

# Value Objects

**Prof. Dr. Dirk Riehle**

**Friedrich-Alexander University Erlangen-Nürnberg**

**ADAP C07**

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- Are timeless abstractions
  - No life-cycle, no birth or death, no change
  - No identity, cannot be counted, there is only one “copy”
- Consequences for programming
  - Often implemented as immutable objects
  - Program state changes by assigning values to fields
- Values are instances of value types
  - Also often called “data” and “data types”
  - We avoid the potential confusion

# Objects

- Are virtual or physical entities from the modeled world
  - Exist in time, have a life-cycle
  - Can be created, changed, shared, destroyed
  - Have identity independent of internal structure
- Consequences for programming
  - Can be implemented as traditional classes with mutable state
  - Leads to side-effects a.k.a. aliasing and source of bugs
- Objects are instances of object types (classes)

# Examples of Value Types

- So-called “primitive data types”
  - Numbers, strings, characters, ...
- Common general value types
  - Names, coordinates, postal codes, ...
- Domain-specific value types
  - SI unit (quantity units), ranges, restrictions, ...
  - Currency, monetary amount, interest rate, stock ticker symbol, ...
  - Protocol names, URLs, HTTP return codes, ...
  - ...

# Value and Object Representations

## Shared Inter-subjective Immaterial Reality

2 : Integer

EUR 42 : Money

sa12 : SavingsAccount

## Shared Material “Physical” Reality

“II” on paper

“EUR 42” on statement

sa12 as booklet

“zwei” on paper

€42 as cash

sa12 in audit trail

## Software System

10

“2”

2.0

42

€

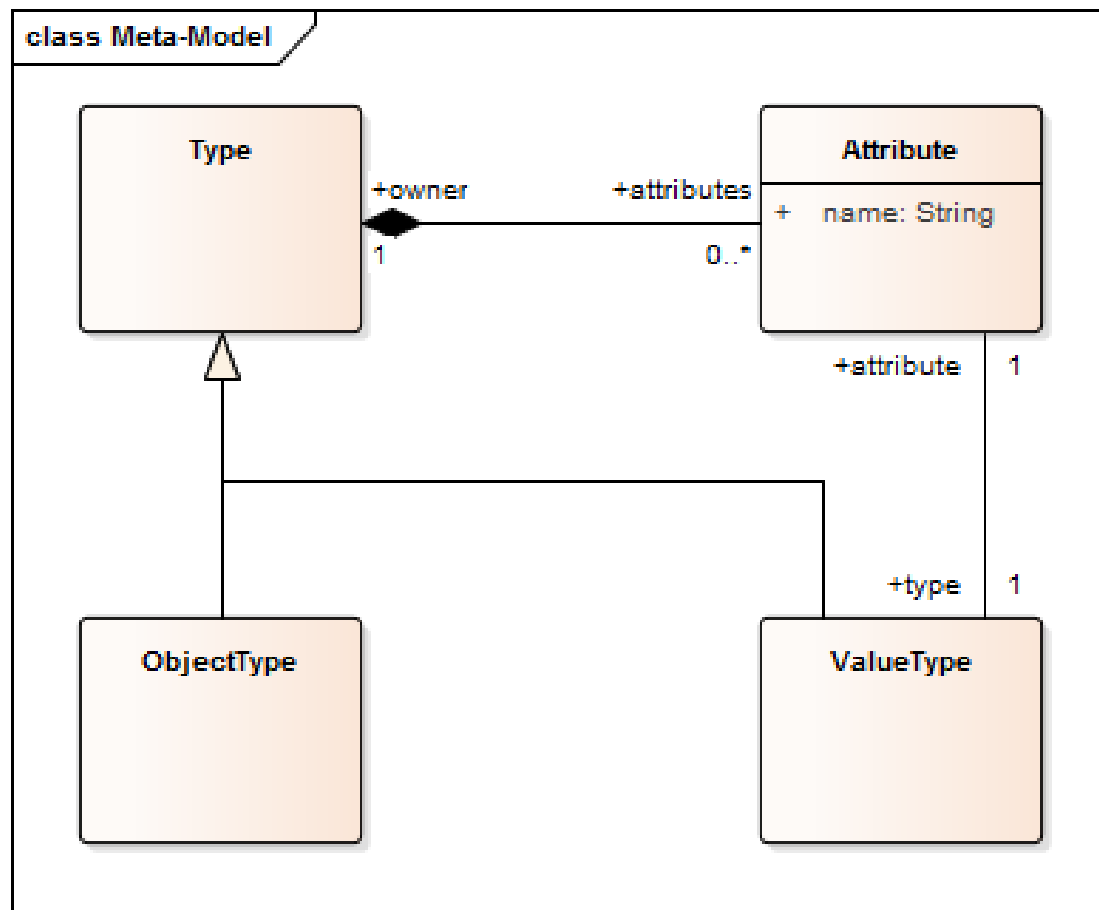
42.0

sa12 : SA

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# Objects and Values

- A software system consists of both objects and values
  - Object attributes have values
- The system is an object graph with values as leaves



# Benefits of Domain-Specific Value Types

- Brings program closer to problem domain
- Restrains a major source of possible bugs (aliasing)
- May enhance system performance (see implementation)

# Quiz: Modeling PostalAddress

- **How would you model a PostalAddress class?**
  - As a value type
  - As an object type
  - As something else



# Answer: Modeling PostalAddress

- **How would you model a PostalAddress class?**
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    - **Conceptually: Yes. A postal address does not have a life-cycle and does not change.**
    - **Pragmatically: No. May be too heavyweight, with little sharing possible.**
  - As an object type
    - **Conceptually no, pragmatically yes. See above.**
  - As something else
    - **Tertium non datur.**

# Implementation 1 / 4: General Semantics

- Implement java.lang.Object equality contract correctly

```
public boolean equals(Object o) {
    if ((o == null) || !(o instanceof Name)) return false;

    Name n = (Name) o;
    int noComponents = getNoComponents();
    if (n.getNoComponents() != noComponents) return false;

    for (int i = 0; i < noComponents; i++) {
        if (!getComponent(i).equals(n.getComponent(i))) return false;
    }

    return true;
}
```

```
public int hashCode() {
    return asString().hashCode();
}
```

# Implementation 2 / 4: Immutability

- Value types as classes defining immutable objects
  - Do not change the state of the object; rather return a new one
    - Affects the interface; no mutation methods of return type void
    - Use Java's final fields to ensure immutability
    - Adjust client code to accept new object

```
public Name remove(int i) {  
    assertIsValidIndex(i);  
    ...  
    Name result = doRemove(i);  
    ...  
}
```

```
protected Name doRemove(int index) {  
    int newSize = getNoComponents() - 1;  
    String[] newComponents = new String[newSize];  
    ... // copy components skipping component at index  
    return getName(newComponents);  
}
```

# Implementation 3 / 4: Sharing

- Value types as classes defining shared objects

```
public Name getName(String[] components) {  
    return getStringArrayName(component);  
}
```

```
public StringArrayName getStringArrayName(String[] components) {  
    String nameString = NameHelper.asNameString(components);  
    StringArrayName result = allStringArrayNames.get(nameString);  
    if (result == null) {  
        synchronized (this) {  
            result = allStringArrayNames.get(nameString);  
            if (result == null) {  
                result = new StringArrayName(components);  
                allStringArrayNames.put(nameString, result);  
            }  
        }  
    }  
    return result;  
}
```

# Benefits of Sharing Value Objects

- Trivial equality contract implementation
- More difficult if you have different implementation classes

```
public boolean equals(Object o) {  
    return this == o;  
}
```

```
public int hashCode() {  
    return super.hashCode();  
}
```

# Implementation 4 / 4: Handle / Body Idiom

- Handle / Body Idiom [C95]
  - Pass around only the handle, which holds the body
  - Forward all method calls from handle to body
- Copy-on-write (mutation method call)
  - Upon mutation method call to handle, copy body
  - This way, the client gets isolated from source context
- Benefits of handle / body idiom
  - Protects client from aliasing effects
  - Minimizes memory consumption

# Implementation Benefits of Value Objects

- Immutable objects are
  - Safe for concurrency
  - Perform well (no need for synchronization)
- Shared objects
  - Make equality easy to implement
  - Minimize memory consumption
- No identity of value objects allows for free copying
  - Database benefit: No need for separate database table
  - Serialization benefit: Value object can be serialized in-line
  - Distributed systems benefit: No cross-process reference

# Quiz: Implementing Base Contracts

- How to implement on `java.lang.Object`
  - For either a value or an object type
    - These comparison methods ...
      - `boolean isSame(Object o)`
      - `boolean equals(Object o)`
    - These creation methods ...
      - `Object clone()`
      - Constructor
    - These other methods ...
      - `int hashCode()`
      - `getId()`



# Answer: Implementing Base Contracts

- Value types

- These comparison methods ...
  - boolean isSame(Object o)
    - **N/A**
  - boolean equals(Object o)
    - **By attribute comparison**
- These creation methods ...
  - Object clone()
    - **return this;**
  - Constructor
    - **Is hidden when sharing values**
- These other methods ...
  - int hashCode()
    - **Calculate hash function**
  - getId()
    - **return ids.get(hashCode())**

- Object types

- These comparison methods ...
  - boolean isSame(Object o)
    - **return this == o;**
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- These creation methods ...
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    - **Create shallow clone**
  - Constructor
    - **Whatever**
- These other methods ...
  - int hashCode()
    - **return super.hashCode()**
  - getId()
    - **Safe version of return (int) this**

# Design Exercise

- Design a function that accepts a distance and a speed as input and returns the time it takes to go that distance at that speed

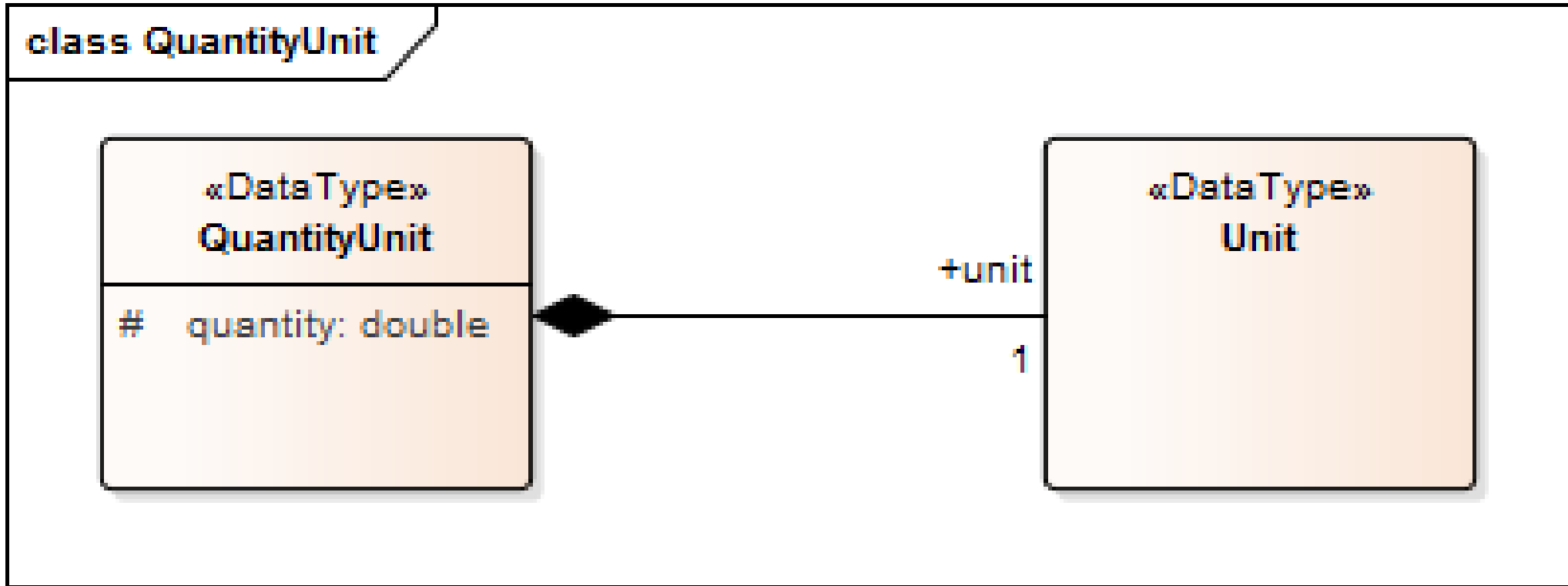
- Functional properties
  - Precision of calculation? (Assume double)
  - What types of units? (Assume metric system)
  - Handling of decimal multiples (Assume no)
  - ...
- Non-functional properties
  - Speed of calculation? (Assume as fast as possible)
  - Concurrent computations? (Assume yes)
  - Behavior in boundary cases? (Assume ignore)
  - ...

# Solution in Pseudo Code

```
function calculate_duration
  in: speed
  in: distance
  out: duration

begin
  duration = distance / speed
end
```

# QuantityUnit



# Base Units (of the Metric System)

Quantity	Base Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Luminous Intensity	candela	cd
Amount of Substance	mole	mol

# State Pattern vs. enum

```
public enum BaseUnit {  
    m(0),  
    kg(1),  
    s(2),  
    A(3),  
    K(4),  
    cd(5),  
    mol(6);  
}
```

# Unit (of Measure)

```
public class Unit {  
    // example: m/s = { 1.0, 0, -1.0, 0, 0, 0, 0 }  
    protected double exponents[7];  
    ...  
}
```



# Quantities with Units

```
public class QuantityUnit {  
    protected double quantity;  
    protected Unit unit;  
    ...  
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```

# Value Types in Java

- Not yet, but ...



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<i>Owner</i>	John Rose
<i>Created</i>	2012/10/22 20:00
<i>Updated</i>	2014/09/23 18:58
<i>Type</i>	Feature
<i>Status</i>	Draft
<i>Component</i>	hotspot
<i>Scope</i>	SE
<i>Discussion</i>	mlvm dash dev at openjdk dot java dot net
<i>Effort</i>	L
<i>Duration</i>	L
<i>Priority</i>	4
<i>Issue</i>	<a href="#">8046159</a>

### Summary

Provide JVM infrastructure for working with immutable and reference-free objects, in support of efficient by-value computation with non-primitive types.

### Goals

- Support user-defined and library-defined abstract data types with performance profiles similar to Java primitive types.

# Value Type Constructors

- Arrays
- Enumerations
- Parameterized types
  - Quantity units (SI units)
  - Ranges and range bounds
  - Expressions, restrictions
  - ...

# Enums as Value Type Constructors

- Enumerations provide shared values
  - Constructors can only be private
  - Fields can be mutable, however

# Param. Types as Value Type Constructors

```
public class RangeRestriction<T extends Comparable<T>>
    extends Restriction<T> {

    protected Range<T> range;

    public RangeRestriction(T lowerBound, T upperBound) {
        this(new Range<T>(lowerBound, upperBound));
    }

    public RangeRestriction(Range<T> range) {
        this.range = range;
    }

    @Override
    public boolean isSatisfiedBy(T value) {
        return range.includes(value);
    }
}
```

# Object Identifiers / References

- Plain main memory reference
- Handle (specialized pointers)
- External object identifiers
- Primary key to relation

# Reality Check [B+97]

- Large financial system (1997)
  - More than 2500 (regular) C++ classes
- Utilization of value object (classes)
  - About 50 unique value types (implemented as classes)
  - About 20 unique value type constructors
  - More than 200 code (enum) like value types

# The JValue Value Object Framework

- JValue, originally a framework for value objects in Java
  - Since 1998 but in its third (modern Java) incarnation
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# Review / Summary of Session

- Value objects / types
  - Definition, characteristics, benefits
  - Values vs. objects
  - Implementation strategies
- Examples

# Thank you! Questions?

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- Contributions
  - ...

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It is Friedrich-Alexander University Erlangen-Nürnberg – FAU, in short.  
Corporate identity wants us to say “Friedrich-Alexander University”.

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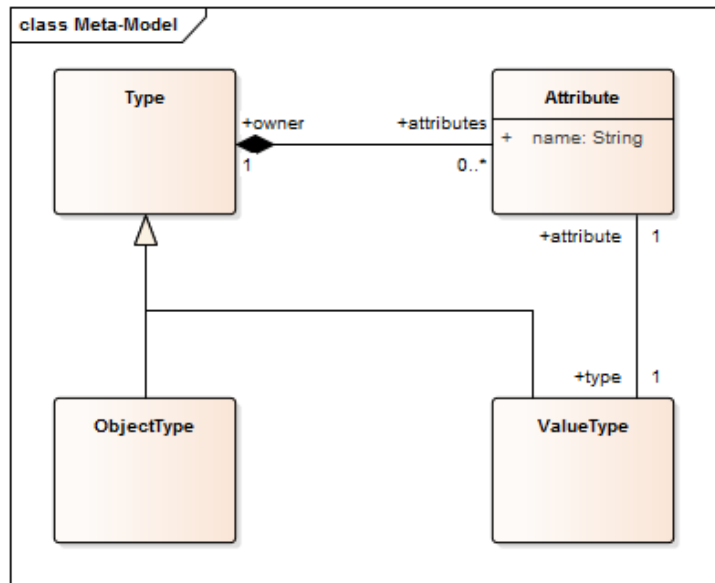
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## Missing Information

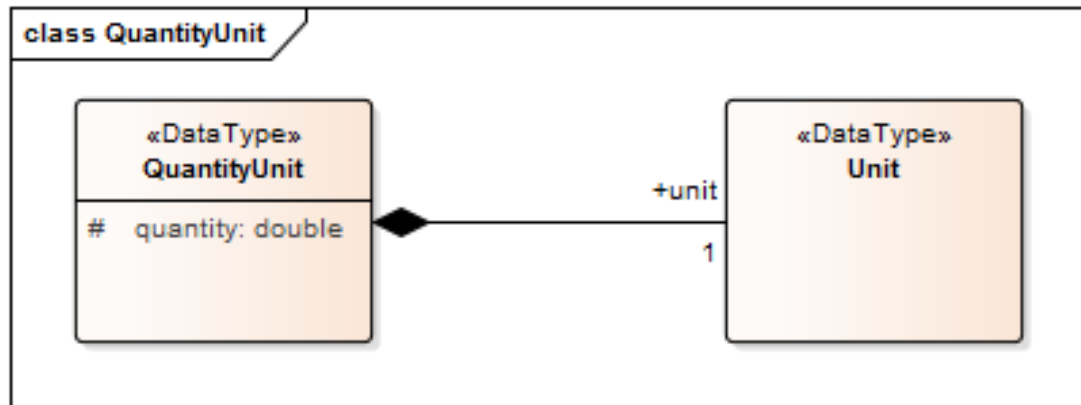
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## Solution in Pseudo Code

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## QuantityUnit





## Base Units (of the Metric System)

Quantity	Base Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
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Thermodynamic Temperature	kelvin	K
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Amount of Substance	mole	mol

## State Pattern vs. enum

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## Unit (of Measure)

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    // example: m/s = { 1.0, 0, -1.0, 0, 0, 0, 0 }  
    protected double exponents[7];  
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    protected Unit unit;  
    ...  
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## JEP 169: Value Objects

*Owner* John Rose  
*Created* 2012/10/22 20:00  
*Updated* 2014/09/23 18:58  
*Type* Feature  
*Status* Draft  
*Component* hotspot  
*Scope* SE  
*Discussion* mlvm dash dev at openjdk dot java dot net  
*Effort* L  
*Duration* L  
*Priority* 4  
*Issue* [8046159](#)

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DR

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