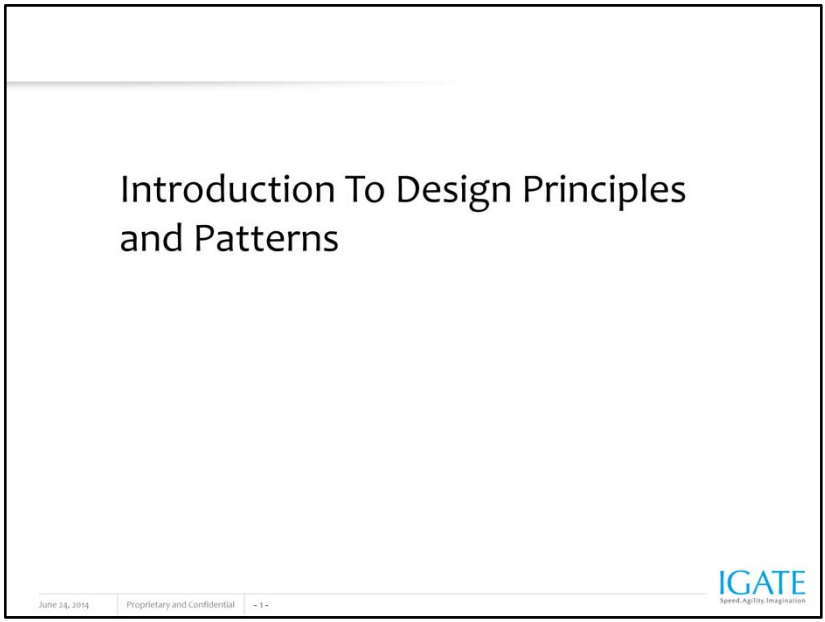
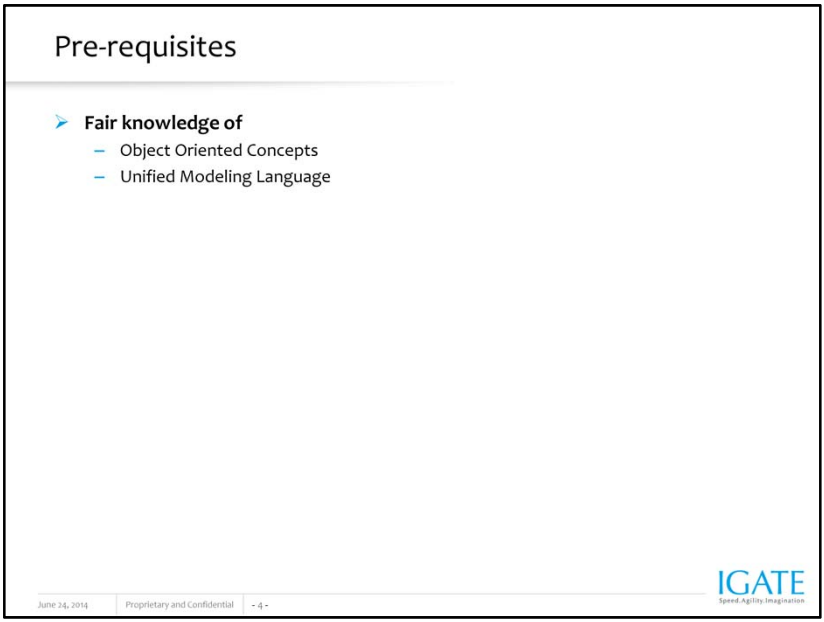


Document History

Date	Course Version No.	Software Version No.	Developer / SME	Change Record Remarks
15-Feb-2011	0.01D	NA	Veena Deshpande	Content Compilation
26 Jul 2011	1.0	NA	Veena Deshpande Kishori Khadilkar	Baselining after content and format Review

Course Goals and Non Goals

- **Course Goals**
  - At the end of this course, participants gain an understanding of
    - Key Design Principles
    - Overview of Design Patterns with some examples
- **Course Non Goals**
  - Identification and application of design patterns for the purpose of designing


Pre-requisites
Fair knowledge of
Object Oriented Concepts
Unified Modeling Language
June 24, 2014
Proprietary and Confidential
- 4 -
IGATE
Speed.Agility.Imagination

Intended Audience

- **Programmers working with Object Oriented Languages**

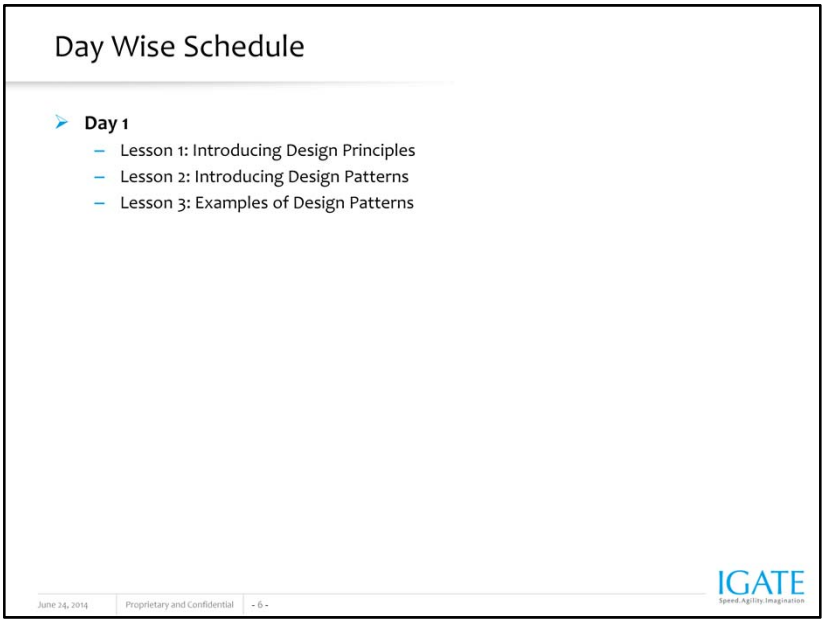

Day Wise Schedule
Day 1
Lesson 1: Introducing Design Principles
Lesson 2: Introducing Design Patterns
Lesson 3: Examples of Design Patterns
June 24, 2014
Proprietary and Confidential
- 6 -
IGATE
Speed.Agility.Imagination

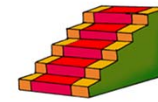
Table of Contents

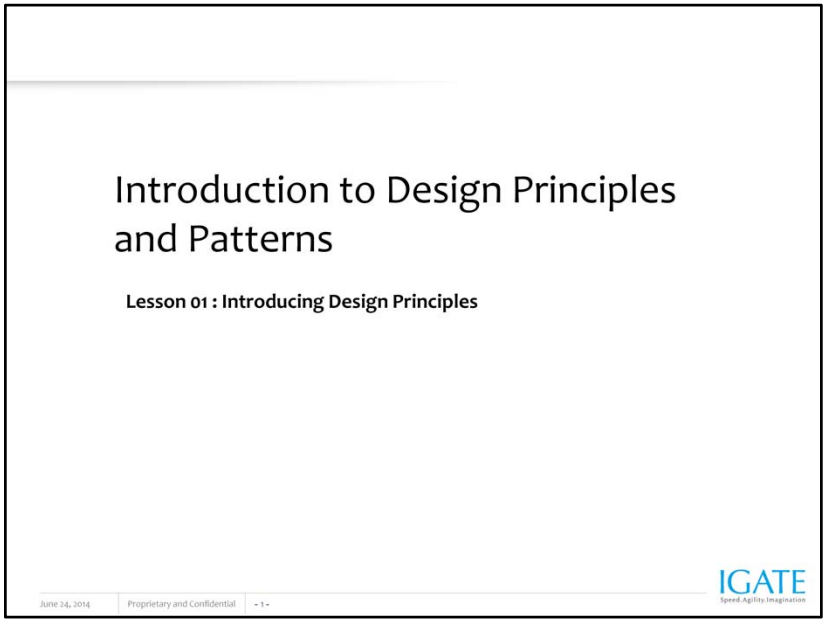
References

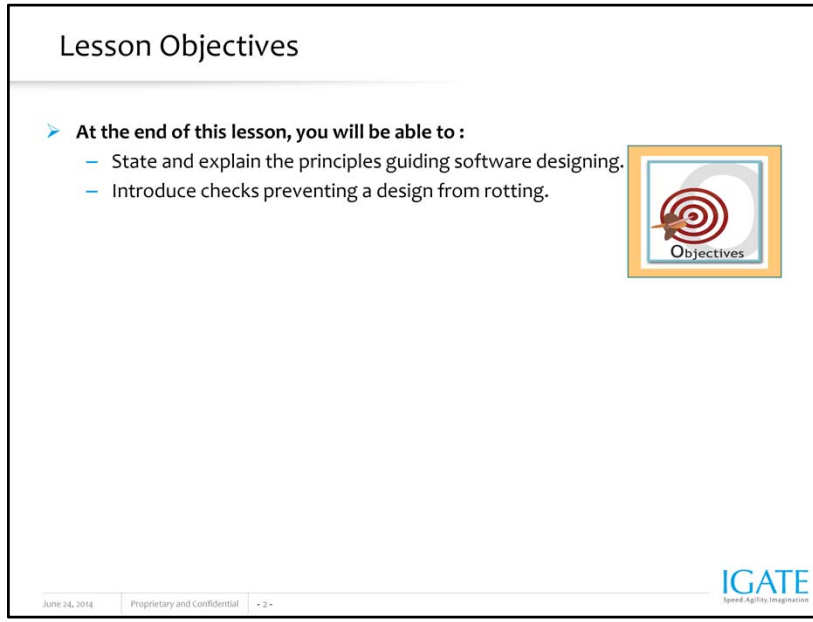
- **Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and the Unified Process**
  - By Craig Larman
- **Object Oriented Design Heuristics**
  - By Arthur J. Riel
- **Head First Design Patterns**
  - By Elisabeth Freeman, Eric Freeman, Bert Bates, Kathy Sierra

Next Step Coursess

- Object Oriented Analysis and Design
- GoF Design Patterns
- Technology Specific Designing and Technology Specific Design Patterns




Introduction to Design Principles and Patterns
Lesson 01 : Introducing Design Principles
June 24, 2014
Proprietary and Confidential
- 1 -
IGATE
Speed. Agility. Imagination

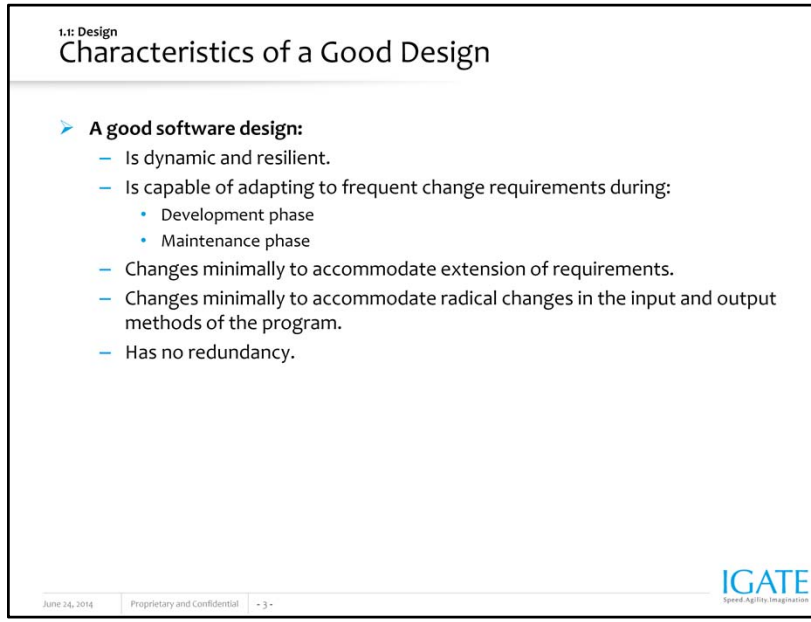


Lesson Objectives:
We are now familiar with features of an object oriented language
We write our Object Oriented programs based on the designs provided for the application
For a given design, is there any method to gauge whether it is good, bad, or somewhere in between?

We may get the answer from an "OO Guru". If the design "feels right", the Guru certifies that the design is good.

How do we know if the design "feels right"?

We can get the answer by looking at the design heuristics and principles introduced in this lesson.



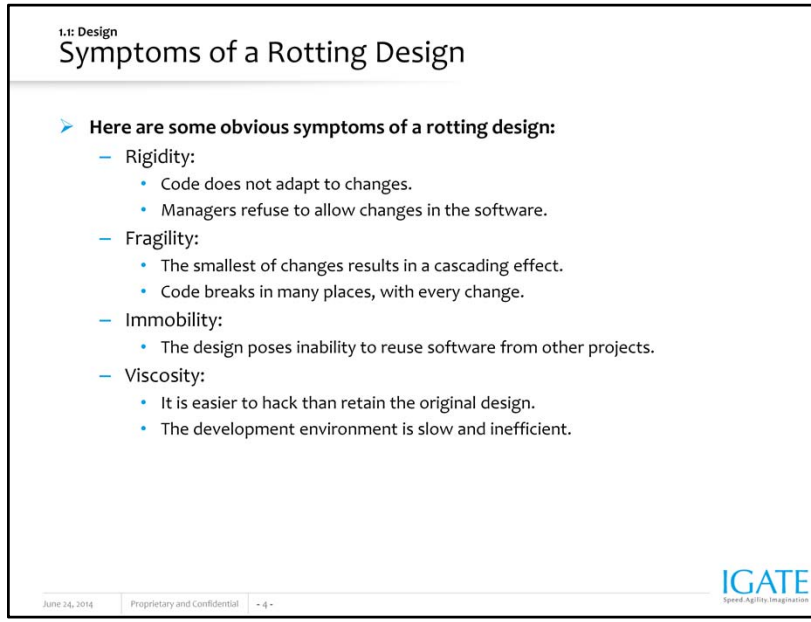
Characteristics of a Good Design:

Today, we live in a world that is highly dynamic and diverse in nature. As a result, our requirements too are constantly changing. Therefore it is not surprising that "dynamic" and "resilient" software systems are the need of the day.

The challenge is in developing a software system capable of adapting to the ever changing requirements, complexities of the problem domain, and difficulty of managing software processes.

A good design and code adapts easily to the frequent changes that are done during development and maintenance. Very often extensive changes are involved, when a new functionality is added to an application. The design should be able to incorporate the added functionality with minimum change to the existing codes.

Existing codes are already tested units, and changing them may result in unwanted changes in related functionalities. A software designer should make his or her design foolproof against such eventualities.



Symptoms of a Rotting Design:

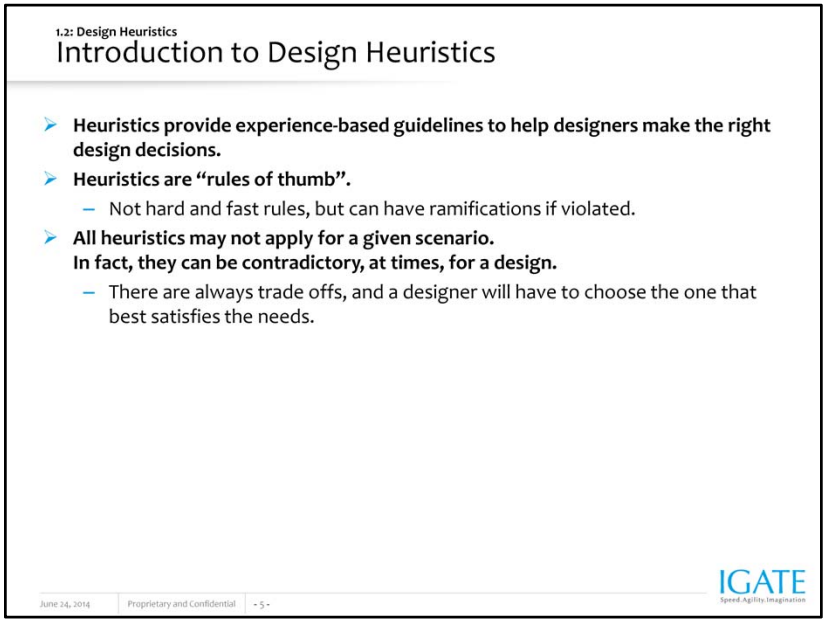
There are four primary symptoms of a rotting design:

Rigidity: It is the tendency of a software to change even in the smallest of ways. Every change results in a cascading effect, bringing about subsequent changes in related modules. When software exhibits such characteristics, the managers avoid fixing even the simplest of problems.

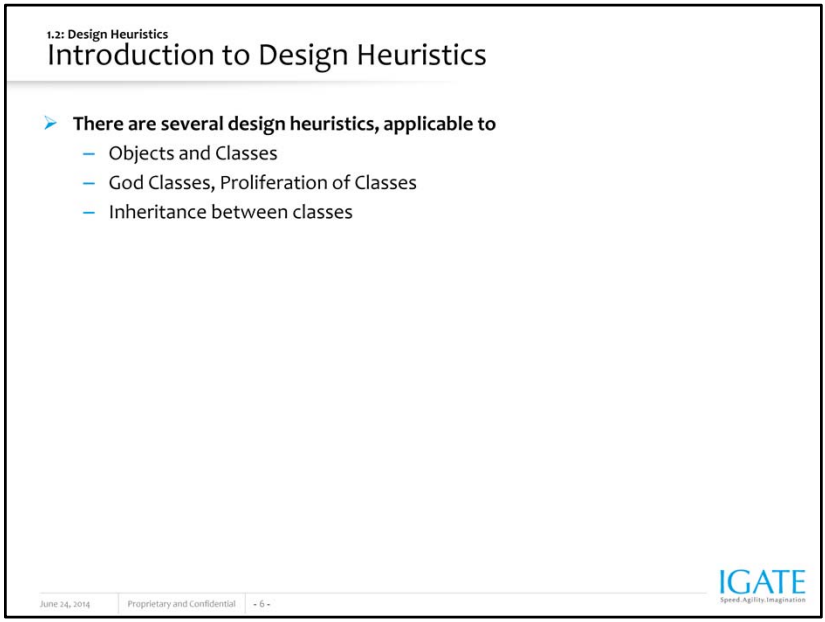
Fragility: It is the tendency of the software to break in many places every time it changes. Often the break occurs at a point remotely connected with the point of change. In fact, the two points may not be related at all. Due to the break, the fragility increases, and soon the situation goes beyond control.

Immobility: It is the inability to reuse software from other projects or from other parts of the same project. This situation occurs when a module has too much related software that it depends on.

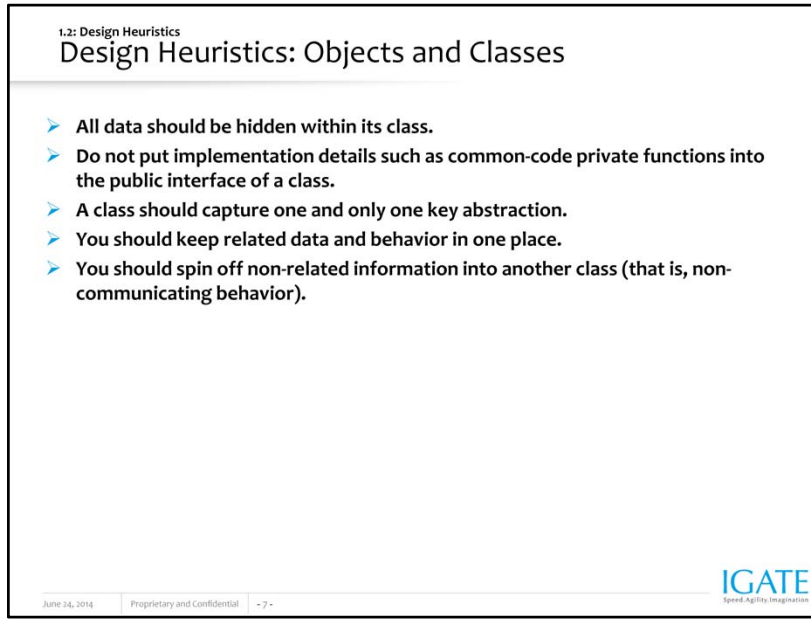
Viscosity: Viscosity is of two types: viscosity of design and viscosity of environment. When design preserving methods are more difficult to implement than the hacks, then we can say that the viscosity of design is very high. When the design environment is slow and inefficient we can say that the viscosity of environment is high.



Design Heuristics:
How do we know whether right decisions are taken with respect to designing? This is where guidelines captured over the years through experience help in taking the right decisions.
These guidelines, also referred as "rules of thumb", are not hard and fast rules. However, these can be thought of as "warning bells" if violated. Using these guidelines, appropriate changes can be brought about for removing the heuristic violation, wherever necessary



Design Heuristics:
Arthur J. Riel has put together 60 design heuristics, and these are applicable for various aspects like Objects and Classes, God Classes and Proliferation of classes, Inheritance between classes etc.
We will see some of these on the subsequent slides.



Design Heuristics: Objects and Classes:
The above slide lists some of the design heuristics related to objects and classes.

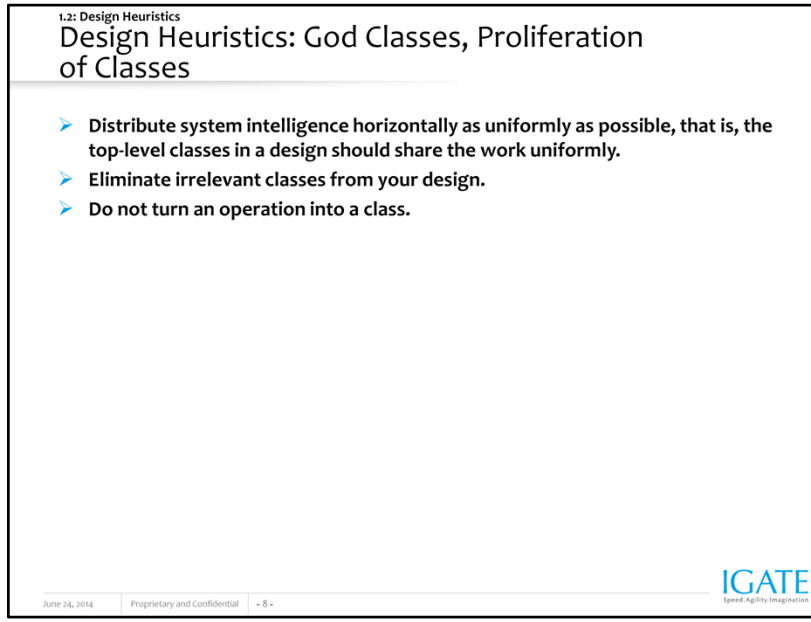
Data is operated upon by operations, so there is a direct dependency between them. Data is bound to change, so it is useful to isolate consequences of that change to within the same class by enforcing encapsulation. For example, if data type changes, operations too will need modification. By keeping data, and operations that act on the data together, maintenance becomes easier.

This heuristic aims to reduce the complexity of class interface. Implementation details are meant to be "service operations", which merely factors code within class considering reusability and modularity. They are not expected to be directly used by clients of class and hence must remain private.

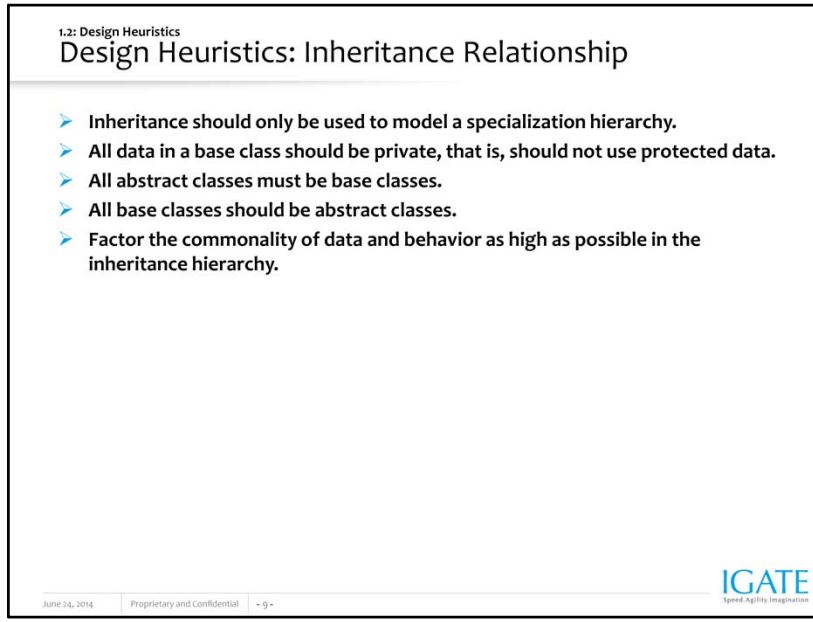
Key abstraction is usually defined as an element of the problem domain. This heuristic implies the need for a class to be cohesive.

Violating this would mean that more than one class is affected in case of change in data because data and behavior actually belong to the same key abstraction and should have been captured in the same class.

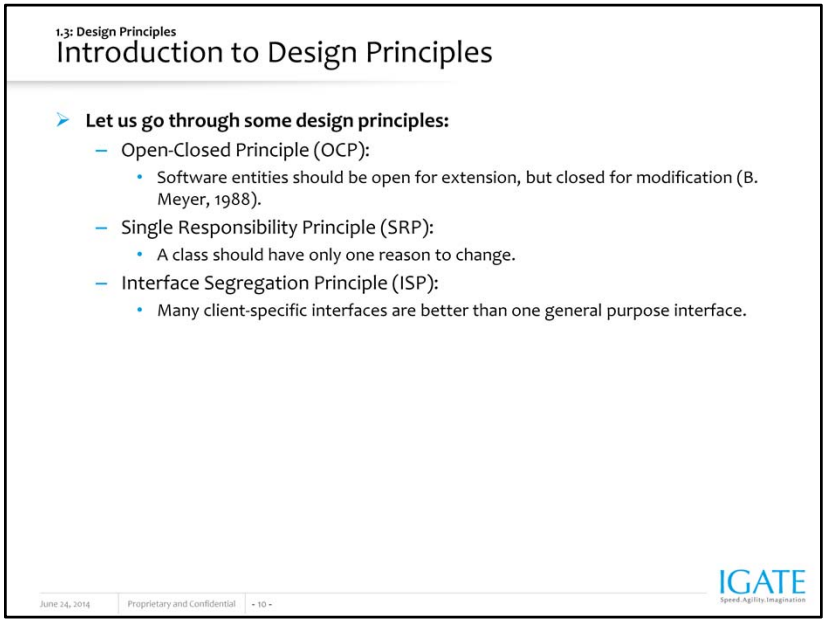
Look out for classes where a subset of methods operate on a proper subset of data. In this case, one must spin off the other subset of related data and operations into another class.



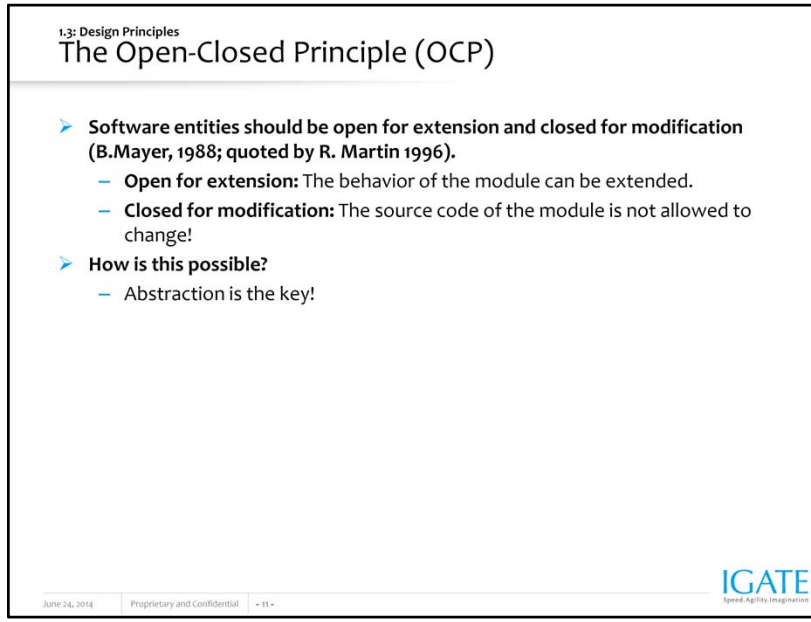
Design Heuristics: God Classes, Proliferation of Classes:
The above slide lists some of the design heuristics related to God classes and proliferation of classes.
Object oriented paradigm can go haywire if the design moves in the direction stated above. Poorly distributed system intelligence and creation of too many classes vis-à-vis the problem at hand are respectively referred to as "God Class" and "Proliferation of Classes".
Especially when one moves from procedural to object oriented platforms, the tendency is to create God object which will do most of the work and leave smaller details to rest of the classes.
It is said that one cannot get spaghetti code with OO systems, but one can get ravioli code instead! If spaghetti is pasta in long thin strings which makes it easy for them to get entangled ("spaghetti code" refers to unstructured code where control can jump from one point to another), ravioli is small pasta pouches containing cheese / vegetables / meat ("ravioli code" is characterized by number of small and loosely coupled software components). If raviolis become too many ("Proliferation" of classes), then there is a different kind of maintenance problem. In which of these multiple classes should changes be incorporated?



Design Heuristics: Inheritance Relationship:
The above slide lists some of the design heuristics related to inheritance relationship.
The first point actually compares inheritance with containership. It emphasizes that inheritance has to be used only in the cases where there is specialization hierarchy coming into picture. "Favor composition over inheritance" comes from here!
The 2nd point hints at the fact that inheritance potentially violates encapsulation! When something is protected, it becomes available in the derived classes, thereby weakening data hiding.
There are recommendations on how abstract classes and base classes must be considered in design. It is ideal to have an abstract class sitting at the base of the hierarchy.
By factoring commonality of data and behaviour as high up in the hierarchy as possible, multiple derived classes can leverage the commonality.



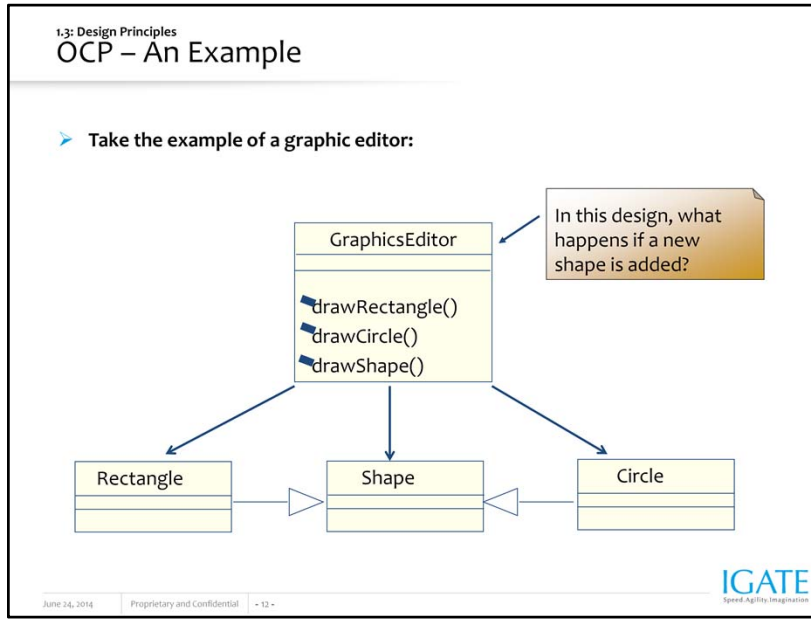
Some Design Principles in more details:
We have looked at some design heuristics. In the above slide, we now look at some key Object-Oriented design principles.



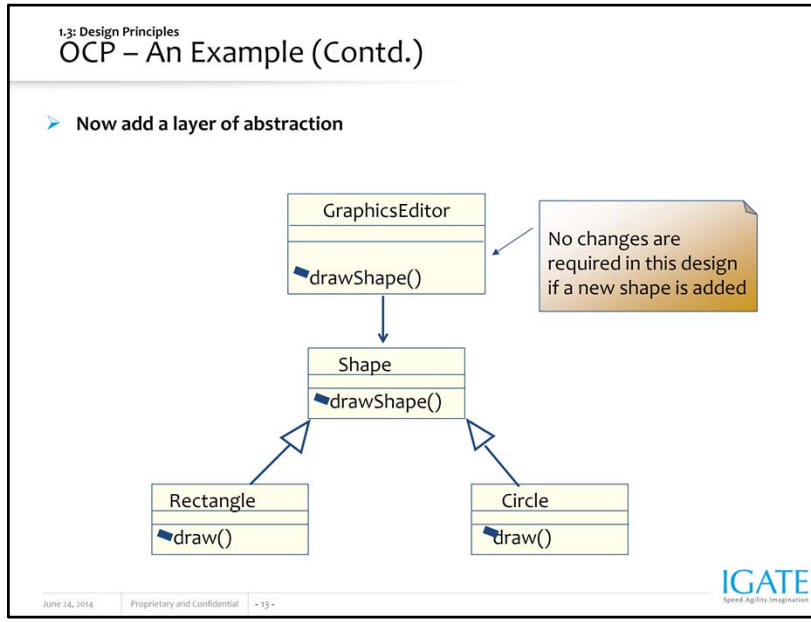
The Open-Closed Principle (OCP):
Software modules that conform to the open-closed principle, exhibit two primary attributes:

They are Open to Extension: This implies that the behavior of the module can be extended. The system can be made to behave in new and different ways as requirements change, or to meet new applications.
They are Closed to Modifications: This implies that the source code of such a module remains intact. New codes are added to implement new and changed behavior.

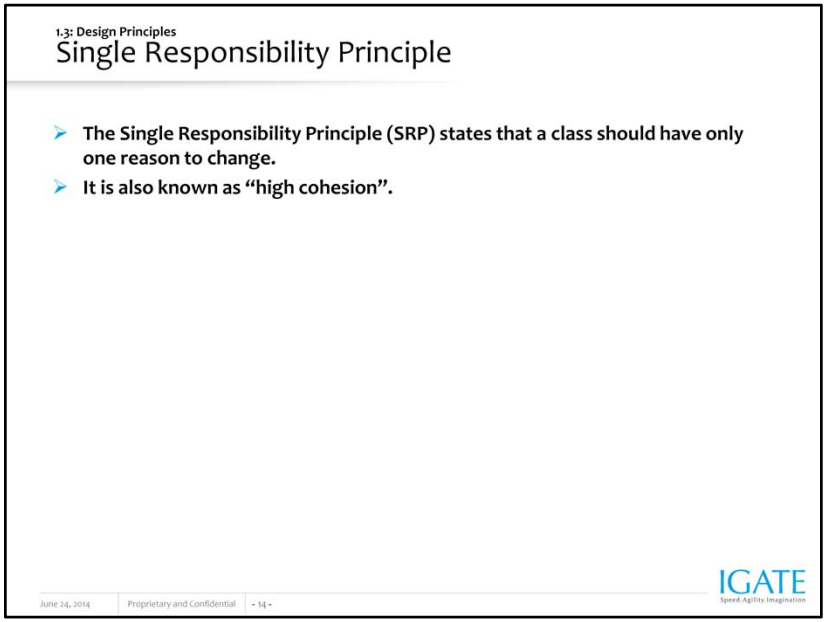
At first glance, these two attributes appear to be contradicting each other. The normal way to extend behavior of a module is by making changes to that module. A module that does not lend itself to change, is said to have fixed behavior. So how does one change existing modules without changing the source code?
You can use the principle of abstraction to develop modules that are open to extensions and simultaneously closed to modifications. You can create abstractions that are fixed, yet represent an unbounded group of possible behaviors. The abstractions are abstract base classes, and all the possible derivative classes represent the unbounded group of possible behaviors.



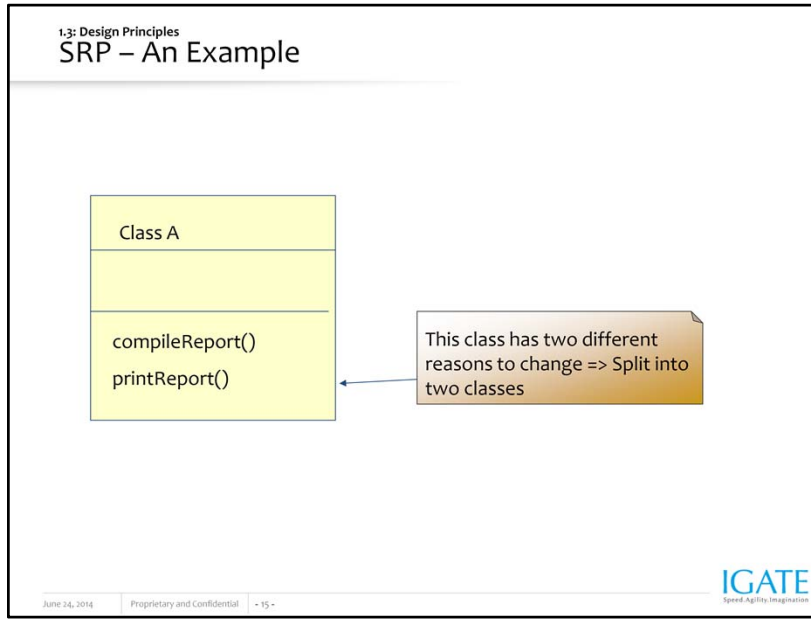
OCP – An Example:
The above slide shows a graphic editor that can draw shapes, circles, and rectangles. However, when a new shape is added, the graphic editor has to be changed. This implies that the source code needs changing. Therefore this example does not conform to the OCP principle. The design cannot be closed against new kinds of shape.
The next slide shows a modified version of the example after incorporating OCP.



OCP – An Example (contd.):
Now, consider adding a layer of abstraction as shown in the above slide.
New shapes can extend the Shape class. So behavior can be extended without modification of GraphicsEditor class. The source remains intact.
This was a relatively simple example with a simple solution. In the real world, the Shape class would have many more methods. Still adding a new shape to the application is simple and requires the creation of the new derivative and the implementation of all its functions. The designs based on OCP incorporate changes by adding new codes rather than by changing existing codes. Hence one does not encounter the cascading effect seen otherwise.
It is important to note that no application can be 100% closed. The closure cannot be complete. Hence designers look for strategic closure. From a designers angle, this situation requires deciding on the kind of changes against which you want to close your design. This calls for a certain degree of intuition and experience. An experienced designer has his or her finger on the pulse of the industry and the user. He or she can normally foresee the probability of different kinds of changes and design accordingly.



Single Responsibility Principle (SRP):
In this context, a responsibility is considered to be one reason to change. This principle states that if we have two reasons for a class to change, then we have to split the functionality into two classes. Each class will handle only one responsibility and in future if we need to make one change, then we are going to make it in the class which handles it. When we need to make a change in a class having more responsibilities, the change might affect the other functionality of the classes.
Cohesion is sticking or working together, that is, the state or condition of joining or working together to form a united whole, or the tendency to do this. A class should be cohesive, that is, the class should have only a single purpose to live and all its methods should work together to help achieve this goal.
The Single Responsibility principle is a simple and intuitive. However, in practice it is sometimes hard to get it right.



SRP – An Example:

As an example, consider a class that compiles and prints a report. Such a class can be changed for two reasons.

First, the content of the report can change.

Second, the format of the report can change.

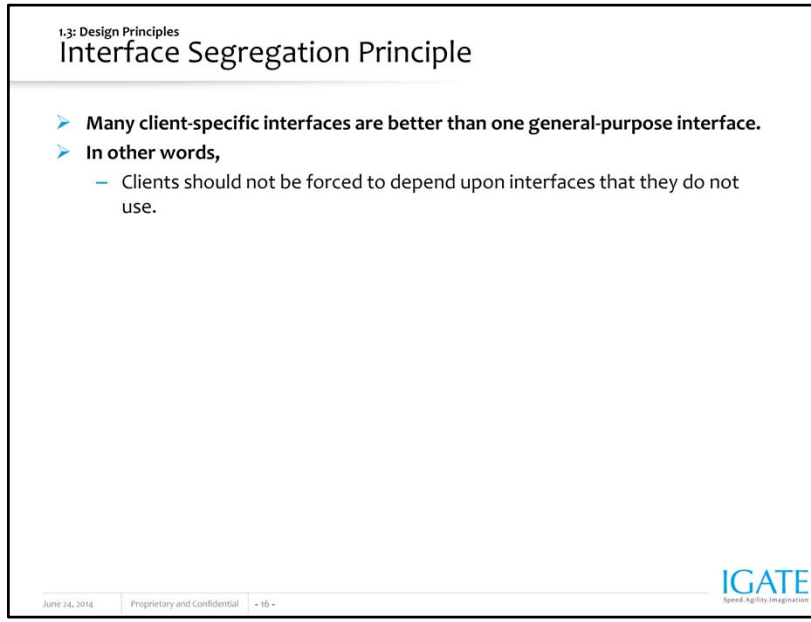
These two things change for very different causes – one substantive, and one cosmetic. The SRP says that these two aspects of the problem are really two separate responsibilities, and should therefore be in separate classes.

It is important to keep a class focused on a single concern because it makes the class more robust. Continuing with the foregoing example, if there is a change to the report compilation process, then there is a greater danger that the printing code will break if it is part of the same class.

When a class has more than one responsibility (that is, reason to change), these responsibilities are coupled. This scenario makes the class more difficult to understand, more difficult to change, and more difficult to reuse. Cohesion should also be applied at the method level, and for the exact same reasons.

The challenge with SRP is getting the granularity of a responsibility right. Sometimes, it is easier to see the responsibilities are unrelated. But more often, it needs thorough thinking!

One last point regarding SRP is that if you cannot separate the responsibilities into separate classes, then at least consider separating them to different interfaces.



Interface Segregation Principle (ISP):

Interface Segregation Principle (ISP) deals with designing "cohesive" interfaces and avoiding "fat" interfaces. It focuses on the cohesiveness of interfaces with respect to the clients that use them. The idea here is that each client may use a particular object or subsystem in a different way.

ISP states that clients should not be forced to implement interfaces they do not use. Instead of one fat interface, many small interfaces are preferred based on groups of methods, each one serving one sub-module.

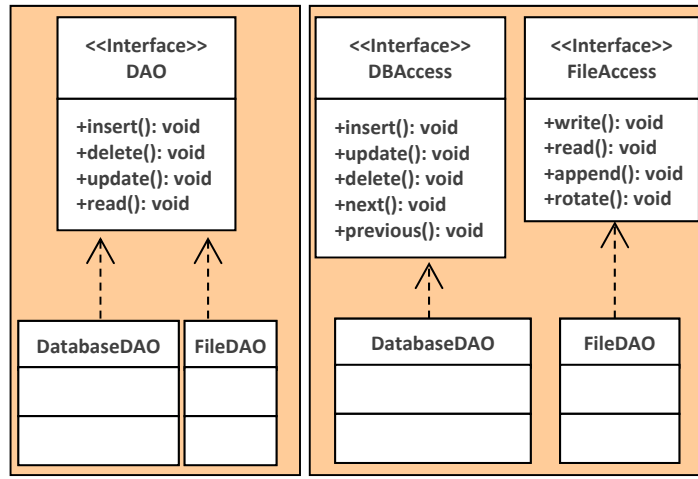
Why should "fat" interfaces be avoided?

Each client depends on the single class interface. Hence there is an inadvertent coupling between the clients.

How is the client coupling harmful?

Suppose a client needs that additional functionality be added to the single class interface. When this functionality is added to the interface, every other client must change to support the functionality even though none of them need it. Thus one change of a client forces the change to propagate throughout the system. This situation, in turn, can result in time consuming code maintenance and hard to locate bugs.

ISP – An Example:



Which of these designs follow ISP?

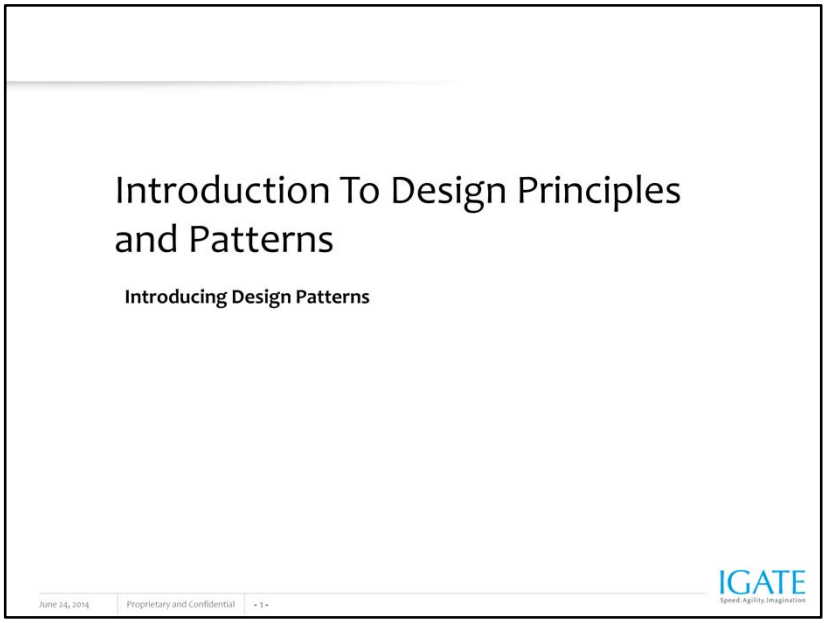
- Imagine that in your application you are required to write some **Data Access Objects (DAOs)**. These data objects should support a variety of data sources. Let us consider that the two main data sources are file and database. You must be careful enough to come up with an **interface-based design**, where the implementation of data access can be varied without affecting the client code using your DAO object.
- What happens if the data source is read-only?
  - The methods for inserting and updating data are not needed. On the other hand, if the *DAO* object should implement the DAO *interface*, then it will have to provide a null implementation for those methods defined in the *interface*. This is still acceptable, but the design is gradually going wrong.
- What if there is a need to rotate the file data source to a different file once a certain amount of data has been written to the file?
  - That will require a separate method to add to the DAO *interface*.
- When a single interface is designed to support different groups of behaviors, then they are, by virtue, inherently poorly designed, and are called Fat interfaces. They are called **Fat** because they grow enormously with each additional function required by clients using that interface. Thus, for the problem with the Data Access Objects, follow the Interface Segregation Principle, and separate the interfaces based on the behaviors. The database access classes and file access classes should subscribe to two separate interfaces.

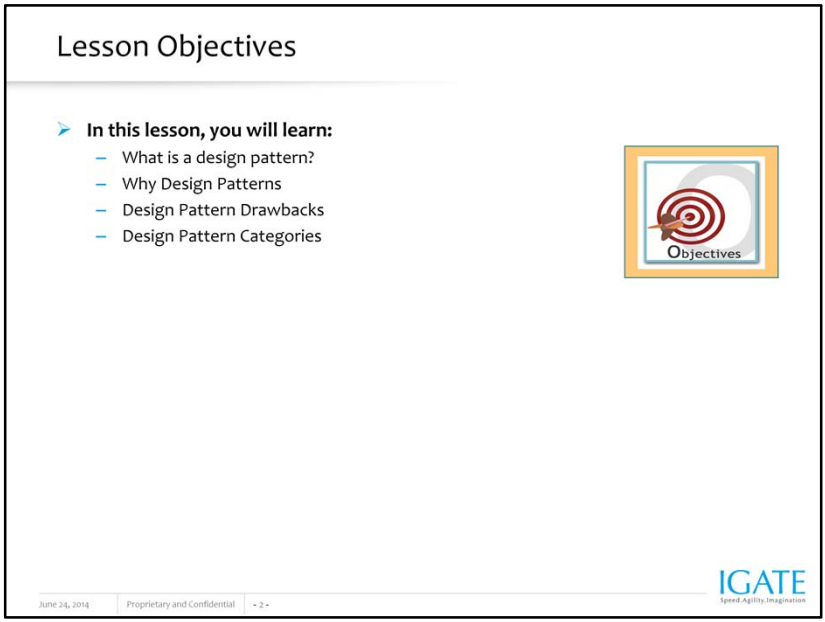
Summary

- **In this lesson, you have learnt:**
  - OO Design Principles help us understand what constitutes a good design!

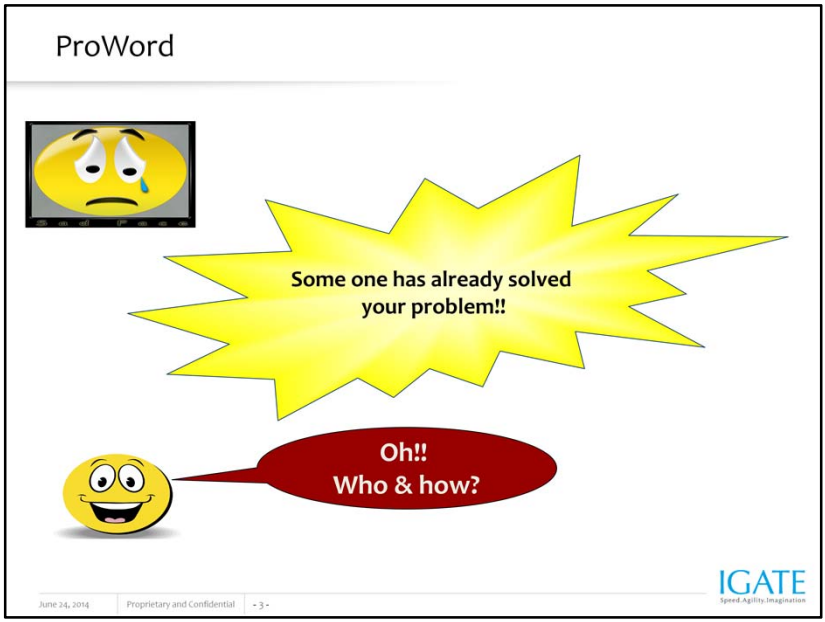
Review Question

- **Question 1: Related data and behavior should be kept in same class. (True/False)**
- **Question 2: A God class should centrally control the application. (True/False)**
- **Question 3: Favor ___ over ___.**
- **Question 4: ___ principle says modules should be open for extension but closed for modification.**
- **Question 5: ___ principle discourages use of Fat interfaces.**

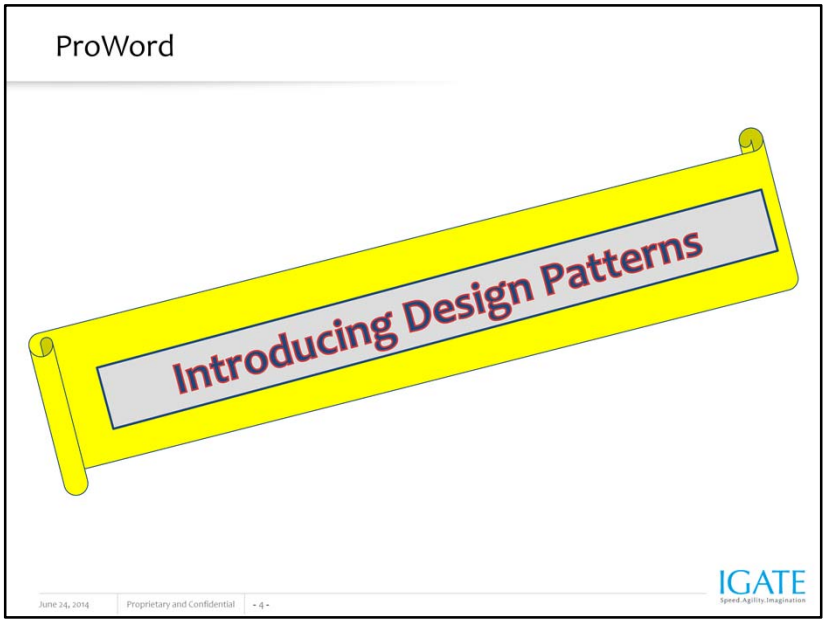

Introduction To Design Principles and Patterns
Introducing Design Patterns
June 24, 2014
Proprietary and Confidential
- 1 -
IGATE
Speed.Agility.Imagination



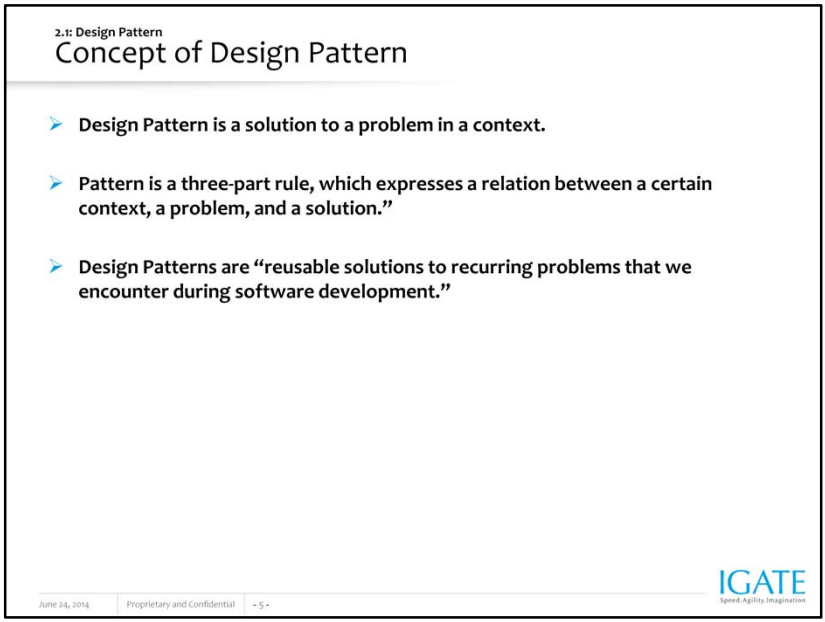
Lesson Objectives:
In this lesson, we will understand the what and why of design patterns, see how design patterns are classified; and have a look at some of these design patterns.



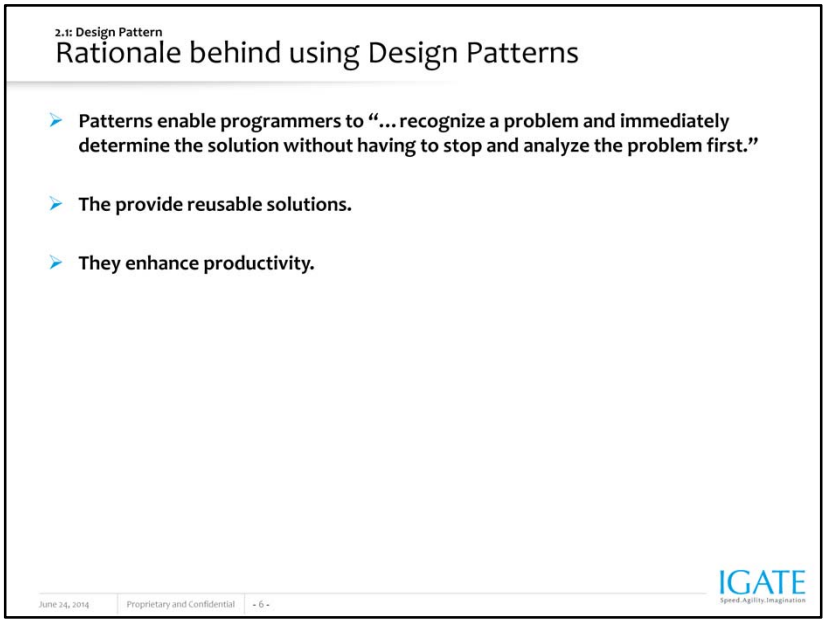
Is it possible that solutions to some of our problems already exist??



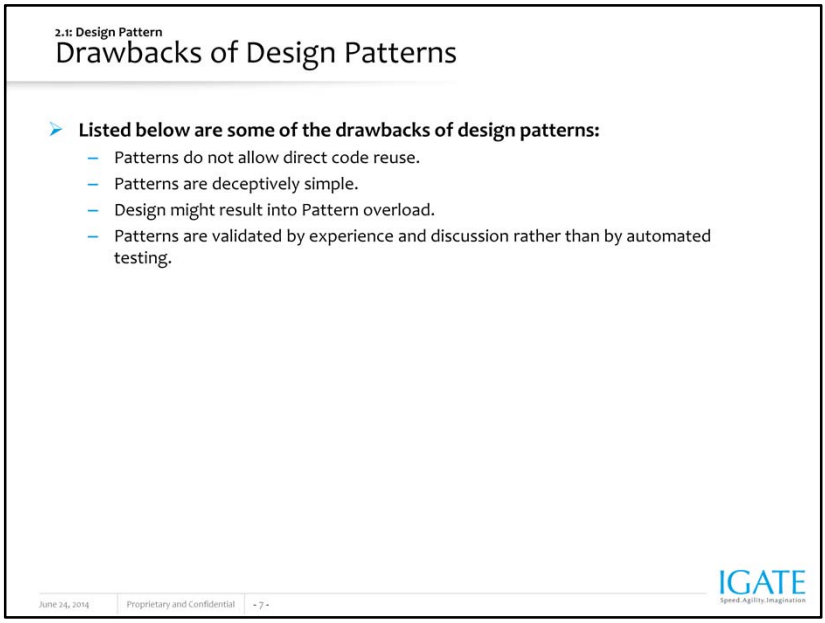
Yes… design patterns provide just that!



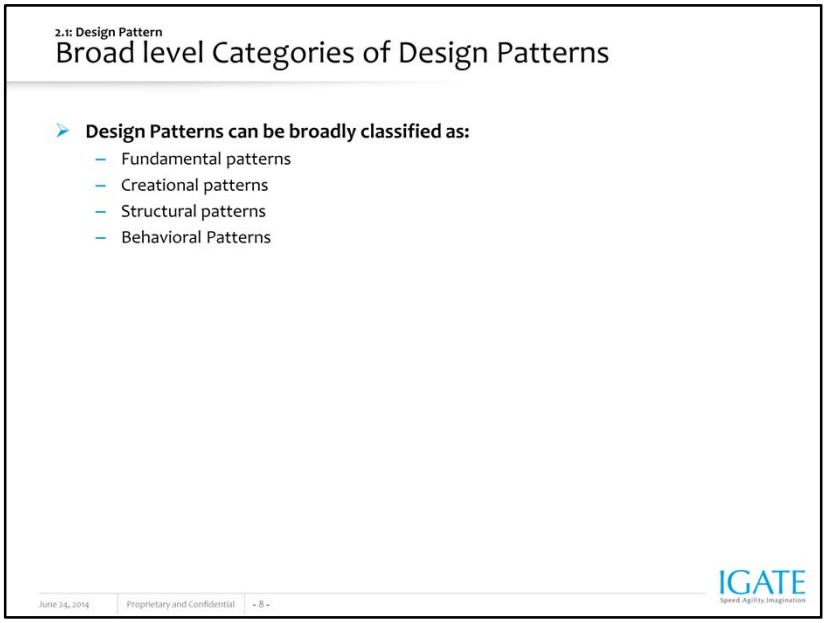
What is a Design Pattern?
"A pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem in such a way that you can use this solution a million times over, without ever using it the same way twice."
Patterns can be applied to many areas of human endeavor, including software development.



Why Design Patterns?
Designing object-oriented code is hard, and designing reusable object-oriented software is even harder.
Patterns enable programmers to "… recognize a problem and immediately determine the solution without having to stop and analyze the problem first."
Well structured object-oriented systems have recurring patterns of classes and objects.
The patterns provide a framework for communicating complexities of OO design at a high level of abstraction. Bottom line is productivity.
Experienced designers reuse solutions that have worked in the past.
Knowledge of the patterns that have worked in the past allows a designer to be more productive and the resulting design to be more flexible and reusable.

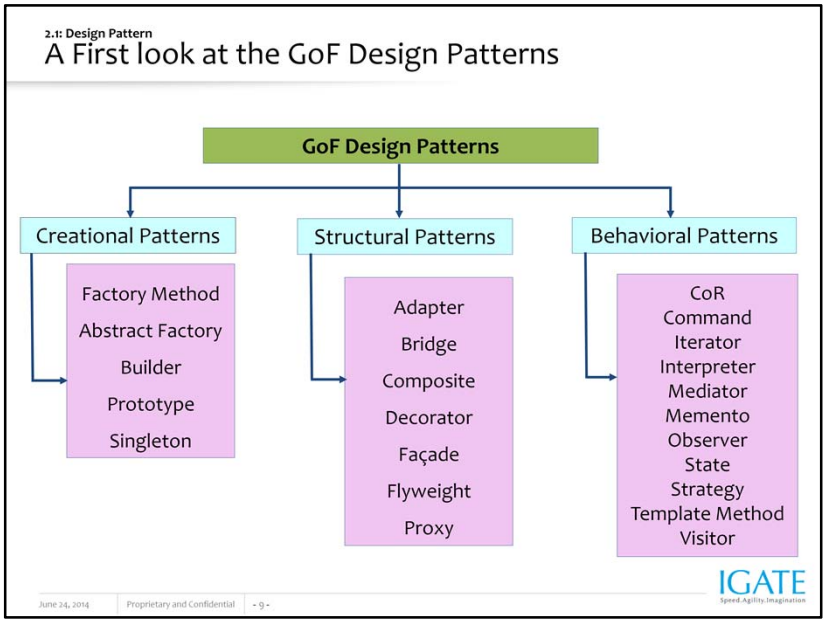


Note:
Design patterns have drawbacks too! Besides the drawbacks mentioned in the slide, Integrating patterns into a software development process is a human-intensive task.



Classification of GOF Design Patterns:
The Gang of Four (GoF) Design Patterns can be broadly classified as :

Fundamental Patterns: They are the building blocks for the other three categories of Design Patterns.
Creational Patterns: They deal with creation, initializing, and configuring classes and objects.
Structural Patterns: They facilitate decoupling interface and implementation of classes and objects.
Behavioral Patterns: They take care of dynamic interactions among societies of classes and objects. They also give guidelines on how to distribute responsibilities amongst the classes.



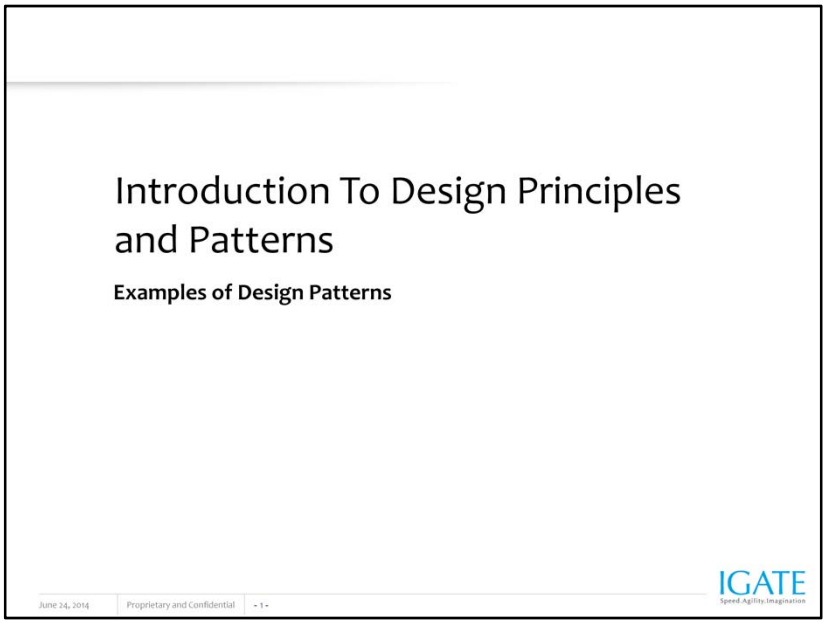
Note:
There are 23 GOF Design Patterns.
They have been classified as shown on the slide. We shall see some more details with examples for some of these design patterns in the next lesson.
Another classification for design patterns is class based or object based. Class based Design Patterns uses "inheritance" as the basic principle whereas the object based patterns use "composition".
We have seen, "Favor Composition over Inheritance".
Note that in design patterns, "composition" is being favored as most of the Design Patterns are "Object-based". The class based design patterns are Factory Method, Adaptor, Interpreter and Template Method.

Summary

- **In this lesson, you have learnt:**
  - Concept of Design Pattern
  - Rationale behind using Design Patterns
  - Drawbacks of Design Patterns
  - Classification of Design Patterns

Review Question

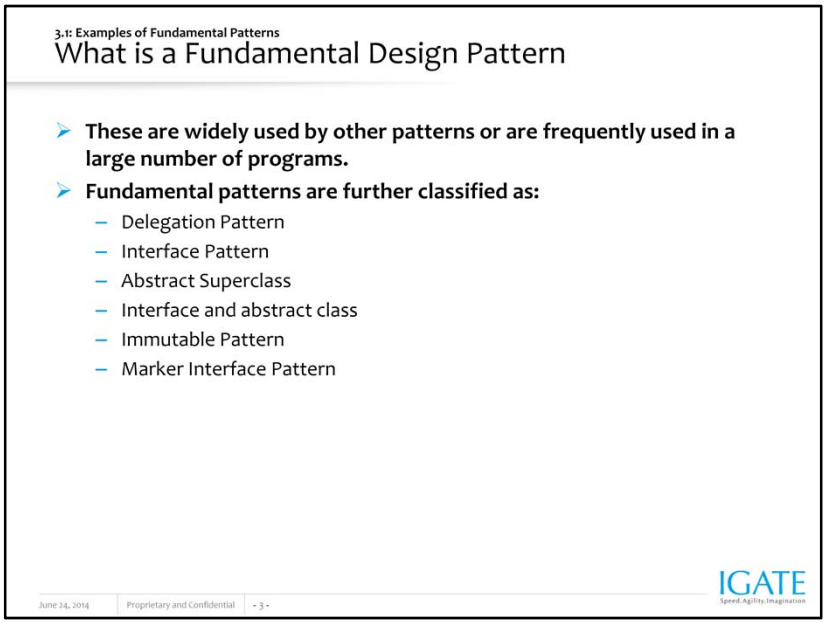
- **Question 1: Design pattern is a solution to ___ within a particular ___.**
- **Question 2: Name different types of GOF Design Patterns.**


Introduction To Design Principles and Patterns
Examples of Design Patterns
June 24, 2014
Proprietary and Confidential
- 1 -
IGATE
Speed.Agility.Imagination

Lesson Objectives

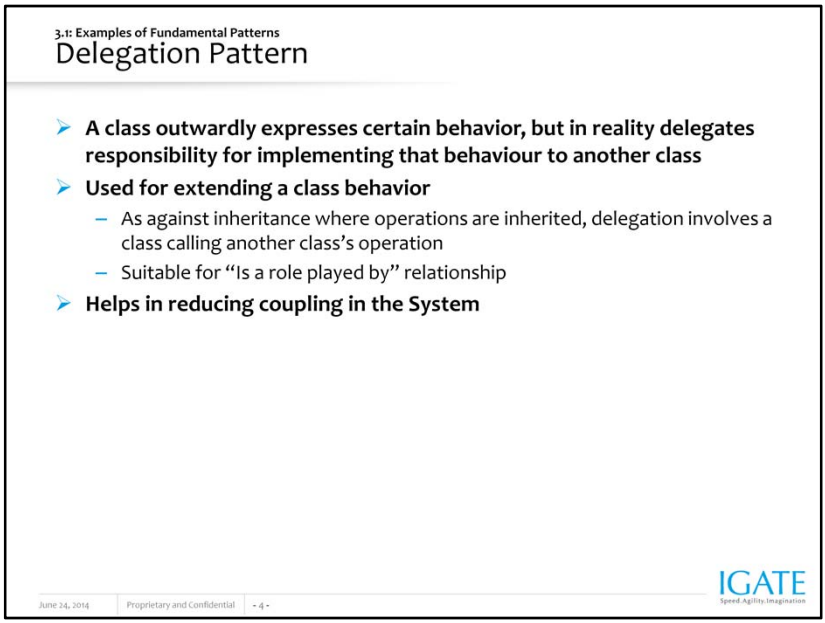
- **In this lesson, you will learn some examples of design patterns:**
  - Fundamental Patterns: Delegation Pattern, Interface Pattern, Abstract Superclass Pattern
  - Creational Patterns: Factory Method, Singleton
  - Structural Patterns: Adapter, Façade
  - Behavioural Patterns: State, Strategy, Template Method

Lesson Objectives:
This lesson provides some examples for design patterns.

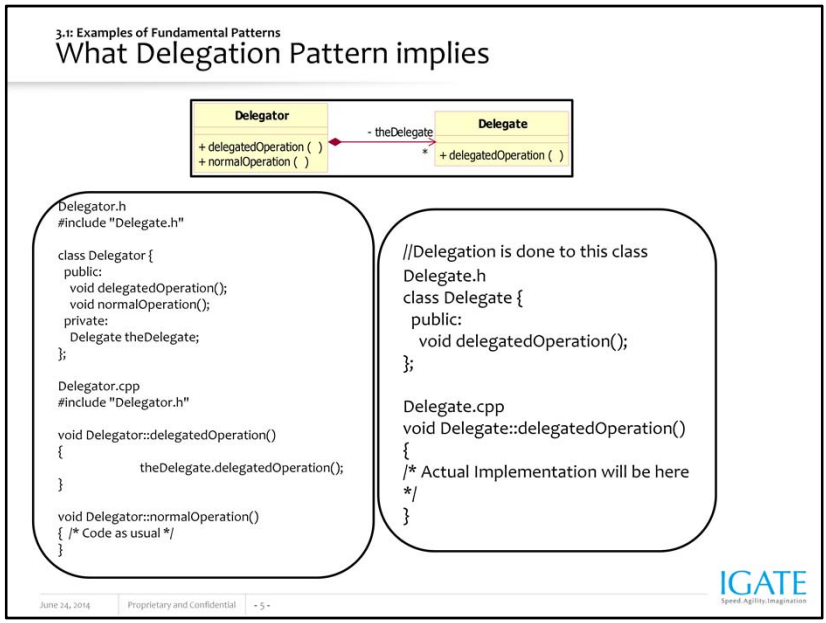


Note:
The fundamental design patterns are the building blocks of the other design patterns.
Fundamental Design Patterns:
Delegation Pattern: It is a way of extending and reusing a class using composition rather than inheritance.
Interface Pattern: This pattern facilitates the design principle – "Program to Interface rather than Implementation".
Abstract Superclass: It ensures consistent behavior of conceptually related classes by giving them a common abstract superclass.
Interface and abstract class: It is a combination of Interface and Abstract superclass Patterns.
Immutable Pattern: This pattern prevents the object from changing its state information after it is constructed thereby eliminating the issues related to concurrent access of the object.
Marker Interface: It is used to mark an object to be part of a particular group thereby allowing other objects to treat them in a uniform way.

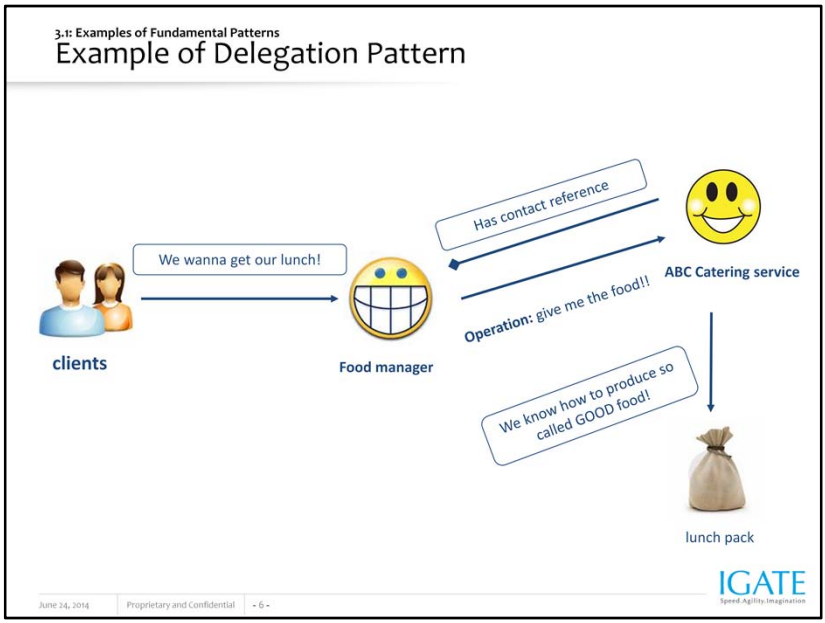
We will see Delegation, Interface, and Abstract Superclass in some more detail.



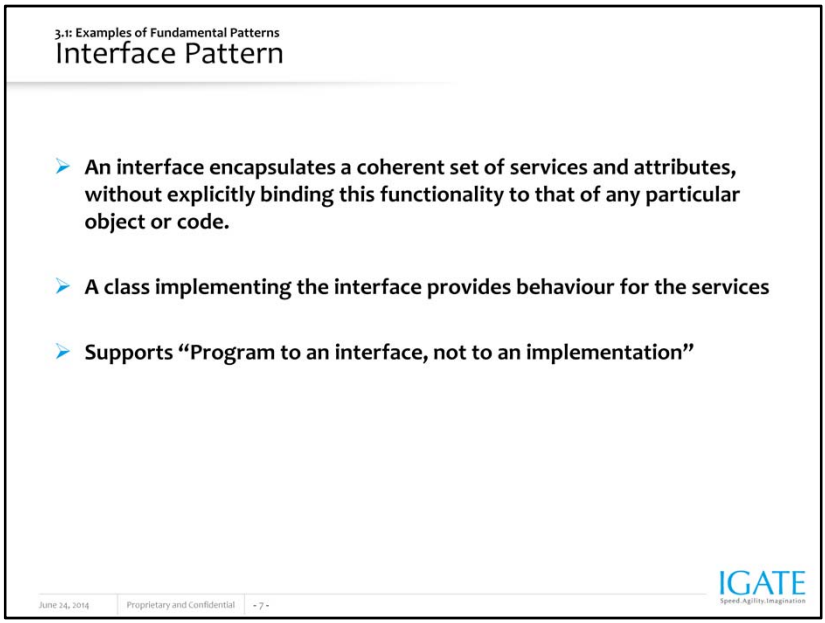
Delegation Pattern:
The delegation pattern is a technique where an object outwardly expresses certain behavior but in reality delegates responsibility for implementing that behavior to an associated object in an Inversion of Responsibility.
Inheritance is a common way to extend and reuse the functionality of a class. Delegation is a more general way for extending a class's behavior that involves a class calling another class's methods rather than inheriting them.
Inheritance is useful for capturing "is-a-kind-of" relationships because of their static nature. Delegation is suitable for "is-a-role-played by" relationship.
Suppose it is found that a class attempts to hide a method or variable inherited from a super class or from other classes. Then that class should not inherit from the super class. There is no effective way to hide methods or variables inherited from a super class. However, it is possible for an object to use another object's methods and variables while ensuring that it is the only object with access to the other object. This accomplishes the same thing as inheritance but uses dynamic relationships that can change over time.



Structure of Delegation Pattern:
You can use delegation to reuse and extend the behavior of a class. You do this by writing a new class (the delegator) that incorporates the functionality of the original class by using an instance of the original class (the delegatee) and calling its methods.
Delegation is more general purpose than inheritance. Any extension to a class that can be accomplished by "inheritance" can also be accomplished by "delegation".
The implementation of delegation is very straightforward, for it simply involves the acquisition of a reference to an instance of the class to which you want to delegate and call its methods. The best way to ensure that a delegation is easy to maintain is to make its structure and purpose explicit.

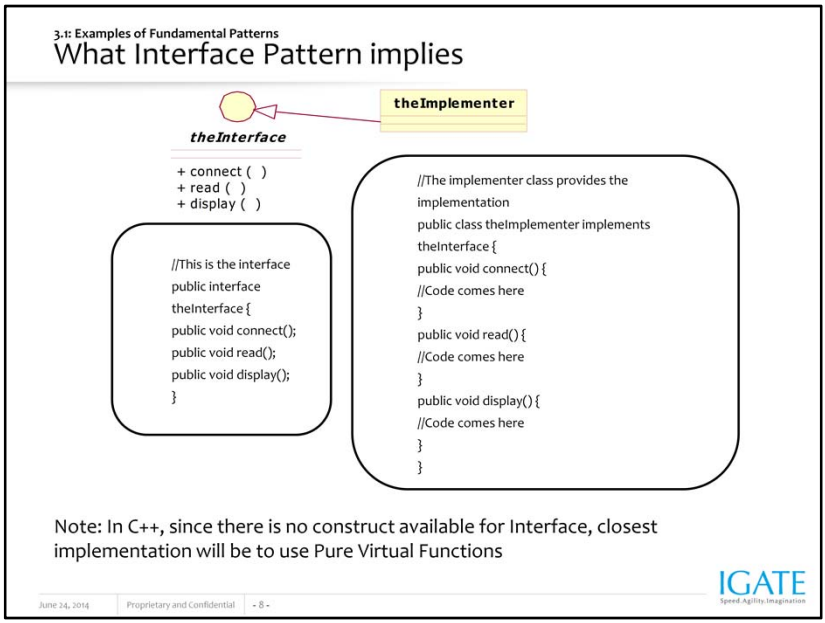


Example of Delegation Pattern:
In real-life, the Delegation Pattern is used almost everywhere. The example on the slide shows how the food manager delegated the request for lunch to a catering service, who would actually prepare the lunch and deliver it to the client.

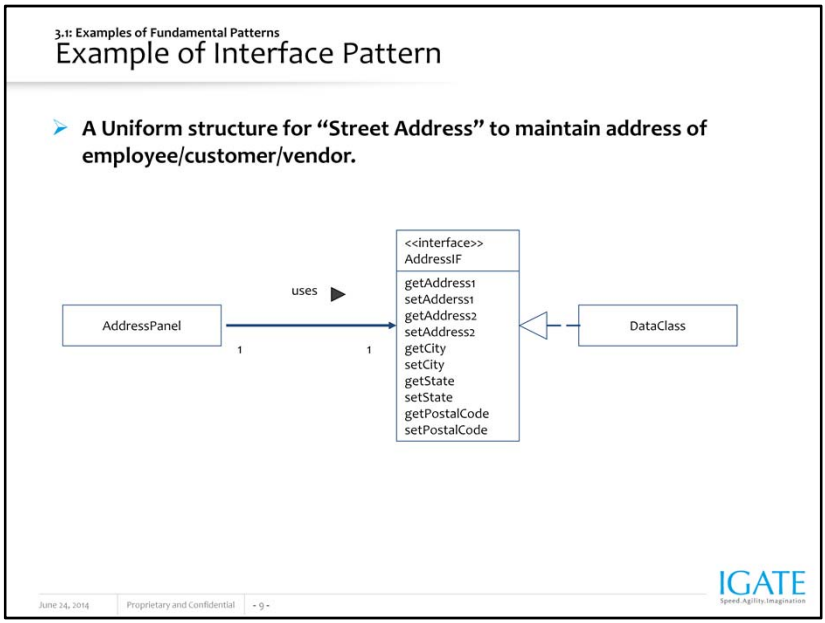


Interface Pattern:
Interfaces are "more abstract" than classes since they do not say anything at all about representation or code. All they do is describe public operations.

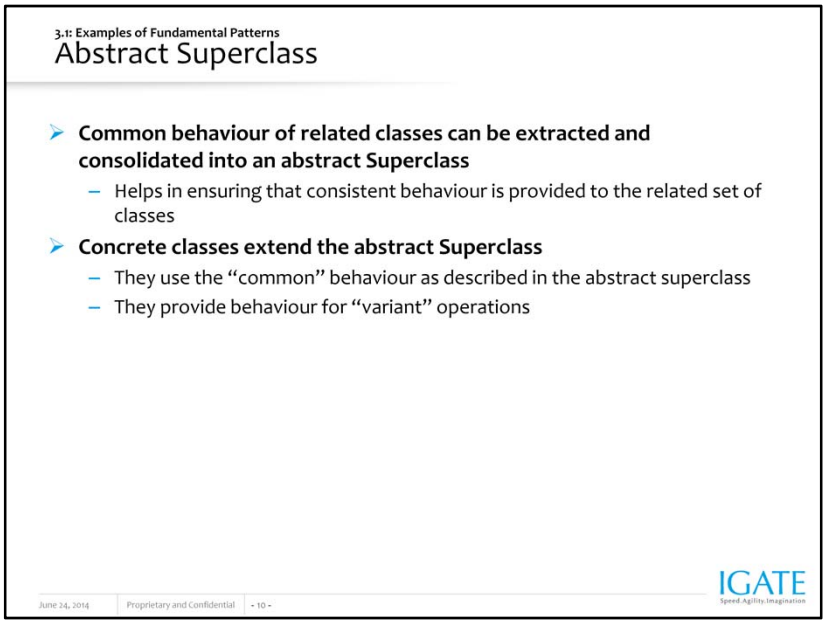
You can keep a class that uses data and services provided by instances of other classes independent of those classes by having it access those instances through an interface.



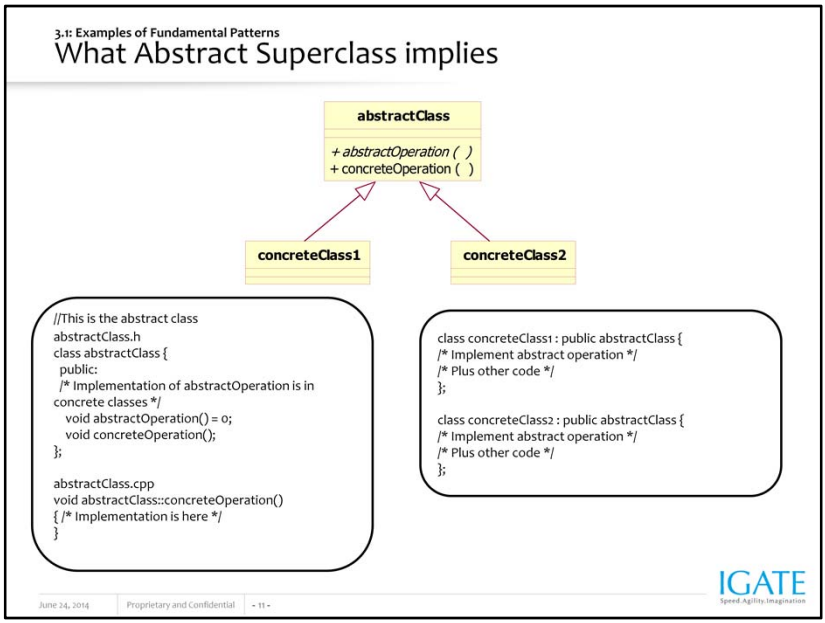
The interface is only specifying the services. It is the implementer which needs to provide the actual behaviour through the implementation of these services.



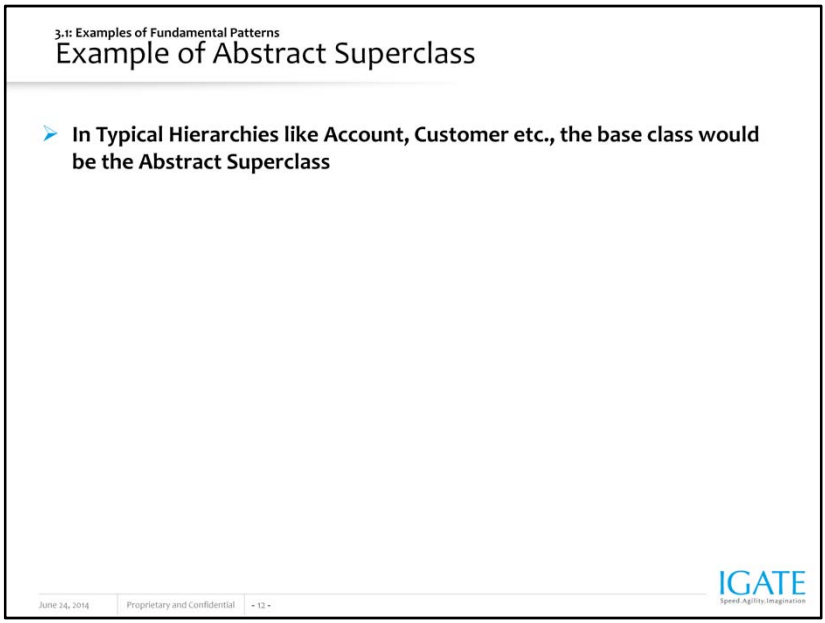
Interface Pattern:
For example, suppose you are writing an application to purchase goods for a business. Your program will need to be informed of such entities as vendors, freight companies, receiving locations, and billing locations. One thing these have in common is that they all have a street address. These street addresses will be displayed in different parts of the user interface. You will want to have a class for displaying and editing street addresses so that you can reuse it wherever there is an address in the user interface. We will call that class AddressPanel.
You want AddressPanel objects to be able to get and set address information in a separate data object. This raises the question of what instances of the AddressPanel class can assume about the class of the data objects that they will use. Clearly, you will use different classes to represent vendors, freight companies, and the like. If you program in a language that supports multiple inheritance, like C++, you can arrange for the data objects that instances of AddressPanel use to inherit from an address class in addition to the other classes they inherit from. If you program in a language like Java that uses a single inheritance object model, then you must explore other solutions.
You can solve the problem by creating an address interface. Instances of the AddressPanel class would then simply require data objects that implement the address interface. They would then be able to call the accessor methods of that object to get and set its address information. Using the indirection that the interface provides, instances of the AddressPanel class are able to call the methods of the data object without having to be aware of what class it belongs to. Here is a class diagram showing these relationships.
Here in this example we have seen that the AddressPanel class is independent or does not have to specifically assume the data object it is going to deal with. In turn, it will work upon the data object with the help of the AddressIF interface which is actually implemented by the data classes.



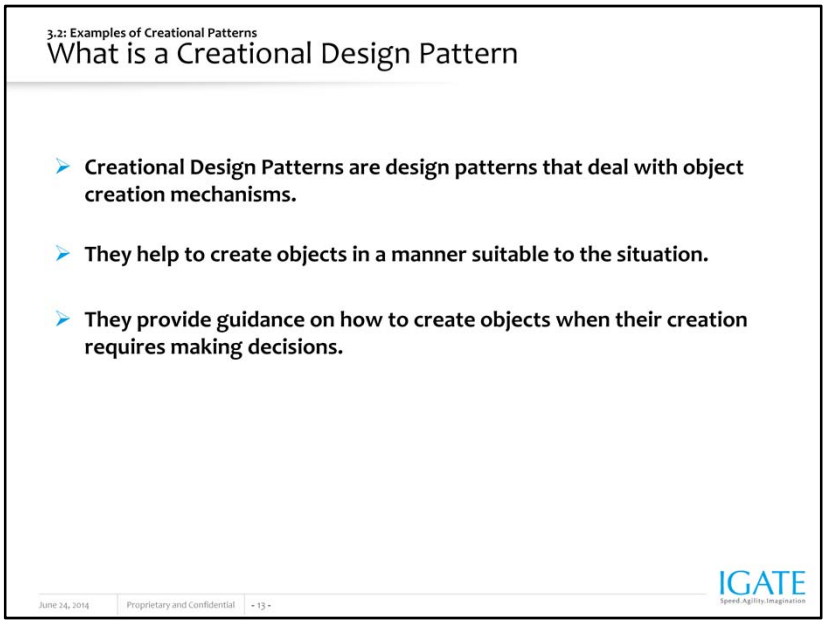
Abstract Superclass:
The abstract Superclass helps in ensuring that logic common to related classes is implemented consistently for each class. It helps avoid the maintenance overhead of redundant code and makes it easy to write related classes.
Concrete classes then extend the abstract superclass. The commonality of behaviour as defined in the abstract superclass is directly used by the concrete classes. For the operations that are defined as abstract in the superclass, the concrete class provides the behaviour.



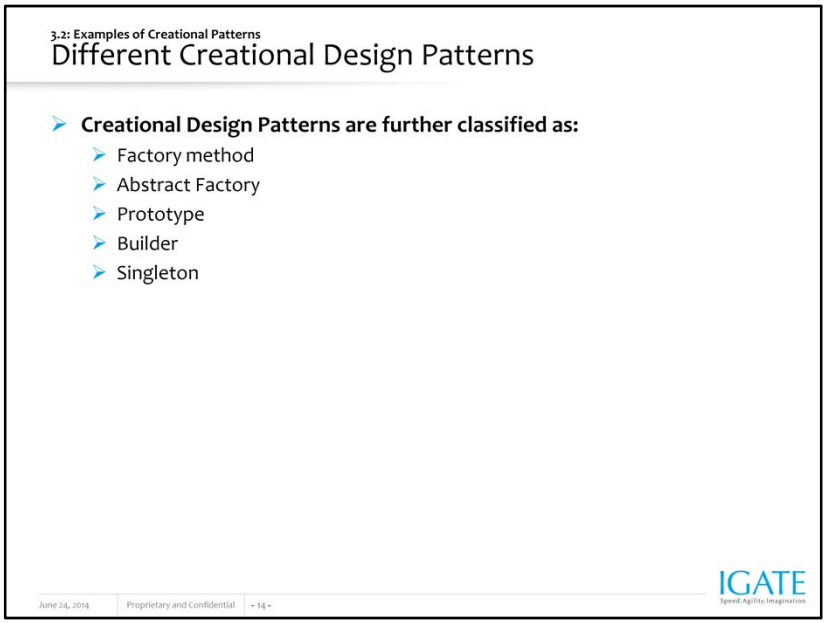
The abstract class defines the abstract operations, which are implemented by the concrete classes that extend the abstract class.



Abstract Superclass Pattern:
We have seen examples like Savings and Current Account extending from a base "Account" superclass which is abstract. Similarly if there are difference types of customers, an abstract "Customer" Superclass can be at the base of the Customer Class Hierarchy.



Introduction to Creational Patterns:
Creational Patterns provide guidelines on creation, configuration, and initialization for objects.
"Decisions typically involve dynamically deciding which class to instantiate or which objects an object will delegate responsibility to."



Different Creational Patterns:

Creational Design Patterns are further classified as:

Factory Method: It creates objects without specifying the exact object to create.

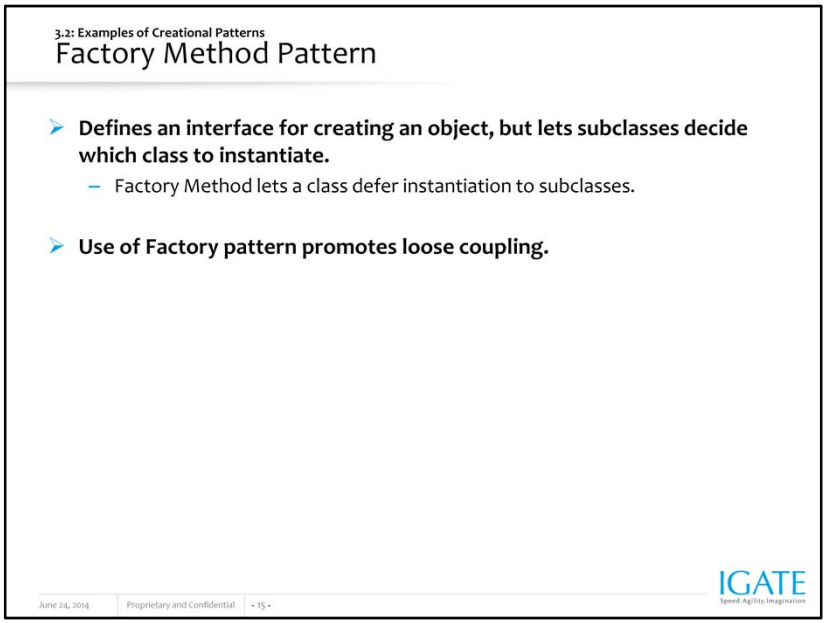
Abstract Factory: It groups object factories that have a common theme.

Prototype: It creates objects by cloning an existing object.

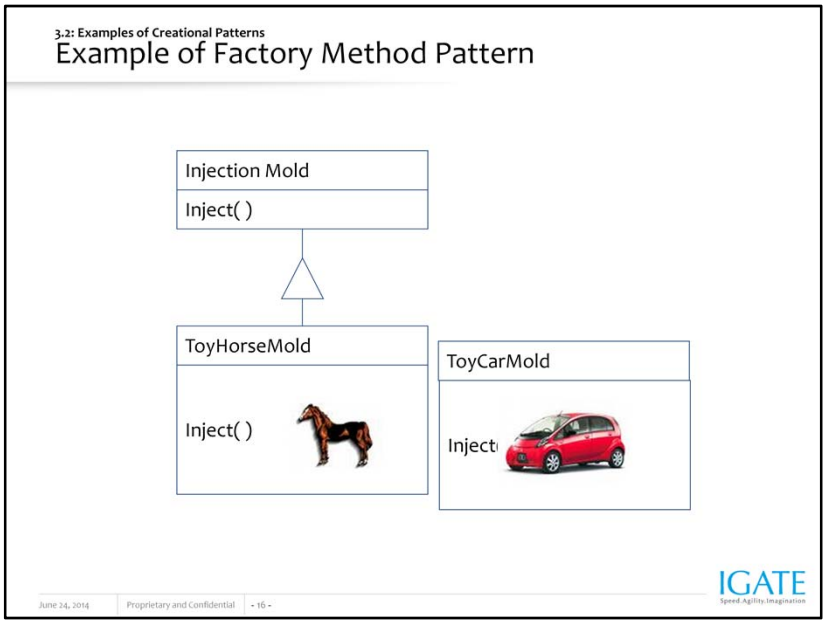
Builder: It constructs complex objects by separating construction and representation.

Singleton: It restricts object creation for a class to only one instance.

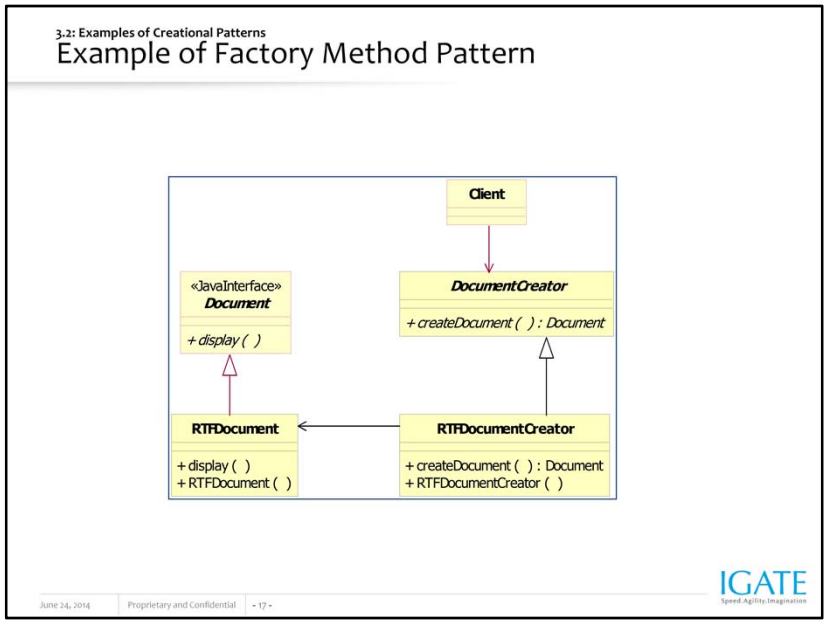
We will see Factory and Singleton in some more detail.



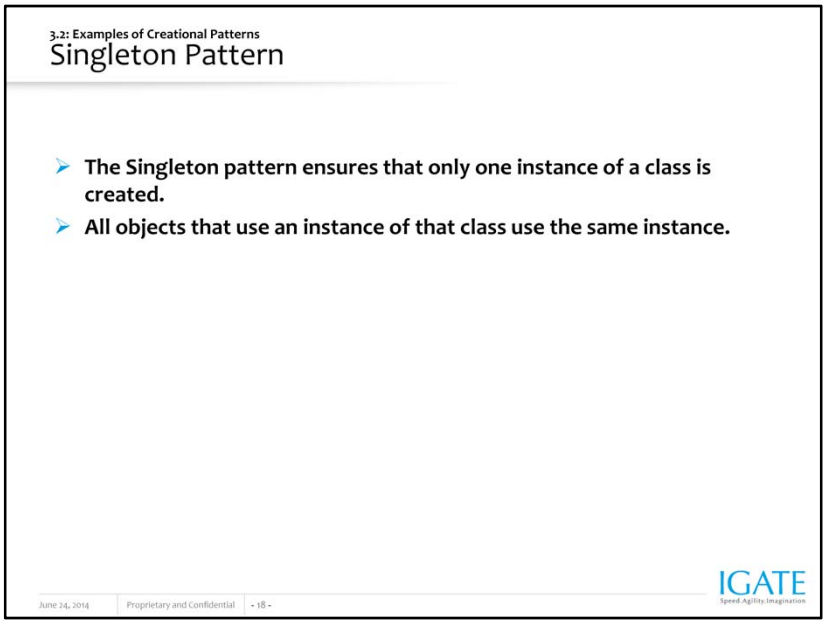
Factory Method:
You can define an interface for creating an object, however, let subclasses decide which class to instantiate. Factory Method lets a class defer instantiation to subclasses.
It is also called as a Factory Pattern since it is responsible for "manufacturing" an Object.
The Factory Method pattern is an object-oriented design pattern. Like other creational patterns, it deals with the problem of creating objects (products) without specifying the exact class of object that will be created. Factory Method handles this problem by defining a separate method for creating the objects, which can then be overridden by subclasses to specify the derived type of the product that will be created.
They promote loose coupling by eliminating the need to bind application specific classes into the code.



Example of Factory Method Pattern:
The Factory Method defines an interface for creating objects, but lets subclasses decide which classes to instantiate.
Injection molding presses demonstrate this pattern. Manufacturers of plastic toys process plastic molding powder, and inject the plastic into molds of the desired shapes. The class of toy (car, action figure, etc.) is determined by the mold.



In this example, the factory pattern is being used to create documents of different types – while RTF is an example shown, other types could be Plain text, HTML etc. Here, Document is the interface of the objects the factory method creates. RTFDocument implements this interface. The DocumentCreator declares the factory method which returns an object of type Document. The RTFDocumentCreator overrides the factory method to return an instance of RTFDocument. Similarly, we could have classes like HTMLDocumentCreator and PlainTextDocumentCreator overriding the factory methods to return specific concrete instances of the desired objects.

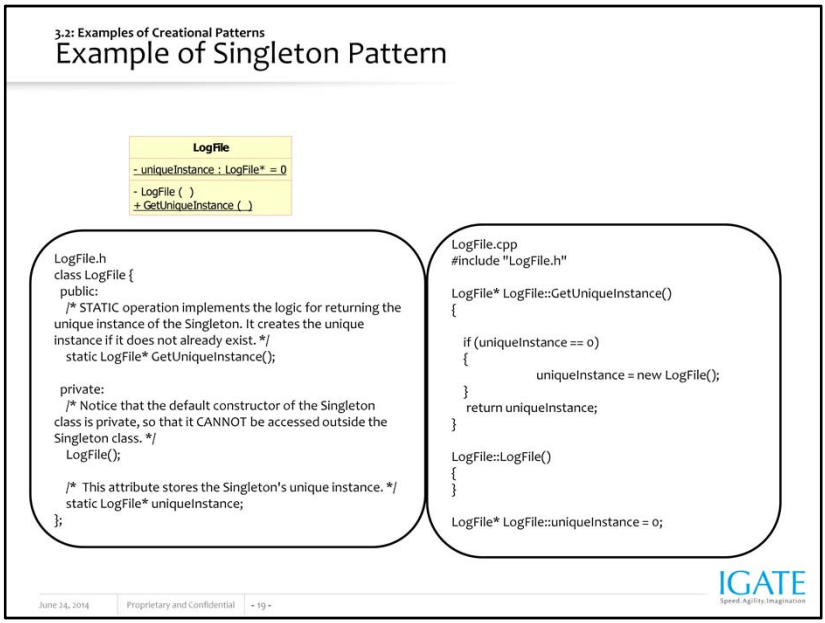


Singleton Pattern:
There are cases in programming where you need to ensure that there can be one and only one instance of a class which is used by the application.
The Singleton pattern ensures that a class has only one instance, and provides a global point of access to it.
It is important for some classes to have exactly one instance.

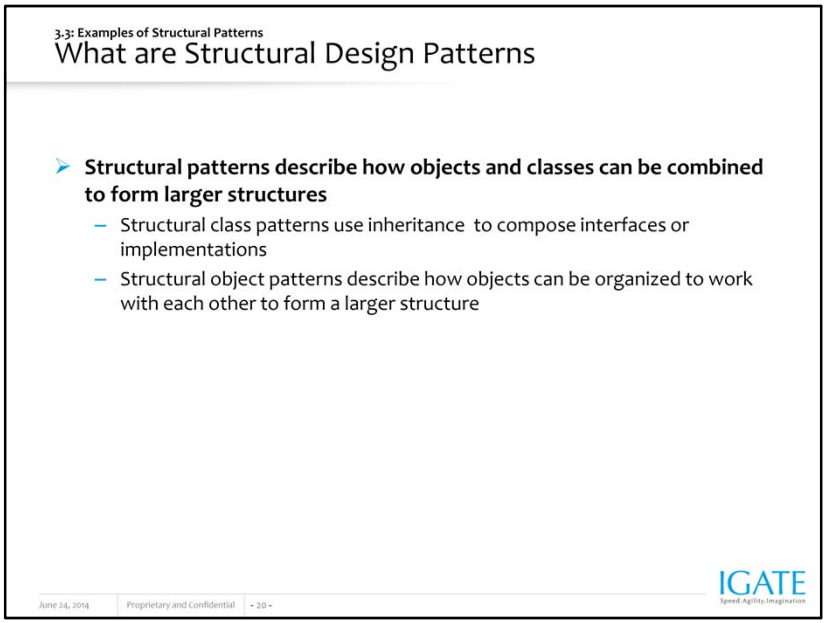
Although there can be many printers in a system, there should be only one printer spooler.
There should be only one File system and one Window manager.
A digital filter will have one A/D converter.
An accounting system will be dedicated to serving one company.

How do we ensure that a class has only one instance and that the instance is easily accessible?

A global variable makes an object accessible. However, it does not keep you from instantiating multiple objects.
A better solution is to make the class itself responsible for keeping track of its sole instance. The class can ensure that no other instance can be created (by intercepting requests to create new objects), and it can provide a way to access the instance. This is the Singleton pattern.



Note the following
A private constructor is used to restrict the application from creating multiple instances of the class
A static instance variable makes the single instance globally available
A getUniqueInstance method is used to ensure that an instance is created the first time round and the same instance is used each time



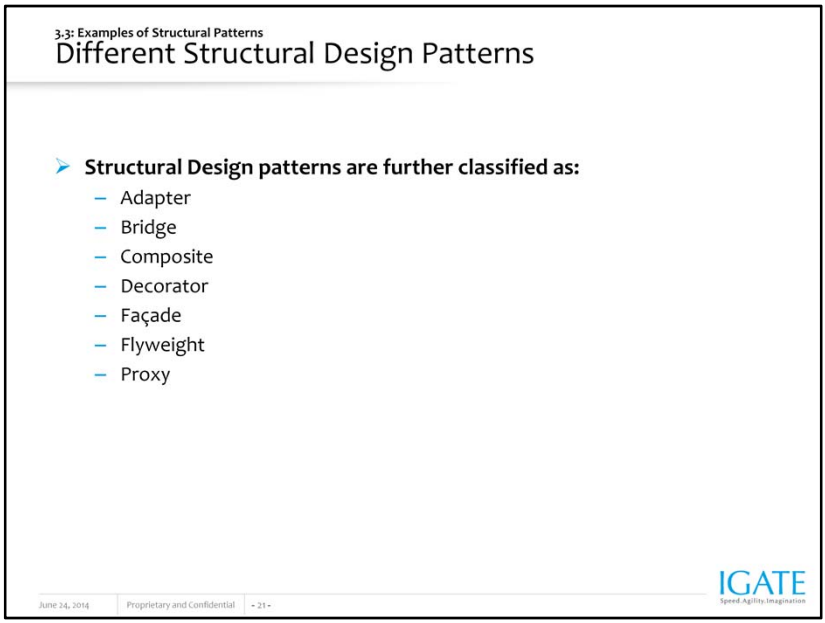
Structural Patterns:

Structural Patterns describe how objects and classes can be combined to form larger structures.

Class patterns describe abstraction with the help of "inheritance" and how it can be used to provide more useful program interface.

Object patterns, on other hand, describe how objects can be associated and composed to form larger, more complex structures.

Structural Patterns are concerned with how classes and objects are composed to form larger structures. Structural class patterns use inheritance to compose interfaces or implementations. As a simple example, consider how multiple inheritance mixes two or more classes into one. The result is a class that combines the properties of its parent classes. This pattern is particularly useful for making independently developed class libraries work together.



Different Structural Patterns:
Adapter: It allows classes with incompatible interfaces to work together by wrapping its own interface around that of an already existing class.

Bridge: It decouples an abstraction from its implementation so that the two can vary independently.

Composite: It composes one-or-more similar objects so that they can be manipulated as one object.

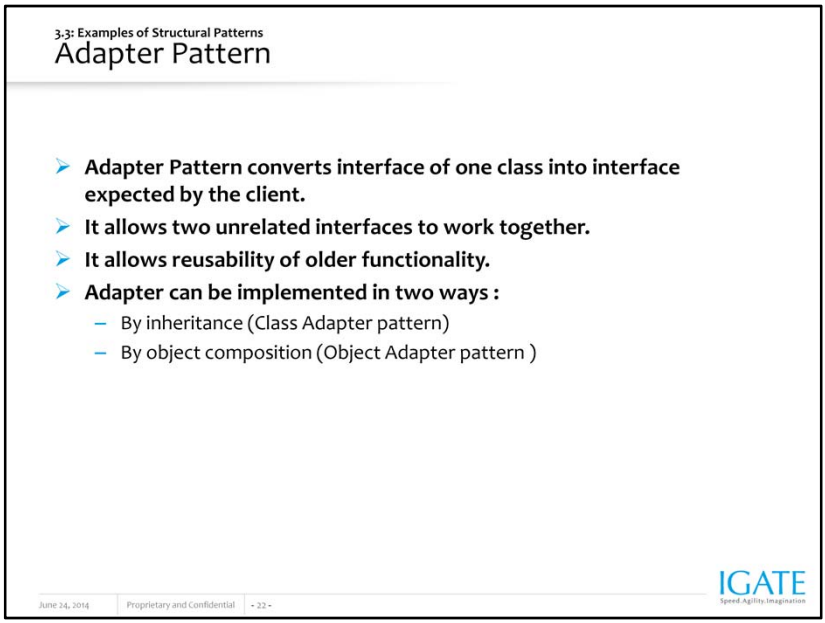
Decorator: It dynamically adds / overrides behavior in an existing method of an object.

Façade: It provides a simplified interface to a large body of code.

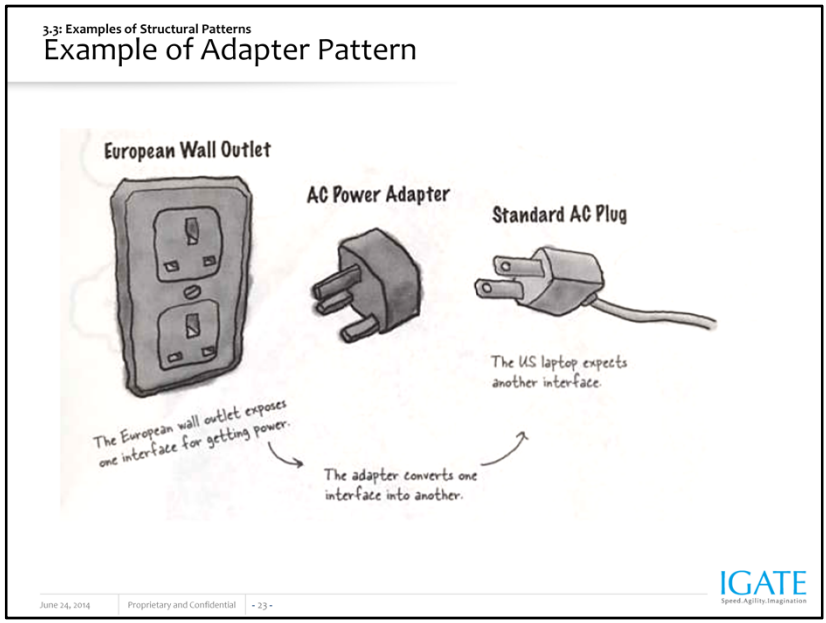
Flyweight: It reduces the cost of creating and manipulating a large number of similar objects.

Proxy: It provides a placeholder for another object to control access, reduce cost, and reduce complexity.

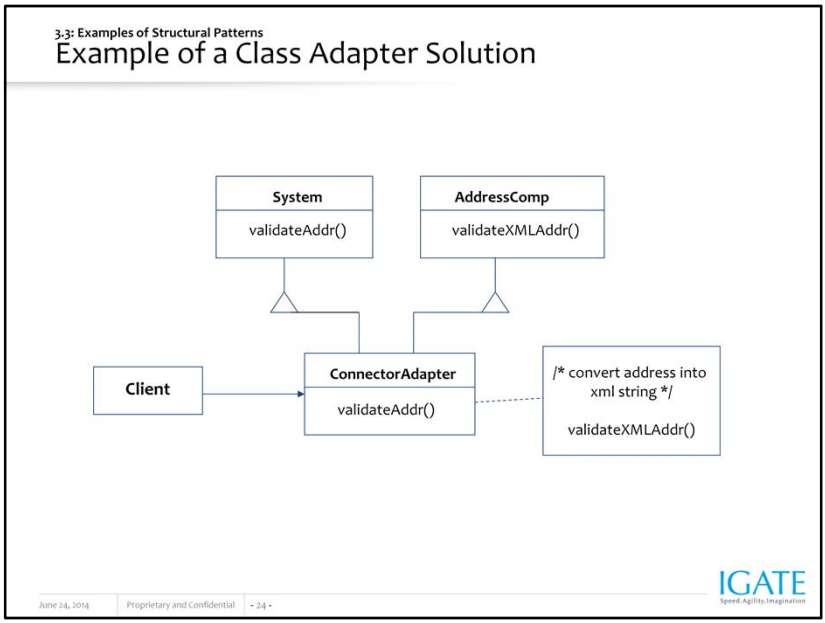
We will understand Adapter and Façade in some detail.



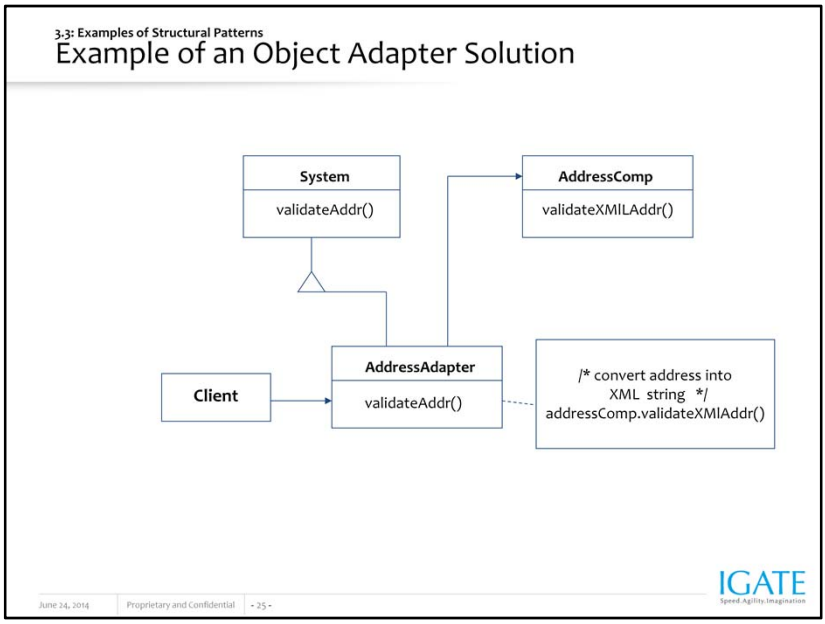
Adapter Design Pattern:
The Adapter Design Pattern is a type of design pattern that is used for converting the interface of a class into an interface that its clients expect to see. This pattern allows incompatible interfaces to work together.
The adapter design pattern (often referred to as the "wrapper pattern" or simply a "wrapper") adapts one interface for a class into one that a client expects. An adapter allows those classes to work together that normally cannot due to their incompatible interfaces. This is done by wrapping its own interface around that of an already existing class.
The adapter is also responsible for handling any logic necessary to transform data into a form that is useful for the consumer.
For instance, if multiple Boolean values are stored as a single integer but your consumer requires a "true" / "false", the adapter will be responsible for extracting the appropriate values from the integer value.
The adapter pattern is useful in situations where an already existing class provides some or all of the services you need but does not use the interface you need.



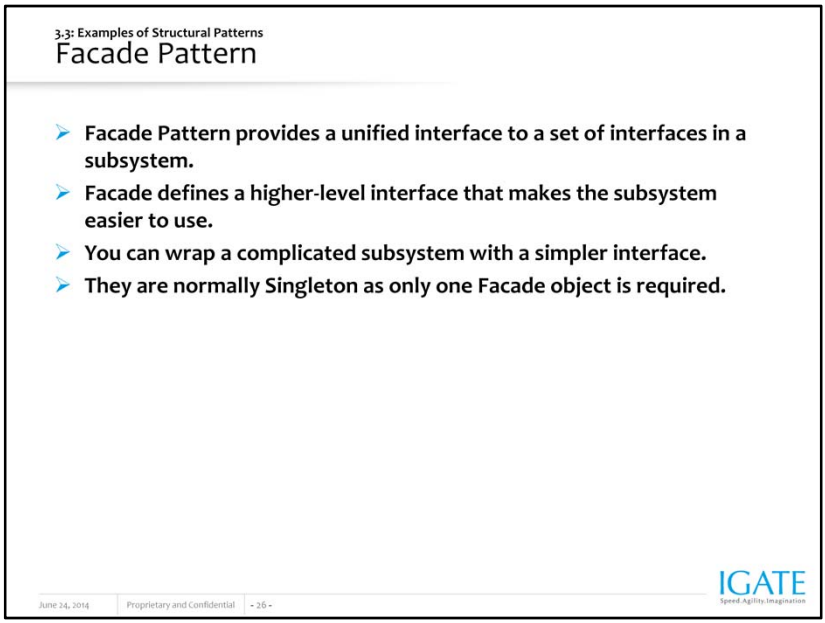
Example of Adapter Pattern:
The Adapter pattern allows incompatible classes to work together by converting the interface of one class into an interface expected by the clients.
Socket wrenches provide an example of the Adapter. The adapter sits in between the plug of your laptop (US-made) and the European AC outlet. The adapter changes the interface of the outlet into one that your laptop expects.



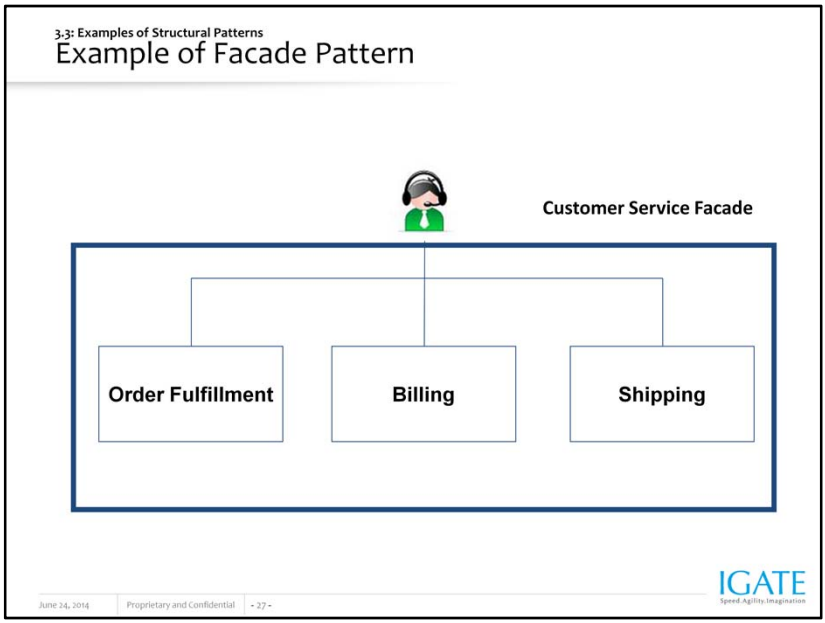
Let us look at the requirement of a system validating Address using a third party address component. The client expects an interface for validating address in the form of a string. However, the address component needs the address in the form of XML string.
The AddressAdapter class will bridge this gap, and provide a interface to the system in form of "validateAddr()" method that will expect the address as a normal string. It will generate an XML out of it and send this XML string as input to the validateXMLaddr() method provided by the AddressComp. Thus you can say, though the interfaces of the system and address component were incompatible, the adapter class has made them work together.
In case of Class adapter solution, the adapter class will inherit the implementations from both "System" and "AddressComp". It will override the implementation of "System" (target) and call the implementation inherited from "AddressComp" (adaptee). Before calling this implementation, it will perform certain activities that are required for adapting (in our case it will convert the string address into xml format).



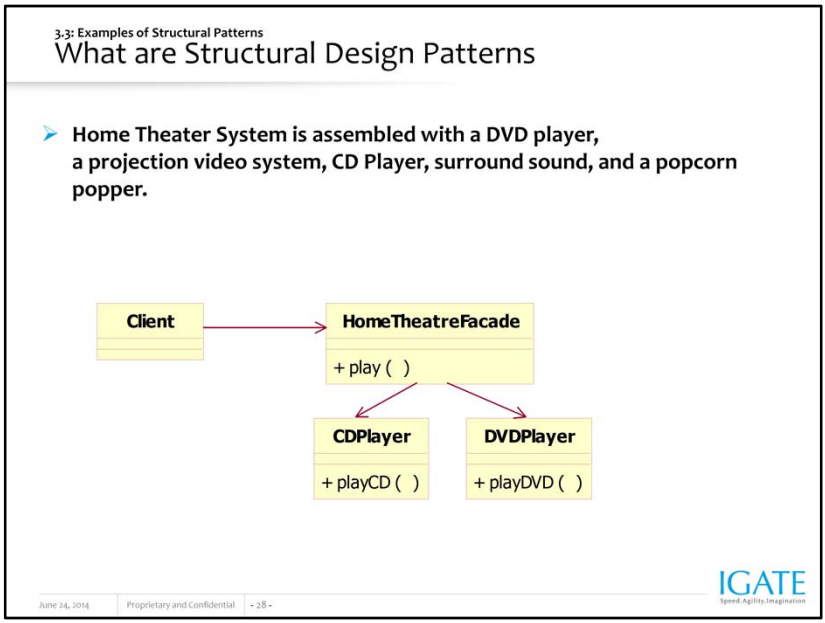
In this solution also, the AddressAdapter class has made the two incompatible interfaces work together.
In case of object adapter solution, the AddressAdapter inherits implementation from System (target) only. Subsequently, it will override this implementation to create an object of "AddressComp" (adaptee) and call the appropriate method on it. In this case also, before calling the method of the adaptee, it will need to perform the activities that are required for adapting.



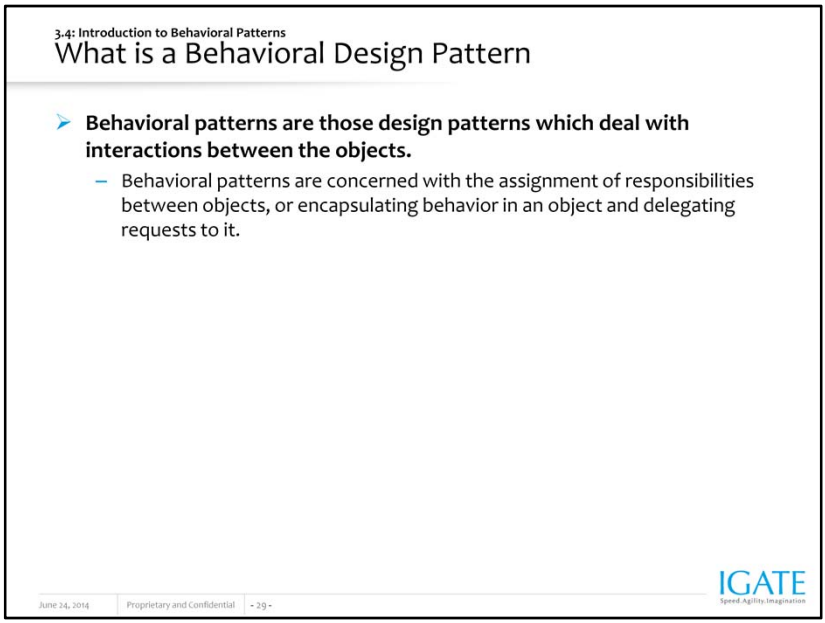
Facade Pattern:
Facade encapsulates a complex subsystem within a single interface object. This reduces the learning curve that is necessary to successfully leverage the subsystem. It also promotes decoupling the subsystem from its potentially many clients. On the other hand, if the Facade is the only access point for the subsystem, it limits the features and flexibility that are needed by "power users".
The Facade Design Pattern is used to provide a high-level interface that makes the subsystem easier to use. It helps create a unified interface to a set of interfaces in the subsystem.
Facade objects are often Singletons because only one Facade object is required.



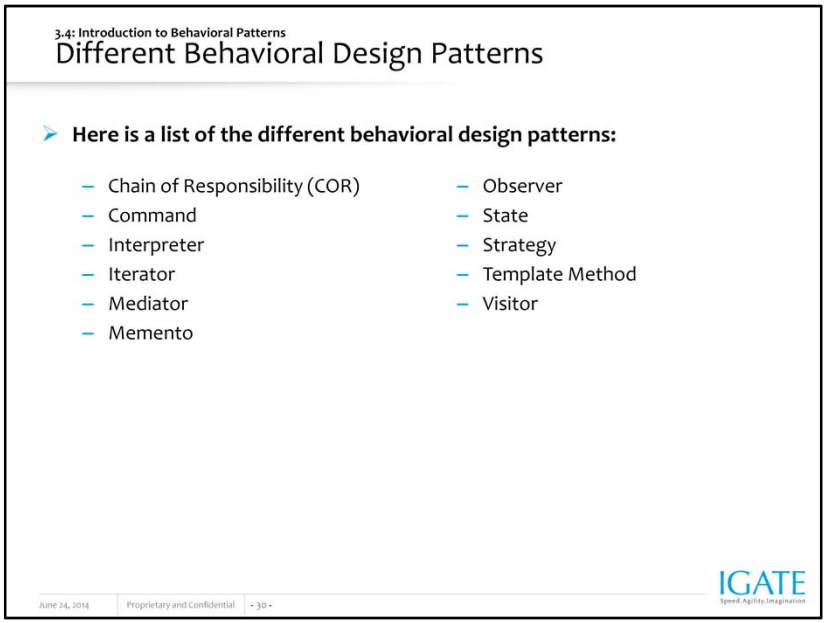
Example of Façade Pattern:
Consumers encounter a Facade while ordering from a catalog. The consumer calls one telephone number and speaks with a customer service representative. The customer service representative acts as a Facade, providing an interface to the order fulfillment department, the billing department, and the shipping department.



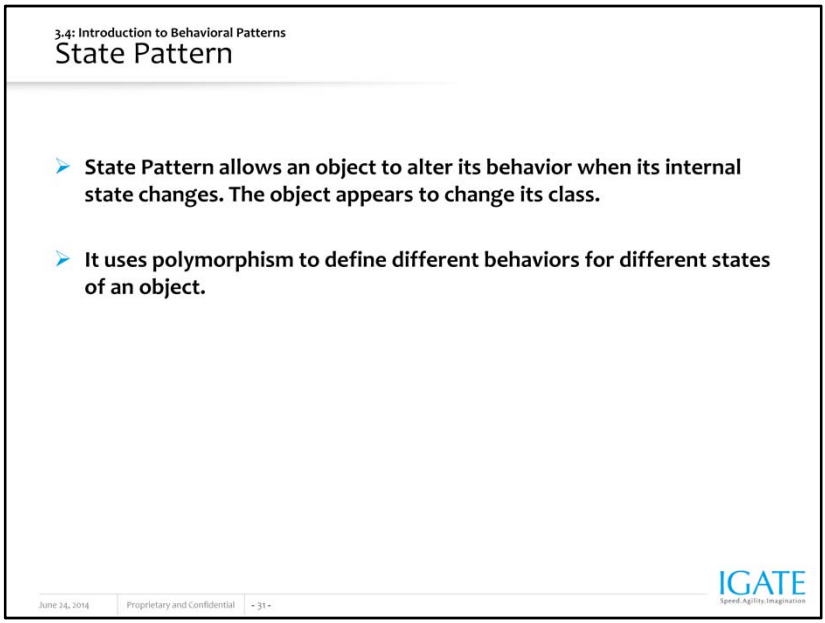
Here the Home Theatre System is the Façade which knows which subsystem the client request has to be passed on to.



Behavioral Patterns:
Behavioral patterns are concerned with algorithms and the assignment of responsibilities between objects. Behavioral patterns describe not only patterns of objects or classes but also the patterns of communication between them. These patterns characterize complex control flow, which is difficult to follow at run-time. These patterns shift your focus away from flow of control, and let you concentrate just on the way objects are interconnected. Behavioral class patterns use inheritance to distribute behavior between classes. Behavioral object patterns use "object composition" rather than "inheritance".
There are 11 different behavioral design patterns. They are Chain of Responsibility, Command, Interpreter, Iterator, Mediator, Memento, Observer, State, Strategy, Template Method, and Visitor.



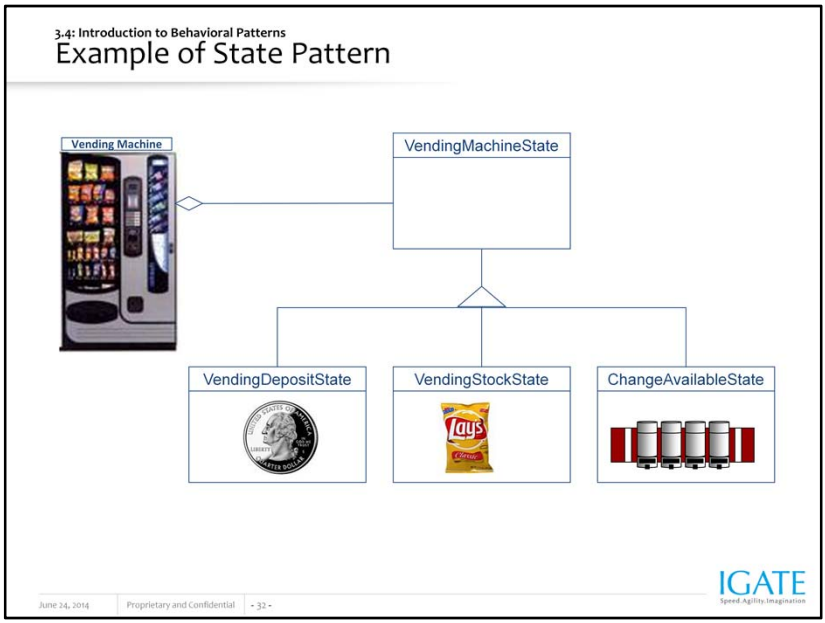
Different Behavioral Design patterns:
Chain of responsibility: It delegates commands to a chain of processing objects.
Command: It creates objects which encapsulate actions and parameters.
Interpreter: It implements a specialized language.
Iterator: It accesses the elements of an object sequentially without exposing its underlying representation.
Mediator: It allows loose coupling between classes by being the only class that has detailed knowledge of their methods.
Memento: It provides the ability to restore an object to its previous state (undo).
Observer: It is a publish/subscribe pattern which allows a number of observer objects to see an event.
State: It allows an object to alter its behavior when its internal state changes.
Strategy: It allows one of a family of algorithms to be selected on-the-fly at runtime.
Template method: It defines the skeleton of an algorithm as an abstract class, allowing its subclasses to provide concrete behavior.
Visitor: It separates an algorithm from an object structure by moving the hierarchy of methods into one object.



State Pattern:
State pattern is a behavioral type design pattern which is widely used in different applications. It is especially used in 3D-Graphics applications and applications for devices. In object-oriented design, object can change its behavior based on its current state. A state pattern design implements state and behavior of an object. By using state pattern, we can reduce the complexity in handling different states of an object. This helps to easily maintain code in future.
A monolithic object's behavior is a function of its state, and it must change its behavior at run-time depending on that state.
Alternatively, an application is characterized by large and numerous case statements that vector flow of control, based on the state of the application.
The State pattern does not specify the location where the state transitions will be defined. There are two choices:

The "context" object
Each individual State derived class

The advantage of the latter option is ease of adding new State derived classes. The disadvantage is that each State derived class has knowledge of (coupling to) its siblings, which introduces dependencies between subclasses.



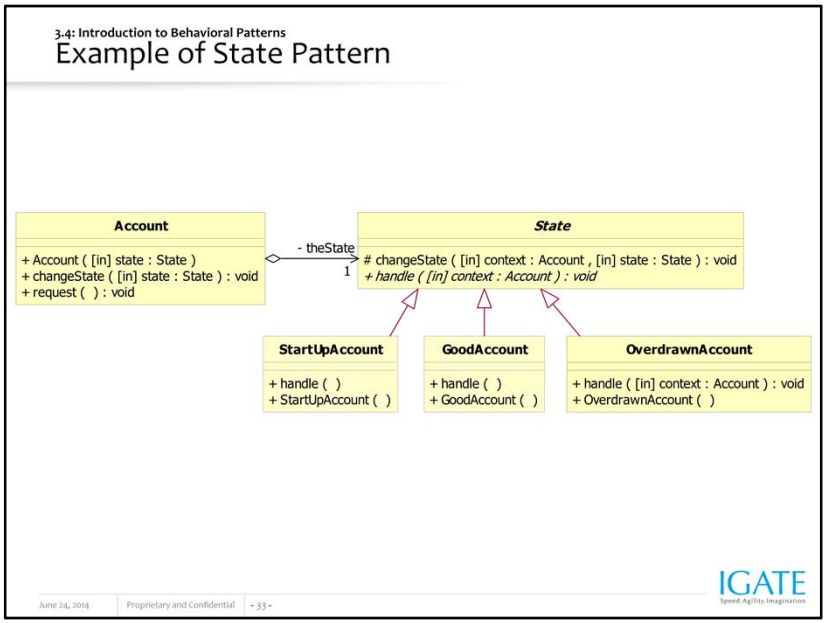
Example of State Pattern:
The State pattern allows an object to change its behavior when its internal state changes.
This pattern can be observed in a vending machine.

Vending machines have states based on:

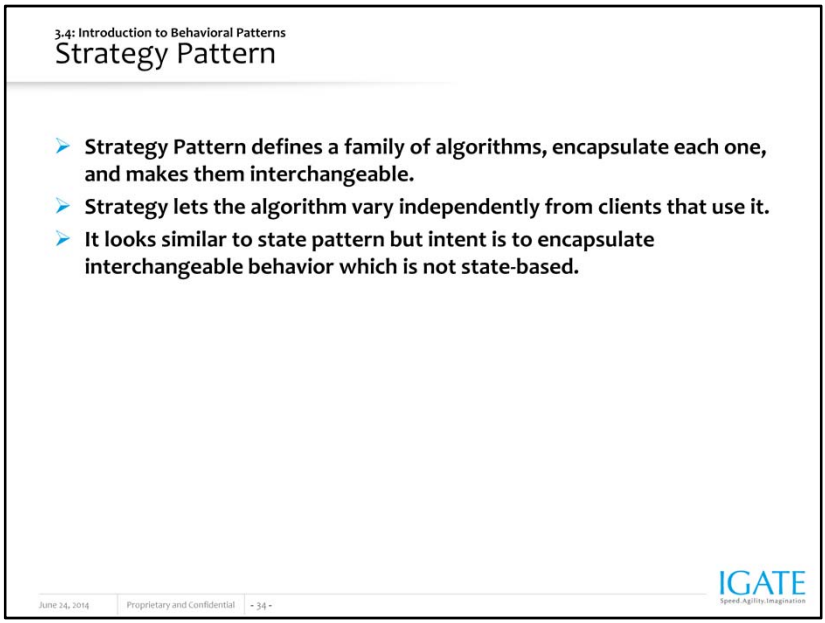
- The inventory
- The amount of currency deposited
- The ability to make change
- The item selected, etc.

When currency is deposited and a selection is made, a vending machine will do either of the following:

- Deliver a product and no change
- Deliver a product and change
- Deliver no product due to insufficient currency on deposit
- Deliver no product due to inventory depletion



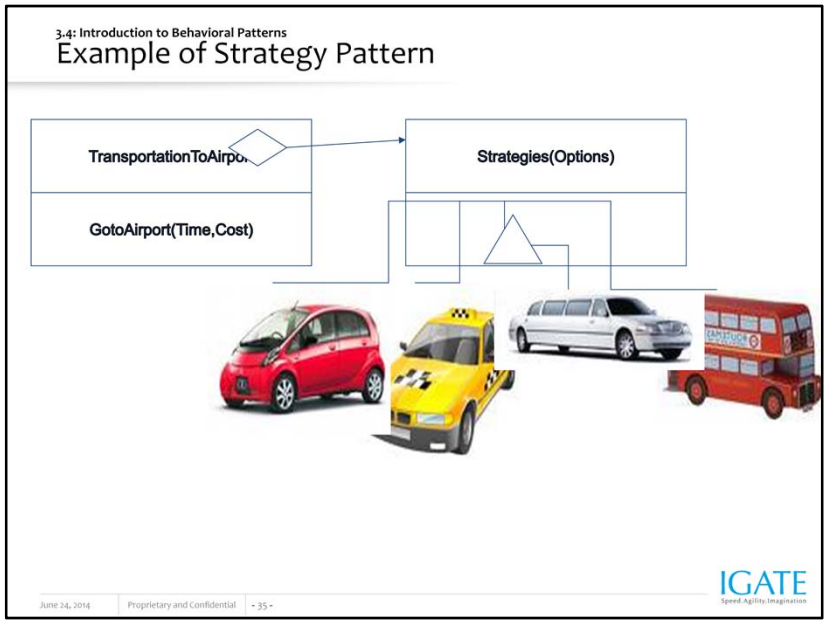
An account holder has an account with ICICI bank and the account behaves differently depending on its balance state.
The difference in behavior is delegated to State objects.



Strategy Pattern:
The Strategy pattern is useful for situations where it is necessary to dynamically swap the algorithms used in an application. The strategy pattern is intended to:

Provide a means to define a family of algorithms
Encapsulate each one as an object, and make them interchangeable

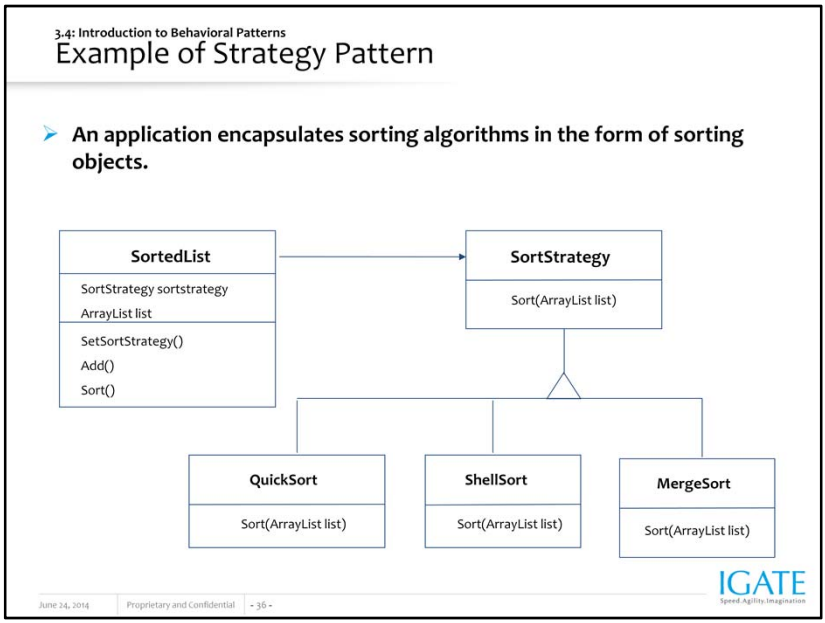
The strategy pattern lets the algorithms vary independently from clients that use them.
The Strategy pattern uses "composition" instead of "inheritance".
It is a good idea to use the Strategy Pattern when you have several objects that are basically the same, and differ only in their behavior. By using Strategies, you can reduce these "several objects" to "one class" that uses several Strategies. The use of strategies also provides a nice alternative to sub-classing an object to achieve different behaviors. When you subclass an object to change its behavior, the behavior that it executes is static.
Strategy is a bind-once pattern, whereas State is more dynamic.



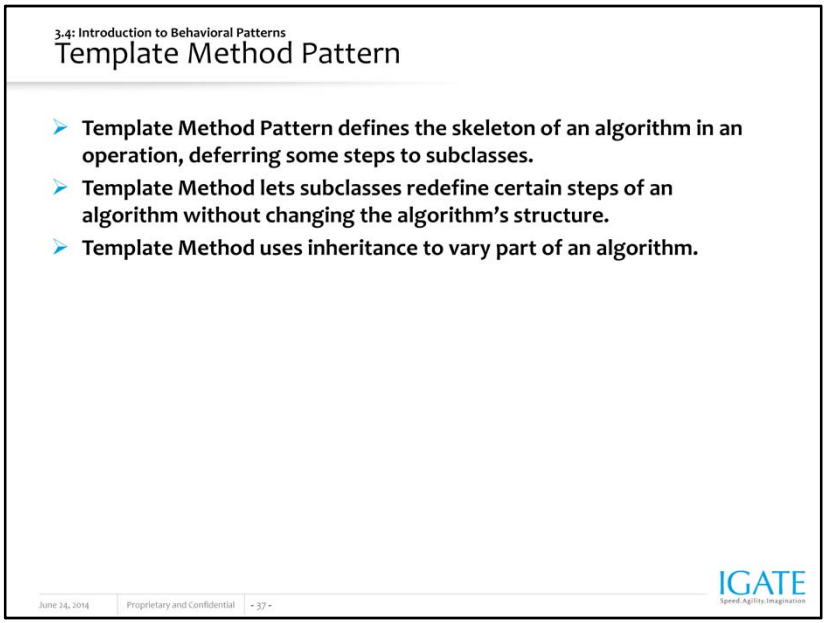
Example of Strategy Pattern:

A Strategy defines a set of algorithms that can be used interchangeably.

Modes of transportation to an airport is an example of a Strategy. Several options exist such as driving one's own car, taking a taxi, an airport shuttle, a city bus, or a limousine service. For some travelers airports, subways, and helicopters are also available as a mode of transportation to the airport. Any of these modes of transportation will get a traveler to the airport, and they can be used interchangeably. The traveler must chose the Strategy based on tradeoffs between cost, convenience, and time.



This allows clients to dynamically change sorting strategies including Quicksort, Shellsort, and Mergesort.



Template Method Pattern:

The Template Method pattern defines the program skeleton of an algorithm. The algorithm itself is made abstract, and the subclasses override the abstract methods to provide concrete behavior.

First a class is created that provides the basic steps of an algorithm design. These steps are implemented using abstract methods.

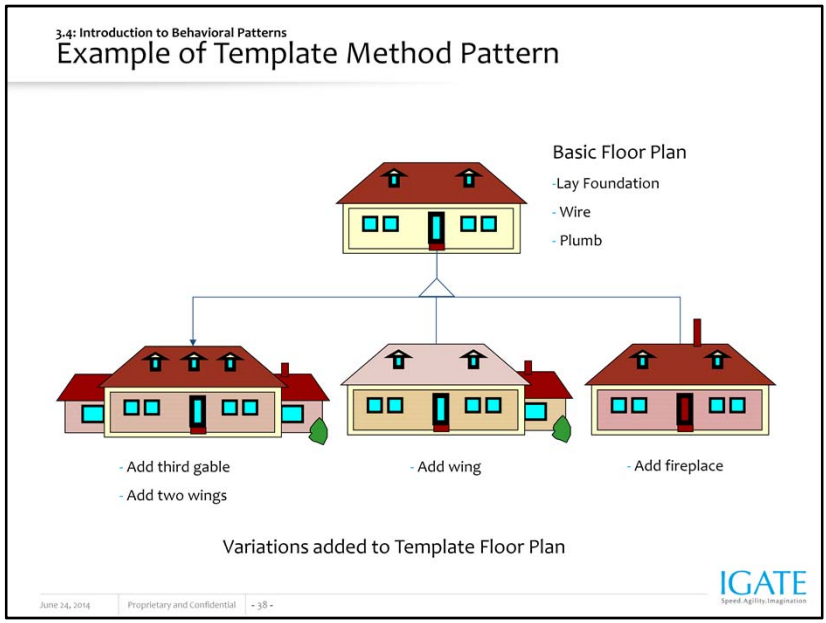
Later on, subclasses change the abstract methods to implement real actions. Thus the general algorithm is saved in one place, however, the concrete steps may be changed by the subclasses.

The Template Method defines a skeleton of an algorithm in an operation, and defers some steps to subclasses.

The component designer decides the steps of an algorithm that are invariant (or standard) and variant (or customizable).

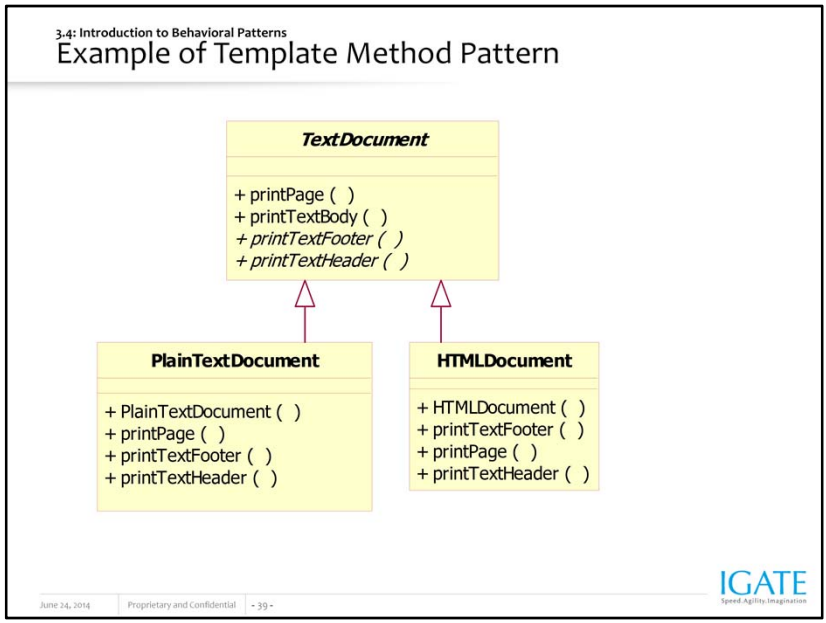
The invariant steps are implemented in an abstract base class.

The variant steps are either given a default implementation, or no implementation at all. The variant steps represent "hooks" or "placeholders", which can or must be supplied by the component's client in a concrete derived class.



Example of Template Method Pattern:
The Template Method defines a skeleton of an algorithm in an operation, and defers some steps to subclasses.
Home builders use the Template Method while developing a new subdivision.

A typical subdivision consists of a limited number of floor plans with different variations available for each.
Within a floor plan, the foundation, framing, plumbing, and wiring will be identical for each house.
Variation is introduced in the later stages of construction to produce a wider variety of models.



In this example, the TextDocument class is the place holder for PlainTextDocument and HTMLDocument classes. Note the abstract methods of the base class which will have an implementation defined in the derived classes.

Summary

- **In this lesson, you have learnt:**
  - Concept of Fundamental Design Pattern with examples
  - Concept of Creational, Structural & Behavioural Design Patterns with examples

Review Question

- **Question 1: ___ pattern provides a level of Indirection for the client who wants to access a particular service.**
- **Question 2: ___ pattern supports the design principle – "Favor composition over Inheritance".**
- **Question 3: ___ pattern allows the subclasses to decide which class to instantiate.**
- **Question 4: ___ pattern allows two unrelated interfaces to work together.**

Review Question: Match the Following

1. State	a. Allows choice one of the family of algorithms at run-time
2. Strategy	b. Defines skeleton of an algorithm as an abstract class
3. Template	c. Used when change in state requires change in behavior