CS 635 Advanced Object-Oriented Design & Programming
Fall Semester, 2020
Doc 20 Active Object
Nov 12, 2020

References

Metadata and Active Object Models, Foote & Yoder, http://hillside.net/plop/plop98/final_submissions/P59.pdf

The User-Defined Product Framework, Johnson & Oakes, https://www.researchgate.net/publication/2640344_The_User-Defined_Product_Framework

Hinges

Business Rules

Some businesses frequently change rules/deals

Buy two X and get third X for 1/2 price

20 cent coffee day

Don't have time to rewrite code

Need to move business logic into data

Metadata and Active Object Models

Metaprogramming

"Writing of computer programs that write or manipulate other programs (or themselves) as their data"

Wikipedia

Forces in Software Evolution

Make programs as general as possible

Push config decisions

- Into the data
- To users
- Defer until runtime

Property Pattern

Property

Attributes
Annotations
Dynamic Slots
Property List

How do you allow individual objects to augment their state at runtime

Therefore, provide runtime mechanisms for accessing, altering, adding, and removing properties or attributes at runtime

What is a Property?

Key (Indicator) - name of the property

Value - the value of the property

Descriptor - information about property
  display name, type, constraints
  default value, accesor functions, etc

Indicates how to downcast

Used by tools

JavaScript

```
class Point {
    constructor(x, y) {
      this.x = x;
      this.y = y;
    }
}
const example = new Point(1,2);

example.name = 'Sample Case';

console.log(example);              //Point { x: 1, y: 2, name: 'Sample Case' }

console.log(Object.getOwnPropertyNames(example))
                                   // [ 'x', 'y', 'name' ]
```

Java Example (Fake)

```
class Example {
  HashMap<String,Object> properties = new Hashmap<String, Object>();

  public void setProperty(String name, Object value) {
    properties.put(name, value);
  }

public Object getProperty(String name) {
  return properties.get(name);
}

public boolean hasProperty(String name) {
  return properties.containsKey(name);
}
```

Some Property methods

void addProperty(Indicator name, Descriptor aboutProperty, Object value);
void removeProperty(Indicator name);
boolean hasProperty(Indicator name);
void setProperty(Indicator name, Object value);
Object getProperty(Indicator name);

Decriptor getDescriptor(Indicator name);
Descriptor[] getDescriptors();
Object[] propertyList();

Java Properties Class

```
Properties defaults = new Properties();
defaults.put("a", "one");
defaults.put("b", 'two");

Properties test = new Properties(defaults);
test.put("c", "three");
test.put("a", "override a default");
```

```
test.get("a");
test.get("b");
test.get("d");
```

Consequences

You avoid a proliferation of subclasses

Fields may be added to individual instances

Fields may be added and removed at runtime

You may iterate across the fields

Metainformation is available to facilitate editing and debugging

Properties can graduate to first-class fields as an application evolves.

Consequences

Syntax is more cumbersome in the absence of reflective support

Property access code is more complex that that for real fields

Reflective mechanisms, where they are available, can be slower

Idiomatic implementations, when reflective support is not available, are also slow

Access to heterogeneous collections can be expensive

A field must be added to all objects, while only a few ever use it

The User-Defined Product Framework

The User-Defined Product Framework

Let users

Construct a complex business object from existing components

Define a new kind of component without programming

Insurance managers can invent a new policy rider

Framework developed at ITT Hartford

Used to represent insurance policies

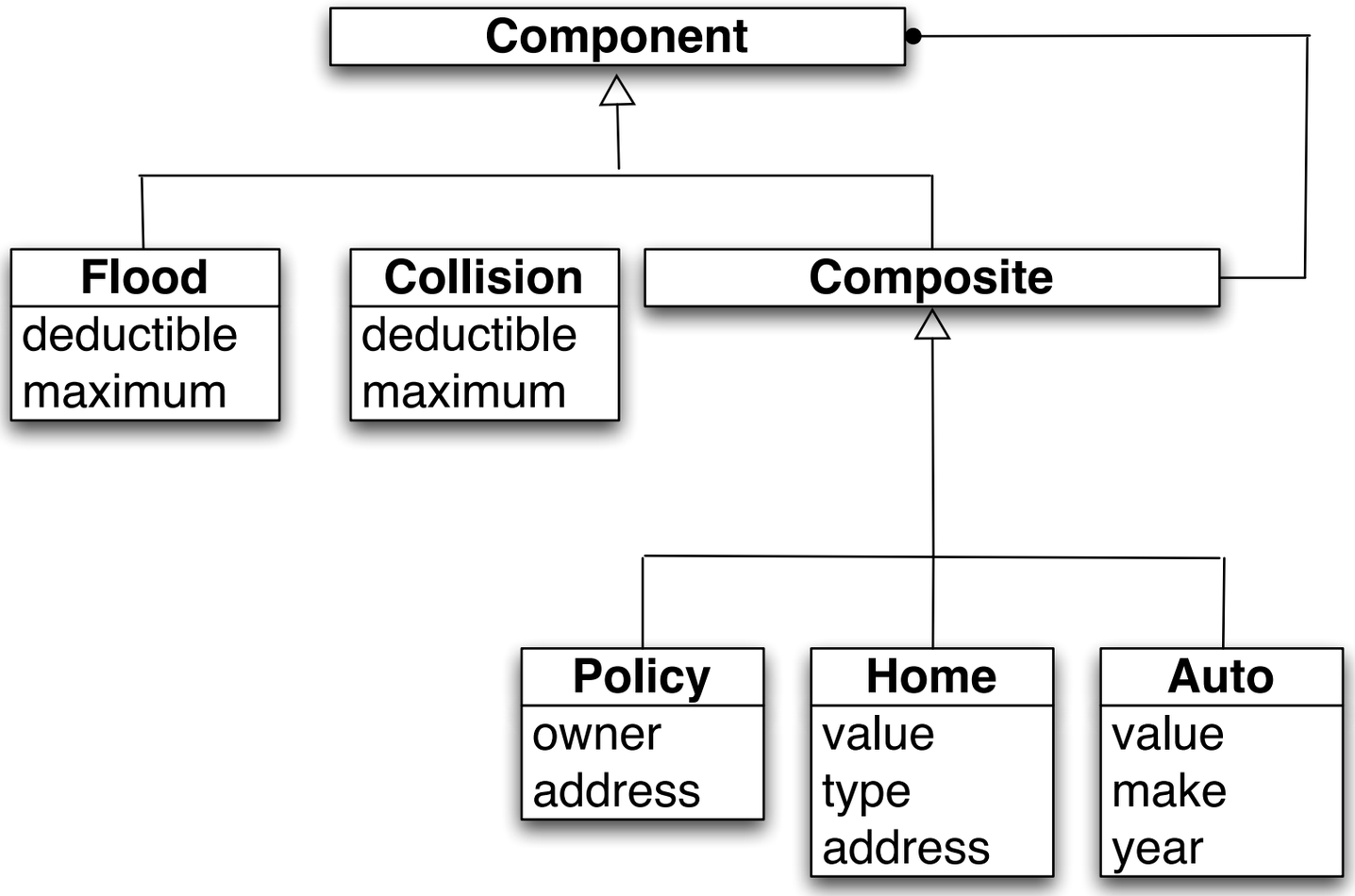
Problem

Which is the best way to combine features, multiple inheritance or composition?

Need 10,000 classes to get all the combinations needed

Use object composition to combine features instead of multiple inheritance.

Solution - Composition



Policy
Auto
Collision
Auto
Home
Flood

Problem

Design is still complex and hard to use

a huge number of Component classes

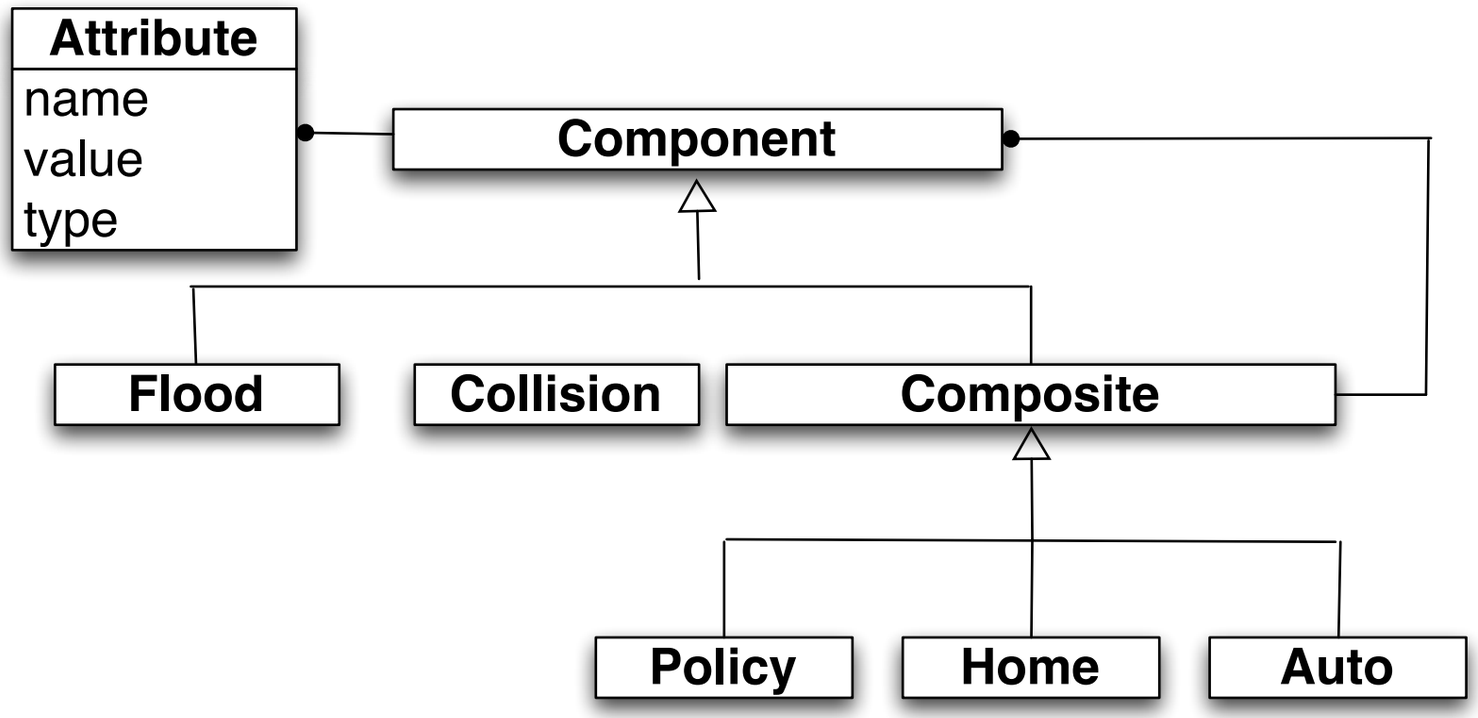
adding a feature means making a new one

Component has too many subclasses.

How can we keep from having to subclass Component?

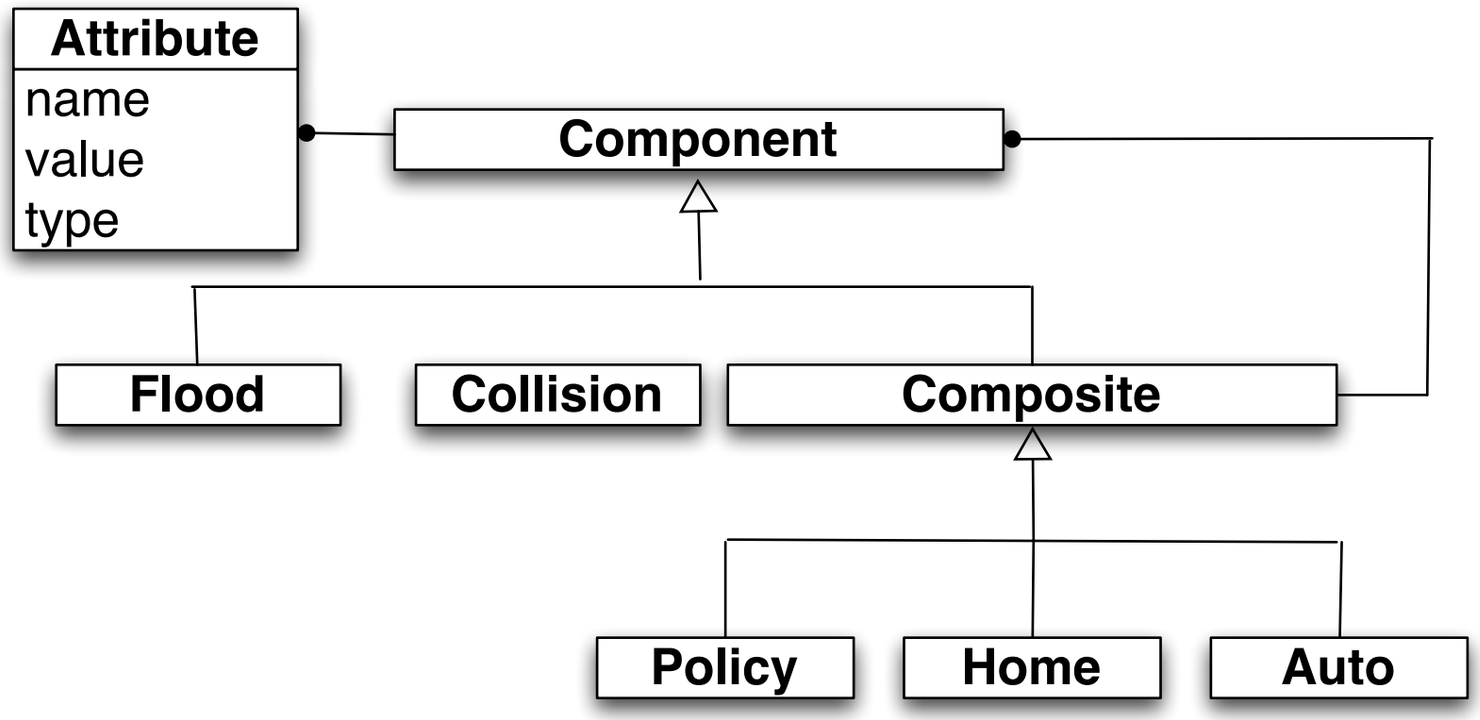
Solution - Properties (Variable State)

Eliminate the need to subclass to add instance variables by storing attributes in a dictionary instead of directly in an instance variable.



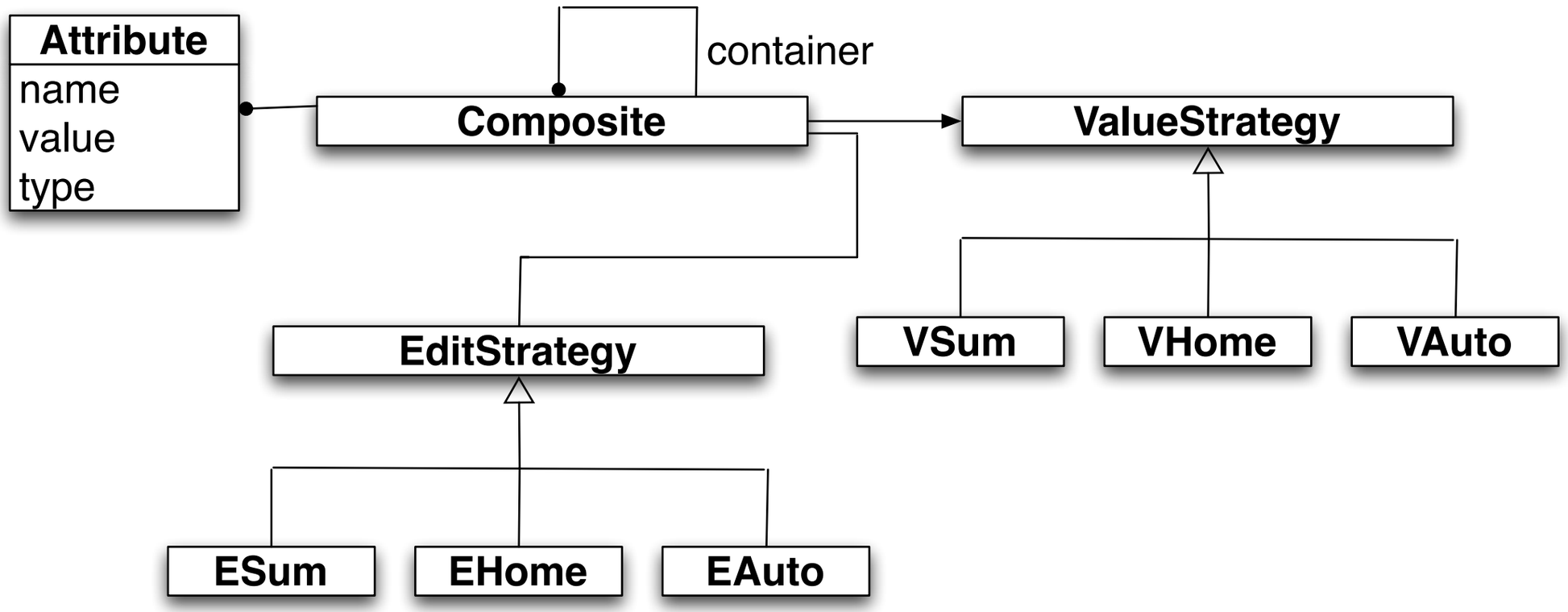
Problem

Still have subclasses for behavior



Solution - Strategy

Make a Strategy for each method of Component that varies in its subclasses.



Problem

But now instead of lots of component subclasses

We have lots of Strategy subclasses

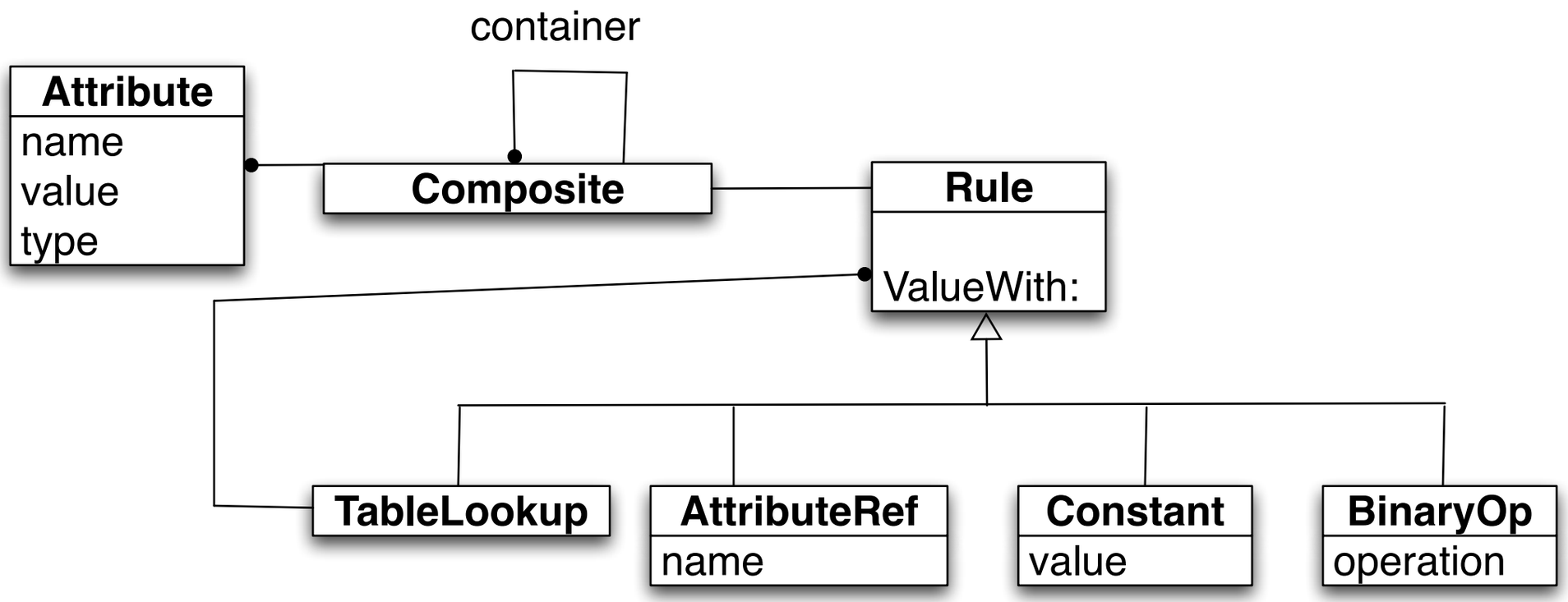
Solution - Interpreter

Create small language for the behaviors of strategies

Value strategies use:

- arithmetic expressions
- table look up
- if statements

Solution - Interpreter



Rules
- read/write attributes
- pre-formula
  - evaluated before component's children
- post-formula
  - evaluated after component's children

Problem

Component subclass replaced with attributes & rules

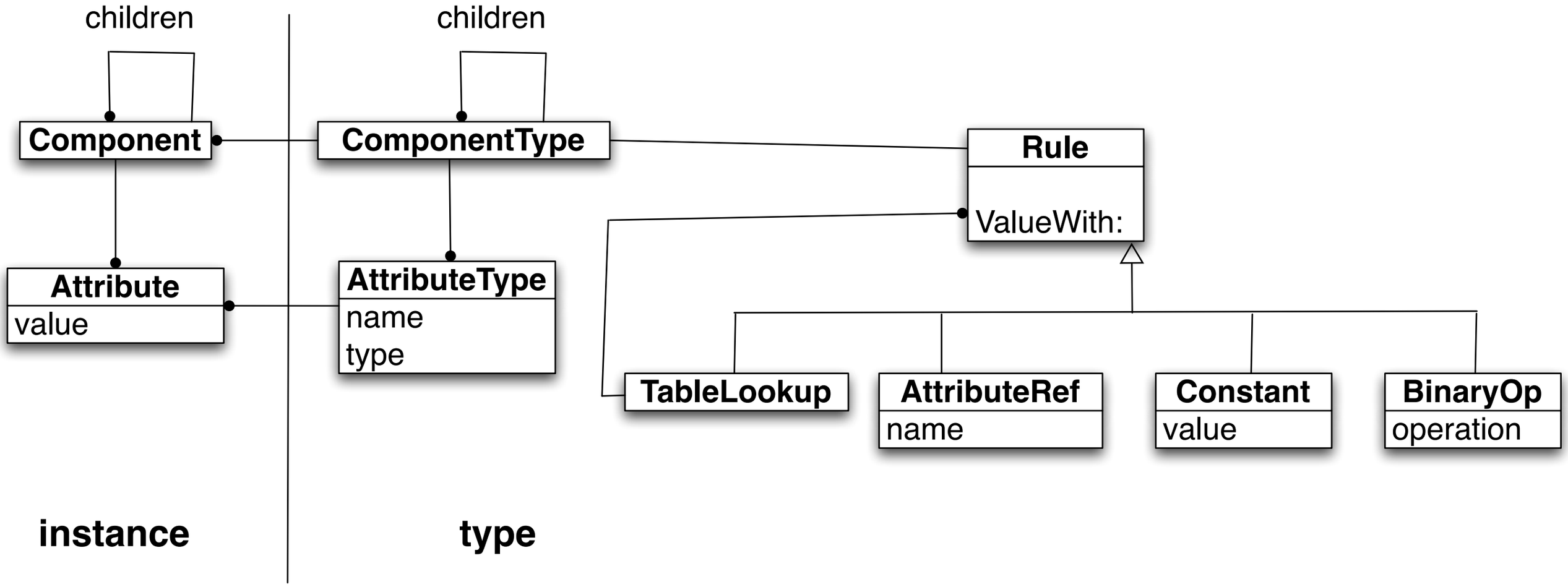
Each "component" instance has own copy of rules - duplication

Without classes to categorize components
  harder to understand code

How can you eliminate duplication in a component system and represent categories of similar components when all components have the same class?

Solution - Type Object

Use the Type Object pattern; i.e. make objects that represent the common features of a category of components, and let each component know its type and access those features by delegating to the type



Problem

Sometimes attributes need to have rules

Life insurance over $1,000,000 has special data and rules

Most attributes don't have rules so why add that option to all attributes

Solution - Decorator

AttributeDecorator - adds rule to attribute

Smart Variable

Issue

Often when a field changes some action is required

Most of the time accessor methods handle this fine

Examples when not

- Debugger - watch points
- Simulations
- Real-time tracking of business

Actions tied to State Change

Dependent Notification
Persistence
Distribution
Caching
Constraint Satisfaction
Synchronization

Swift Property Observers

```
class PositiveTemperature {
    var degreesFarenheit: Double = 0 {
        willSet(newDegree) {
            print("Changing the temperature")
        }

        didSet {
            if degreesFarenheit < 0 {
                degreesFarenheit = oldValue
            }
        }
    }
}
```

```
var test = PositiveTemperature()
test.degreesFarenheit = 10        // Changing the temperature
test.degreesFarenheit             // 10
test.degreesFarenheit = -20       // Changing the temperature
test.degreesFarenheit             // 10
```

Schema

Schema

Descriptor
Map
Database Scheme
Layout

How do you avoid hard-wiring the layouts of structures into your code?
How do you describe the layout of a structure, object, or database row?

Therefore, make a schema or map describing your data structures available at runtime

Participants

Schema - collection of descriptors

Descriptor - describe layout of element
  May contain attributes
    display name, type, default value

Subject - objects being mapped by schema

Grapples - map between symbolic name to actual object

Attributes

Examples

Database Object-Relational mapping

Hibernate, Spring, Active Record in Ruby on Rails

GUI Builders

JavaBeans - Descriptor

GraphQL

Active Object Model

Active Object Model

Object model that provides “meta” information about itself
so that it can be changed at runtime

Why

Both systems and their users must adapt quickly to changing requirements
Dynamic Objects allow for rapid alterations to your program
Users want the ability to change what they do on-the-fly
Changing a program to meet new business requirements is slow and complicated

Problems

Active object-models can be
- difficult to develop
- hard to understand
- hard to maintain

So include editors and other tools
to assist with developing and manipulating the object model