information that you've gathered. The steps include:

- identify the clients of each analysis mechanism.
- identify characteristic profiles for each analysis mechanism.
- group clients according to their use of characteristic profiles.
- proceed bottom up and make an inventory of the implementation mechanisms that you have at your disposal.

Review: Identify Design Mechanisms

- ♦ What does an analysis mechanism do?
- ♦ What is a pattern? What makes a framework different from a pattern?
- ♦ Why should you categorize analysis mechanisms? Identify the steps.

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