Introducing Design Pattern-based Abstract Modeling Construct as a Software Architecture Compositional Technique

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Introduction

Context

- Design patterns are solutions to common recurring design problems.
- Can we use design patterns as solutions to integration problems?

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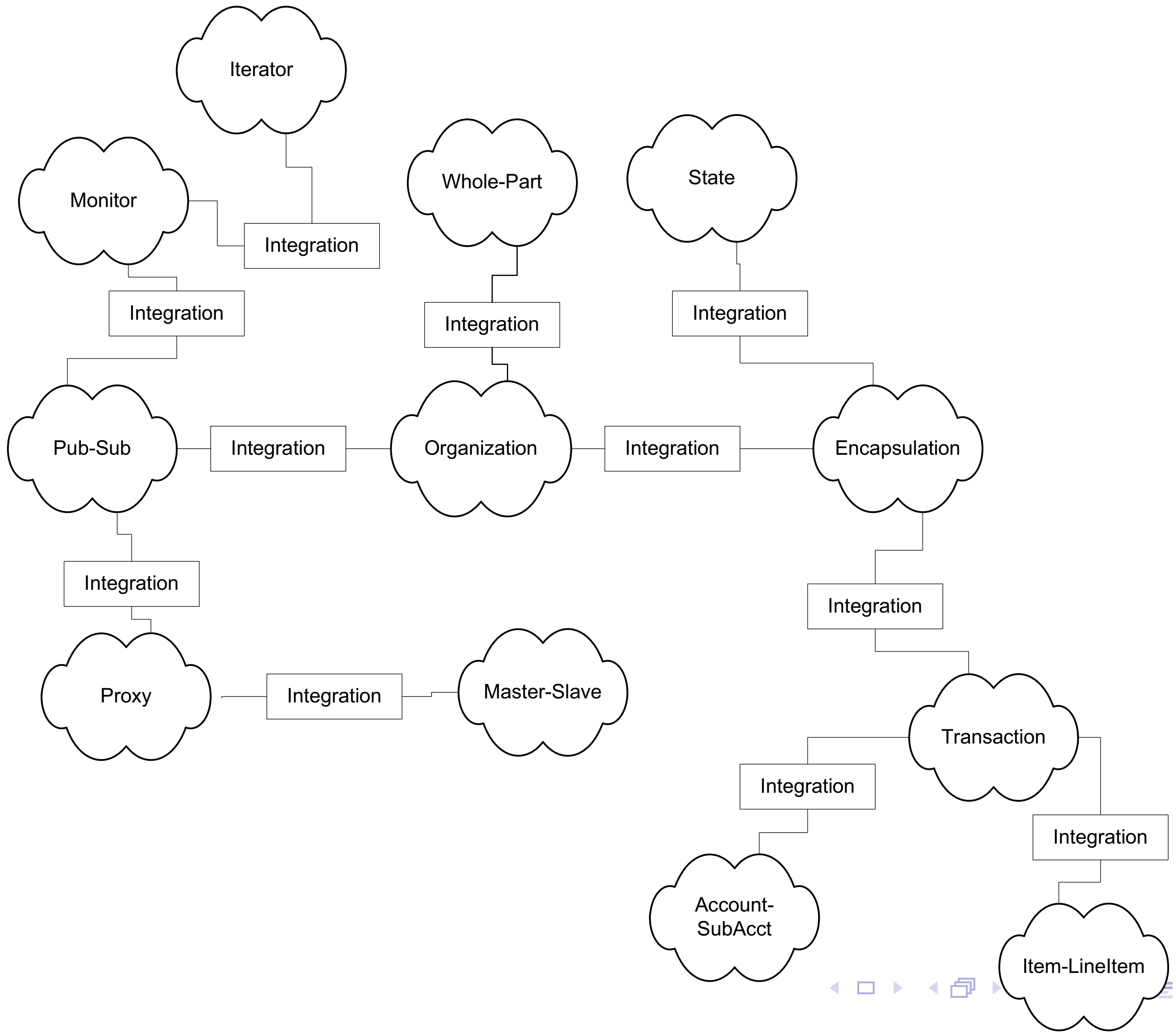
Concrete Practical Problem

- Given a set of requirements stated as design problems.
- Using design patterns, you map design problems to design solutions.
- Much of the published literature on design patterns describes this problem–pattern association.
- What is lacking is how to assemble these resulting components.

Conceptual Depiction of the Integration Problem



Why do we need a new solution to patterns-based integration

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Problem

- Examine how pattern-based components in Lexi Editor [Gam95] and Hierarchical File System [Vli98] are assembled.
- Components get fused together commonly through a shared object.
- Our Students struggle assembling components based on design patterns when building applications similar to Lexi editor.

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- Examine how pattern-based components in Lexi Editor [Gam95] and Hierarchical File System [Vli98] are assembled.
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Proposed Solution

- Specify design patterns as abstract modeling elements to solve concrete software composition problems.
- Introduce a complete design and implementation strategies.
- Provide a simple to follow process and guidelines of what to do and how to do it.

Conceptual Foundation–The Modeling Part...

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Compositional Model

Abstract the behavioral collaboration model of design patterns using role modeling construct.

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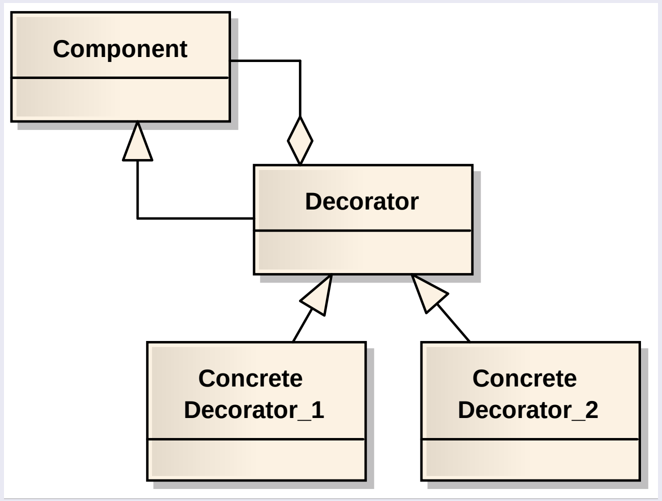
Design Pattern's Collaboration Model

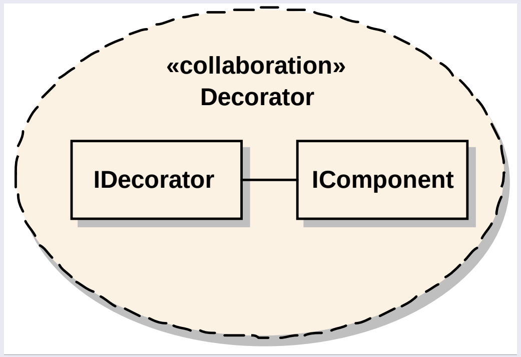
- For each design pattern, we examine its participants' collaboration behavior, and factor out their responsibilities.
- A responsibility is collection of behaviors, functions, tasks, or services.
- In order to describe this collaboration model, specify the design patterns as role models.
- During visual design, use the collaboration modeling construct in UML to depict the resulting role model.

Conceptual Foundation–The Modeling Part

The abstraction process from class model to role model



(a) Decorator Class Model



(b) Decorator Role Model

DCI Architecture as Implementation Strategy–The Practical Part...

Key Concepts

- In DCI [Ree09], the use case model is the driving force to implement an application.
- The architecture of an application comprises the Data part (domain model), and the Interaction part (behavior model).
- What connects the two dynamically is a third element called Context.
- These parts have physical manifestation as components during implementation.

DCI Architecture as Implementation Strategy–The Practical Part...

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Use Cases

- In each use case scenario, system entities interact with each other through defined roles.
- These roles will be mapped onto domain objects instantiated at runtime.
- Object interactions are use case enactments at runtime and are represented by Context objects.

DCI Architecture as Implementation Strategy–The Practical Part...

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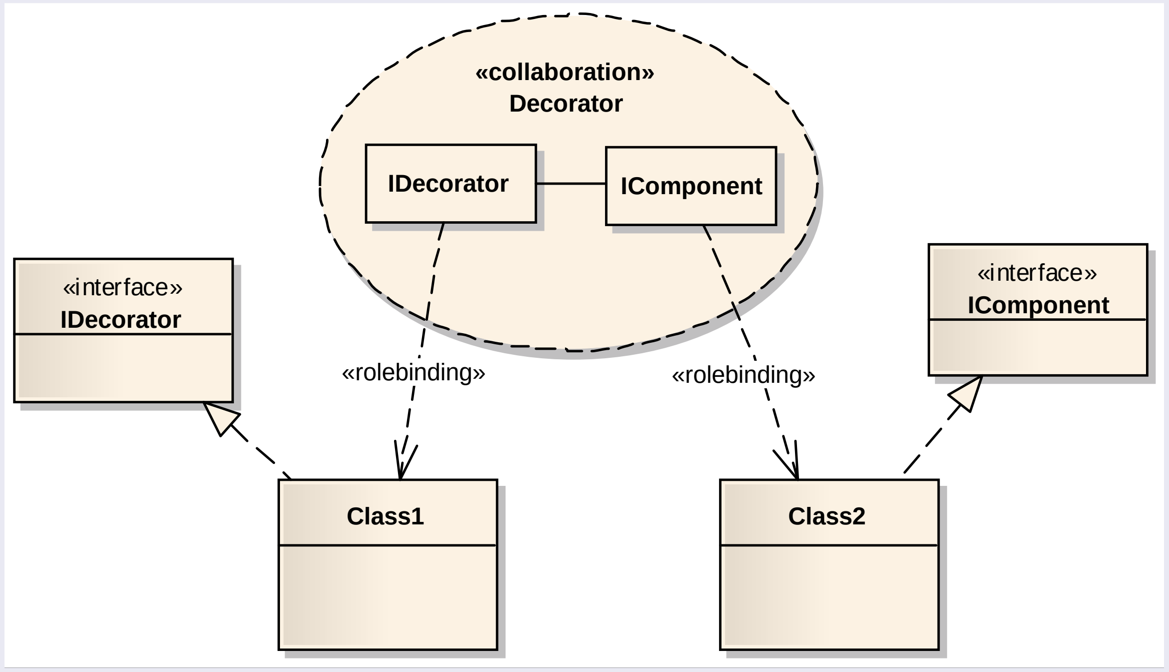
Role (behavior) Injection at Runtime

- System functionality is injected into object at runtime.
- This is accomplished using a programming construct called Traits first introduced by Schärli et al. [Nat03].

DCI Architecture as Implementation Strategy–The Practical Part

The Role Mapping Process to arbitrary class instances



A Software Composition Process using Design Patterns

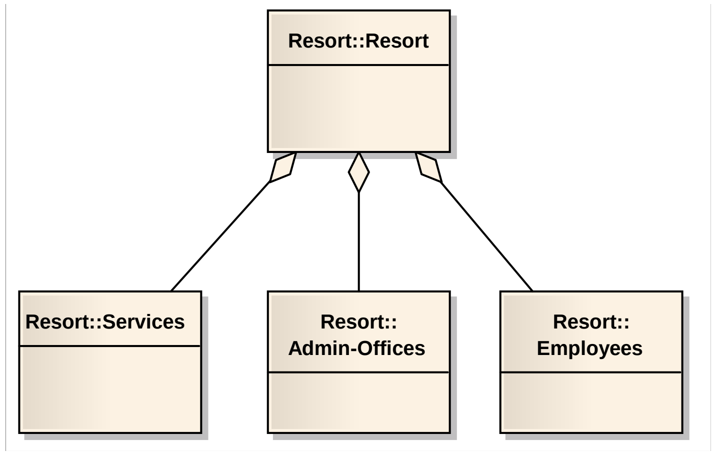
1. Design each component individually.
2. Specify the collaboration requirements between the components.
3. Select one design pattern that may satisfy this requirement.
4. Identify design patterns' participant roles.
5. Code up the roles as methodless interfaces.
6. Identify the responsibility of each role and code it up as a Trait.
7. Select an object from each component that we need to map each role onto.
8. Map the design pattern participants' roles to these objects.
9. Create a context class for the collaboration identified in step 2.

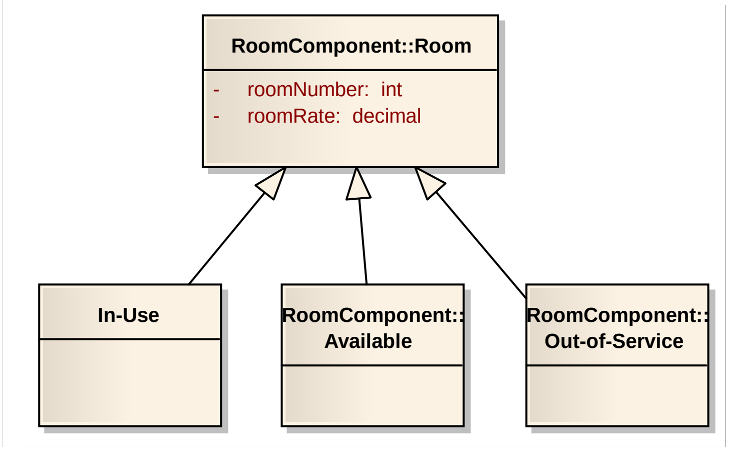
Case Study: Resort System

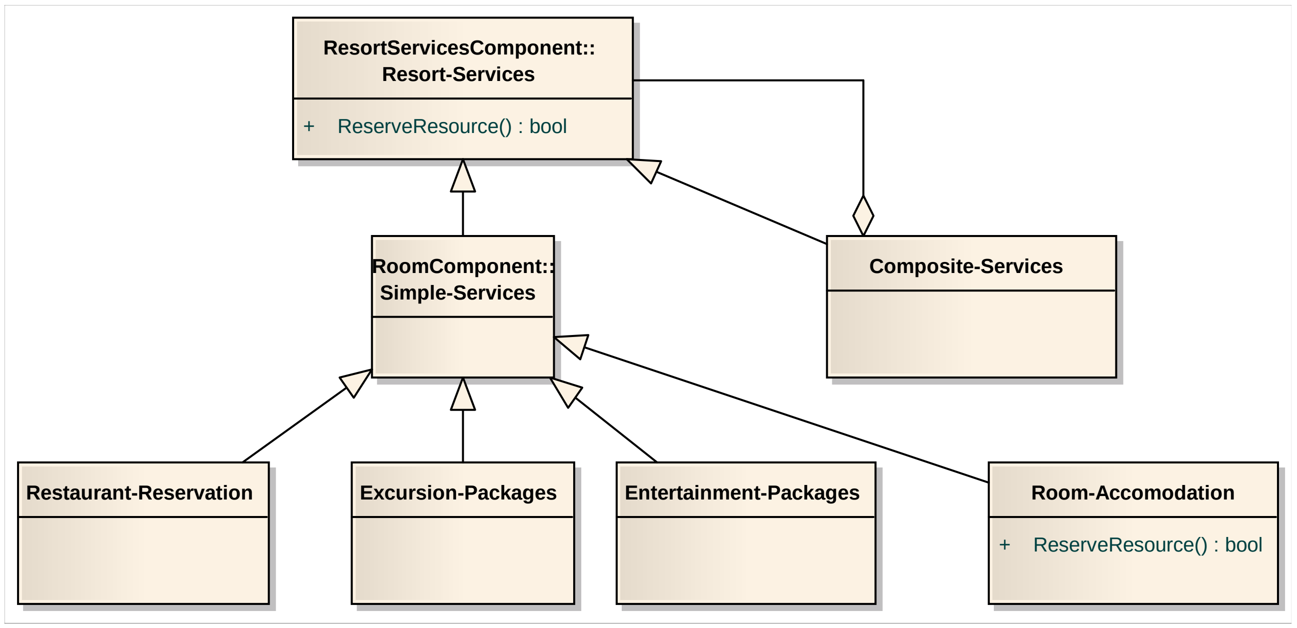
Application Requirements

1. A resort has employees, resort services, and administrative offices.
2. Resort services are either simple services (such as hotel accommodation, food, entertainment, or excursion services) or composite services/packages.
3. Service reservations are made by a reservation clerk at the request of a customer using a calendar of available services.
4. Room accommodations are identified as available, in use, waiting for cleaning or out of service pending repairs.

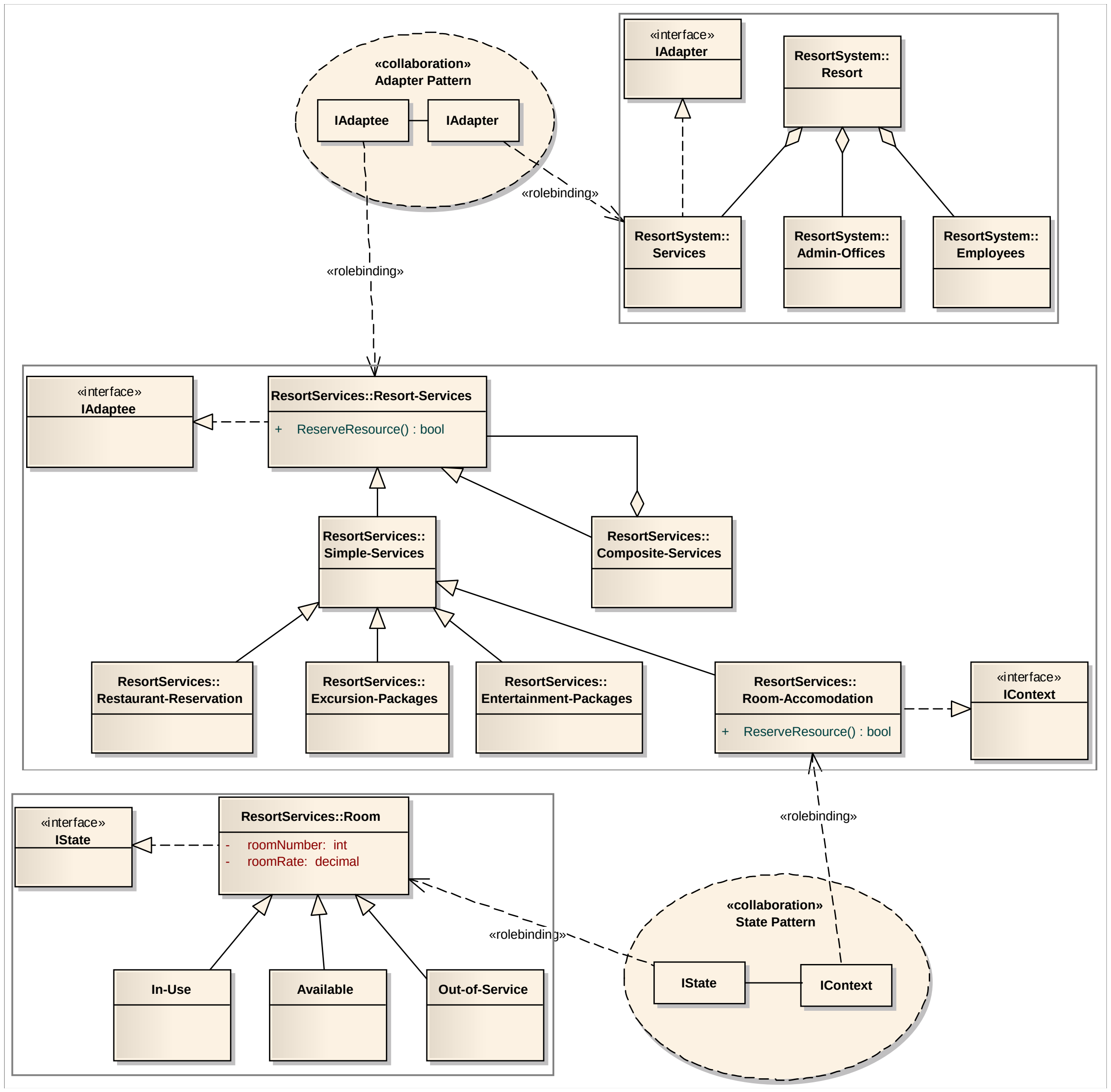
Resort System Components–The Design Part...






ResortServicesComponent:: Resort-Services
+ ReserveResource() : bool
RoomComponent:: Simple-Services
Composite-Services
Restaurant-Reservation
Excursion-Packages
Entertainment-Packages
Room-Accomodation
+ ReserveResource() : bool

Resort System Integration–The Design Part



Resort System–The Implementation Part using C#...

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Coding up Role Models as methodless interfaces

```
public interface IAdapter {}
public interface IAdaptee{}
```

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Coding up Role Models as methodless interfaces

```
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```

Who plays these roles?

```
public class Services : IAdapter {...}
public class Resort_Services : IAdaptee {...}
```

Resort System–The Implementation Part using C#...

Using *Trait* concept to inject behavior

```
// Behavior Request() is injected into IAdapter role so
// now any object who assumes
// this role, will have this method. Using
// extension method to add "Request()"
// method to objects involved in the request service
    public static class RequestTrait {
        public static bool Request(this IAdapter adapter,
            IAdaptee adaptee, RequestType request) {
            ...
            ...
                Resort_Services ra = adaptee
                    as RoomAccommodation;
                bool rc = ra.ReserveResource();
            ...
```

Resort System–The Implementation Part using C#...

The Integration object (context)

- Like the DCI architecture, we create a context that corresponds to the 'collaboration' that acts as integrator.
- `public class RequestResourceContext{...}`

```
public class RequestResourceContext {
    // properties for accessing the concrete objects
    // relevant in this context
    public IAdaptee Adaptee { get; private set; }
    public IAdapter Adapter { get; private set; }
    public RequestType ReqType { get; private set; }
       public RequestResourceContext(IAdapter adapter,
              IAdaptee adaptee, RequestType resource){
            Adaptee = adaptee; Adapter = adapter;
            ReqType = resource; }
```

Resort System–The Implementation Part using C#

Set up the context invoke the integration

```
static void Main(string[] args) {
// demonstrate Adapter pattern integration
    Services services = new Services();
    Simple_Services ra = new RoomAccommodation(){...};
    RequestResourceContext integration = new
    RequestResourceContext(services, ra,
        RequestType.RoomReservation);
    bool rc = integration.Doit();
            ....
```

Resort System–The Implementation Part using C#

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    bool rc = integration.Doit();
            ....
```

Integration through method invocation injected through Trait

```
// this is a method of class RequestResourceContext class
public bool Doit() {
    bool rc = Adapter.Request(Adaptee, ReqType);
    return (rc);
}
```

Conclusion...

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Summary

- We introduced a conceptual framework and an implementation model for software composition using design patterns.
- The approach presented in this research has practical utility.
- The theory validates the concrete implementation and provides generalization to a variety of implementation strategies.

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- We introduced a conceptual framework and an implementation model for software composition using design patterns.
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Key concepts to take away...

- Design patterns' key principal properties are used as abstract modeling constructs through collaboration.

Conclusion...

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- The approach allows for partial and evolutionary design.
- Role to object mapping is a binding mechanism.
- We provide a process anyone can learn and follow.

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Implications

- The process should guide practitioners and students on how individual pattern–based components can be integrated together.
- The approach is scalable and should work with any design pattern.
- Selecting design patterns to solve design problems should also work for solving integration problems.

Conclusion

Drawbacks

- The new design paradigm appears complex at first but once learned, it becomes a powerful tool.
- The compositional model requires creating abstractions out of behavioral collaboration models of design patterns.
- This integration method has richer semantics but it forces you to think and design in the abstract.
- The adoption of the DCI Architecture for implementation strategy creates extra artifacts, cf. Coplien et al. [Cop10].

Notes

Extra

- Thank You!
- An extended paper is available complete with full listing of the sample code.
- Contact Authors.

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