Design Patterns and Frameworks	**Exercise Sheet No. 1**
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Variability Patterns I

Task 1: Template Method vs Template Class

Suppose you have to write a tool for architects that visualizes buildings of different types. Usually, a building is structured from levels, levels are structured from corridors, and corridors from rooms.

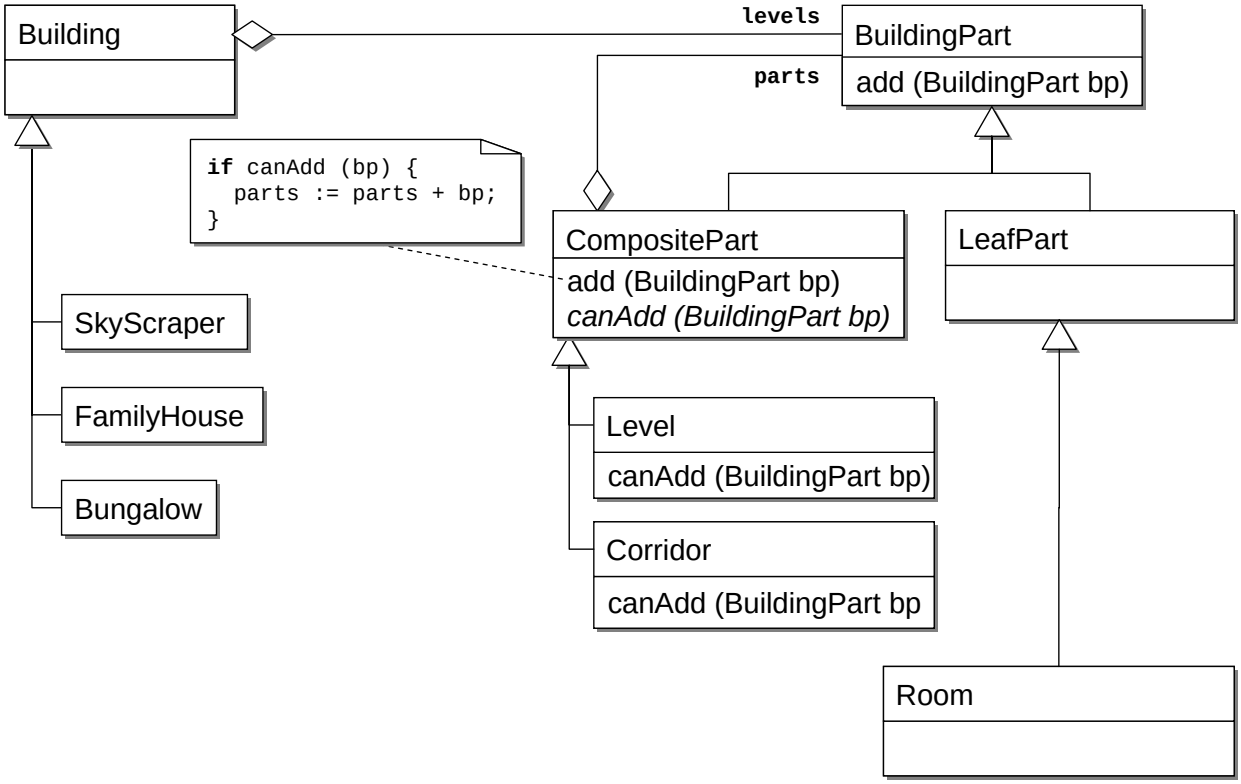
There are different classes of buildings: skyscrapers, bungalows, 1- and 2-family houses.

1a) **Task:**

Create a hierarchy of building types and another hierarchy defining the building's structure. Use TemplateMethod to make sure structural constraints (for example, only corridors may contain rooms) are maintained for the building parts of a concrete building.

Hint: Apply Composite to define the building's structure.

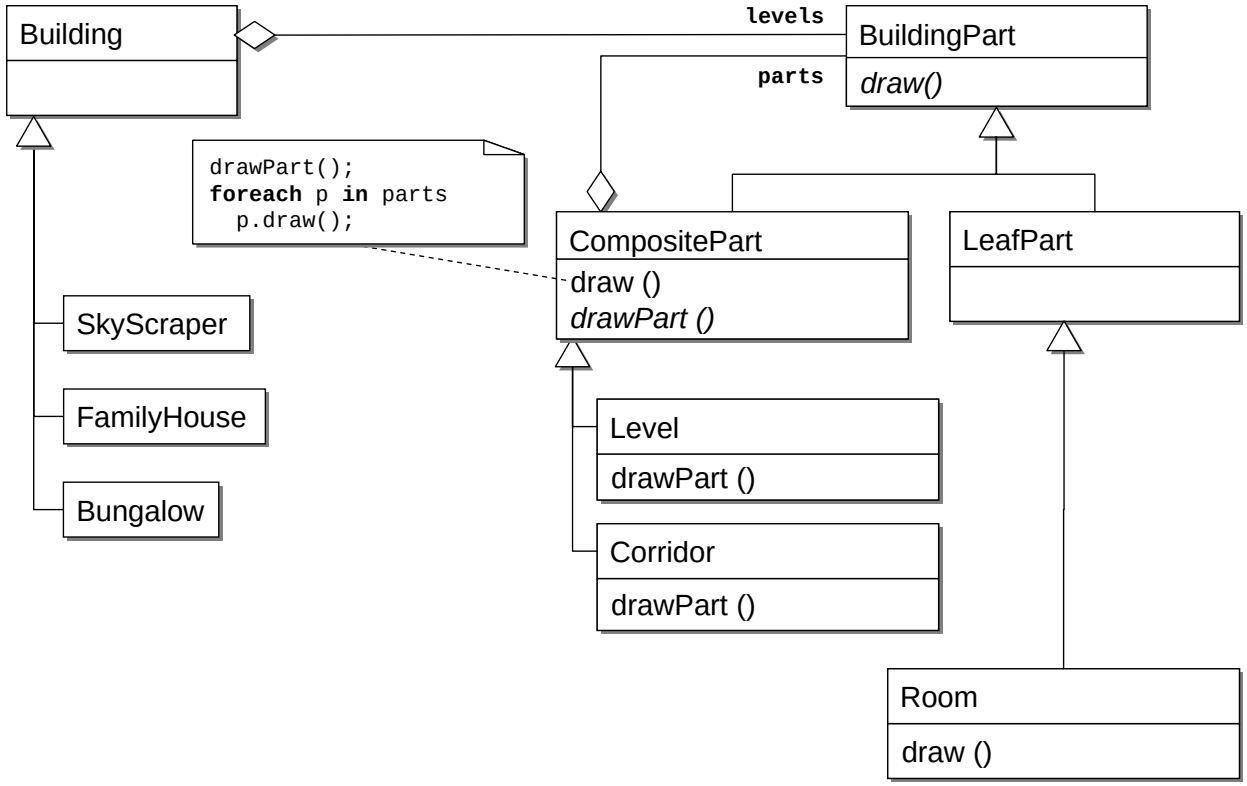
Solution: The following diagram shows a solution. It uses the Composite pattern to define the various elements of buildings. Elements can be added to a building using `BuildingPart`'s `add()` method. For composite parts, this method is implemented using TemplateMethod. `add()` is the template, `canAdd()` the hook. `canAdd()` can now be implemented variously so as to enforce the structural constraints as needed.



1b) **Task:**

Design an iterator algorithm that walks over all types of buildings and draws them room by room on the screen (we assume that only rooms draw themselves). Apply TemplateMethod.

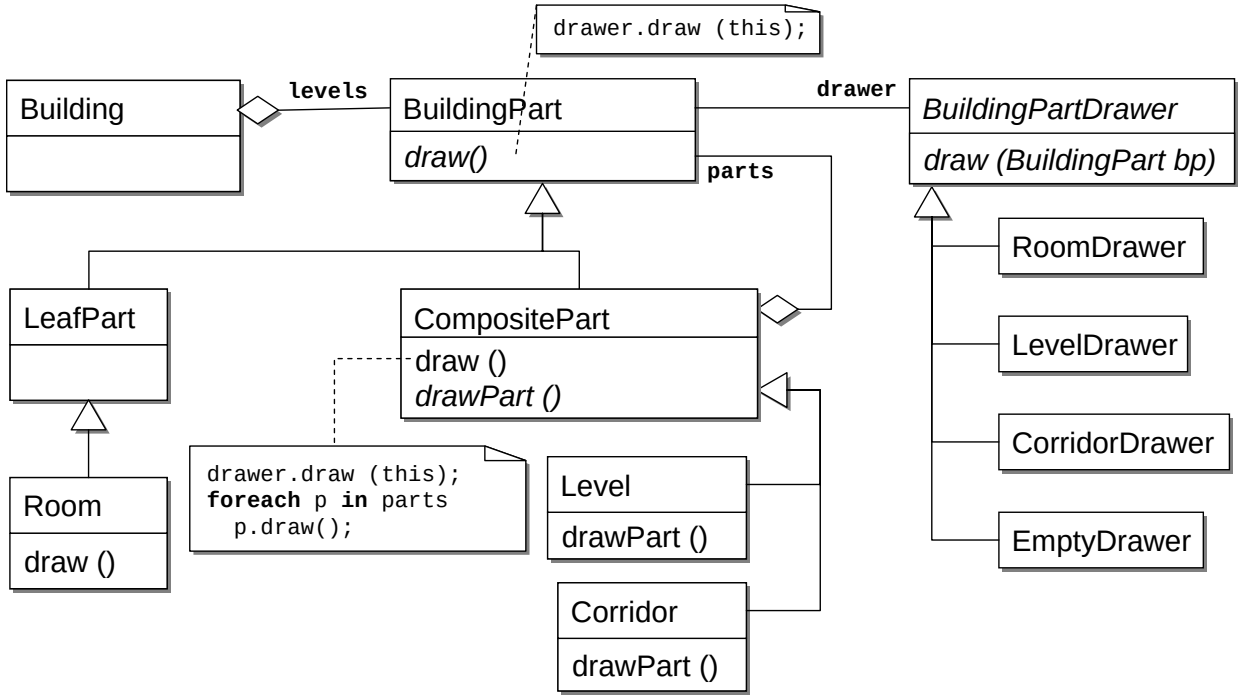
Solution: The following solution uses a similar technique as the solution for the previous subtask. Here, `draw()` is the template and `drawPart()` the hook.



1c) **Task:**

Now, change the TemplateMethod into a TemplateClass pattern (or Strategy). Zip out all hook methods from the concrete template class and put them into a separate hierarchy. Which advantages and disadvantages has your new design?

Solution: The new design creates a `BuildingPartDrawer` for printing (pattern Objectifier, TemplateClass, or Strategy). It creates two objects for drawing a building item at runtime. Hence, it wastes space and allocation time. Also, polymorphic dispatch must be done twice, if the template and the hook classes can be varied. Hence, an application should be slower.



On the other hand, the new design is better extensible and allows for dynamic exchange of the hook code, without changing the client object. Hence, the printing behaviour can be varied at runtime, without changing `BuildingPart` objects.

If template classes can be subclassed, too, we get the DimensionalClassHierarchy pattern, supporting independent changes to both the template class and the hook class.

If the template class is not to be varied, the TemplateMethod pattern restricts severely, how the template method can be varied.

In both designs, families of hook methods can be exchanged together.

1d) **Task:**

So far, only rooms are drawn. Now, draw all elements of a building (building, level, corridor, room) on the screen. Note that for every class of building and every building element you have to vary the behaviour separately; that is, different buildings require different ways of drawing their individual elements. Tip: Again use TemplateClass.

Why is it impossible to use TemplateMethod?

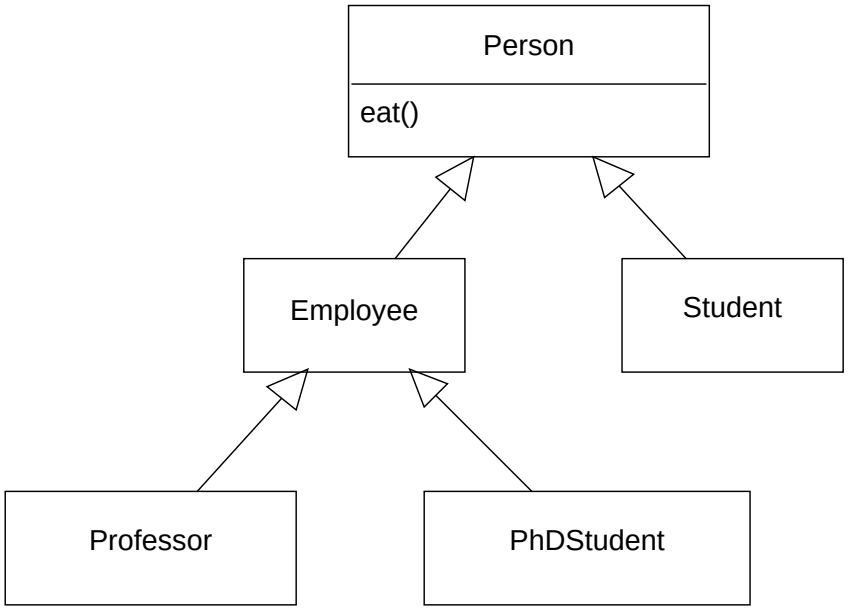
Solution: The design from the previous subtask can be used without problems; only the implementations for the classes `LevelDrawer` and `CorridorDrawer` have to be added, substituting empty printers.

The design would be impossible to do with TemplateMethod because with that pattern, levels are printed as levels, corridors are printed as corridors, and rooms are printed as rooms, independent of which building they are used for. With the above design, however, levels, corridors, and rooms can be configured with building-specific printer objects. (Of course, one would use an AbstractFactory for the printer objects, which allocates precisely what a building needs.)

Task 2: Objectifier, Reifying Methods

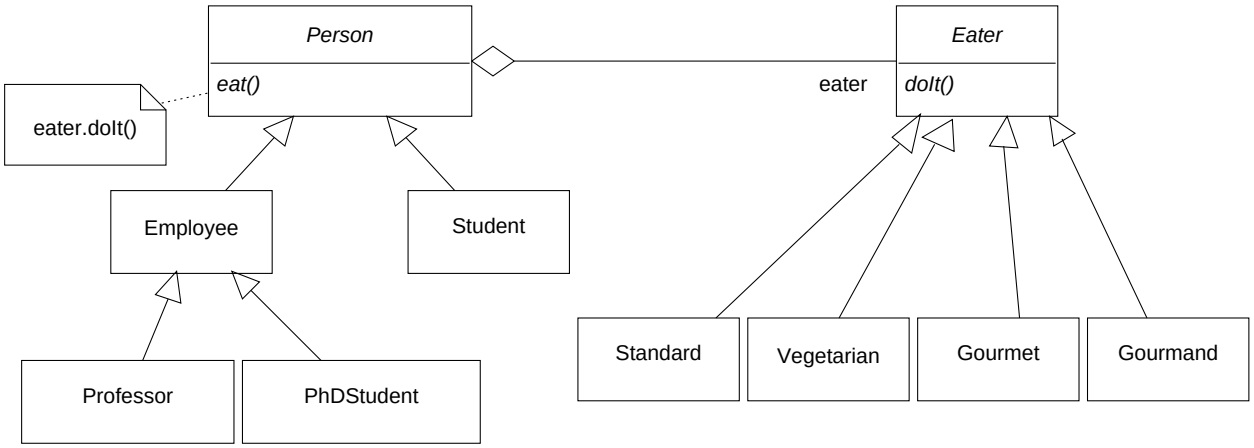
2a) **Task:**

Consider the following simple class hierarchy.



Reify the method `eat` to the pattern Objectifier (or Strategy). Distinguish standard eaters, vegetarians, gourmets, and gourmands.

Solution: The `Person` class gets a reference to the new class hierarchy of `Eaters`. The new class model is:



2b) **Task:**

Which linguistic process corresponds to the reification of methods, i.e., to the Objectifier?

Solution: Turning a verb into a noun.

2c) **Task:**

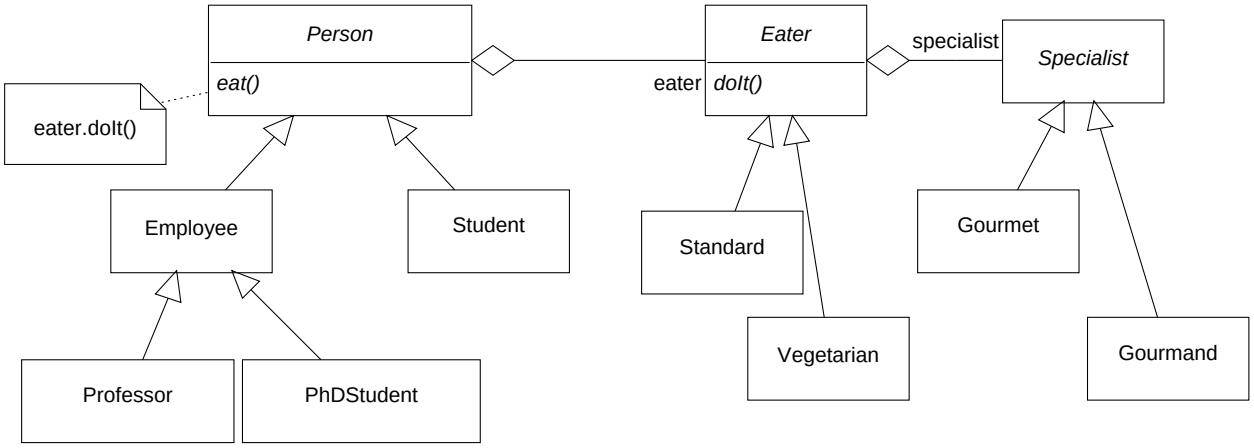
What is the problem if you group all 4 classes of eaters into one class hierarchy?

Solution: They consider different facets of eaters, i.e., do not partition the class `Eater`. Hence, they are not really comparable and should be split into two dimensional hierarchies.

2d) **Task:**

Split the eater hierarchy with a simple DimensionalClassHierarchies (Bridge) pattern.

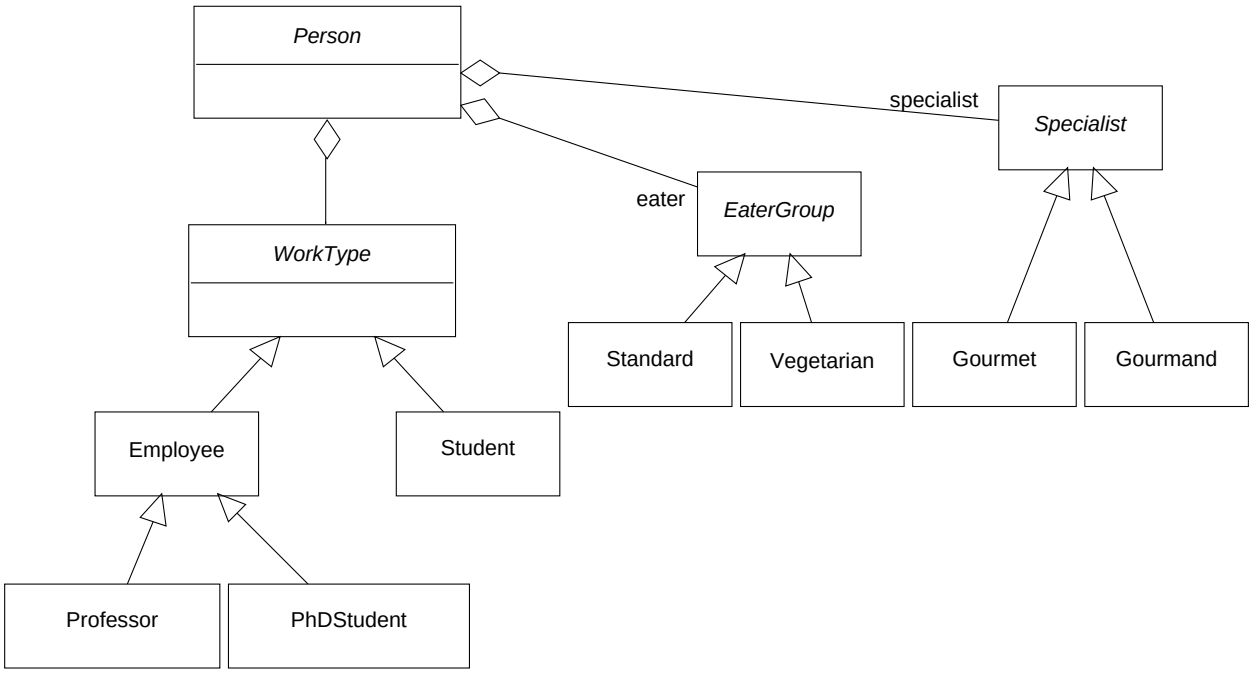
Solution: Splitting the `Eater` hierarchy into a Bridge gives a kind of *sequenced* double bridge.



2e) **Task:**

Now split all facades of `Person` (including the `Eater` hierarchy) into Bridges, using `Person` as the central class.

Solution: The solution changes the inheritance between `Person` and `Employee/Student` into an aggregation to a new class `WorkType:`



This way, no facet gets special attention as the primary facet. For performance reasons, it may be useful to make one of the facets the primary one in the implementation, but this should be an implementation decision based on usage, rather than a design decision based on no good reason at all.

Task 3: Comparison of Variability Patterns

3a) **Task:**

Compare Bridge and TemplateMethod. What are commonalities, what are differences?

Solution: Bridge and TemplateMethod have in common that they define abstract methods in super classes which are implemented in subclasses.

The difference is that an instance of a TemplateMethod implements the abstract method, but a Bridge hides how the abstract methods are implemented; interface and implementation are split. In a Bridge, abstraction and implementation can be refined separately; this is impossible with a TemplateMethod.

3b) **Task:**

Compare TemplateMethod and Strategy. What are commonalities, what are differences?

Solution: TemplateMethod is used when parts of an algorithm should be varied. With a Strategy, the entire algorithm is varied.

The pattern TemplateMethod is checked by the compiler. It can already discover inconsistencies in the inheritance relation, and the typing. With Strategy, problems occur at runtime and cannot be discovered statically.

3c) **Task:**

Compare TemplateClass and GenericTemplateClass.

Solution: TemplateClass uses polymorphism to dispatch to the concrete hook classes. In GenericTemplateClass, the polymorphic dispatch is expanded at compile time, by the generic expansion. Hence, there is more type safety.

GenericTemplateClass flattens the inheritance hierarchy of the hook classes. Hence, if there are too deep inheritance structures resulting, the designer can flatten parts of the hierarchies by generic expansion.