Praktikum WS0304

Formale Entwicklung objektorientierter Software

Introduction to OCL

Andreas Roth

Object Constraint Language

- Part of the UML standard.

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- Formal Specification Language. Precise semantics.

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- Why? Because UML is not enough!

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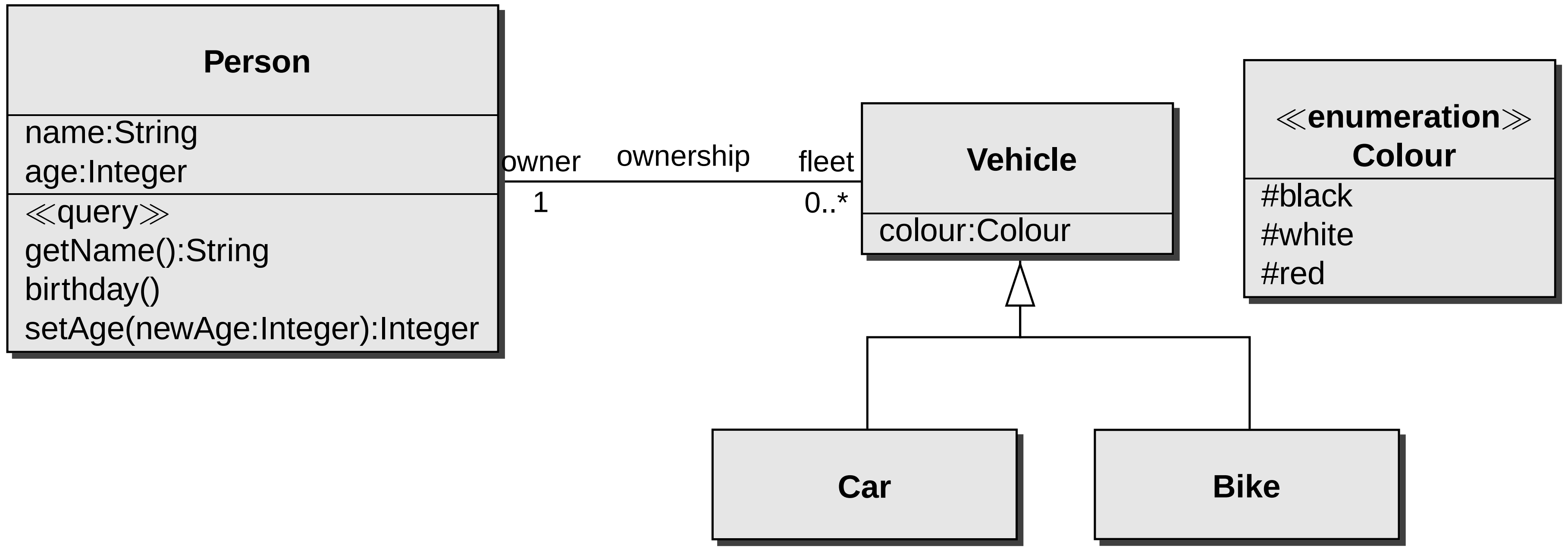
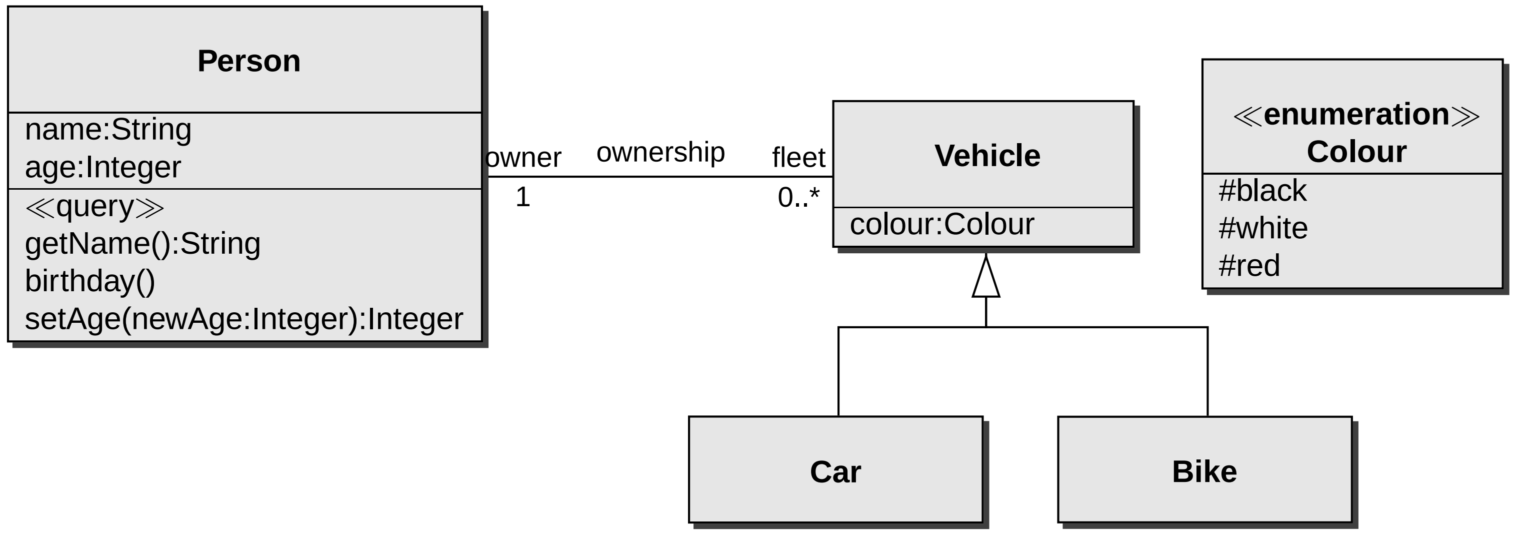


- **How many persons can own a car?**
- **How old must a car owner be?**
- **How can we require that a person must at most own one black car?**

Some OCL examples I



"A vehicle owner must be at least 18 years old":

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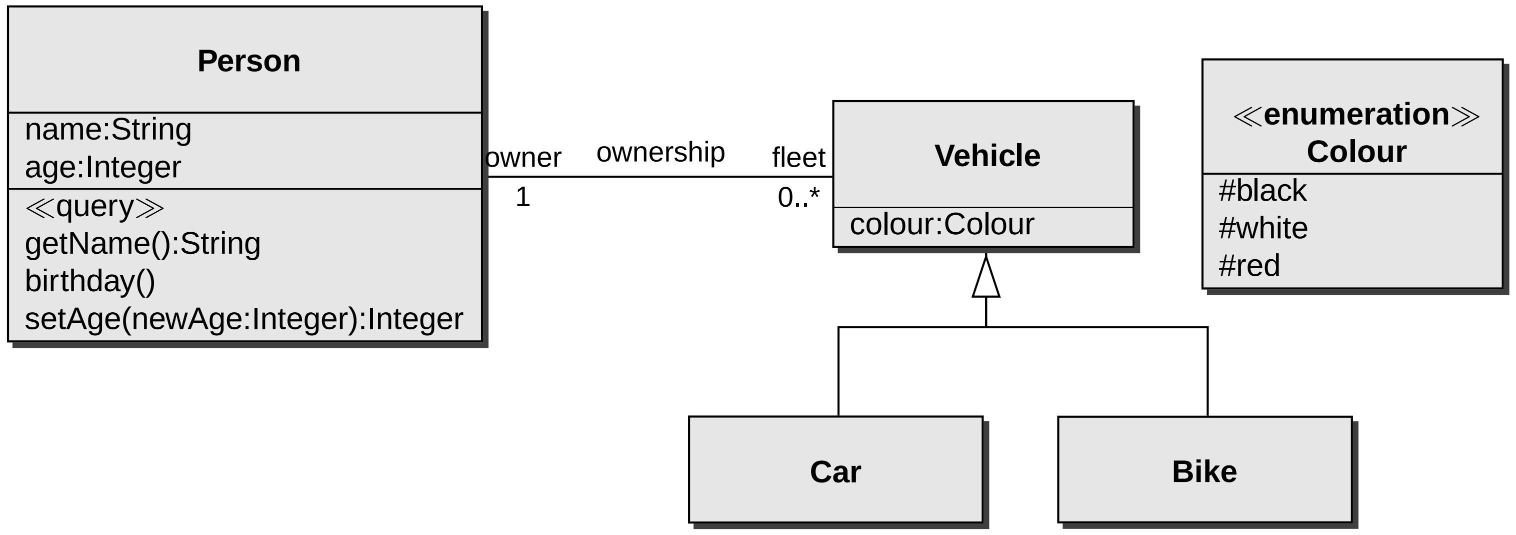

“A vehicle owner must be at least 18 years old”:

context **Vehicle**
inv: **self. owner. age** $>=$ **18**

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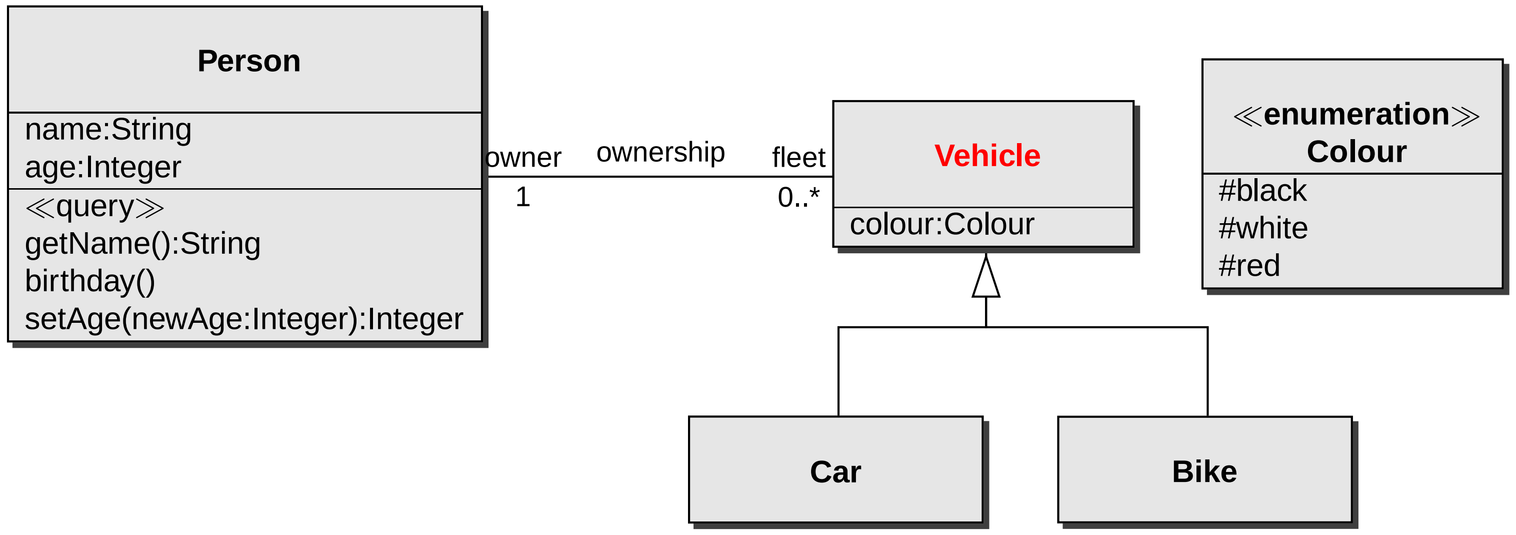

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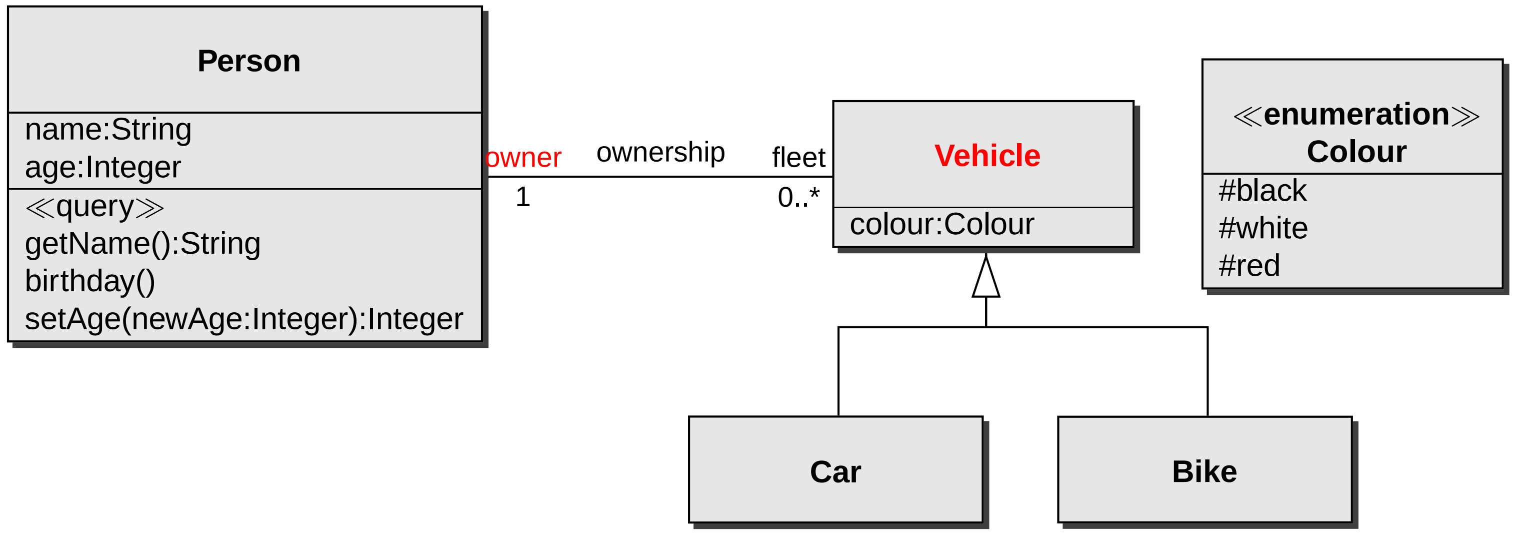
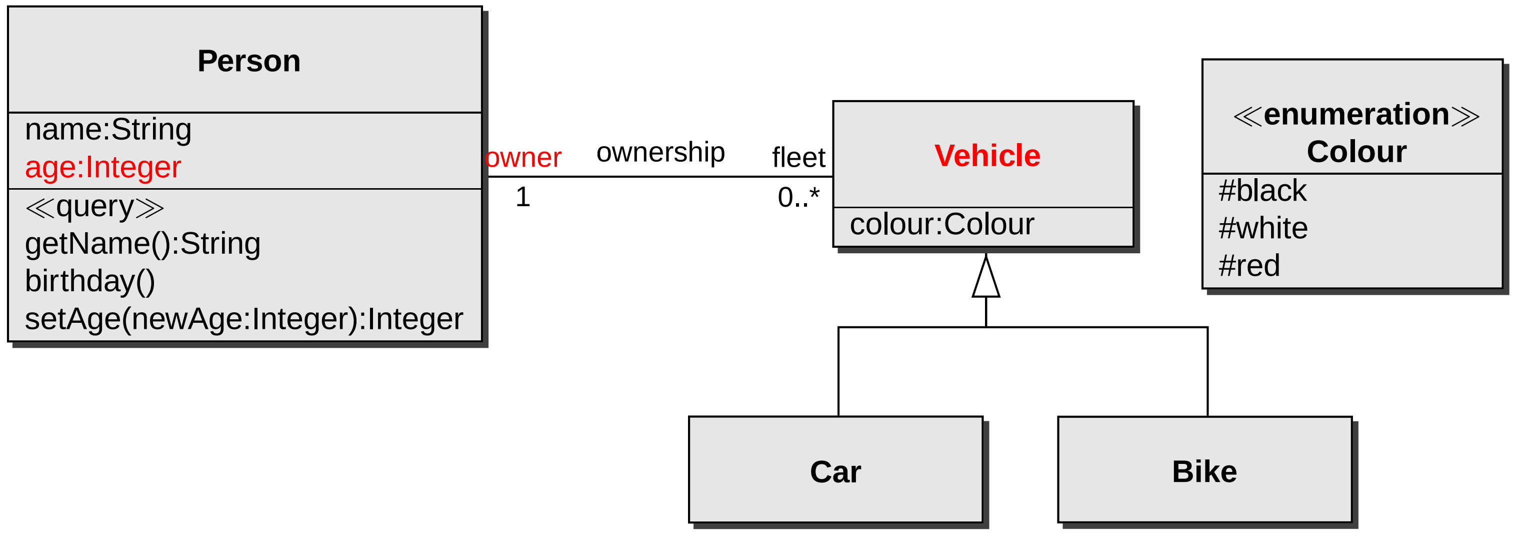


“A vehicle owner must be at least 18 years old”:

```
context    Vehicle
inv:       self. owner. age >= 18
```

Some OCL examples I



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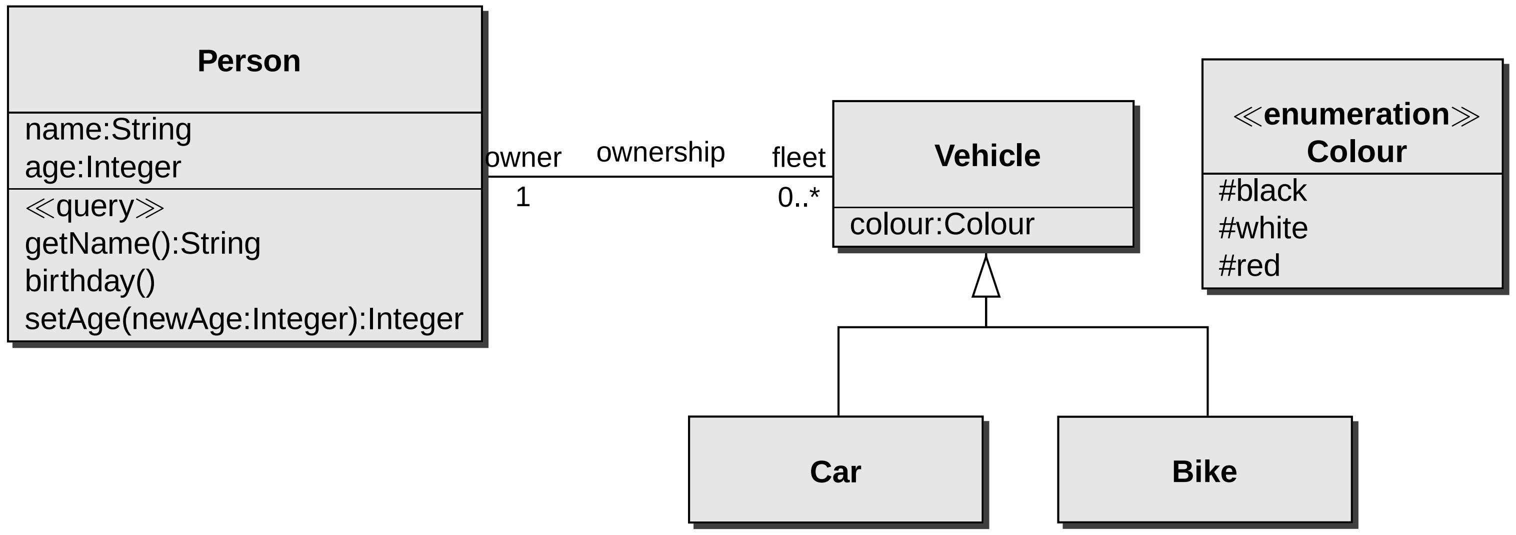

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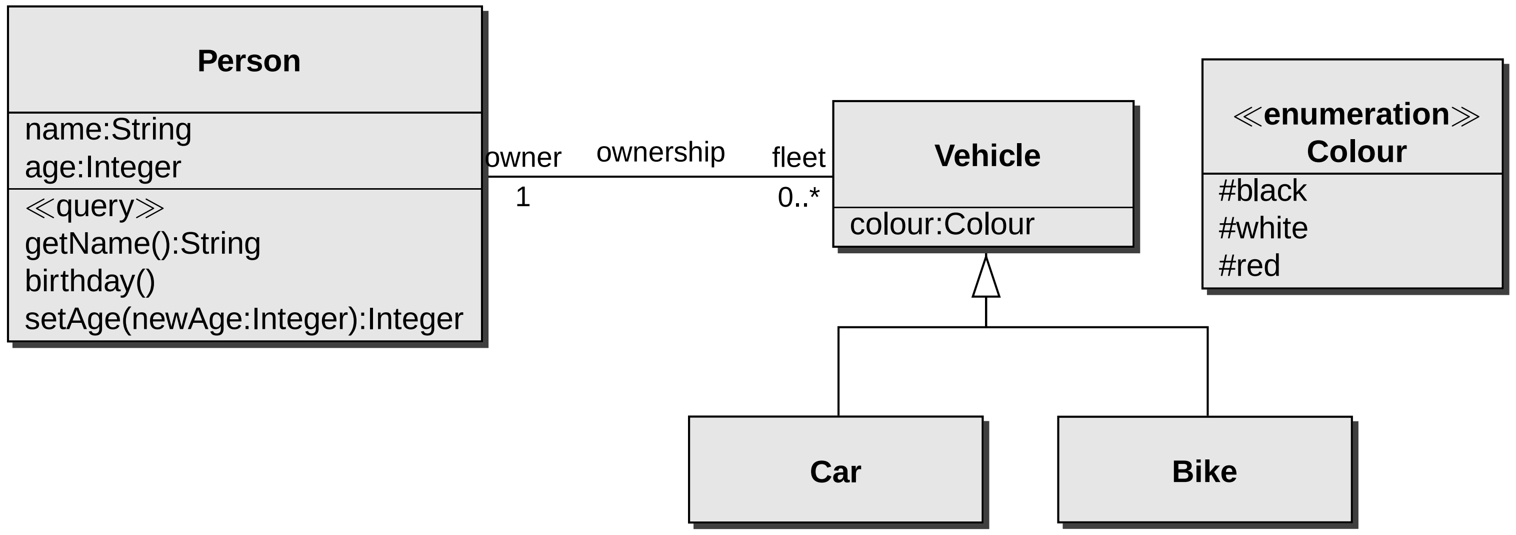


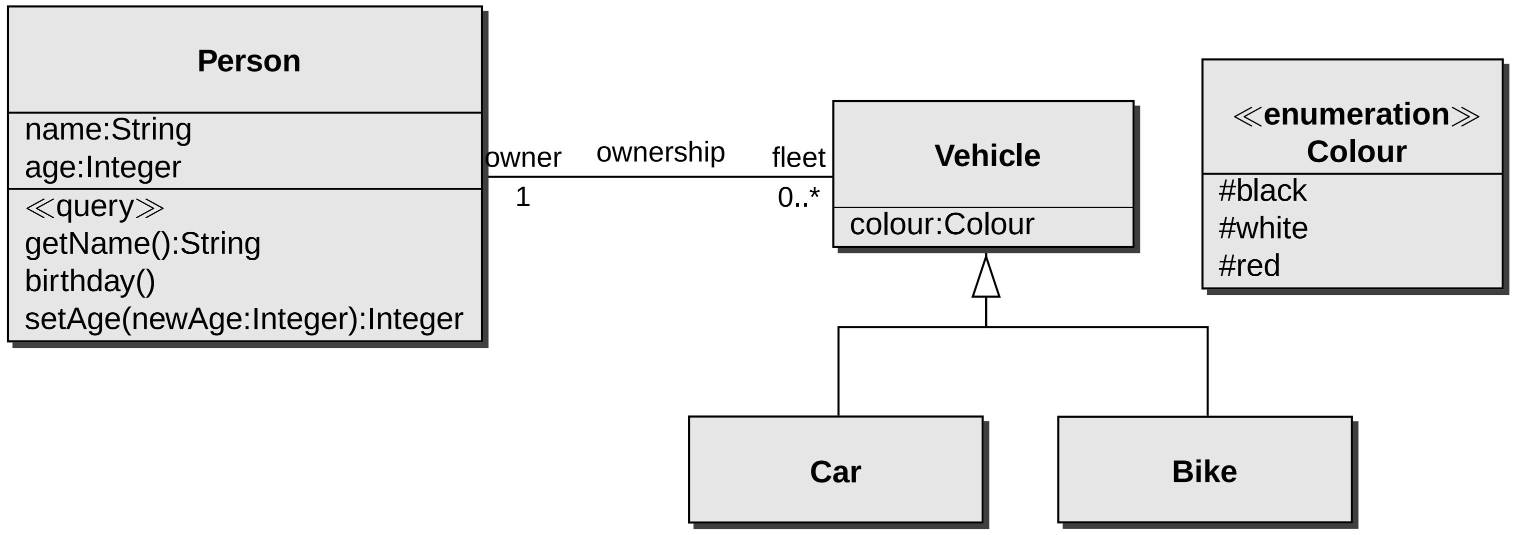
“A vehicle owner must be at least 18 years old”:

context Vehicle
inv: self. owner. age $>=$ 18

What does this mean, instead?

context Person
inv: self.age $>=$ 18

Some OCL examples I



“A vehicle owner must be at least 18 years old”:

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“A car owner must be at least 18 years old”:

context **Car**
inv: **self.owner.age $>=$ 18**

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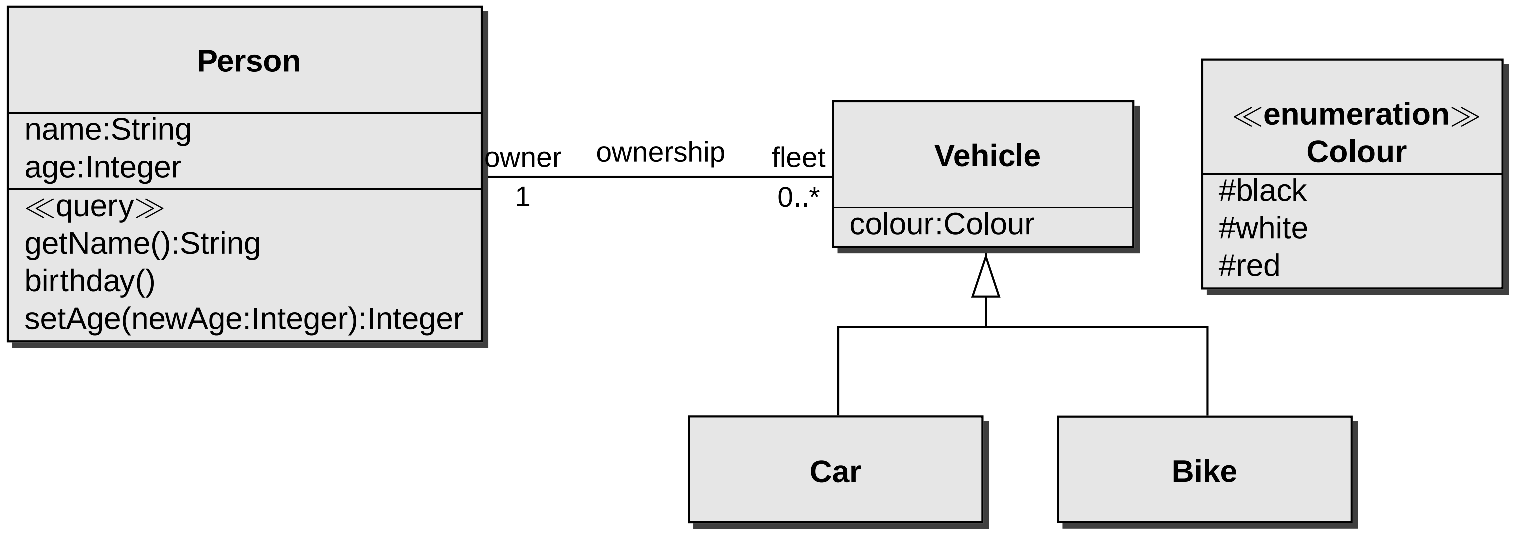

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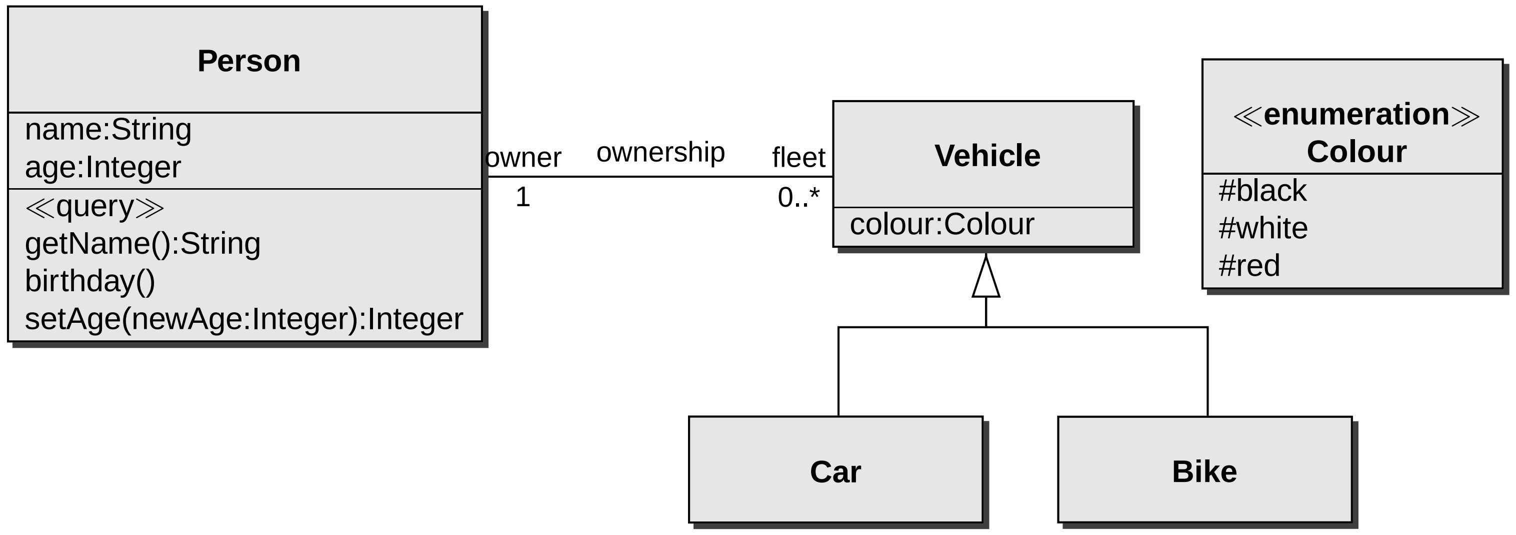
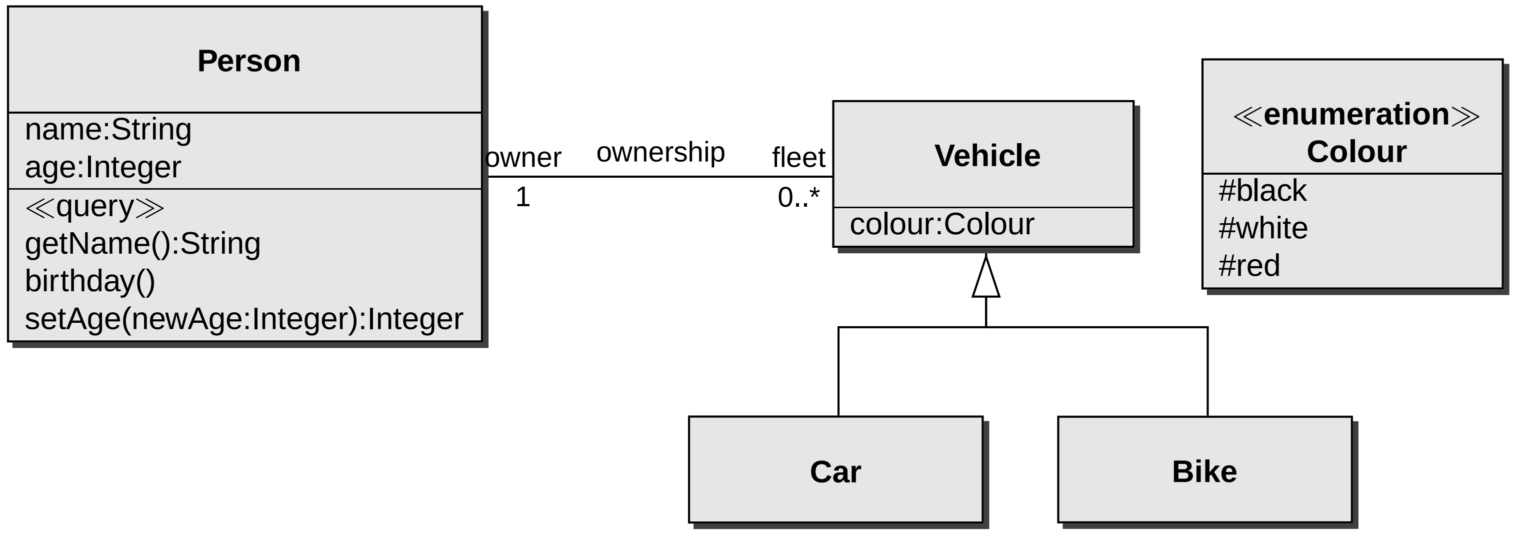


“Nobody has more than 3 vehicles”:

Some OCL examples II

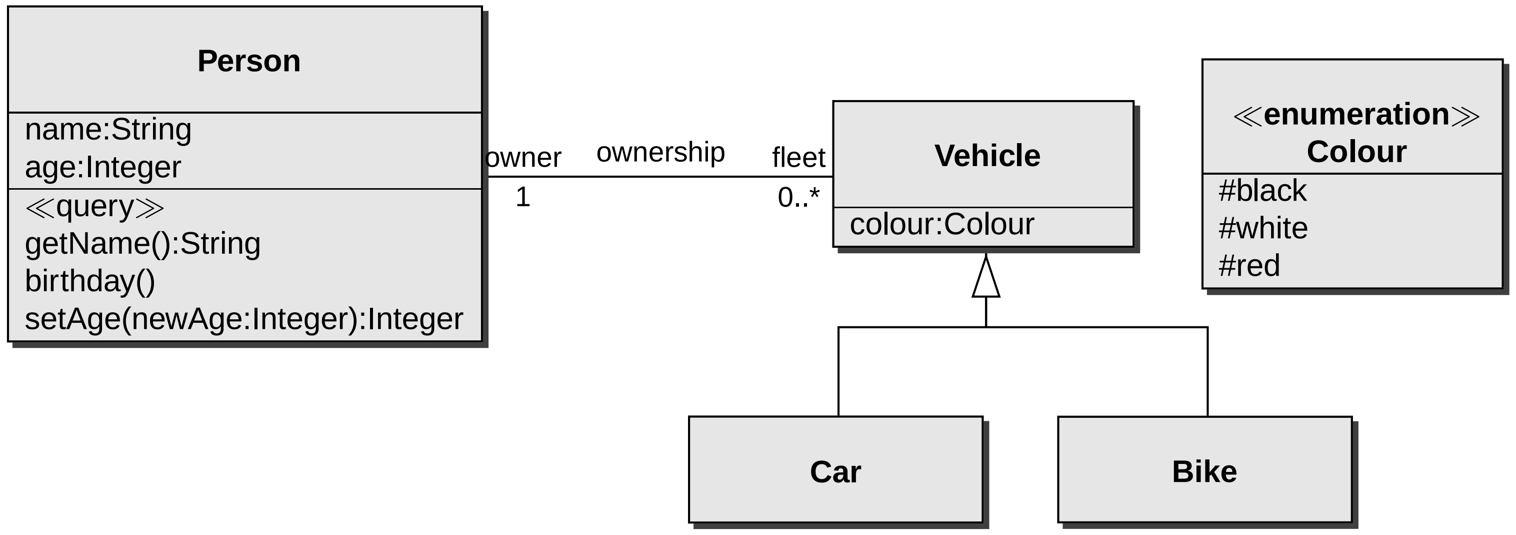


“Nobody has more than 3 vehicles”:

context Person
inv: self.fleet–>size <= 3

or change multiplicity

Some OCL examples II



“All cars of a person are black”:

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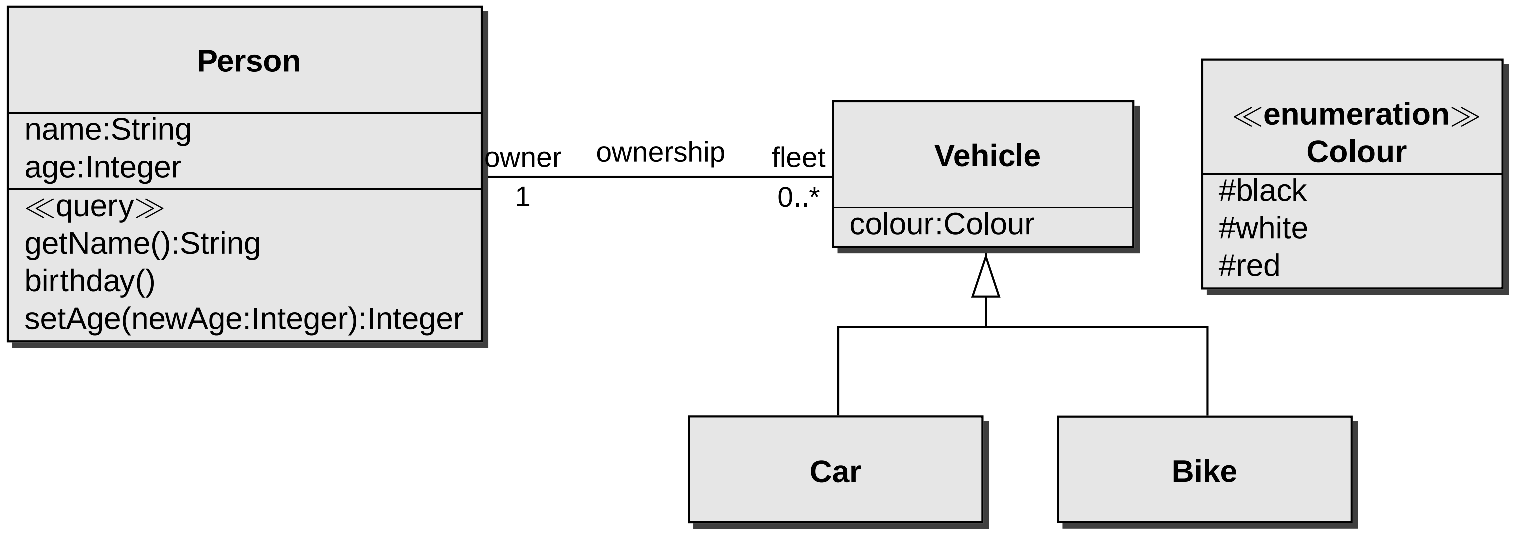

“All cars of a person are black”:

```
context   Person
inv:      self.fleet->forAll(v | v.colour = #black)
```

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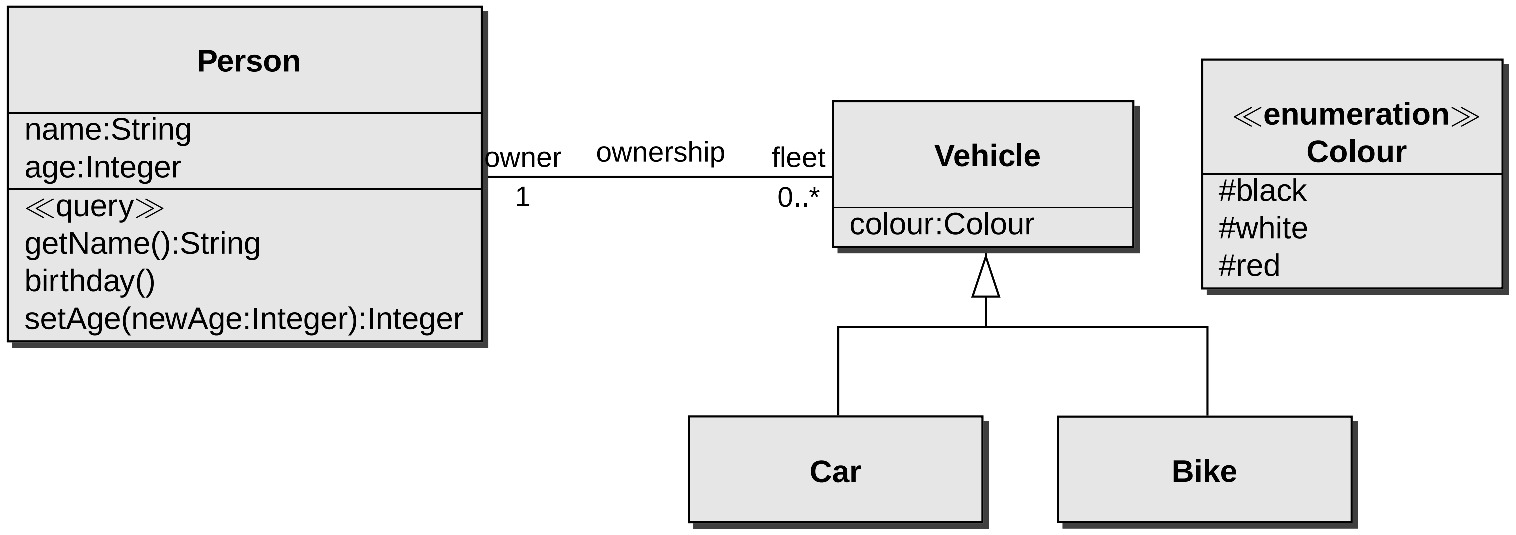

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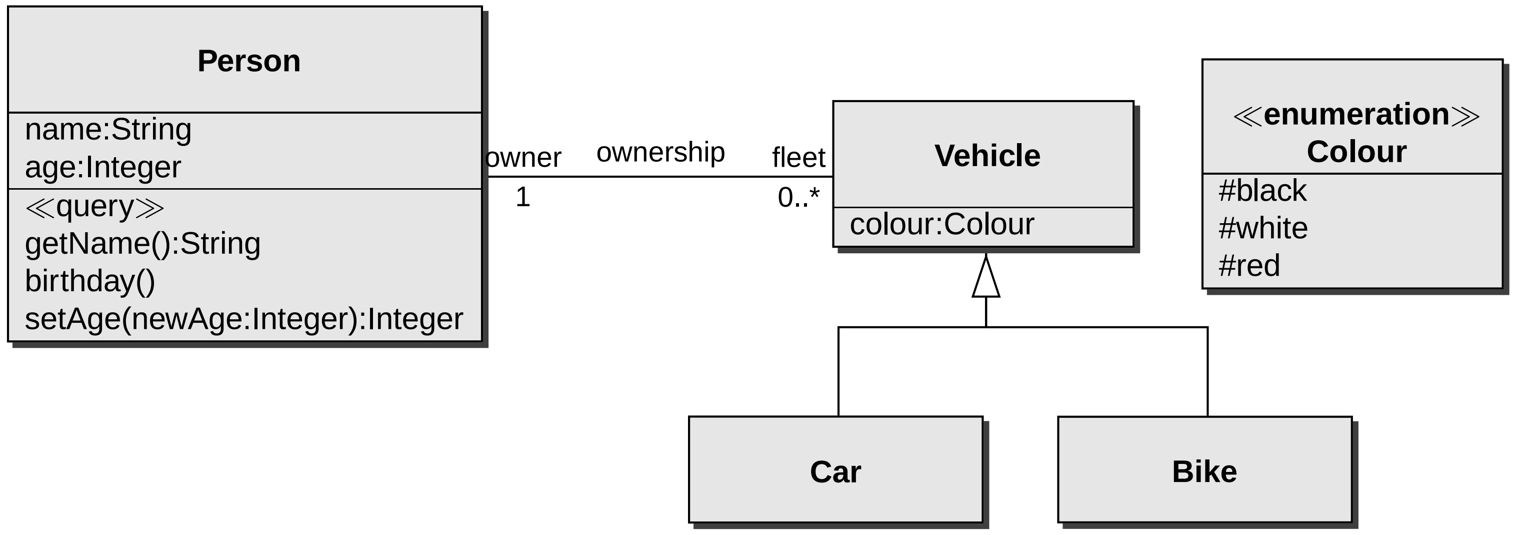


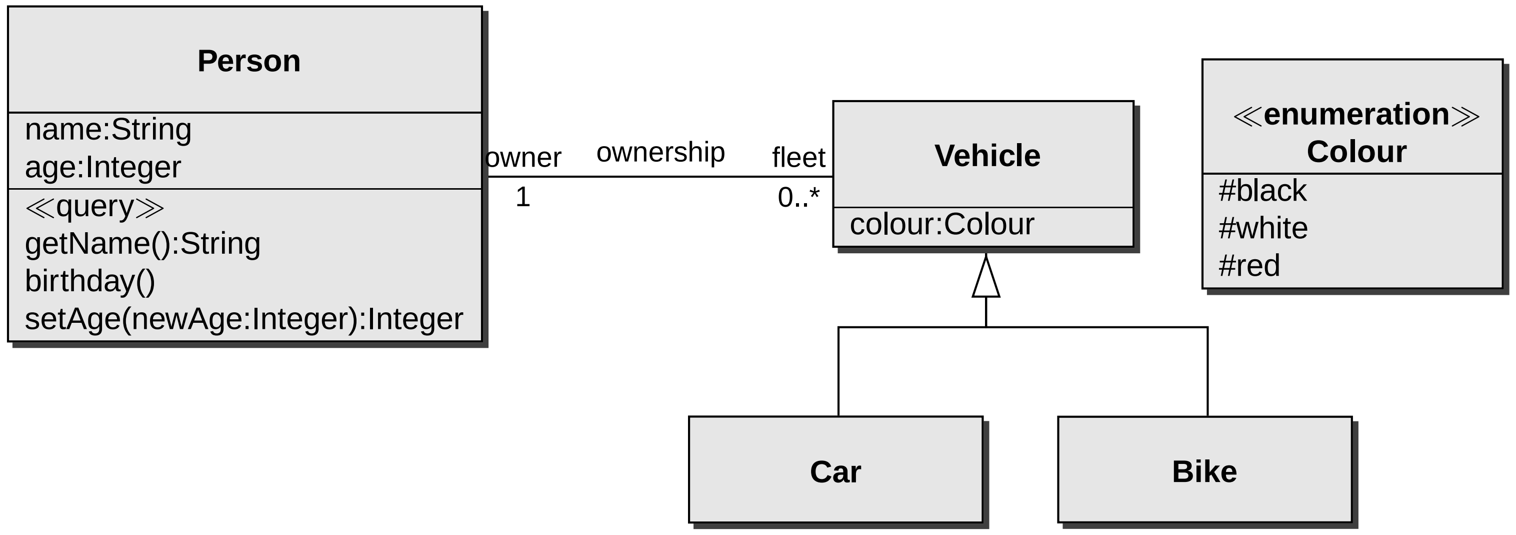
“All cars of a person are black”:

context Person
inv: self.fleet–>forAll(v | v.colour = #black)

“Nobody has more than 3 black vehicles”:

context Person
inv: self.fleet–>select(v | v.colour = #black)–>size <= 3

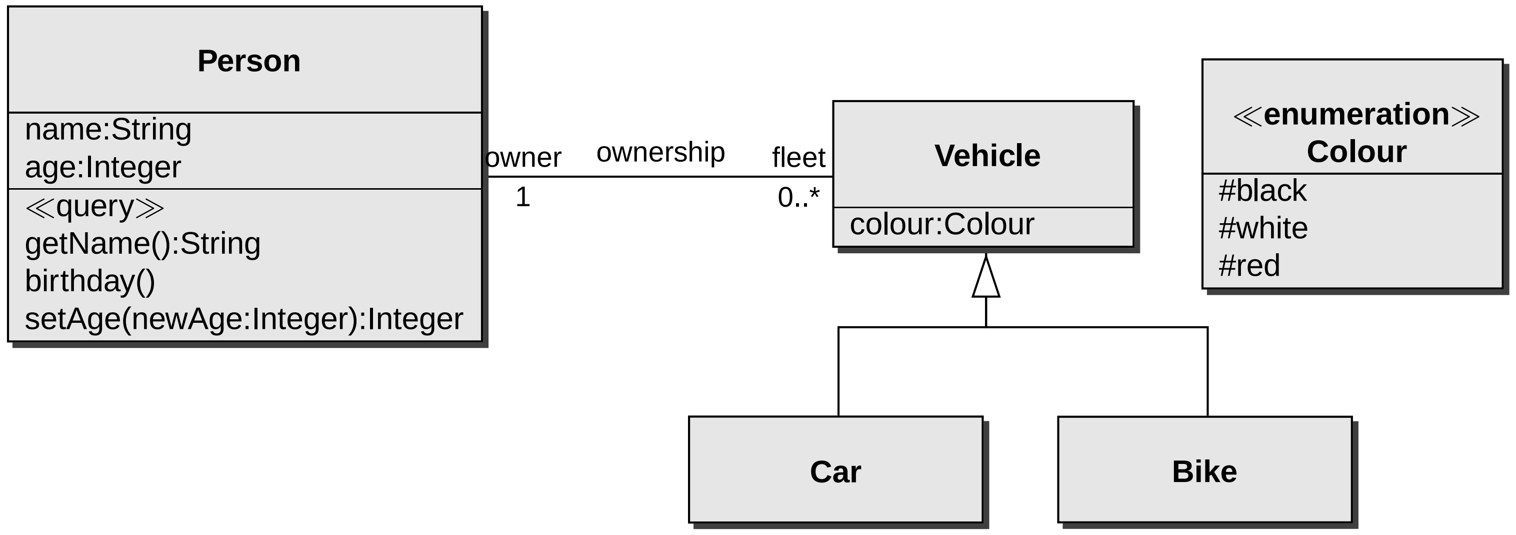
Some OCL examples III — iterate



What does it mean?

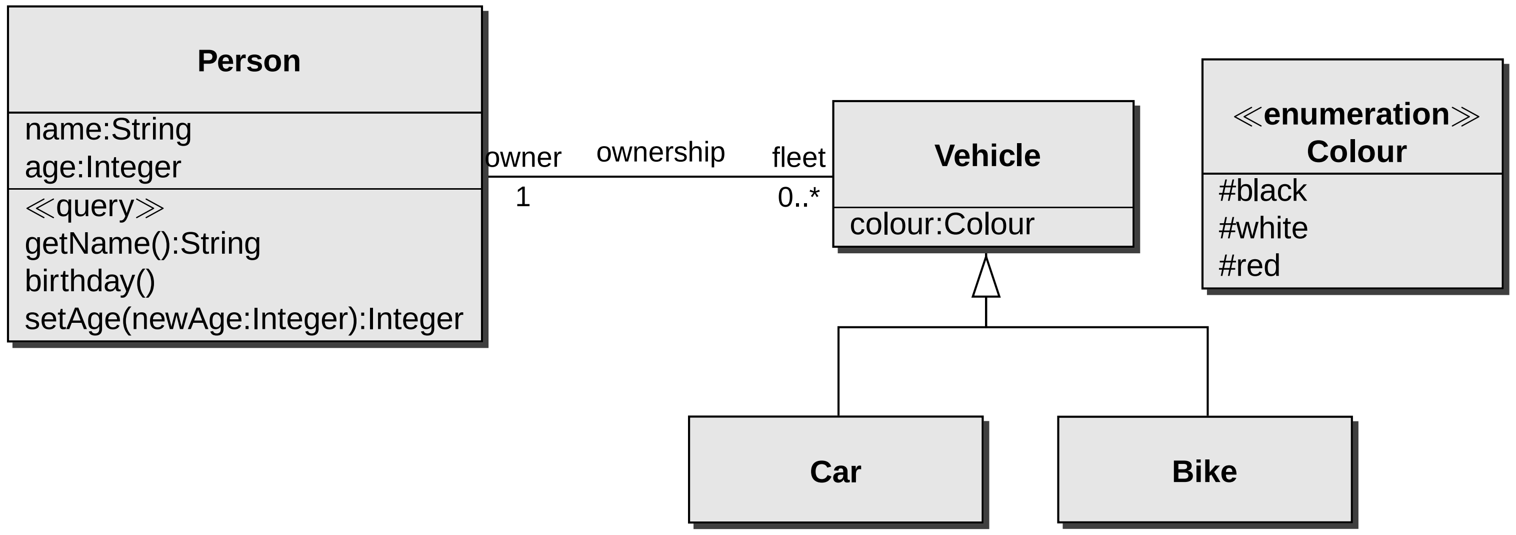
```
context    Person
inv:       self.fleet–>iterate(v; acc:Integer=0
                          | if (v.colour=#black)
                          then acc + 1 else acc endif) <=3
```

Some OCL examples IV — oclIsKindOf



context **Person**
inv: **age<18 implies self.fleet–>forAll(v | not v.oclIsKindOf(Car))**

Some OCL examples IV — oclIsKindOf



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“A person younger than 18 owns no cars.”

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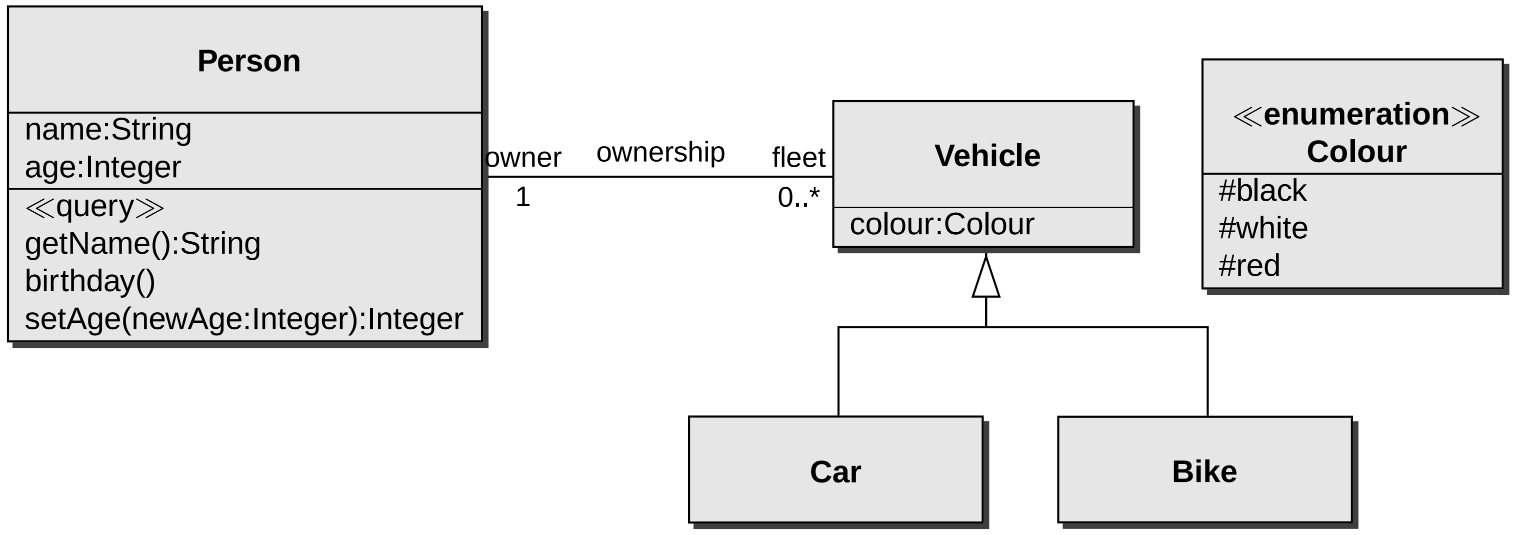

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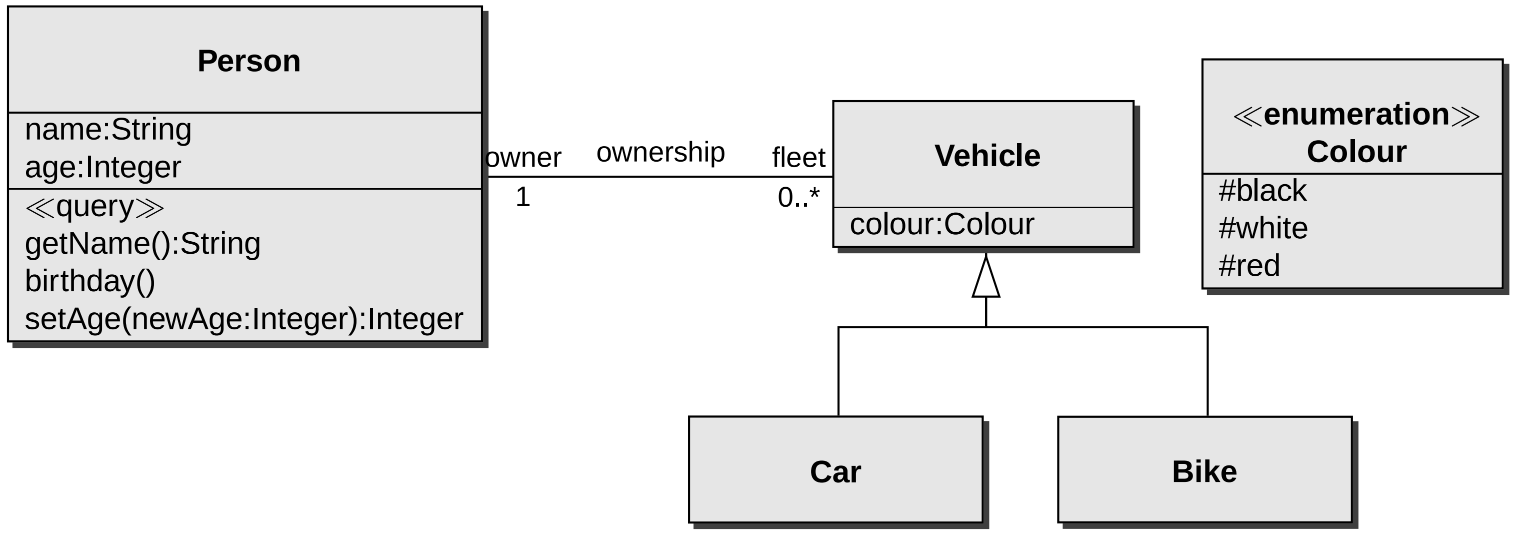

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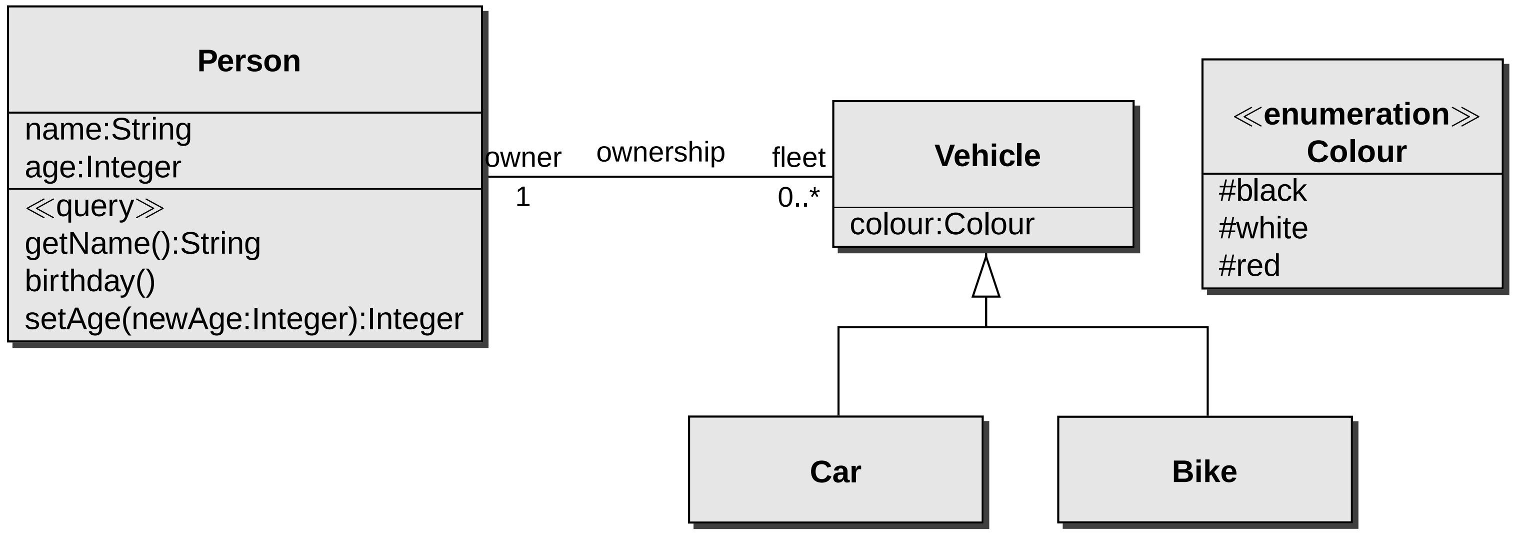
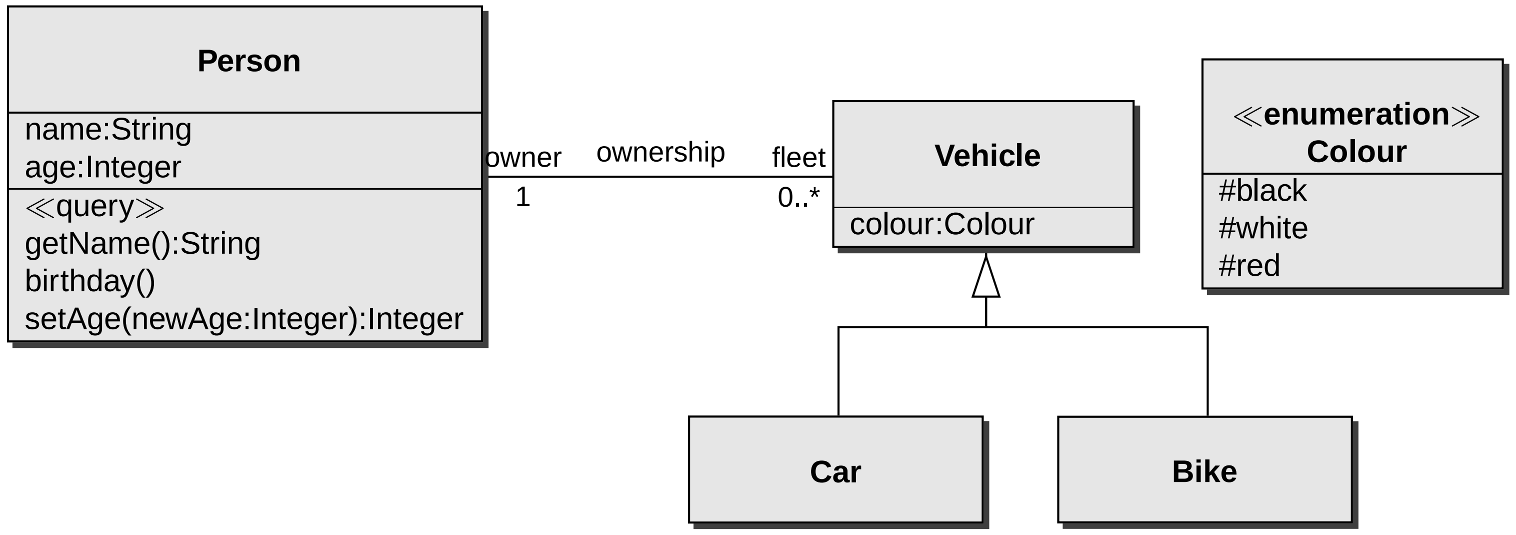
Logical Junctors: and, or, not, implies, if. . . then. . . else. . . endif, =

Some OCL examples V — allInstances



context **Car**
inv: **Car.allInstances()->exists(c | c.colour=#red)**

Some OCL examples V — allInstances



context **Car**
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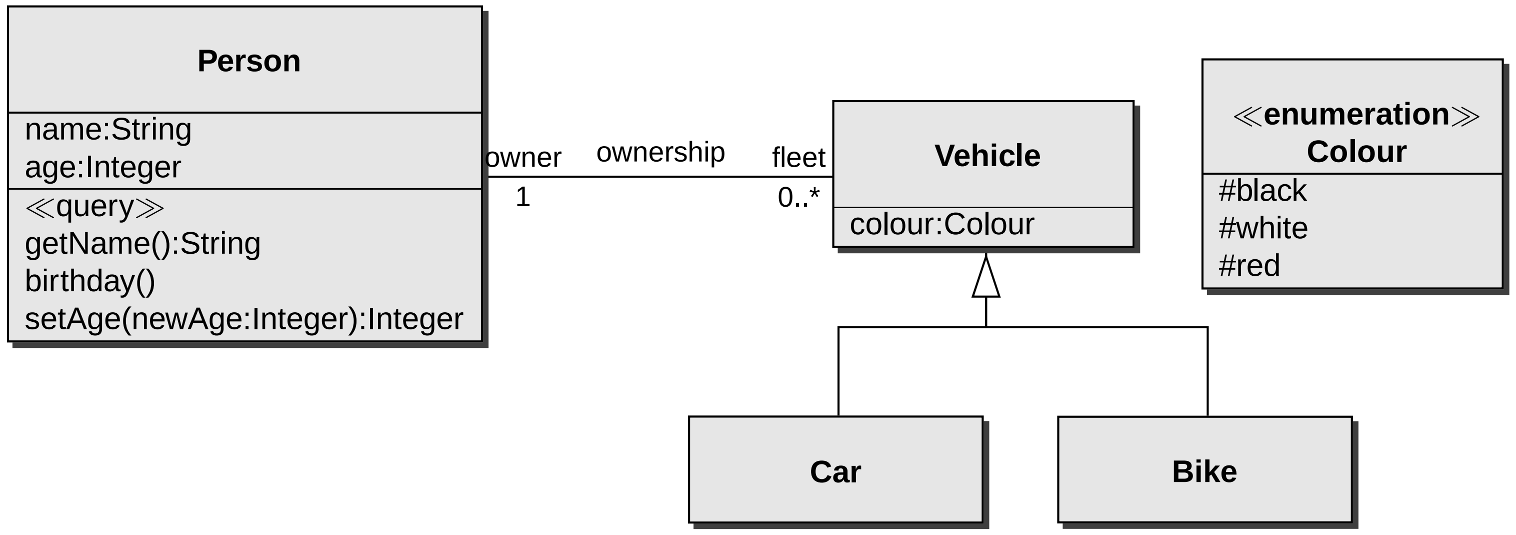
“There is a red car.”

OCL pre-/post conditions — Examples



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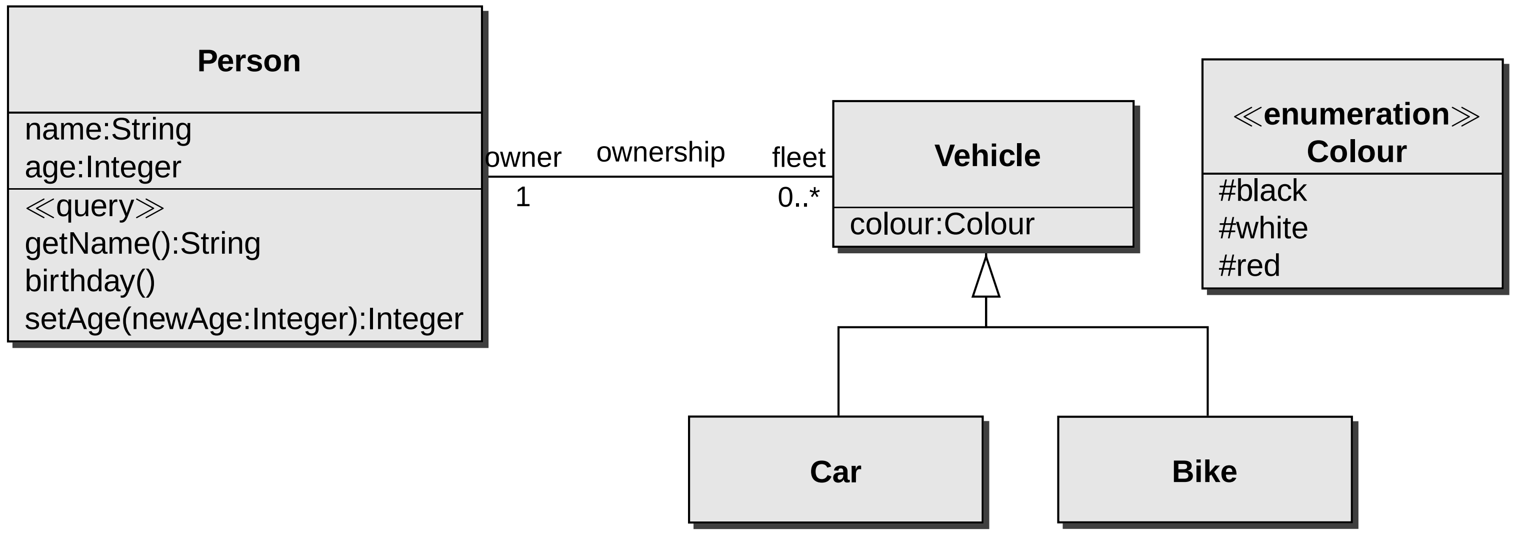

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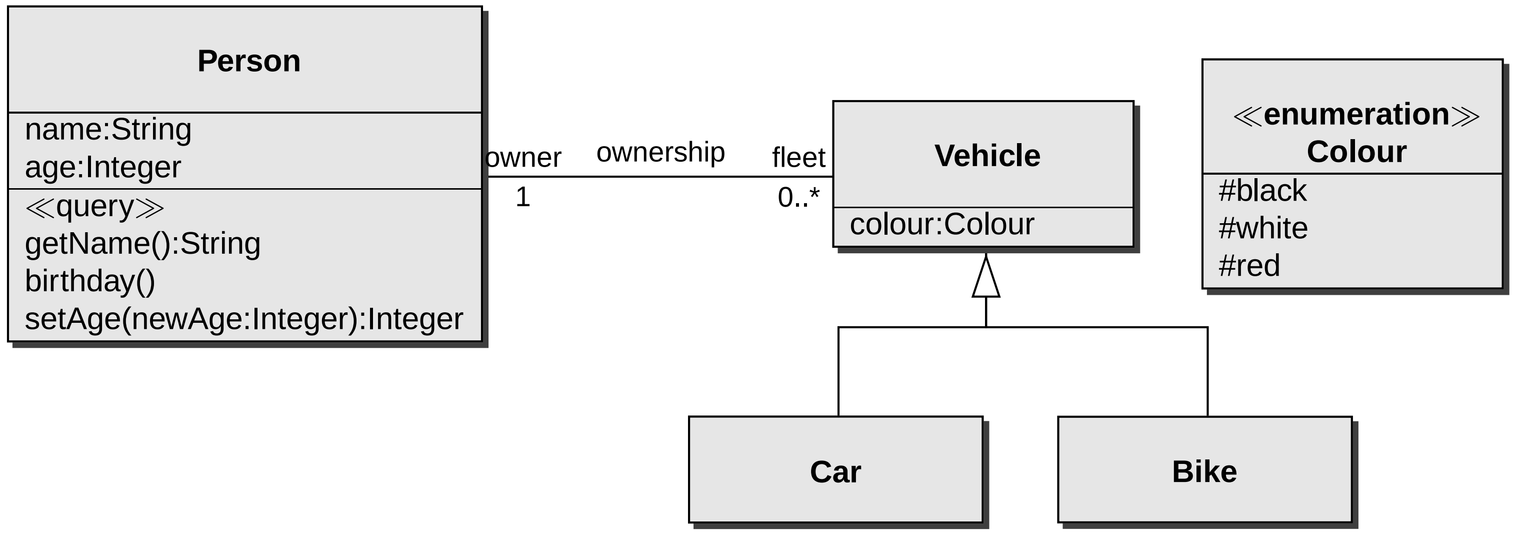

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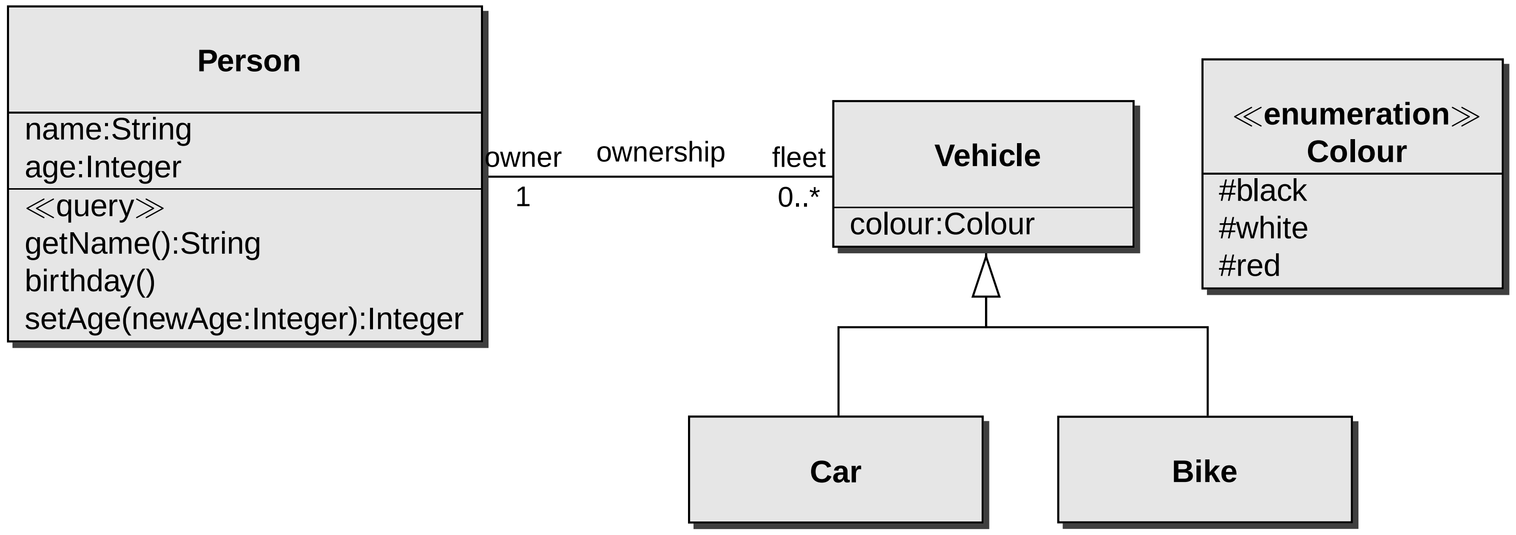
OCL can also specify operations:

“If setAge(. . .) is called with a not negative argument then the argument becomes the new value of the attribute age.”

```
context   Person::setAge(newAge:int)
pre:      newAge >= 0
post:     self.age = newAge
```

OCL pre-/post conditions — Examples



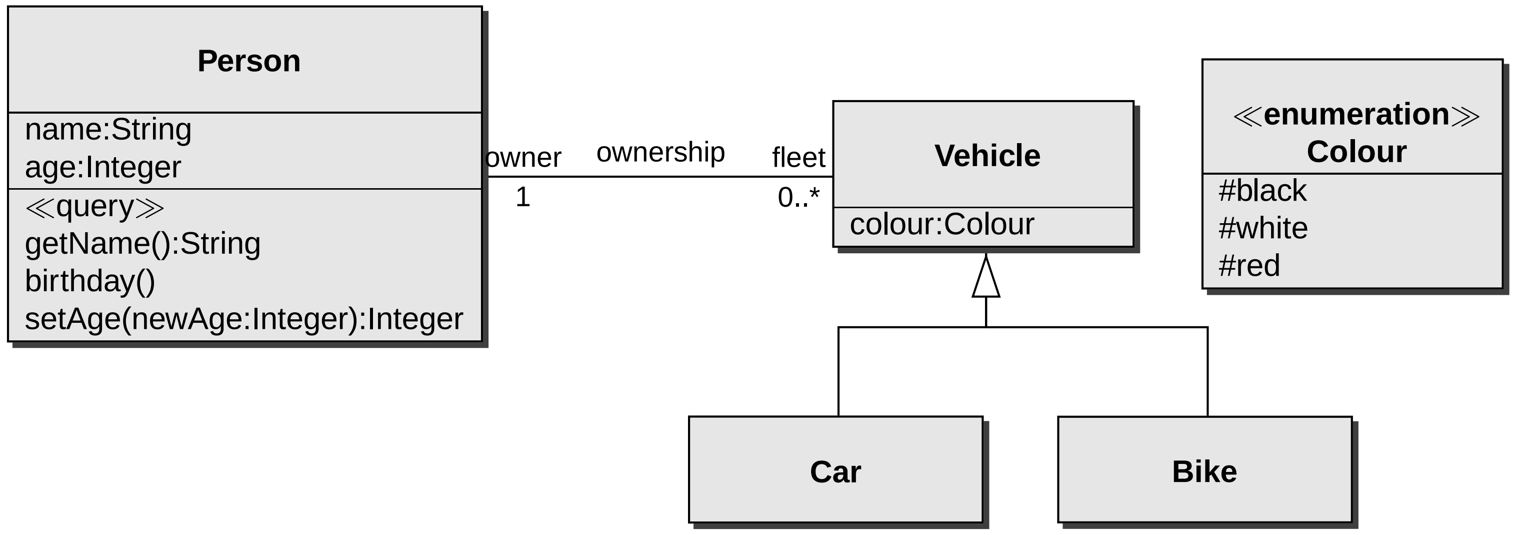
So far only considered class invariants.

OCL can also specify operations:

“Calling birthday() increments the age of a person by 1.”

```
context    Person::birthday()
post:      self.age = self.age@pre + 1
```

OCL pre-/post conditions — Examples



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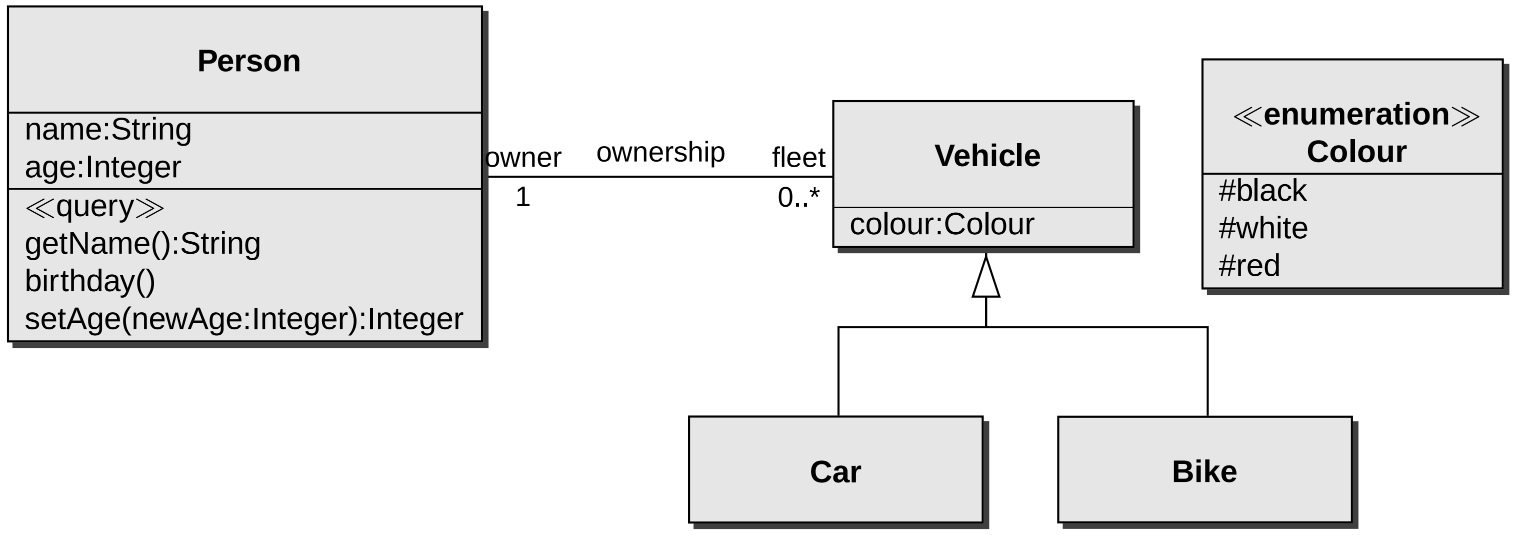
OCL can also specify operations:

"Calling getName() delivers the value of the attribute name."

```
context   Person::getName()
post:     result = name
```

Queries



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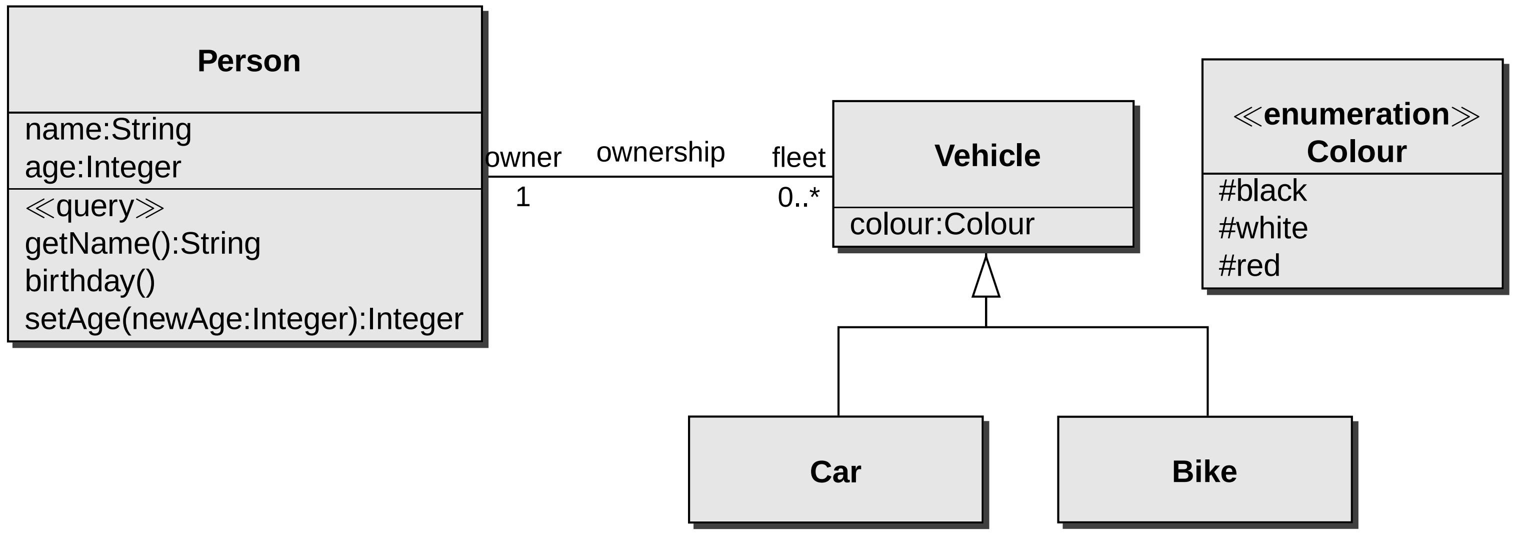

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“Calling getName() delivers the value of the attribute name.”

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inv:      self.getName() = name
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- “context” specifies about which elements we are talking.
- “self” indicates the current object. “result” the return value.

OCL Basics (cont.)

- **OCL can talk about collections (here: sets).**

  Operations on collections: –>

  Example operations: select, forAll, iterate

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- “iterate” can simulate all other operations on collections.

- Queries (= side effect free operations) can be used in OCL expressions.

OCL in TogetherCC/KeY

TogetherCC itself cannot process OCL constraints. It is however possible to specify textual invariants and pre- and post conditions.

With the KeY-extensions to TogetherCC syntax (type) checks of OCL constraints are possible.

System state

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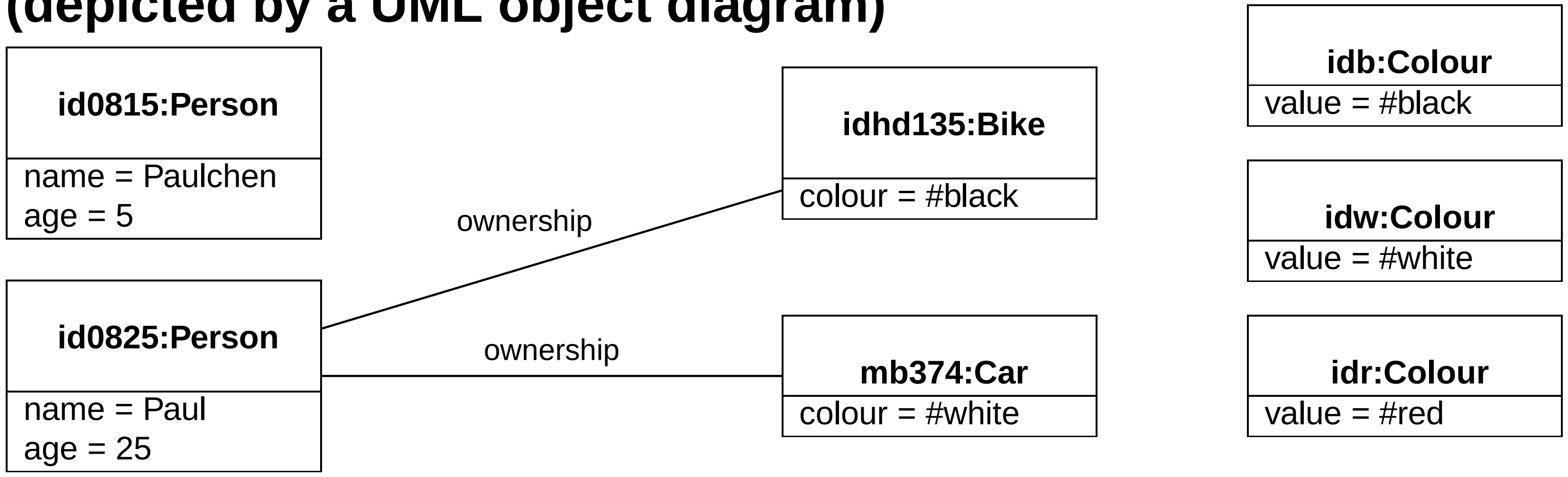
(depicted by a UML object diagram)



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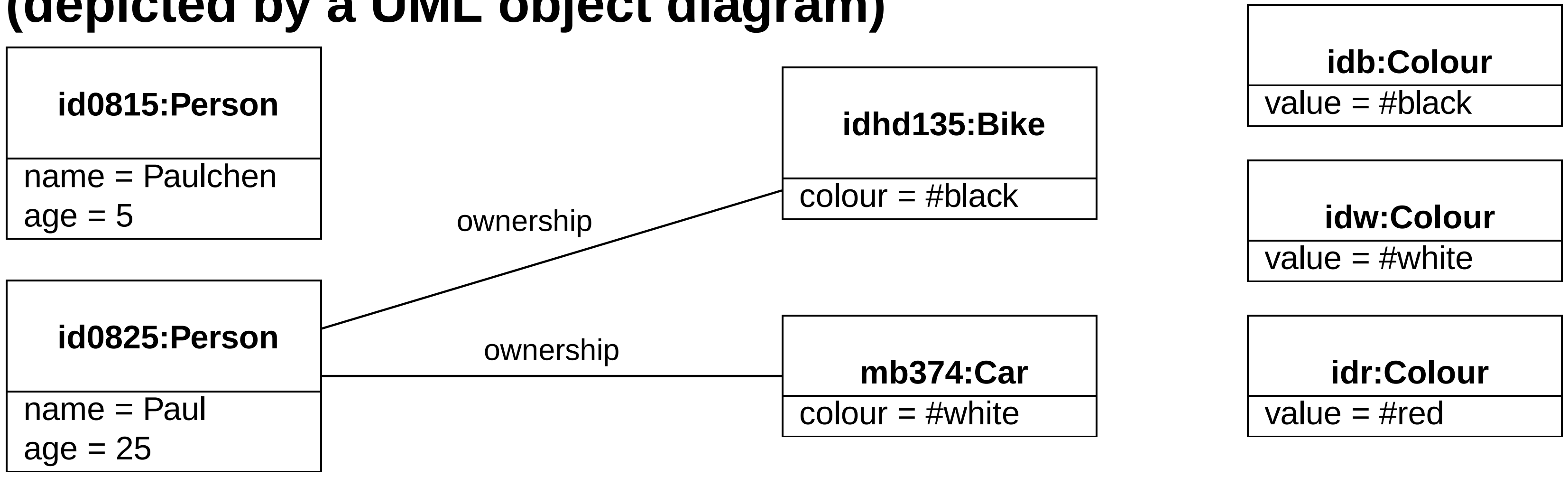

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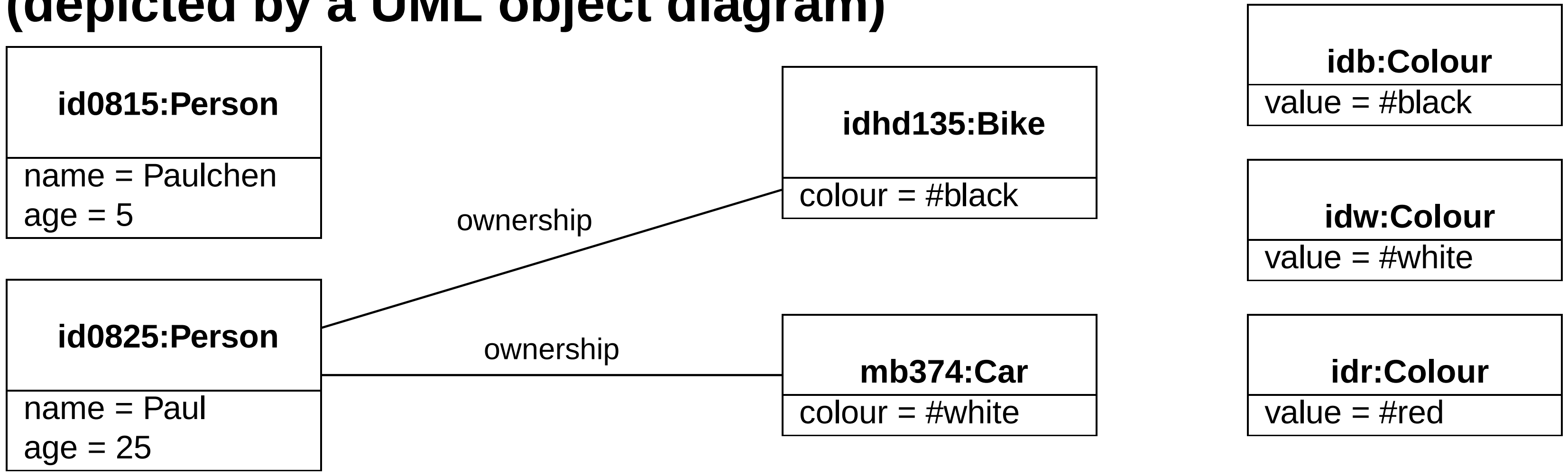

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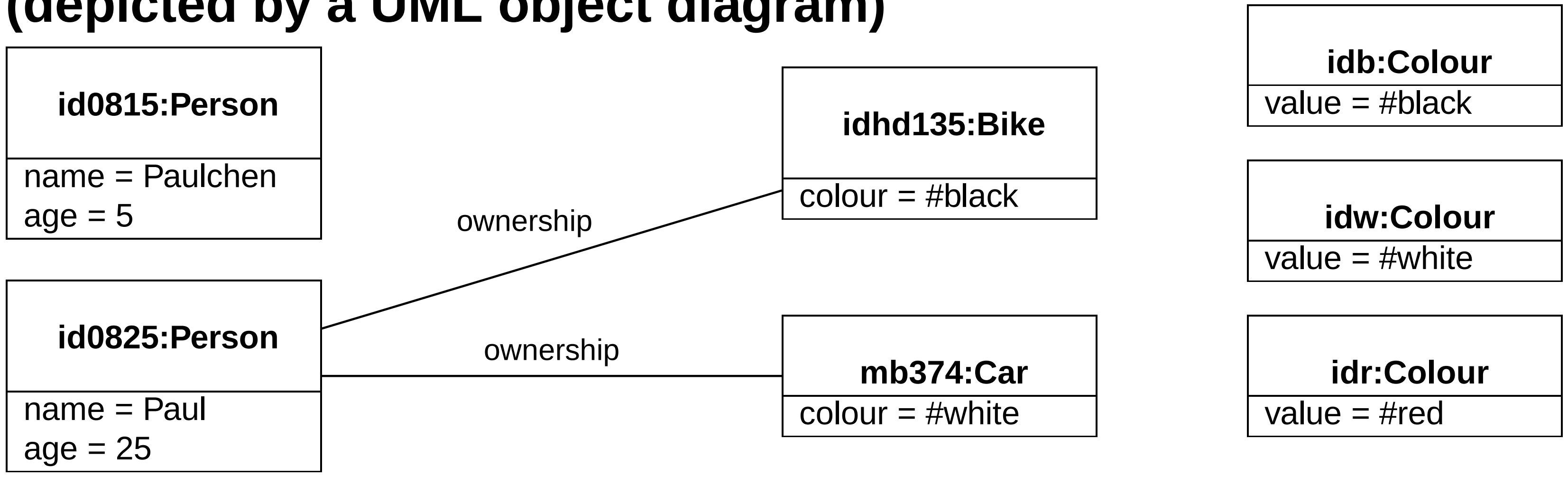

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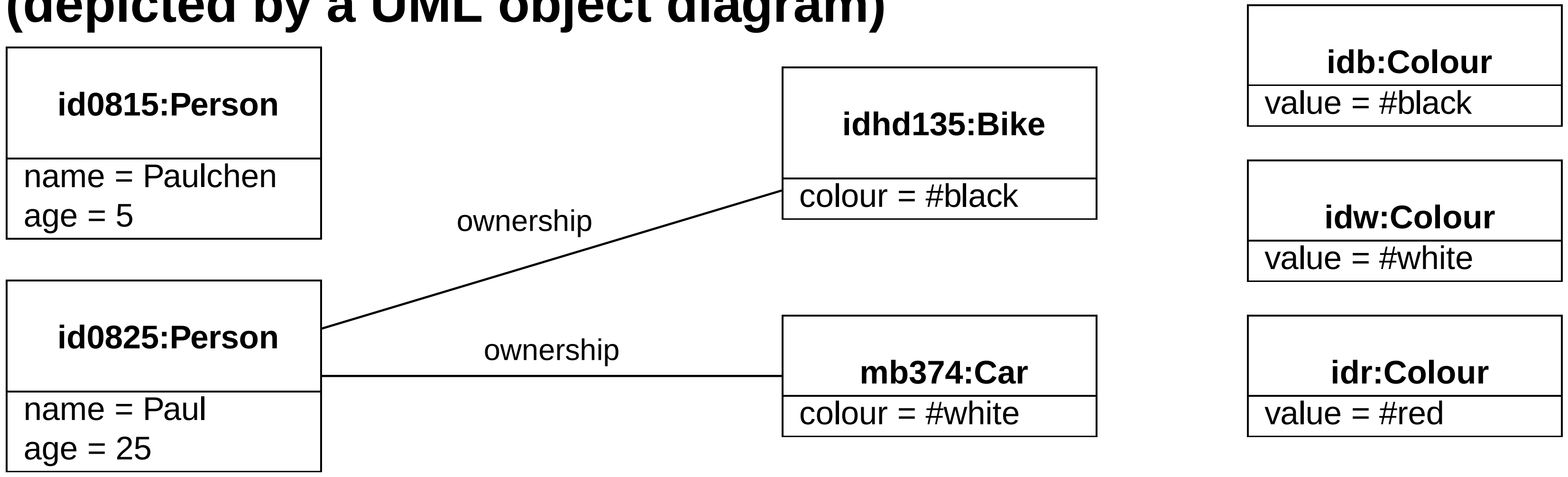

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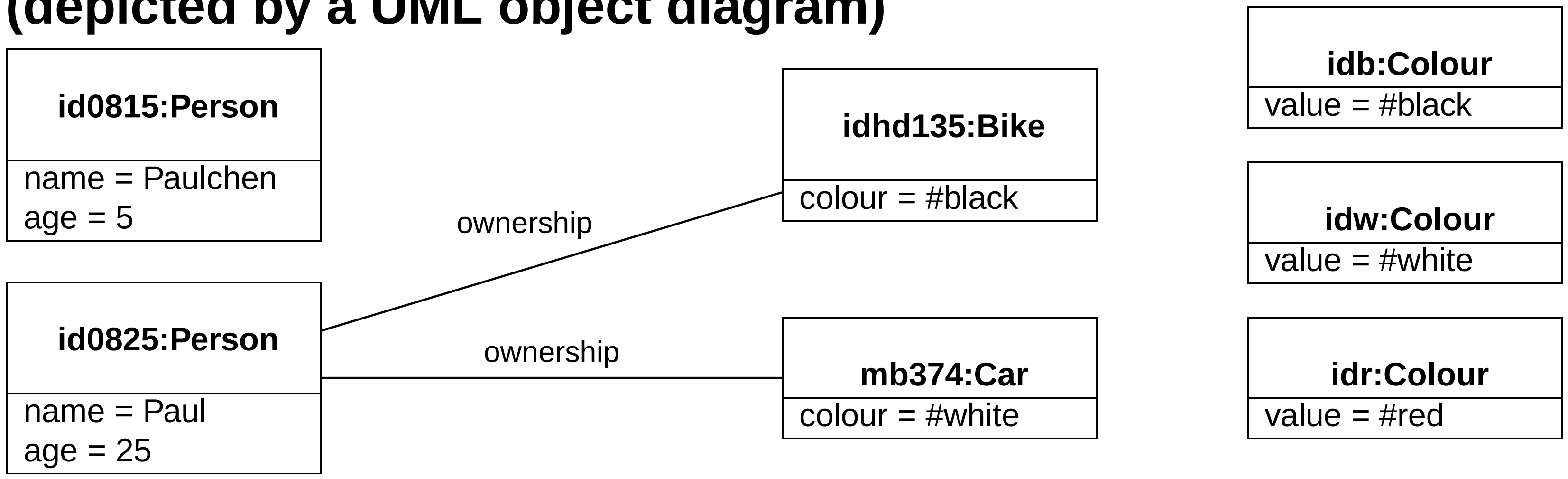

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context **Person**
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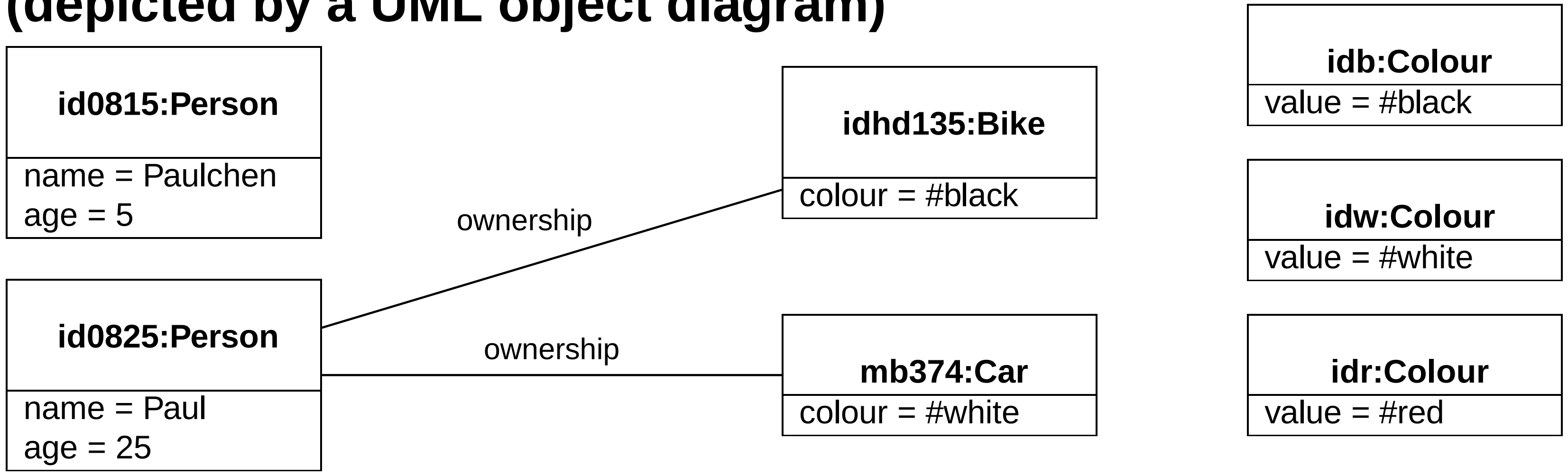

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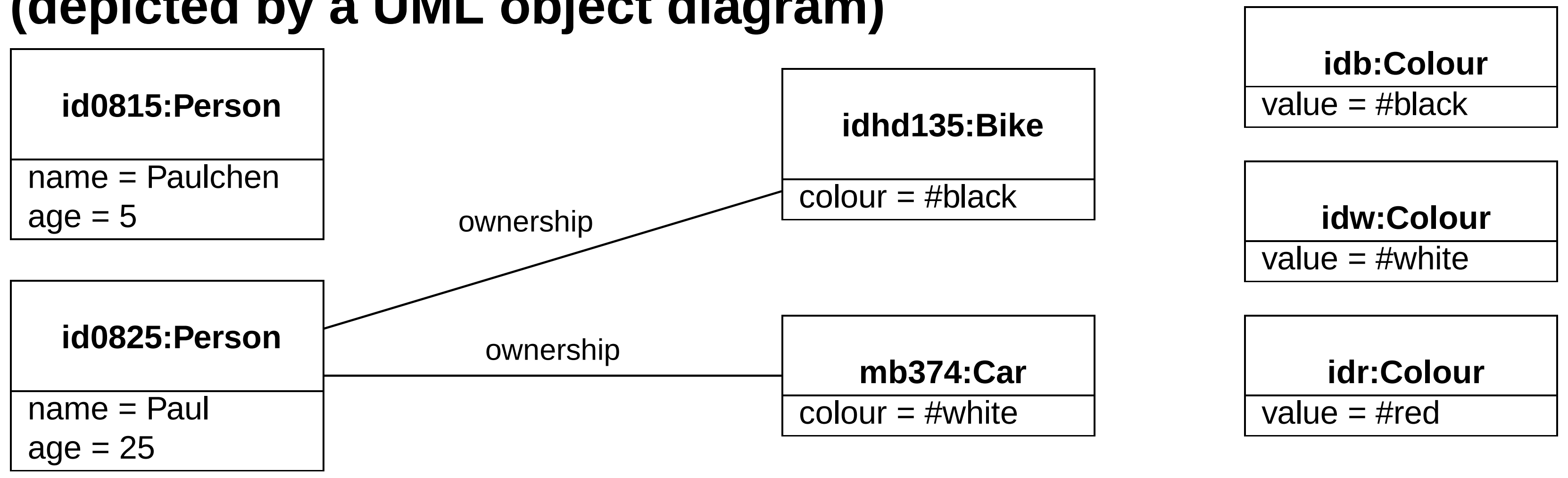

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context **Person**
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inv: **Car.allInstances()–$>$exists(c | c.colour=#red)**

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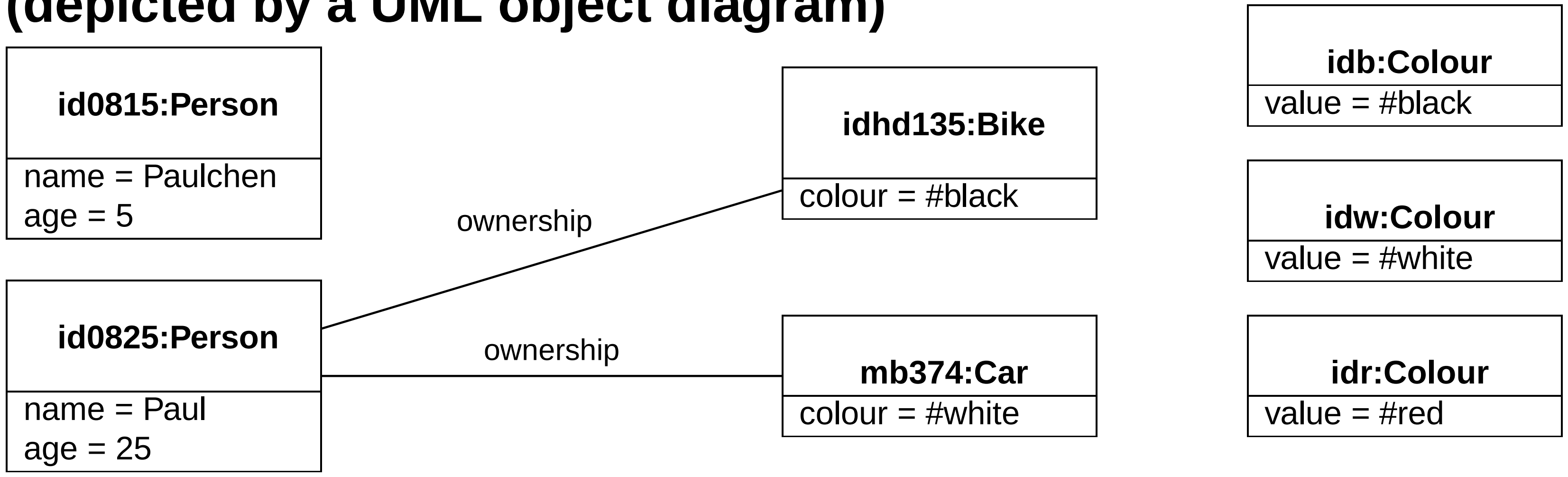

context Vehicle
inv: self.owner.age $>=$ 18 ✓

context Person
inv: self.fleet–$>$forAll(v | v.colour = #black) ☒

context Person
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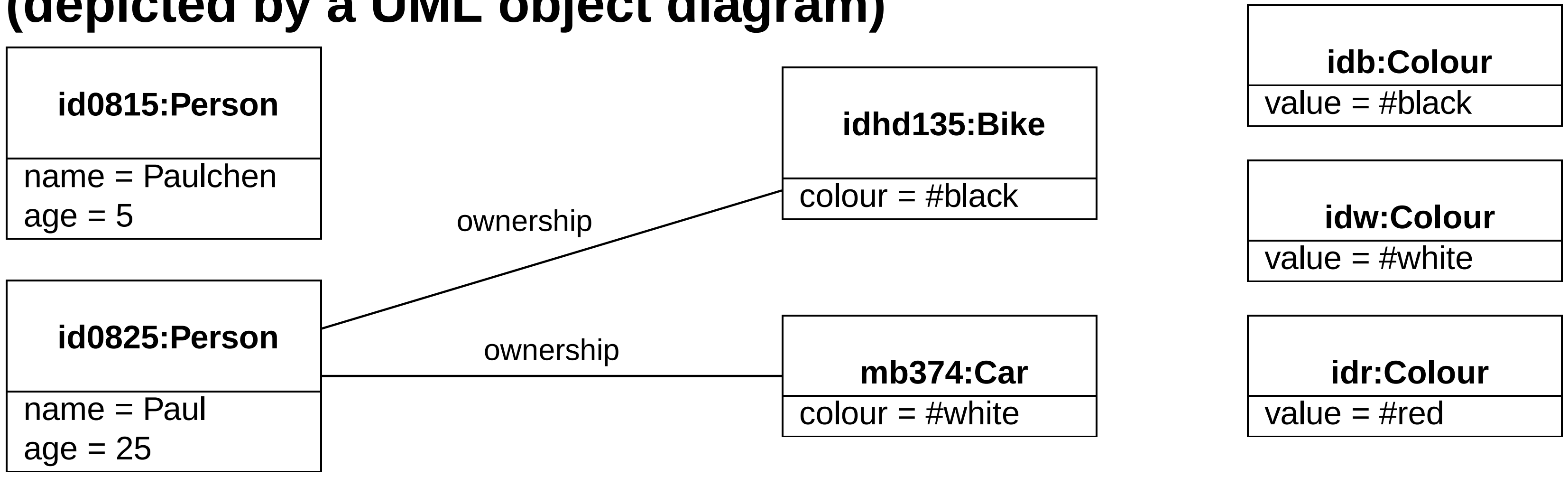

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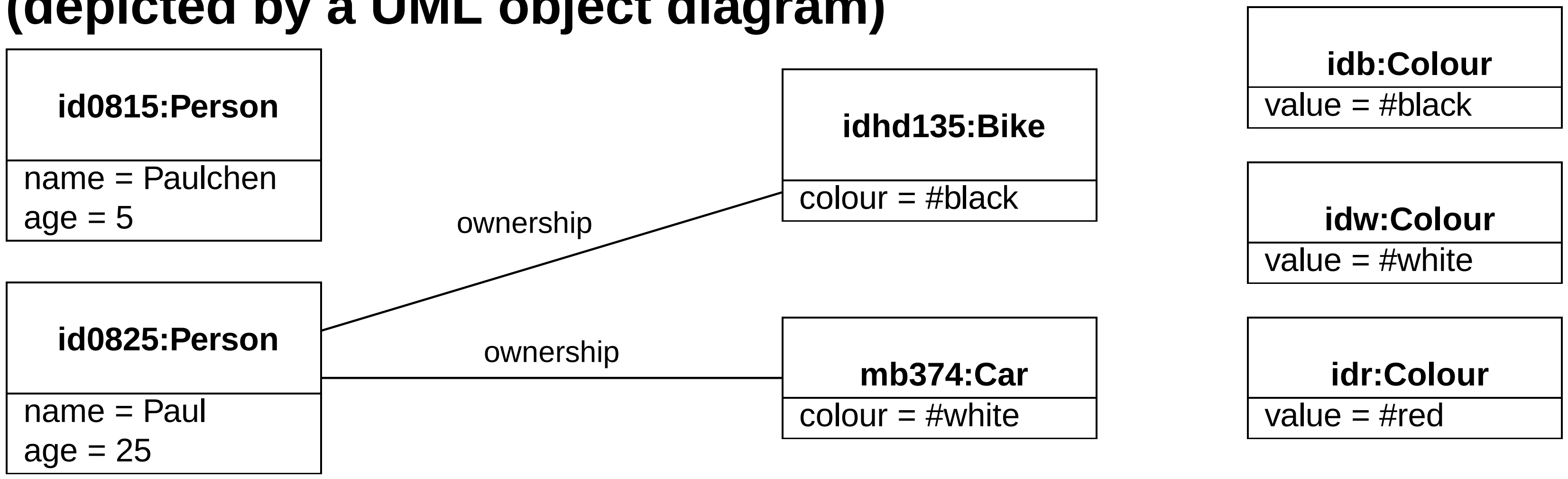

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- a UML object diagram (for the class diagram), giving
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  - attribute-value-assignments
  - instances of associations (“links”)
- an interpretation for operations,
- (standard) interpretation for predefined primitive data types

  (e.g. Integer, String,. . .)

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- Given an implementation of a class diagram, a sequence of system states is reached.
- The interesting question is: How can we check that constraints are satisfied in all system states that are reached by an implementation?

  Answer in three weeks.

Literature

P. Schmitt:

Skript ”Formale Spezifikationssprachen”

Jos Warmer and Anneke Kleppe:

The Object Constraint Language: Precise Modelling with UML.

UML 1.5 OCL Specification.

http://www.omg.org/cgi-bin/apps/doc?ad/03-01-07.pdf

UML 2.0 OCL Revised submission to OMG.

http://www.omg.org/cgi-bin/apps/doc?ad/03-01-07.pdf