Entwicklung objektorientierter Software mit formalen Methoden

Introduction to OCL

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Object Constraint Language

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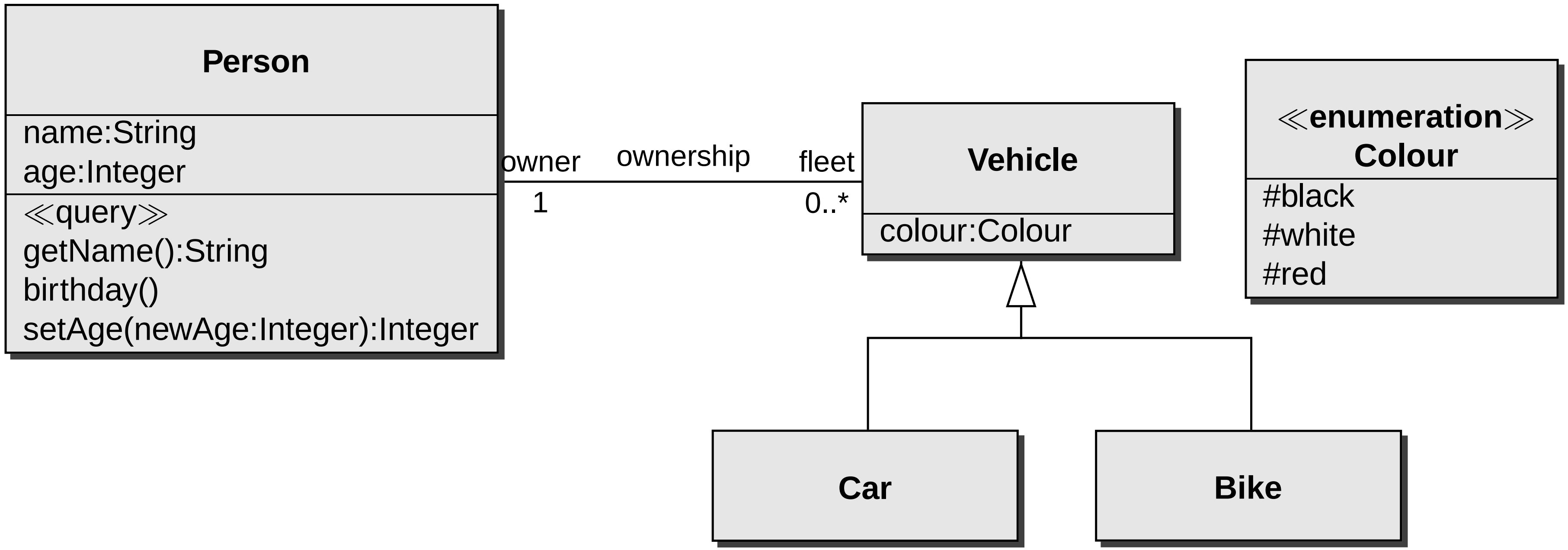
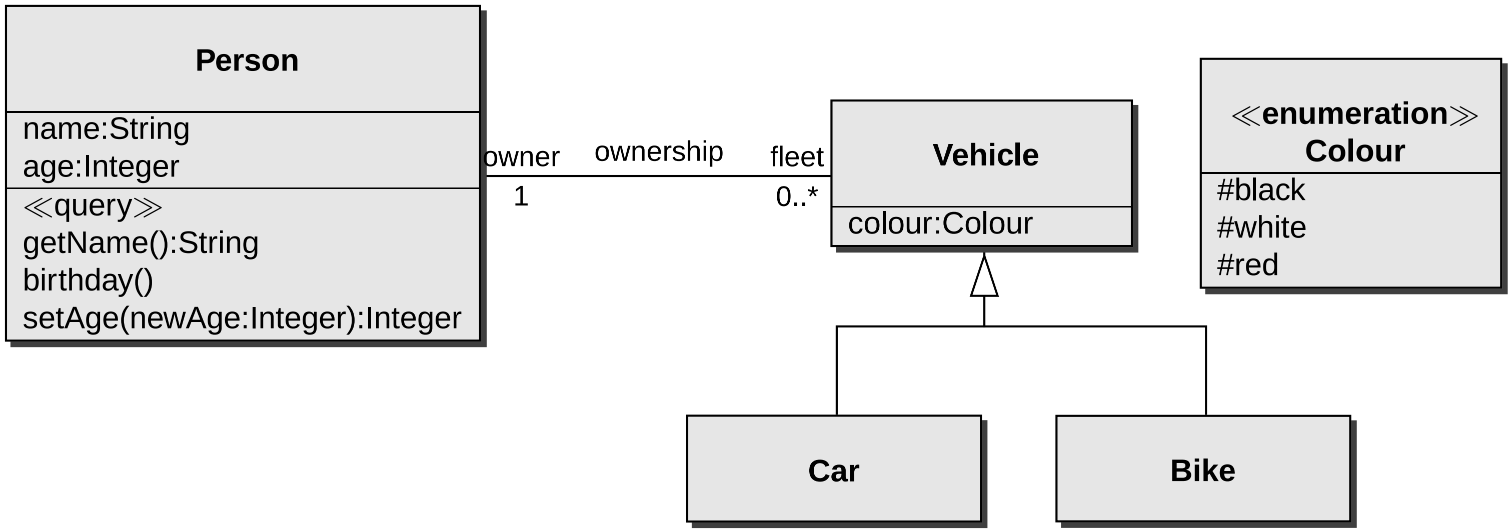
- Why? Because UML is not enough!

UML is not enough…



- **Possible number of owners a car can have**
- **Required age of car owners**
- **Requirement that a person may own at most one black car**

Some OCL examples I



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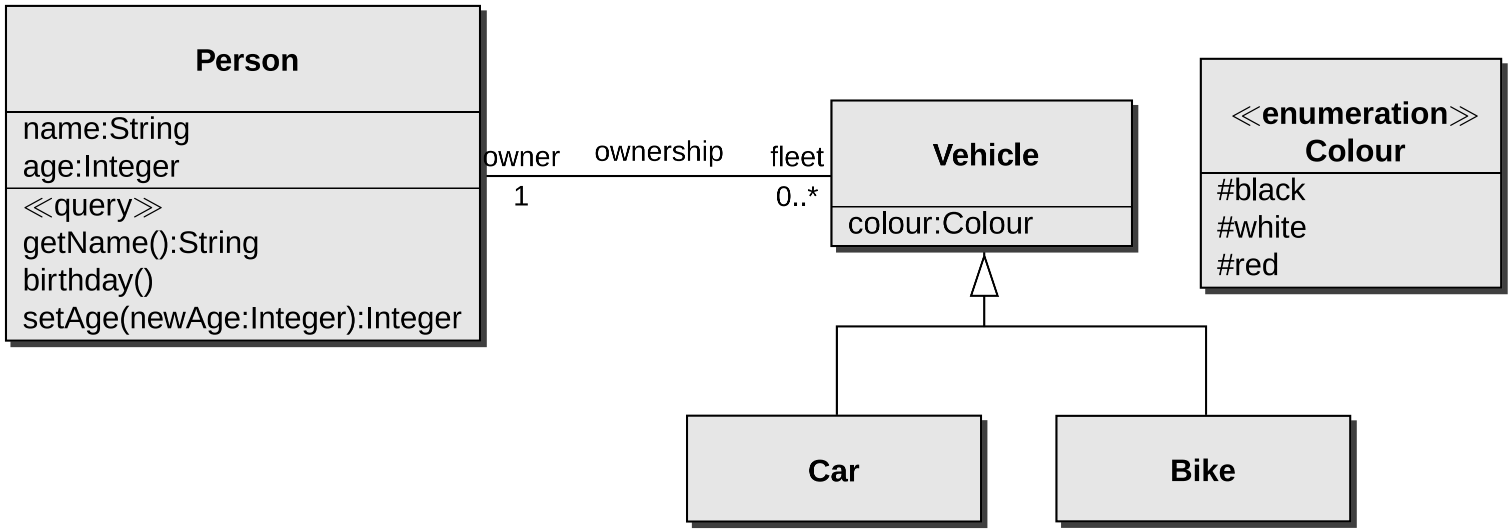

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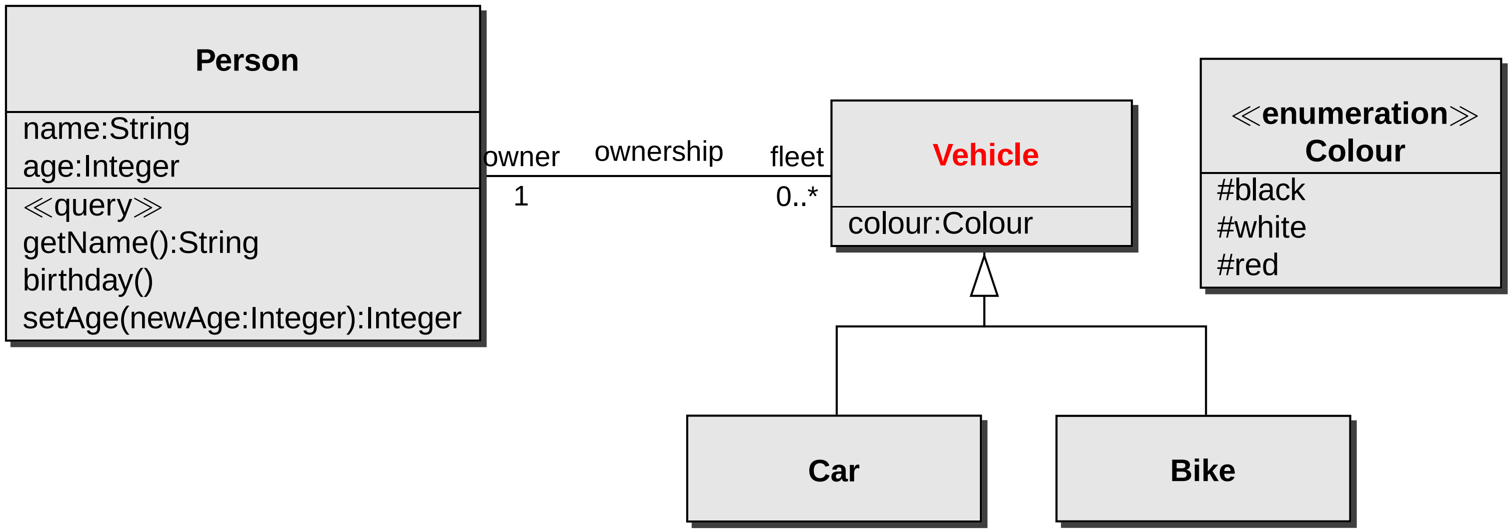

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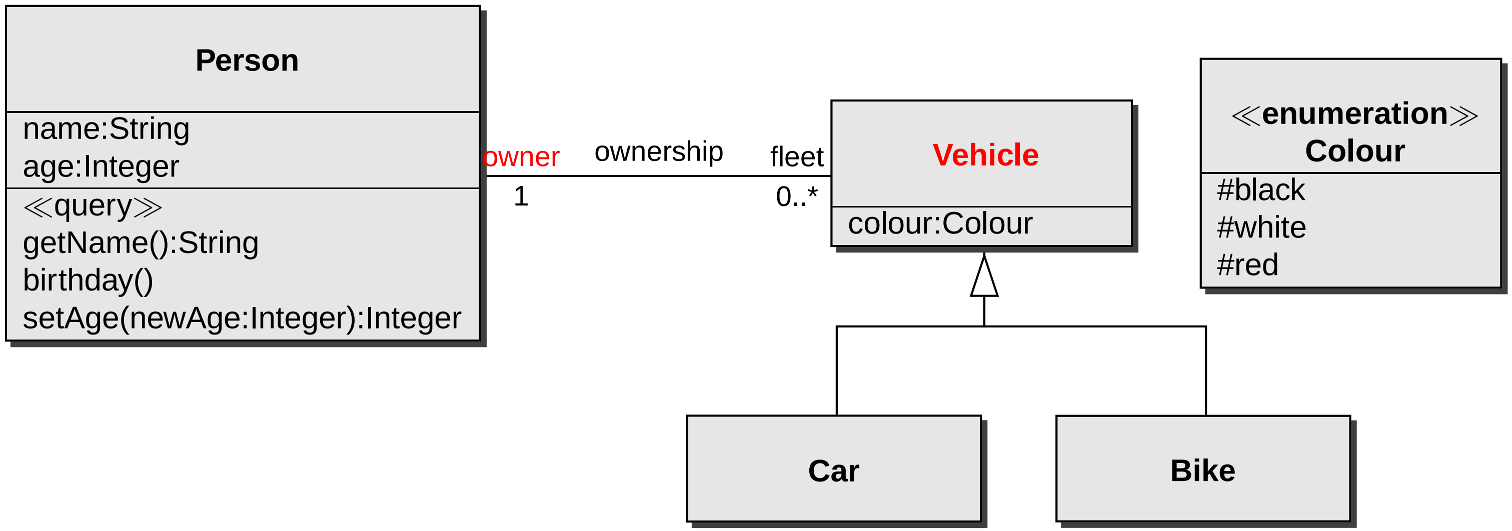

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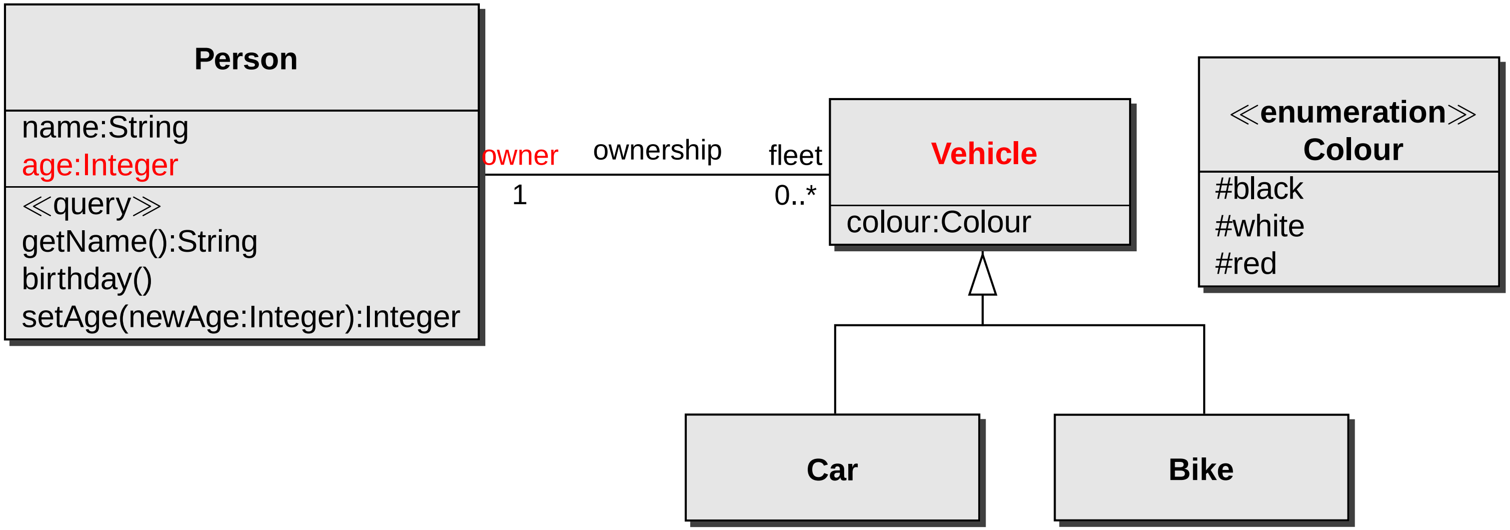

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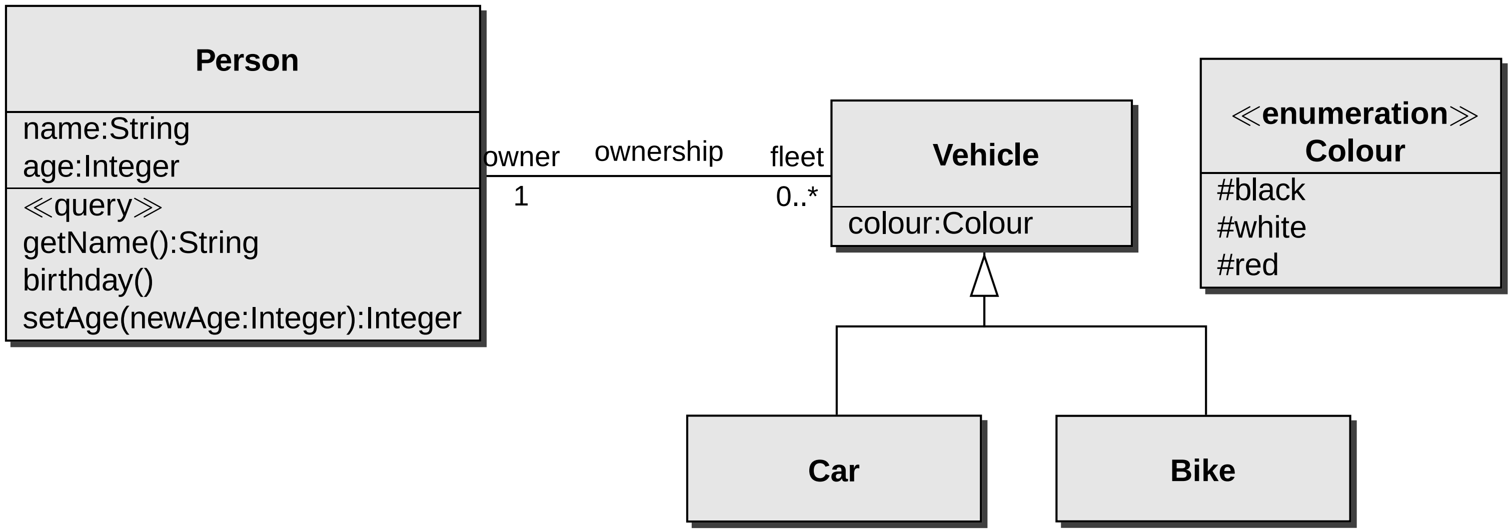

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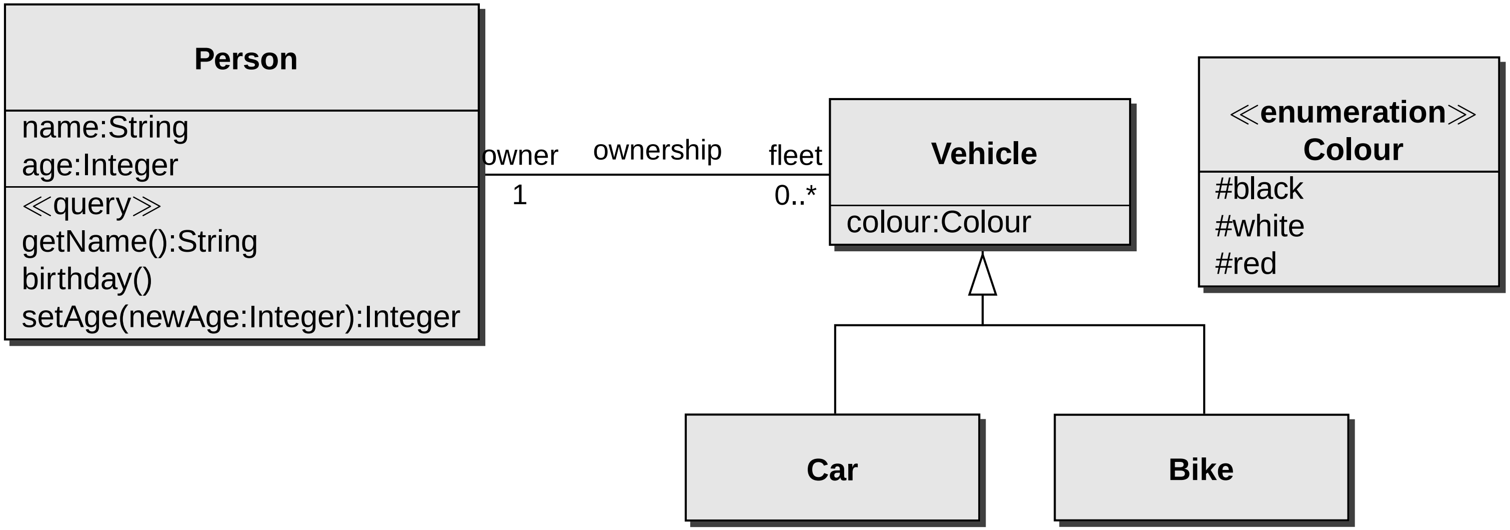

“A vehicle owner must be at least 18 years old”:

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

What does this mean, instead?

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

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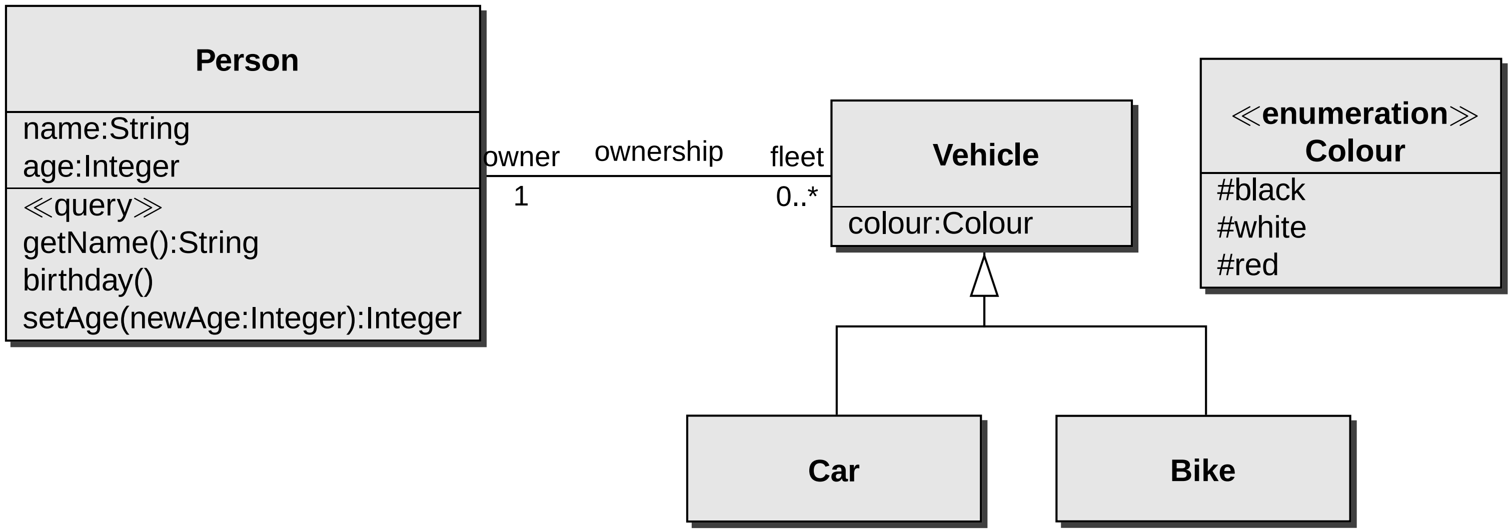

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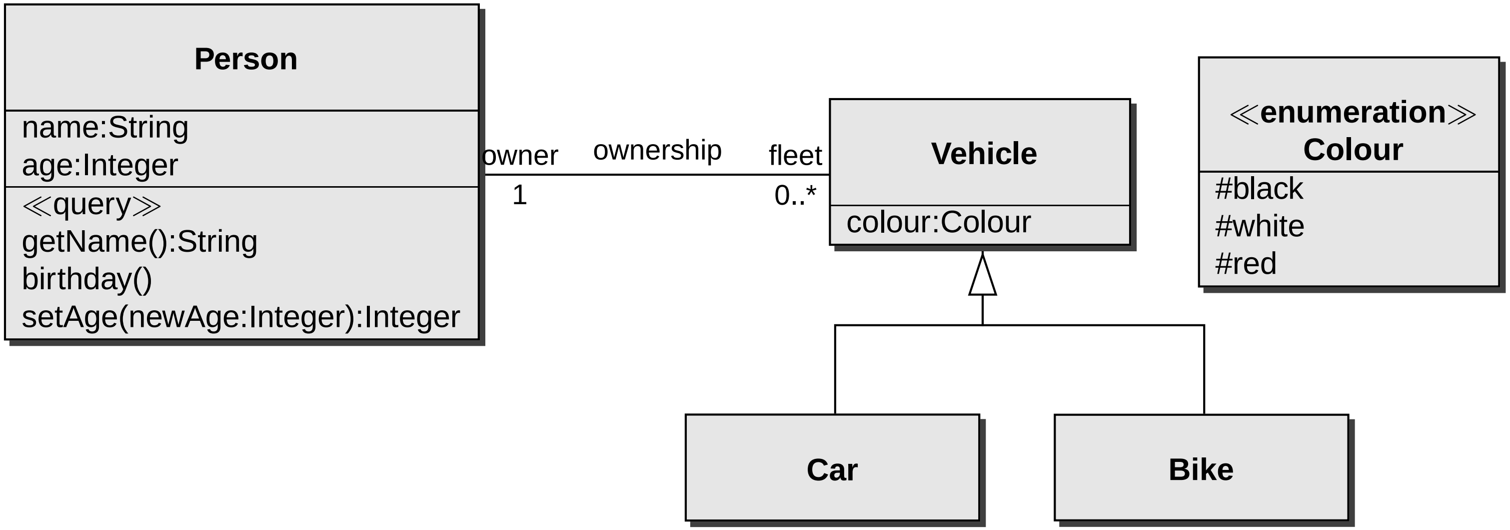

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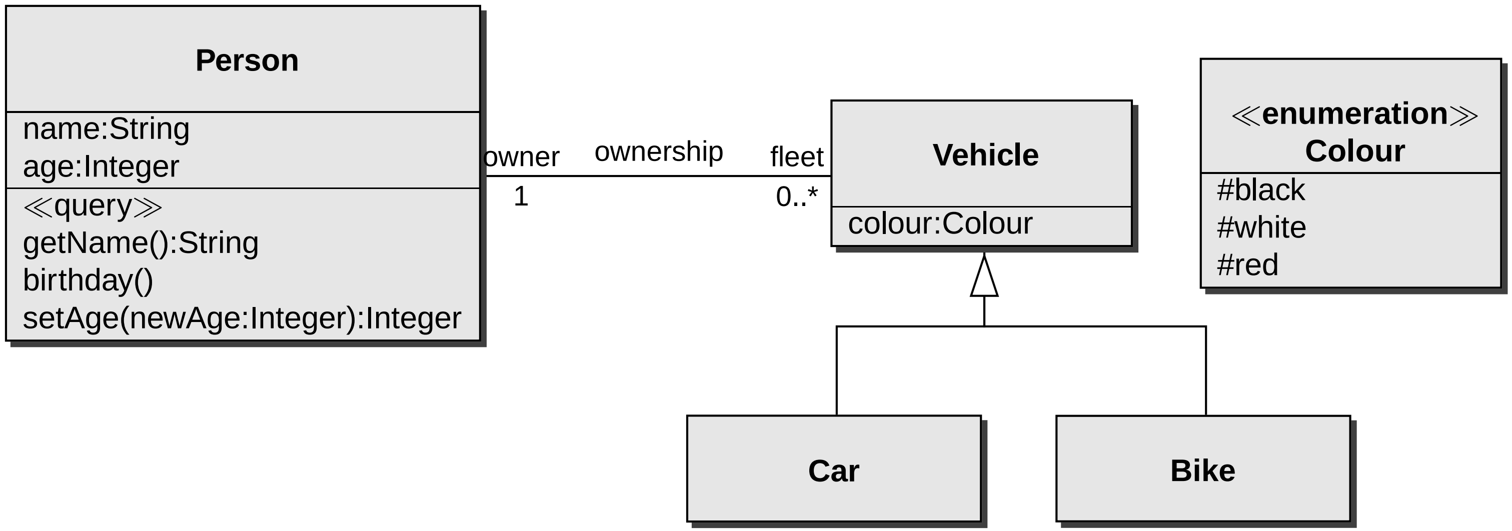

“Nobody has more than 3 vehicles”:

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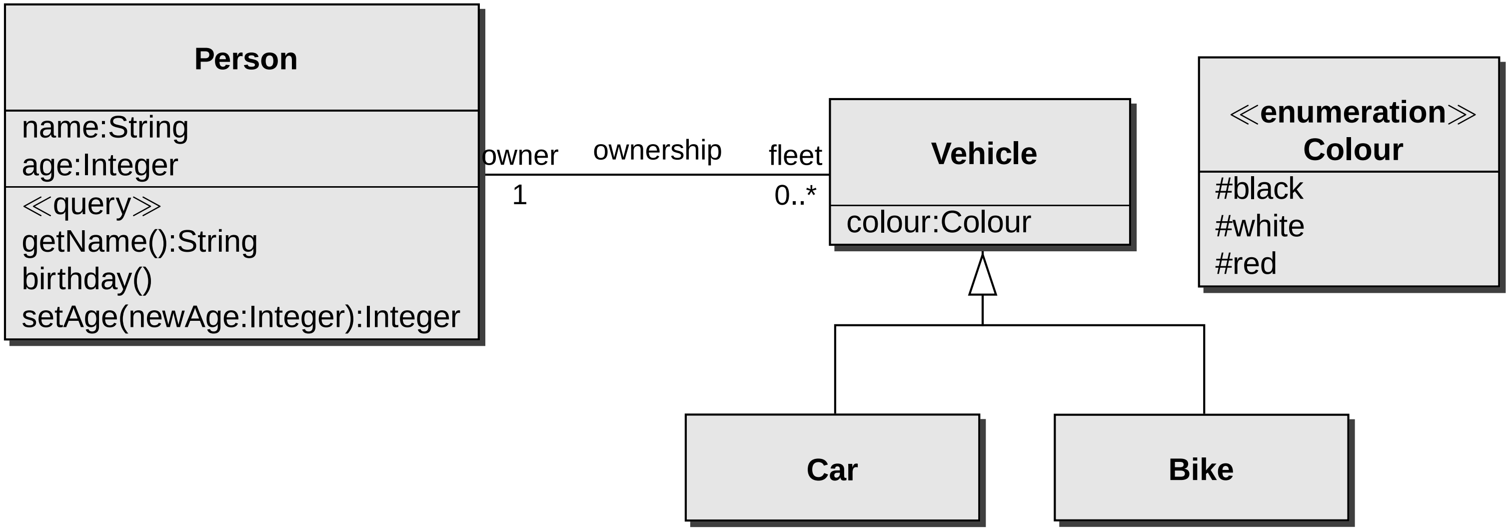

“Nobody has more than 3 vehicles”:

context Person — **or change multiplicity**

inv: self.fleet–>size <= 3

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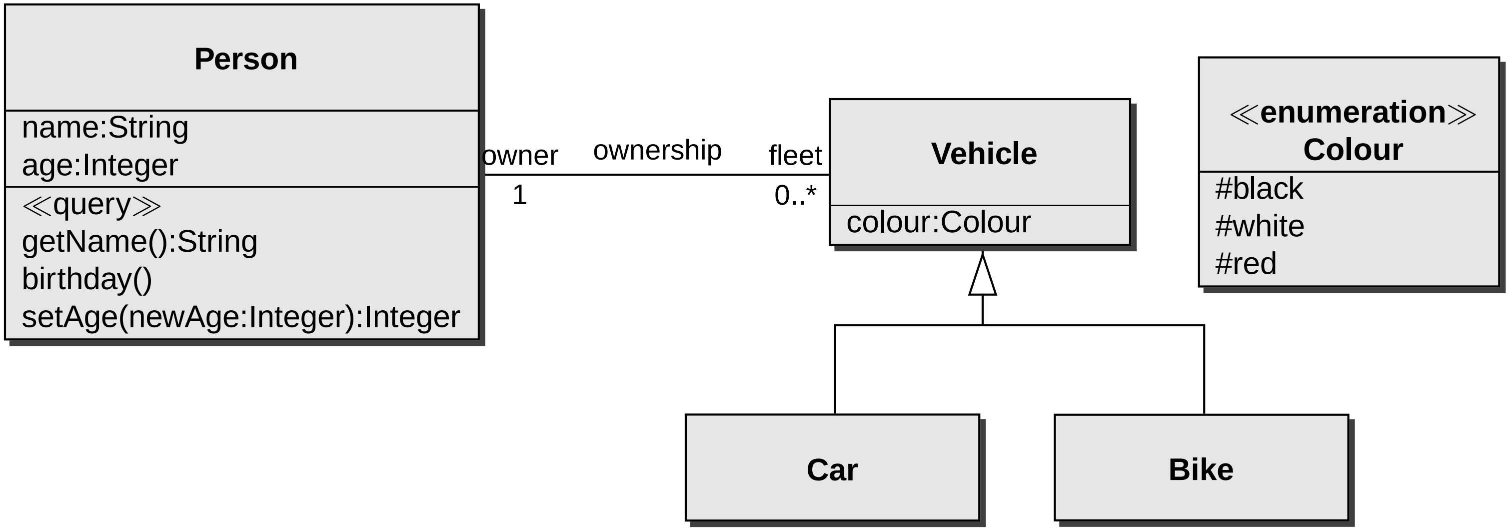

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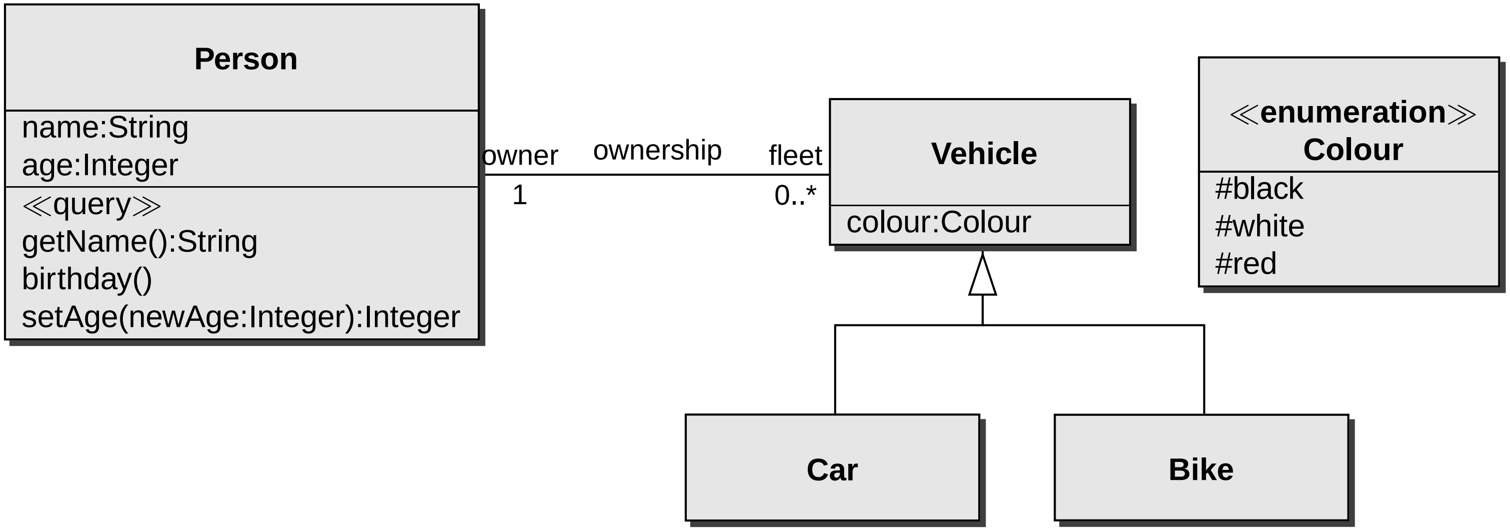

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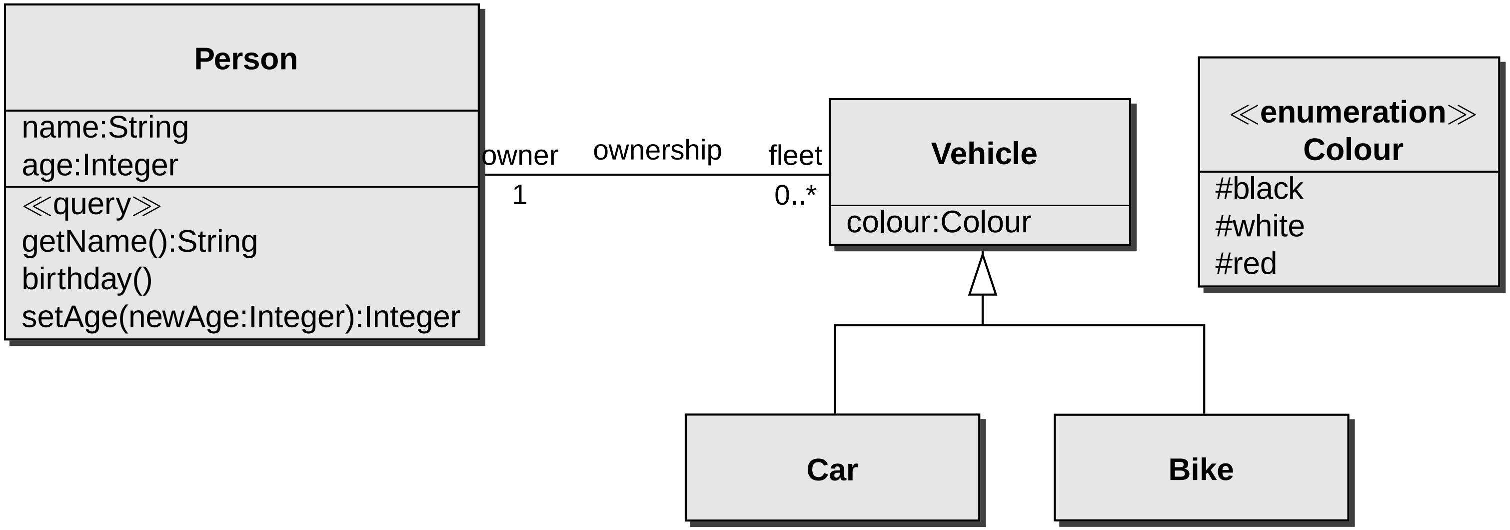

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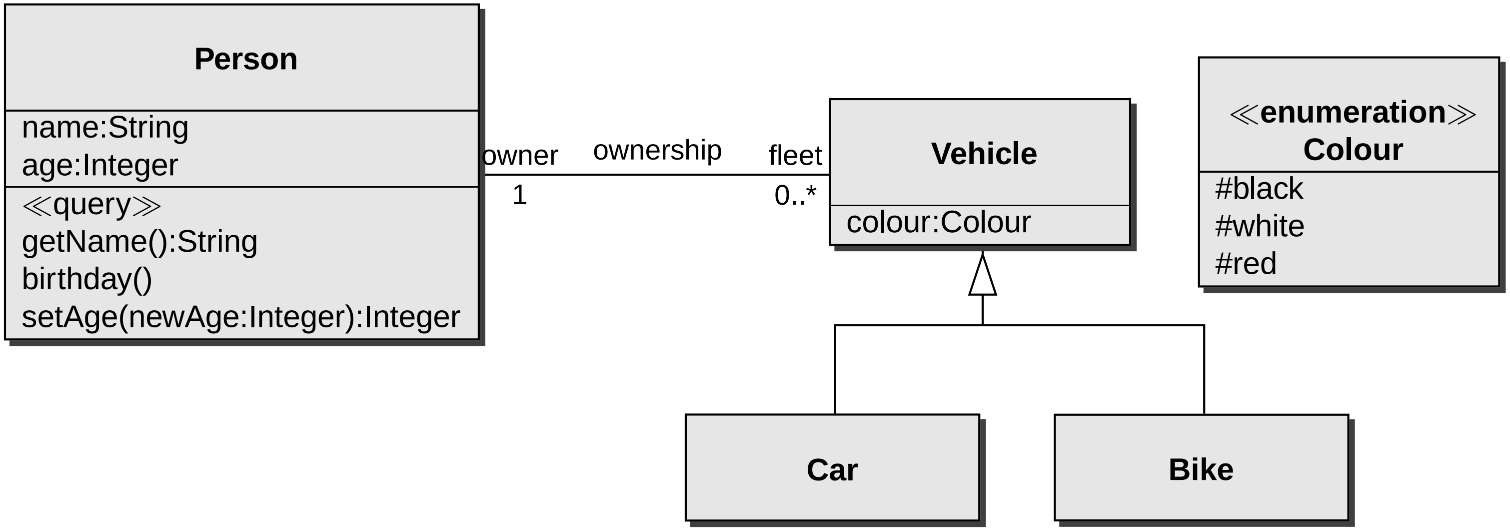

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context **Person**
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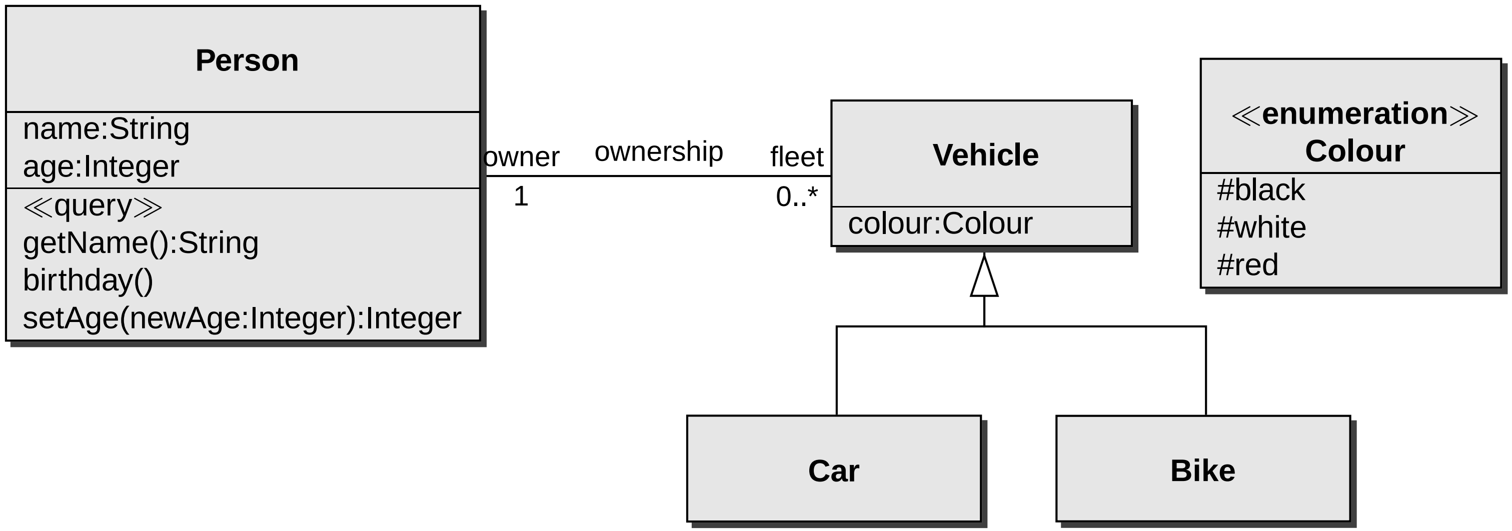
“Nobody has more than 3 black vehicles”:

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

Some OCL examples III — iterate

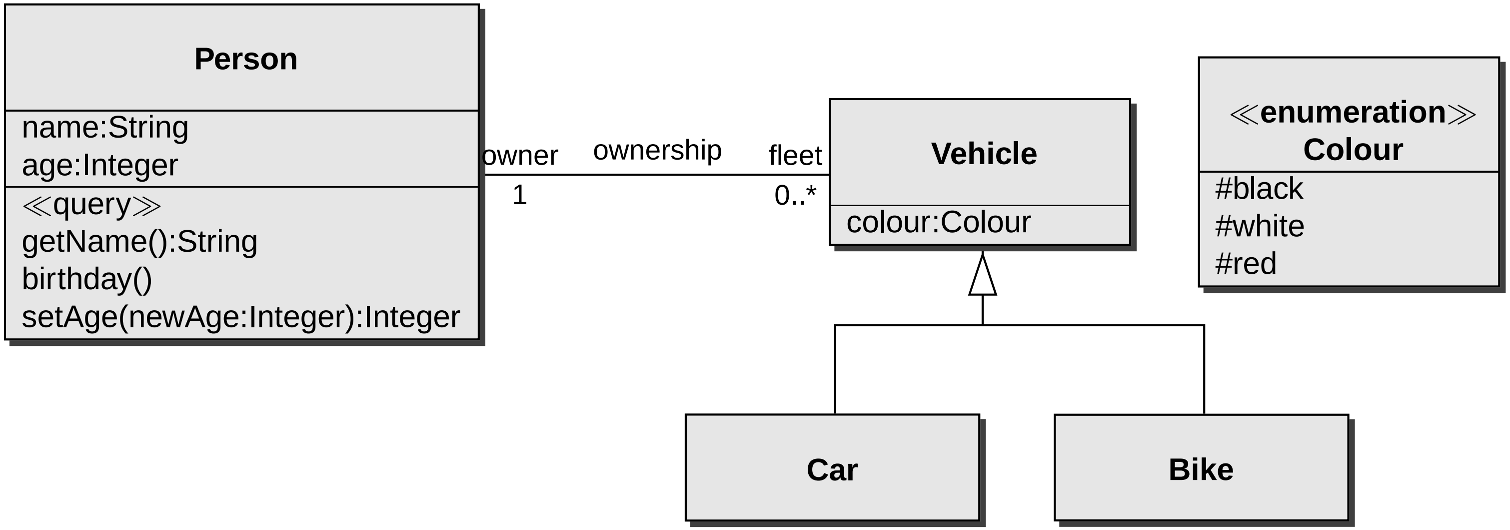


What does it mean?

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



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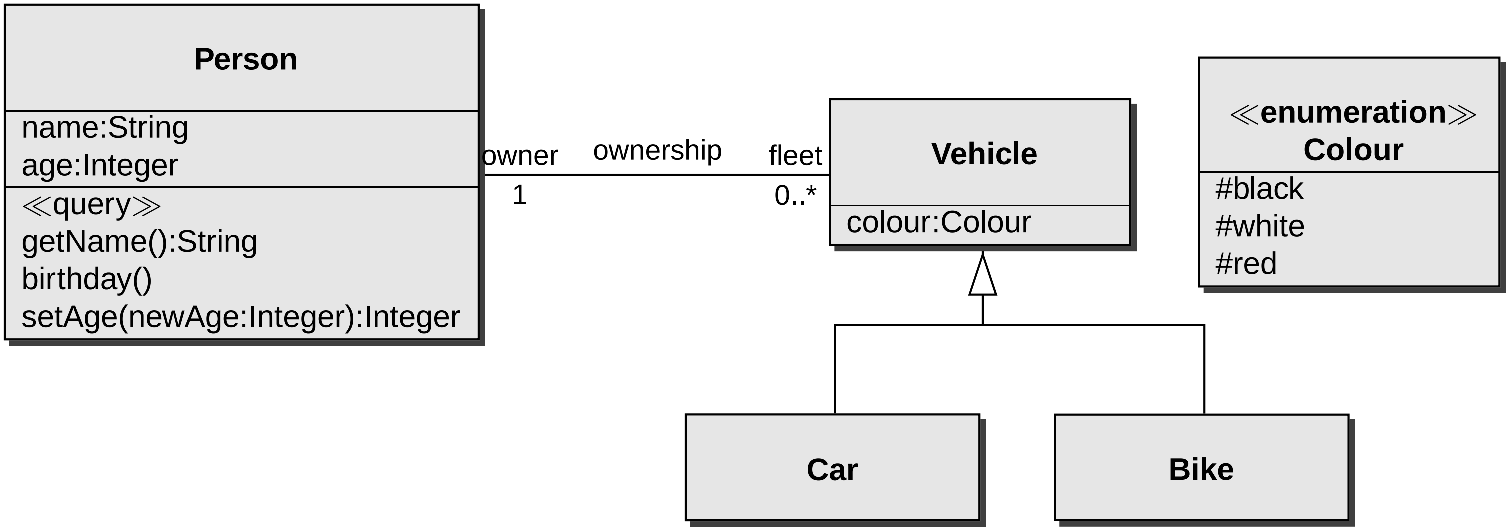

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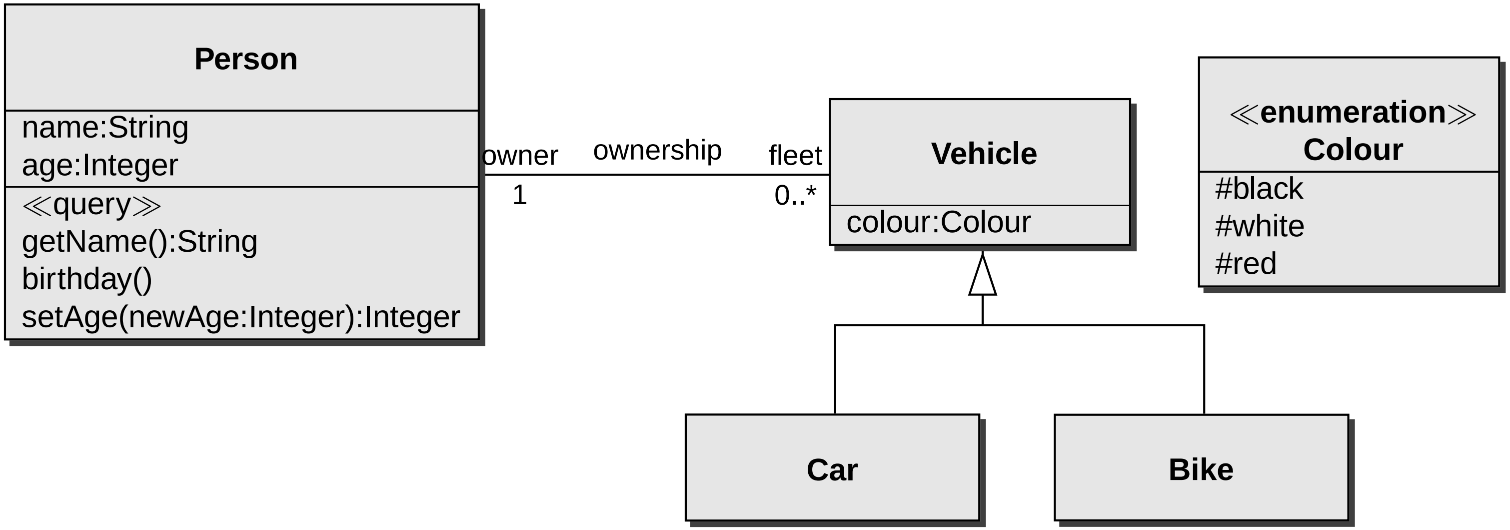

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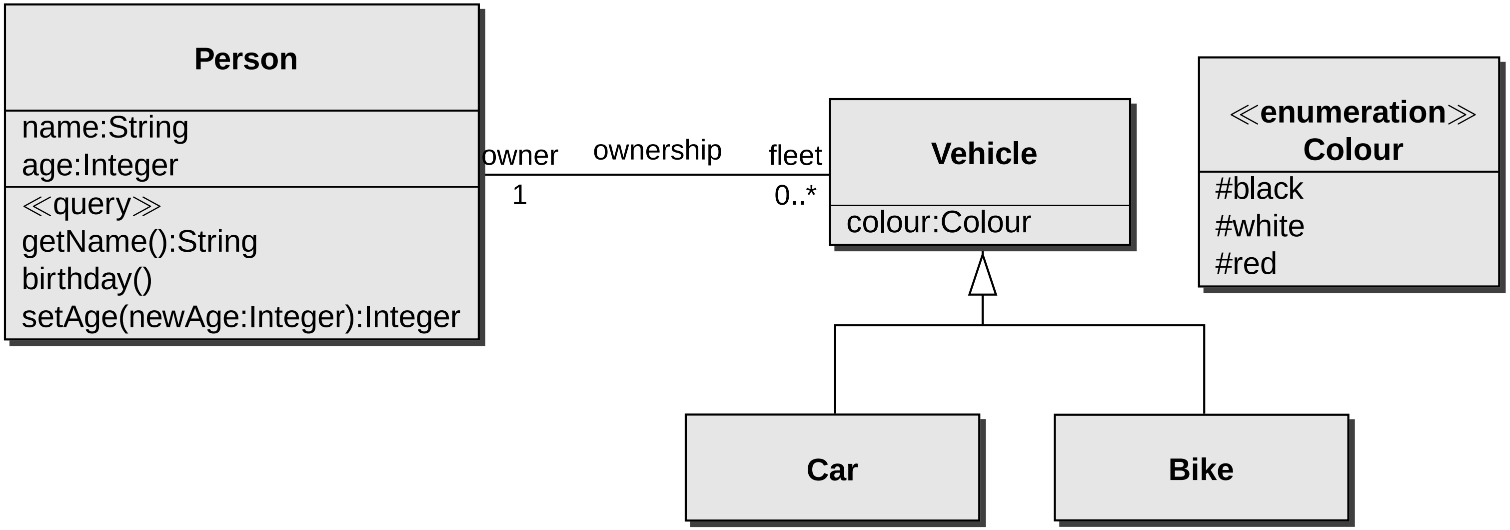

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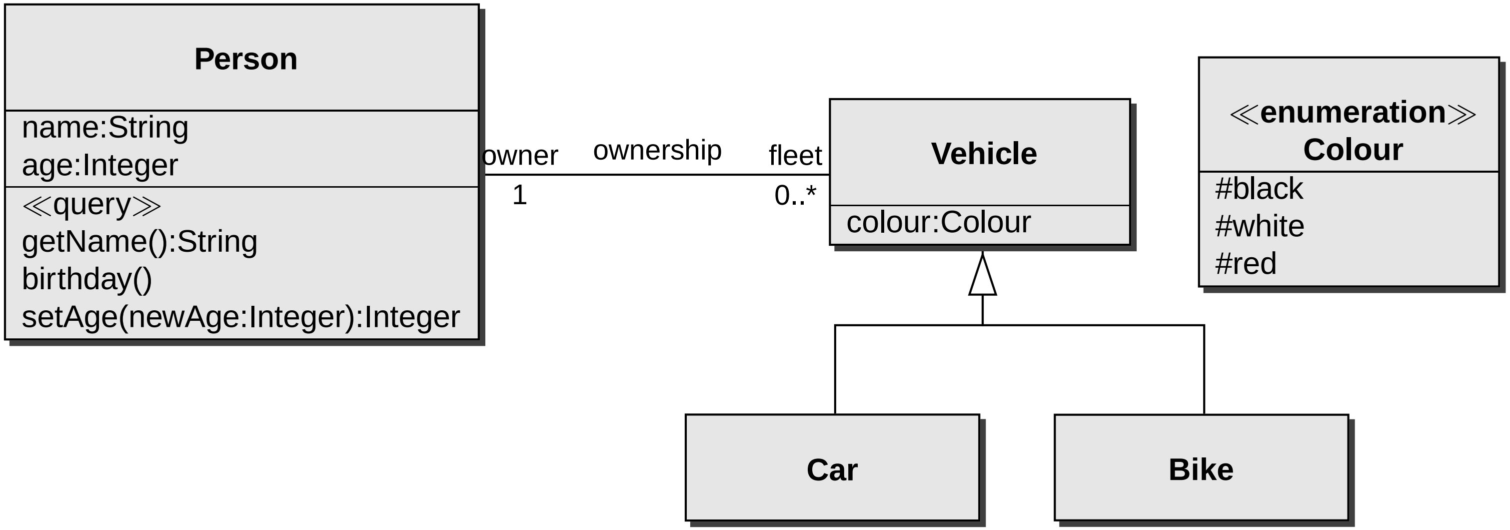
Logical Junctors: and, or, not, implies, if. . . then. . . else. . . endif, =

Some OCL examples V — allInstances



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

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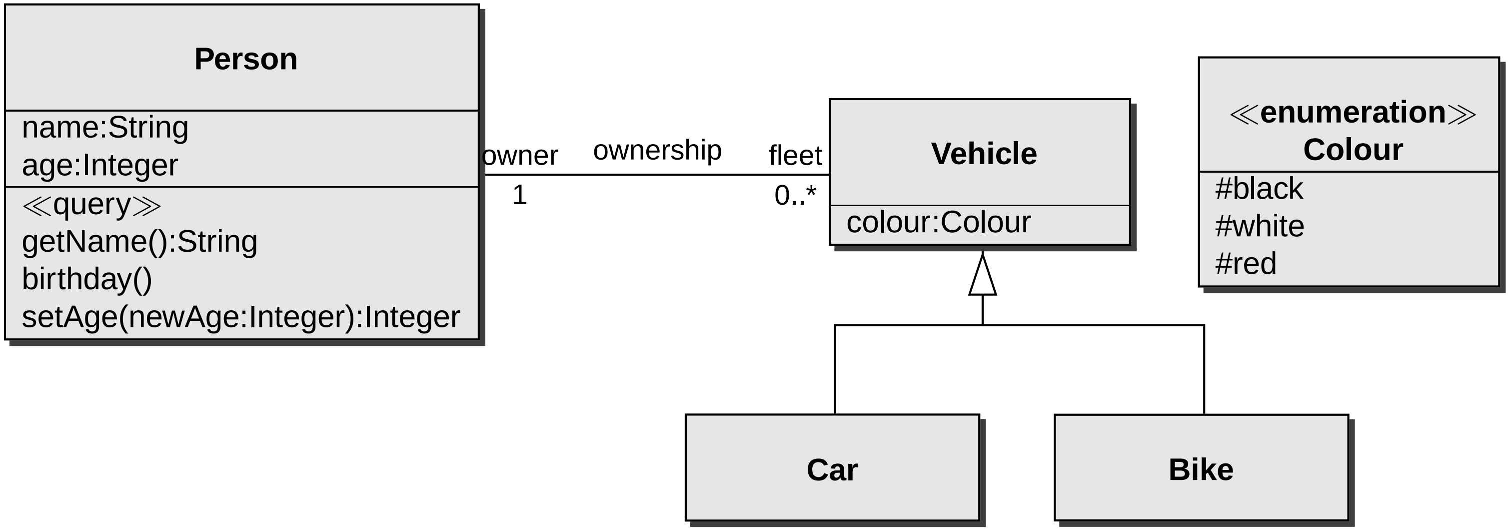

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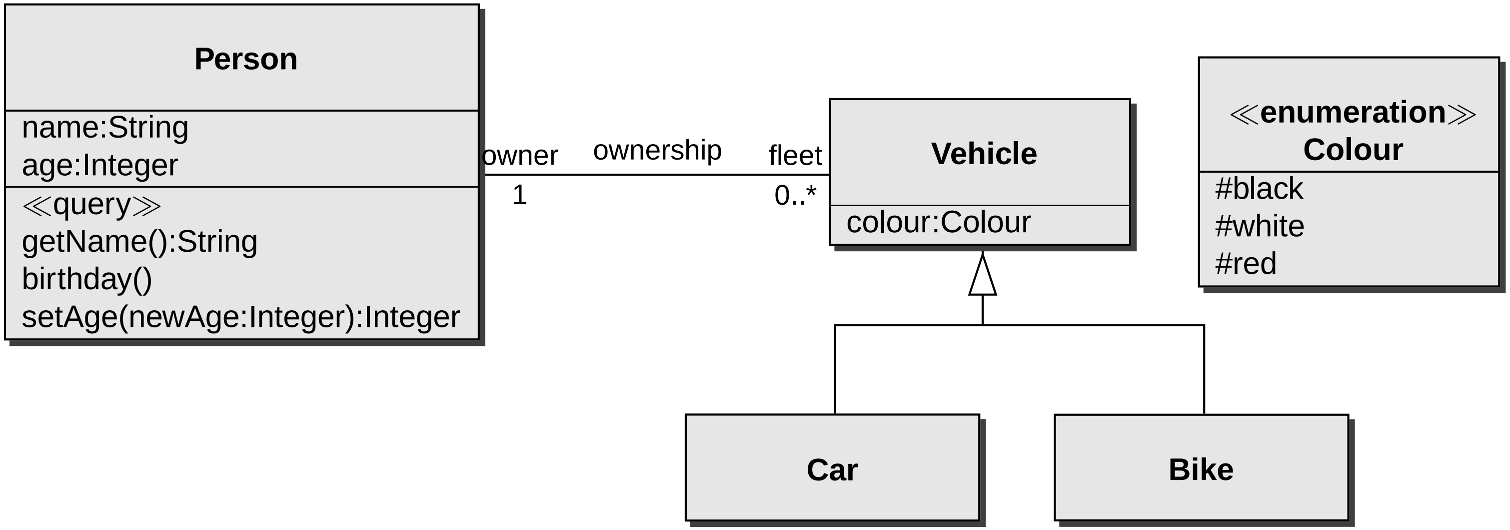
“There is a red car.”

OCL pre-/post conditions — Examples



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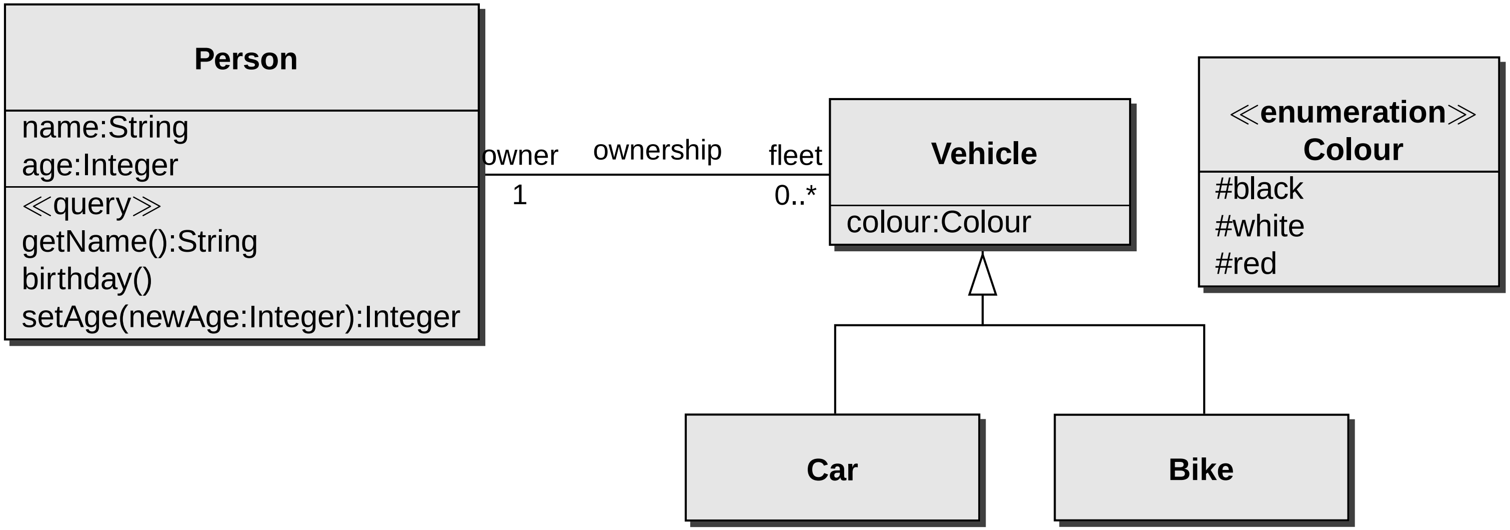

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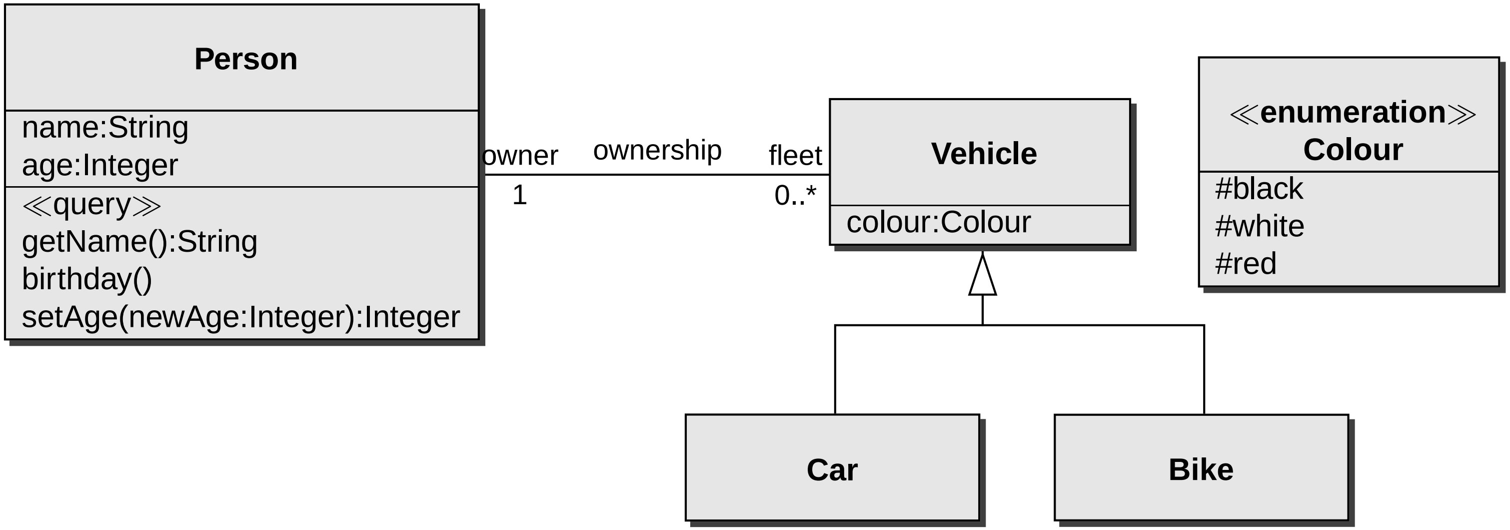

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OCL can also specify operations:

"If setAge(. . .) is called with a non-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

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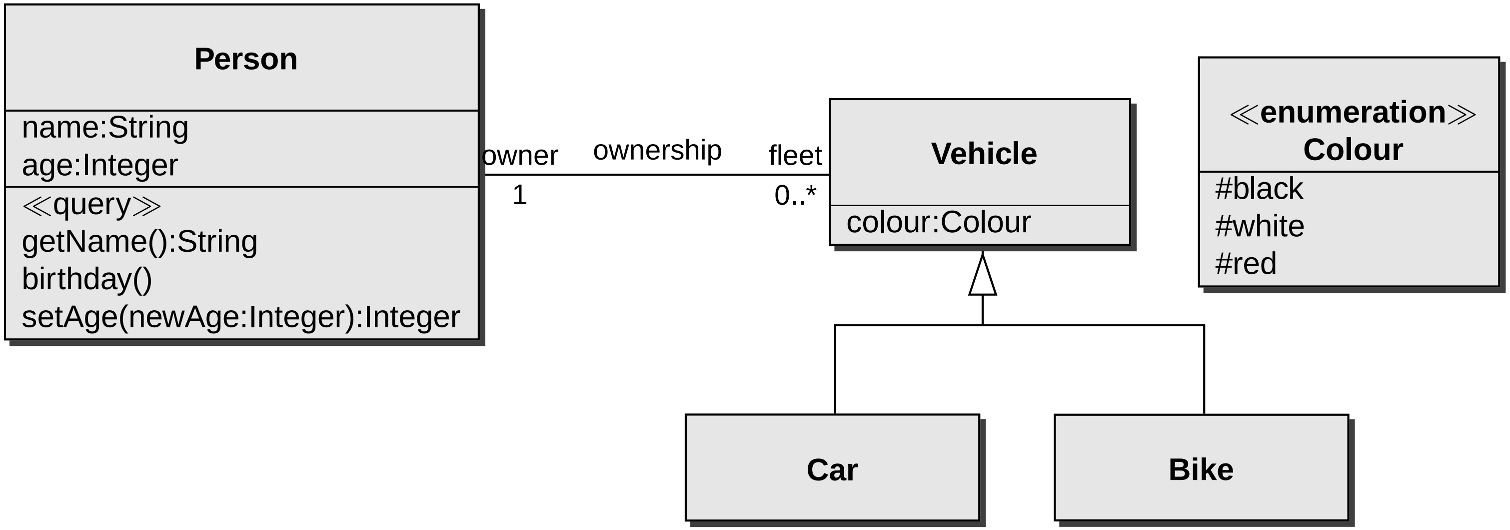

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OCL can also specify operations:

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

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

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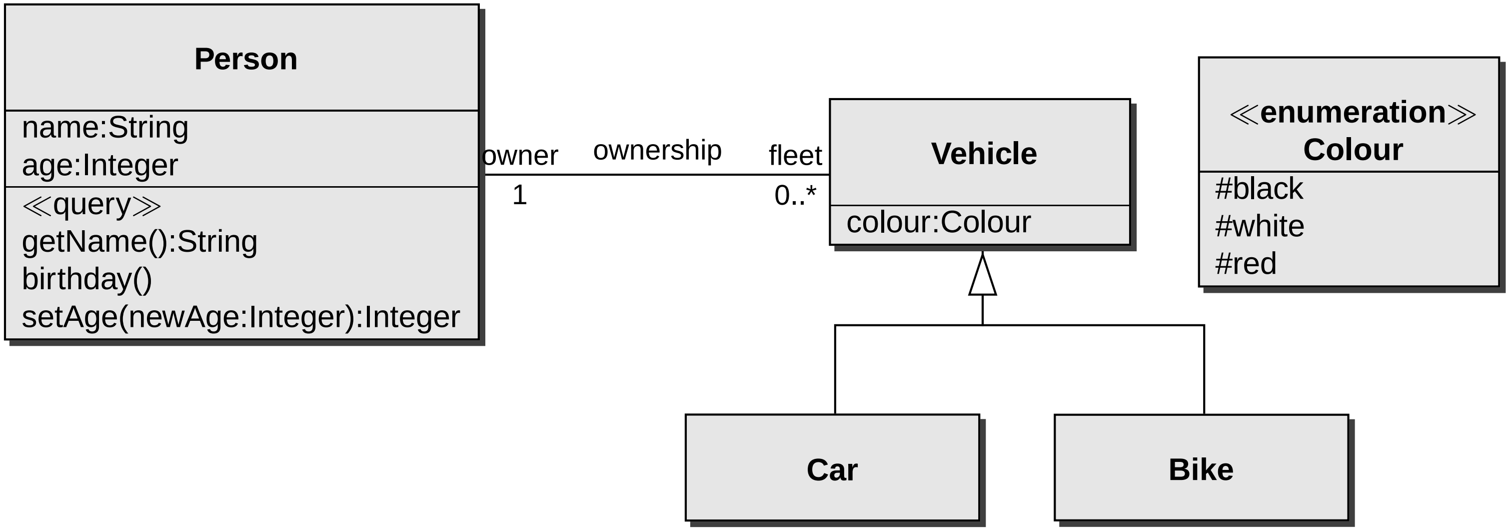

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OCL can also specify operations:

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

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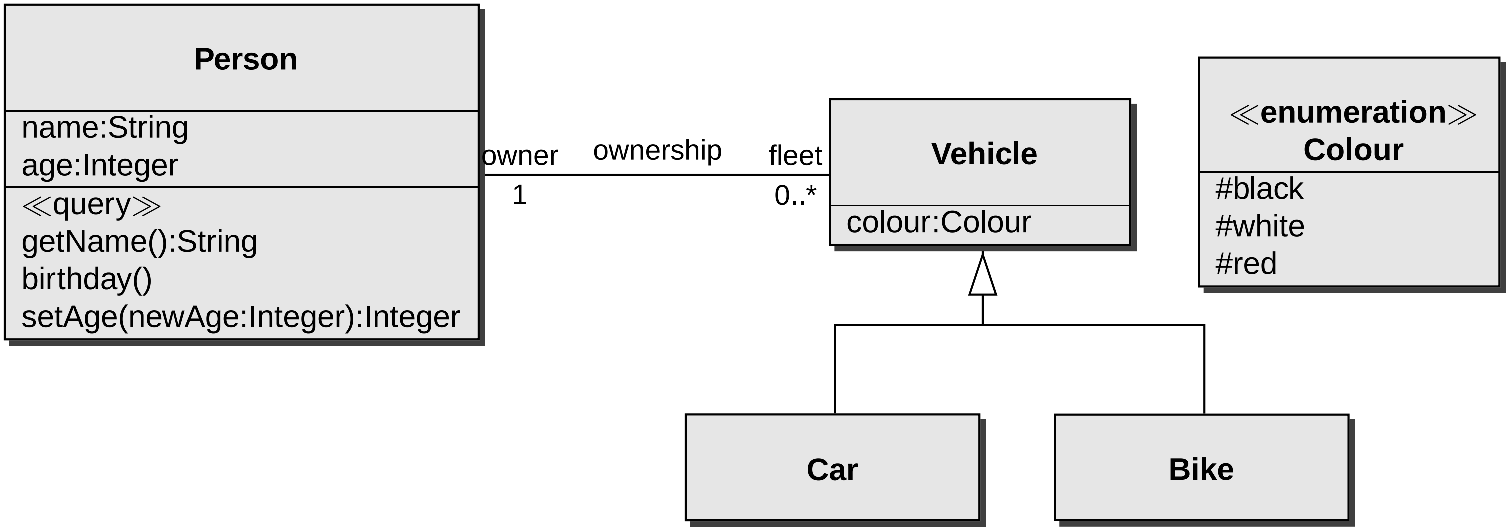
Queries



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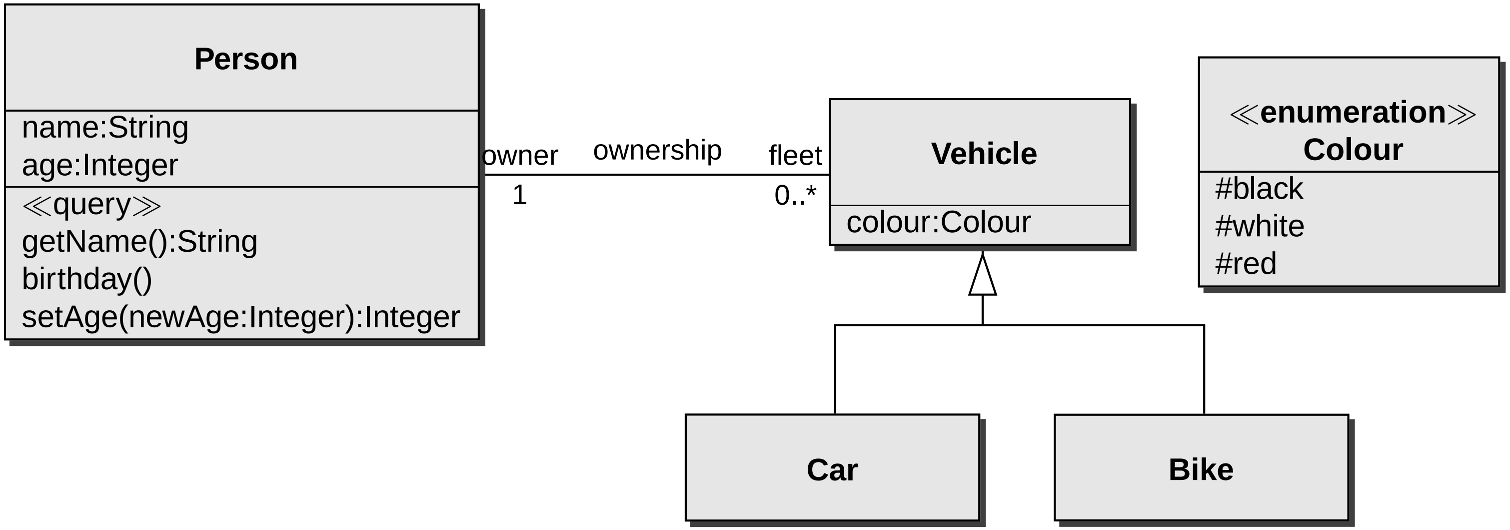

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inv: **self.getName() = name**

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- OCL expressions use vocabulary of UML class diagram.
- OCL attribute accesses “navigate” through UML class diagram.
- “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 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.

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(represented by a UML object diagram)

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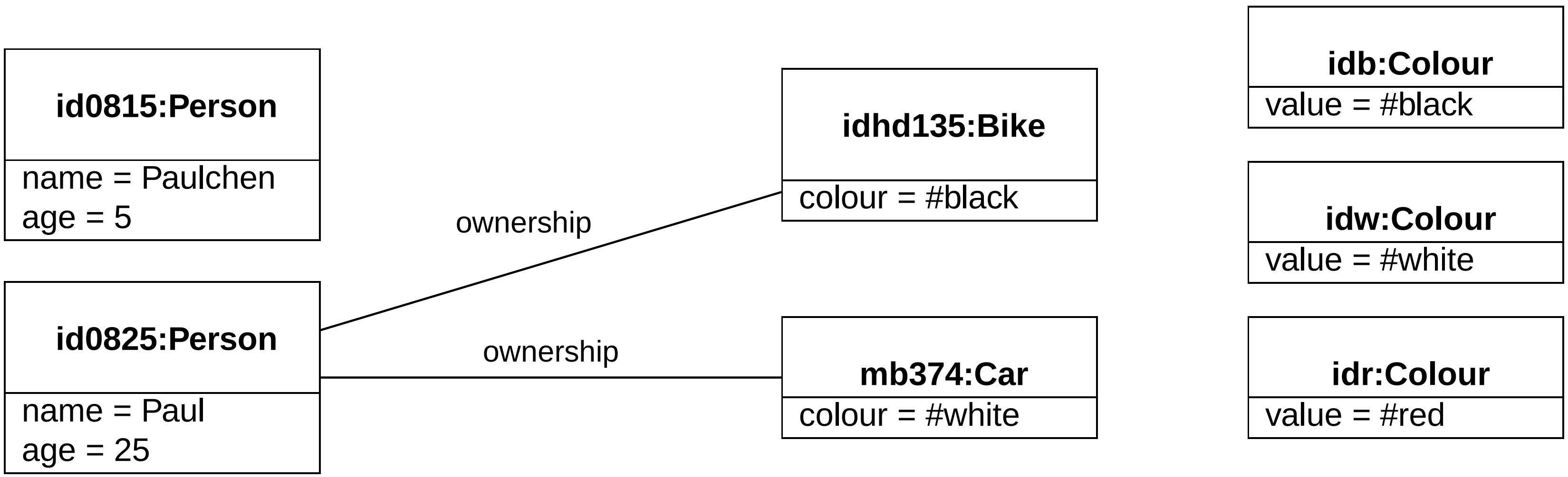

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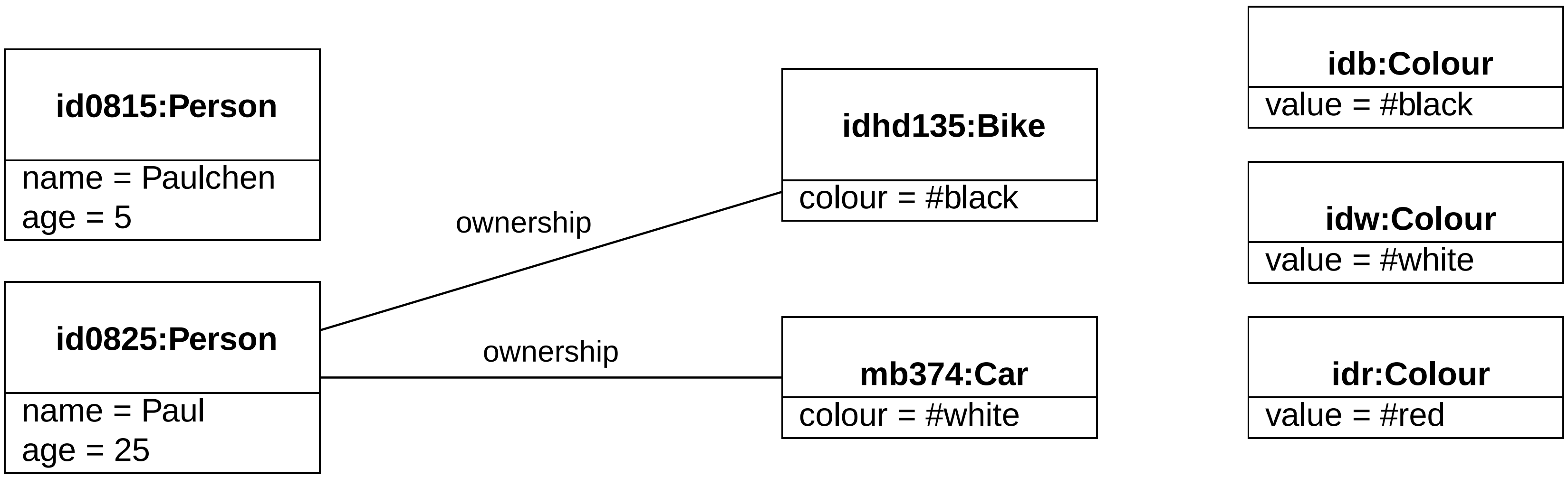

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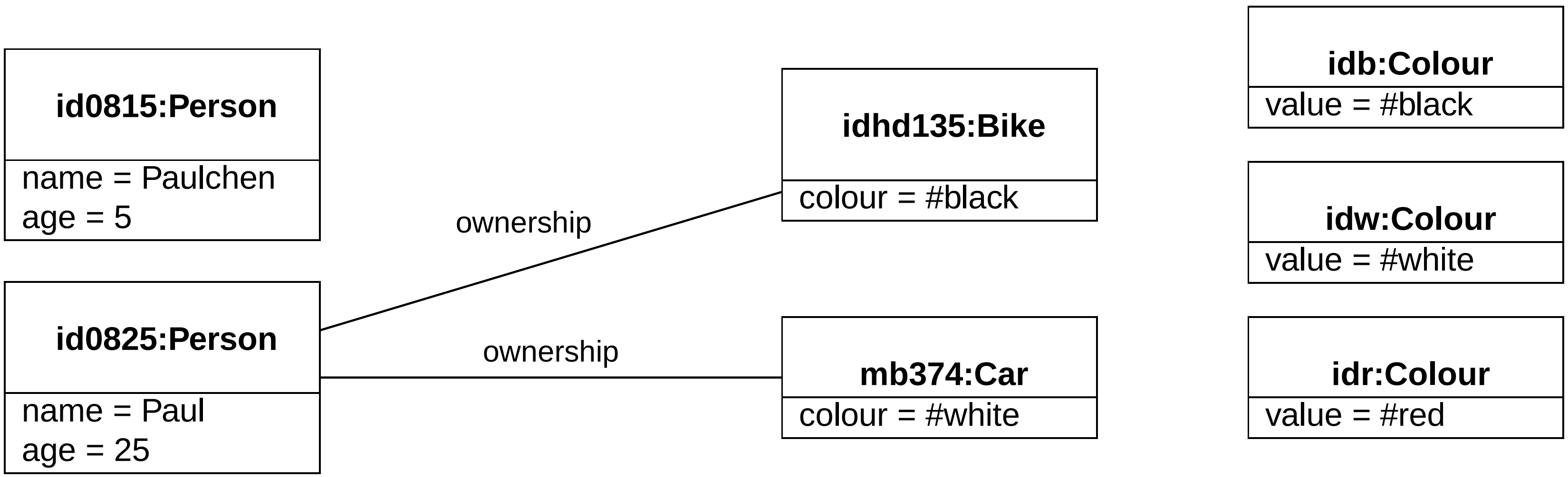

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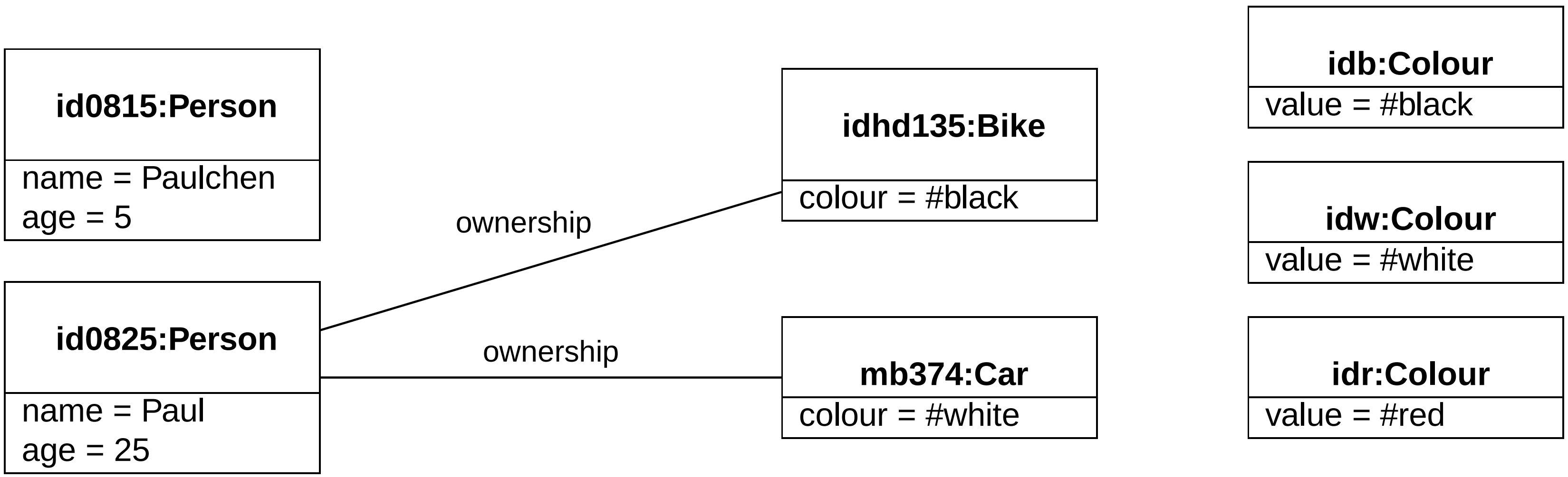

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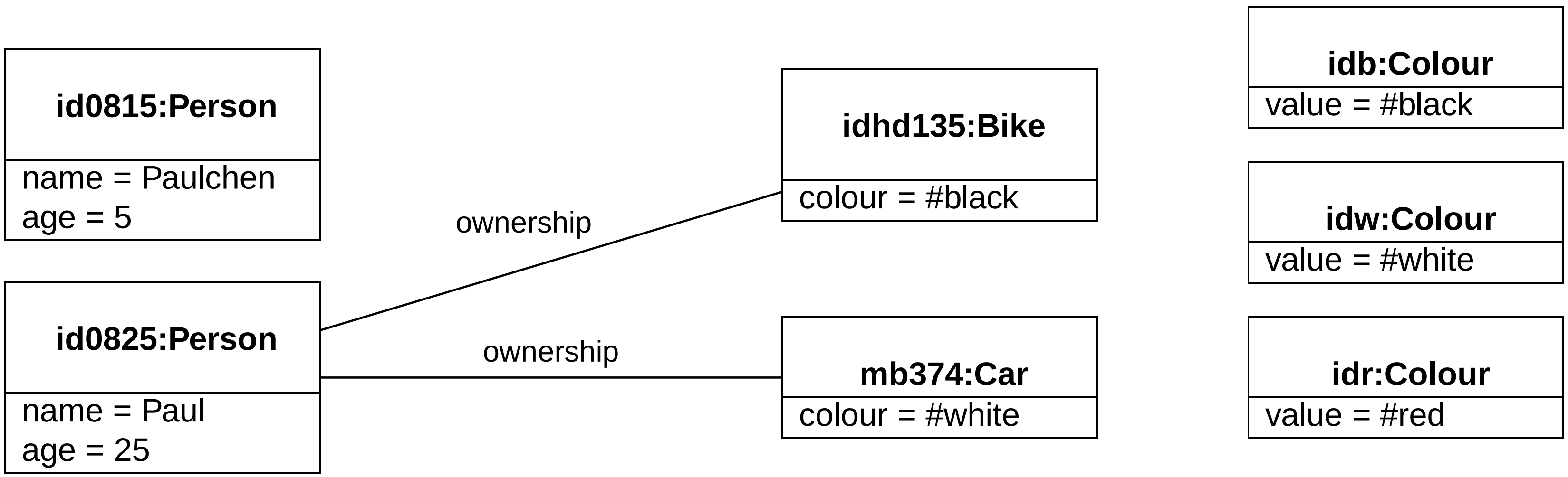

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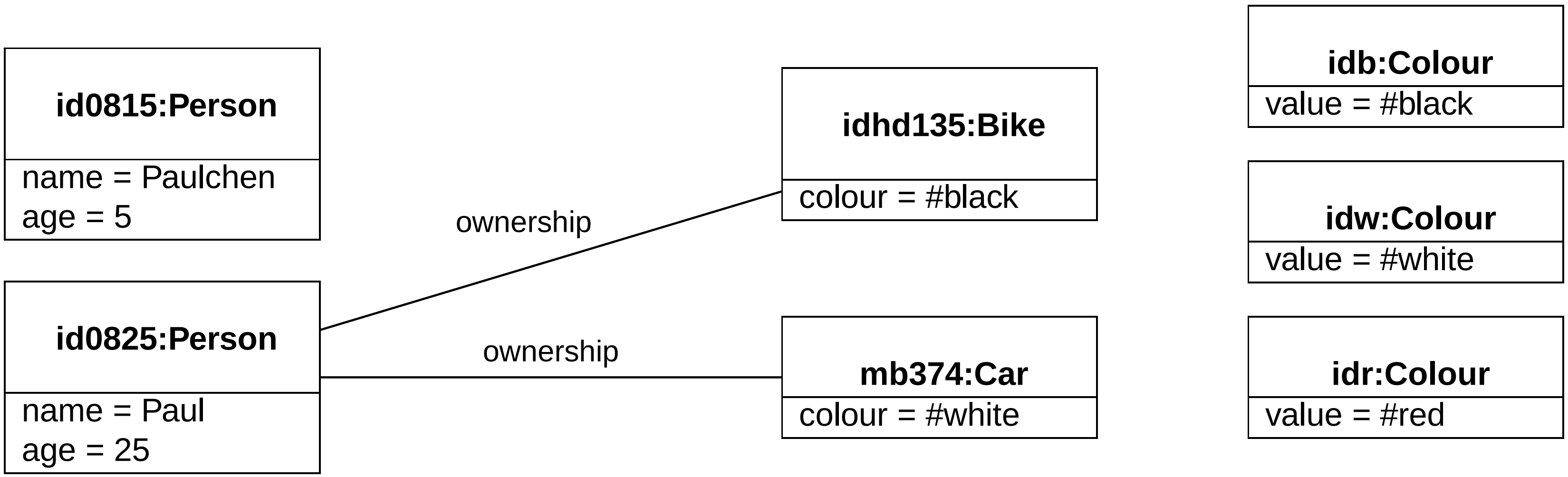

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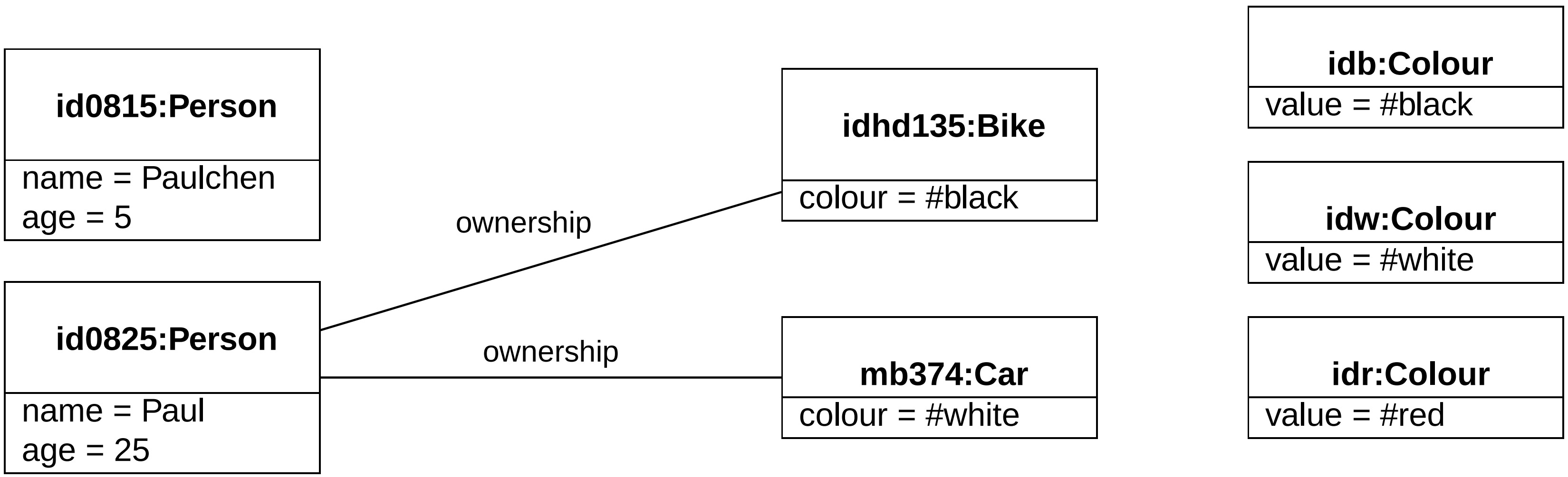

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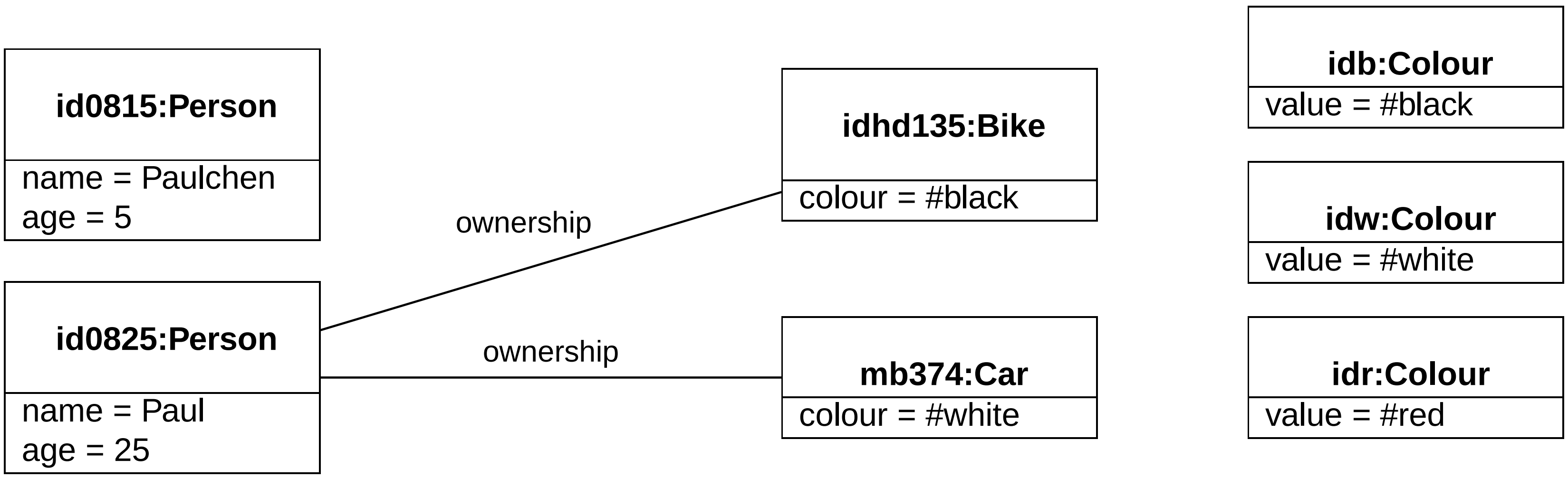

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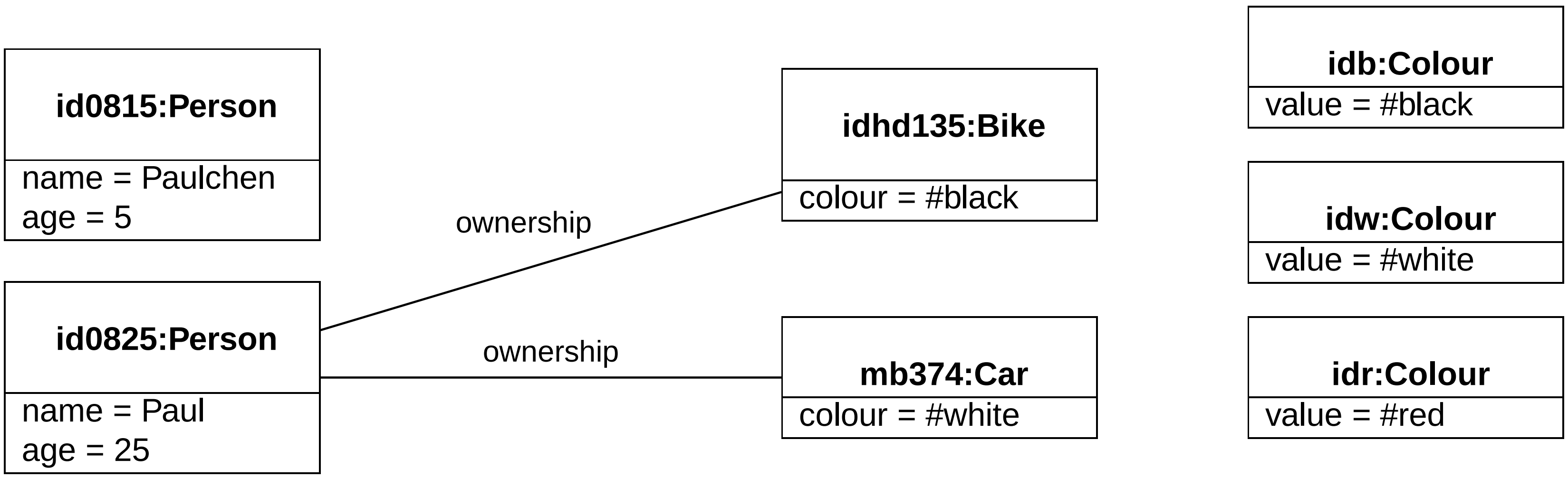

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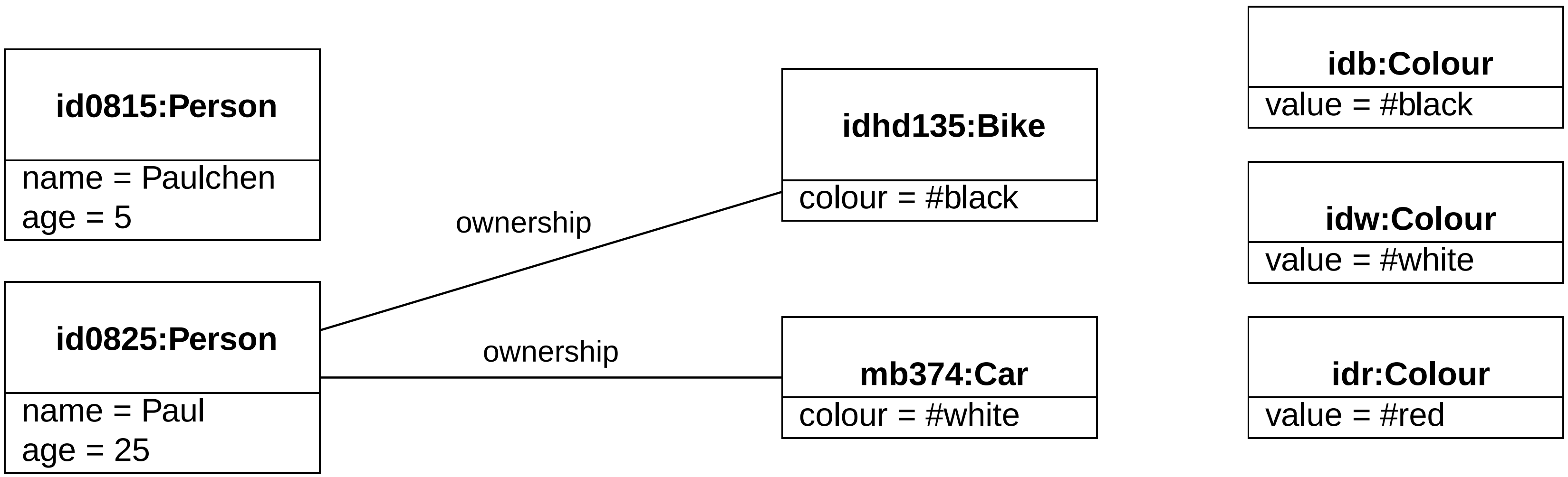

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- (standard) interpretation for predefined primitive data types

  (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