Introduction to OCL

Bernhard Beckert

UNIVERSITÄT KOBLENZ-LANDAU

OCL

Object Constraint Language

- **Part of the UML standard.**

OCL

Object Constraint Language

- Part of the UML standard.
- Formal Specification Language. Precise semantics.

OCL

Object Constraint Language

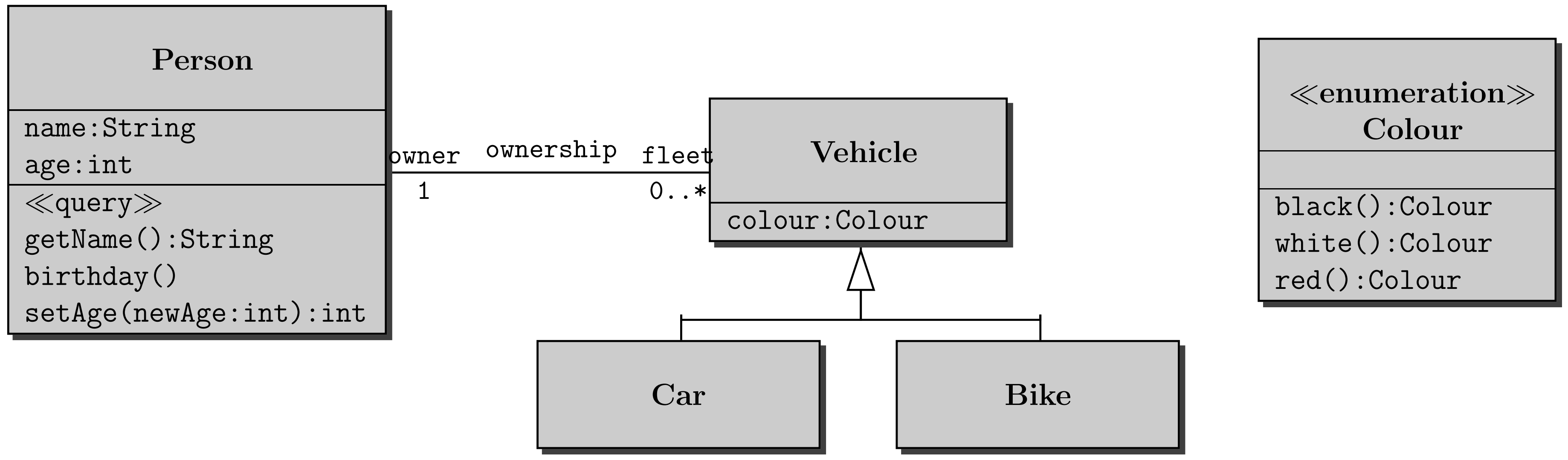
- Part of the UML standard.
- Formal Specification Language. Precise semantics.
- (Quite) easy to read syntax.

OCL

Object Constraint Language

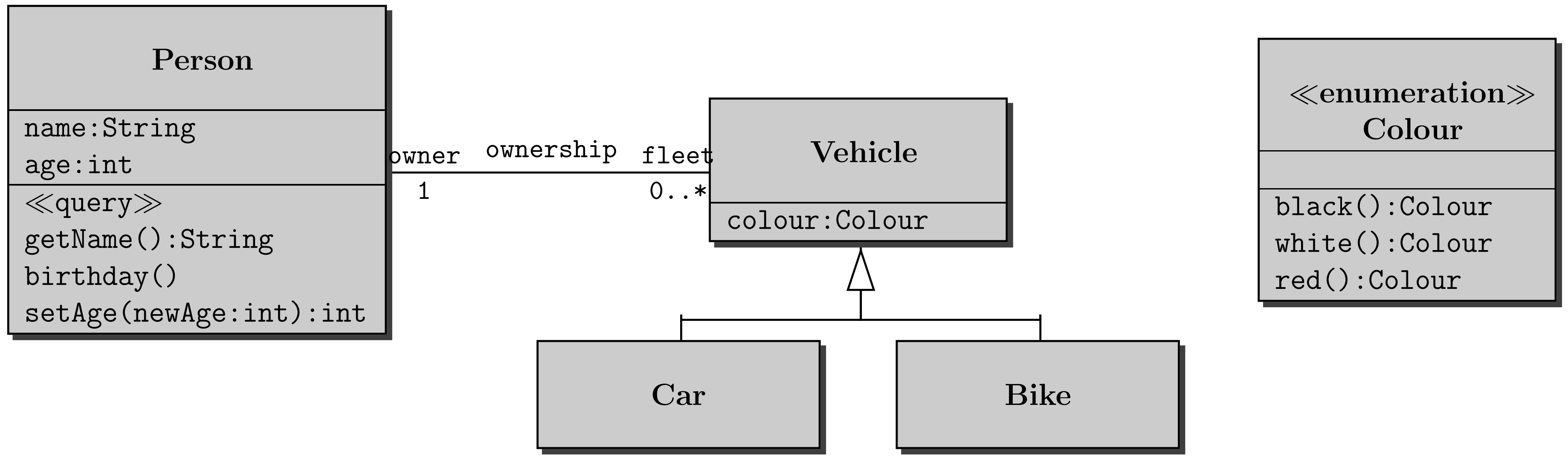
- Part of the UML standard.
- Formal Specification Language. Precise semantics.
- (Quite) easy to read syntax.
- Why? Because UML is not enough!

UML is not enough…



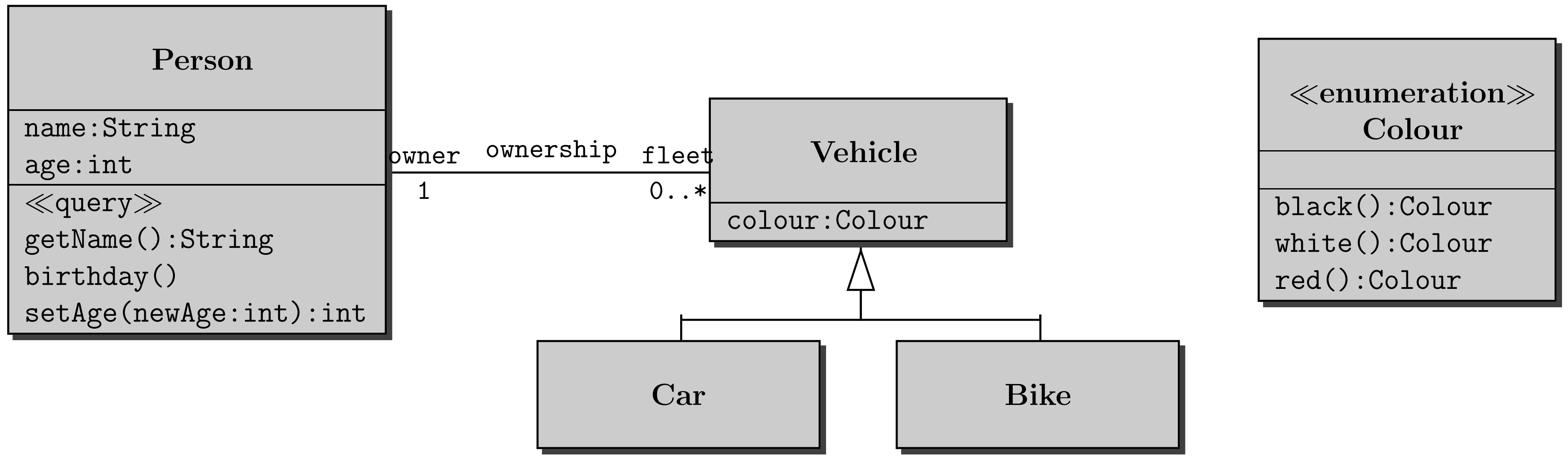
- **Possible number of owners a car can have**
- **Required age of car owners**
- **Requirement that a person may own at most one black car**

Some OCL examples I



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

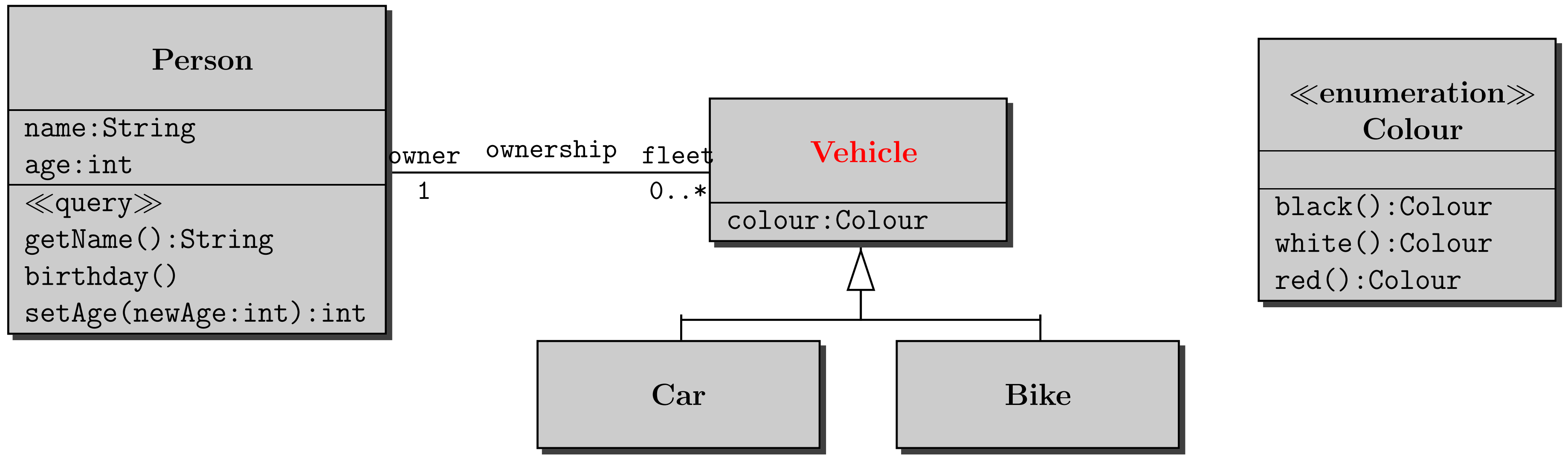
Some OCL examples I



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

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

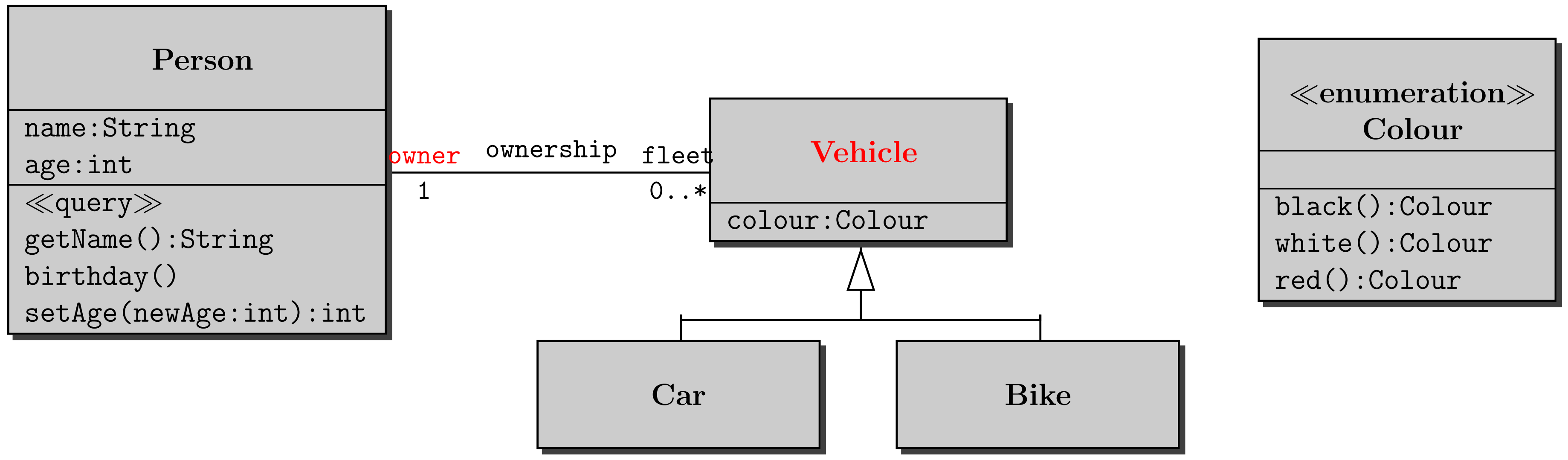
Some OCL examples I



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

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

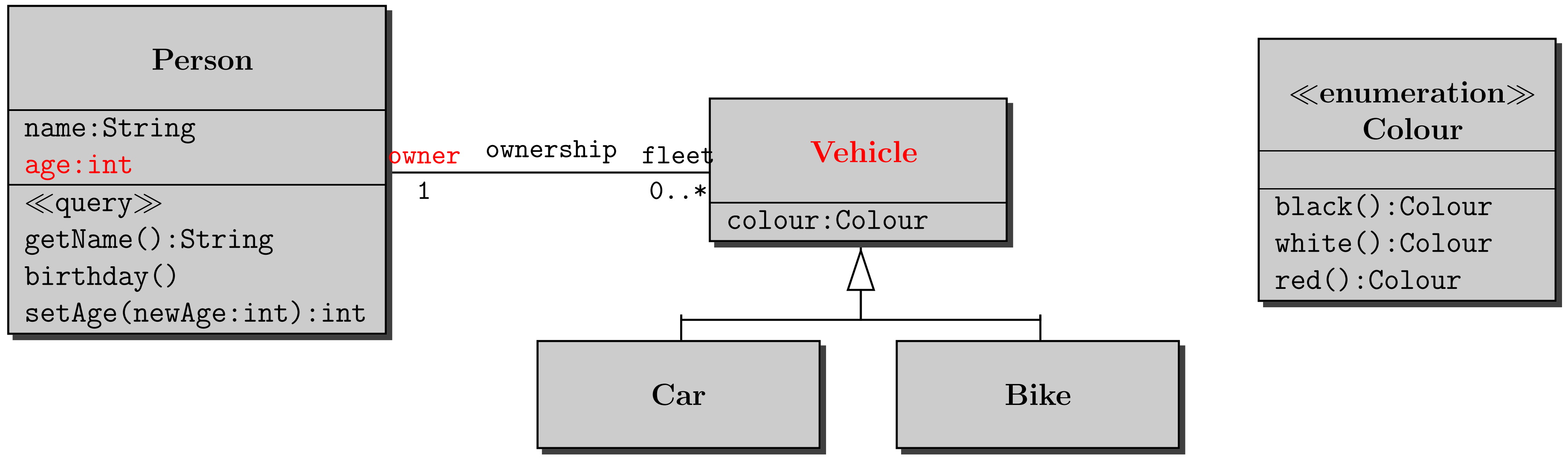
Some OCL examples I



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

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

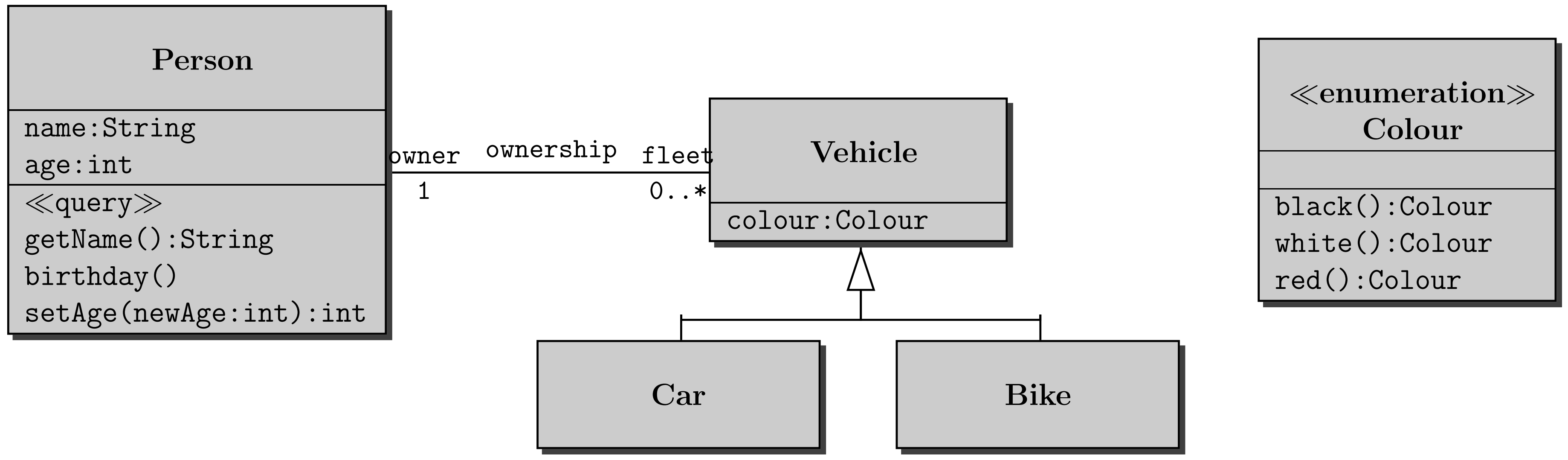
Some OCL examples I



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

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

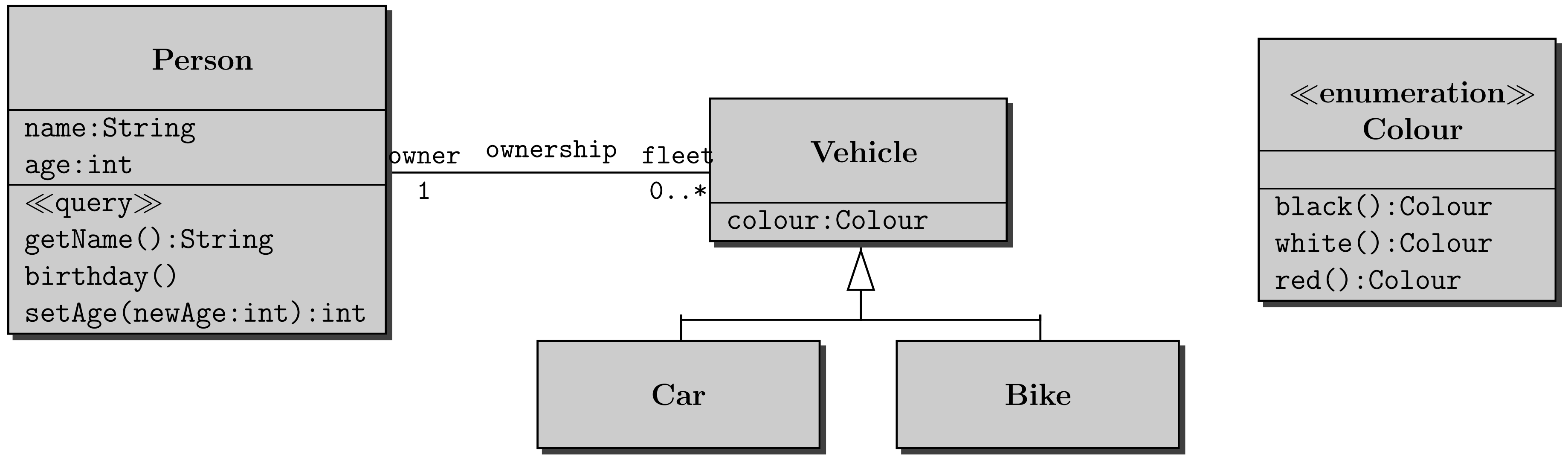
Some OCL examples I



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

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

Some OCL examples I



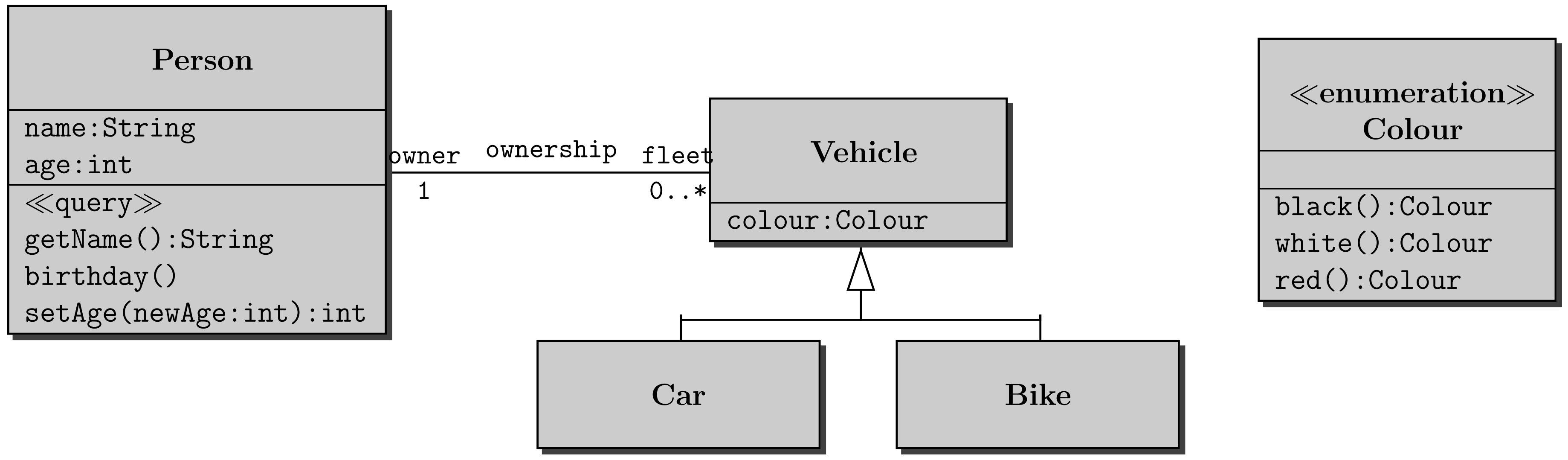
“A vehicle owner must be at least 18 years old”:

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

What does this mean, instead?

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

Some OCL examples I



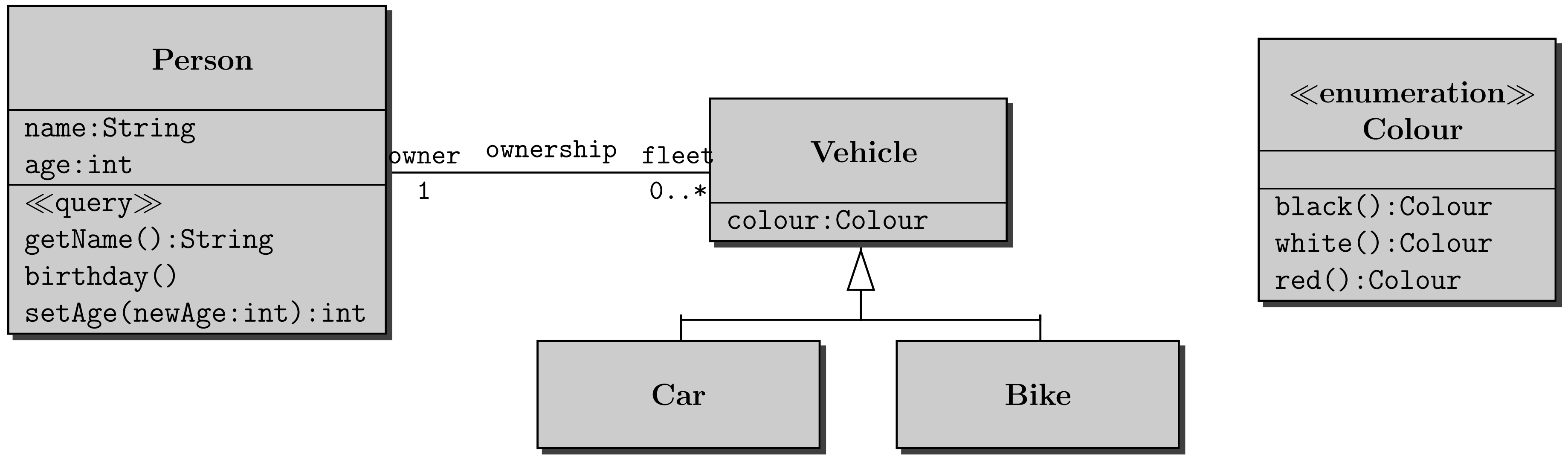
"A vehicle owner must be at least 18 years old":

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

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

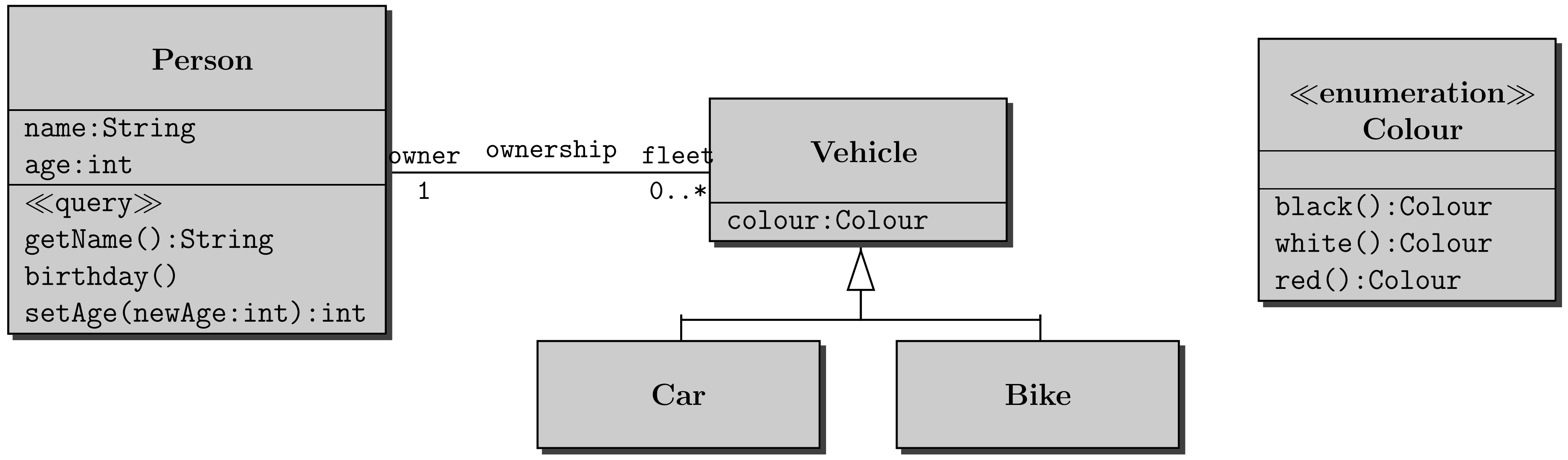
```
context   Car
inv:      self.owner.age >= 18
```

Some OCL examples II



"Nobody has more than 3 vehicles":

Some OCL examples II

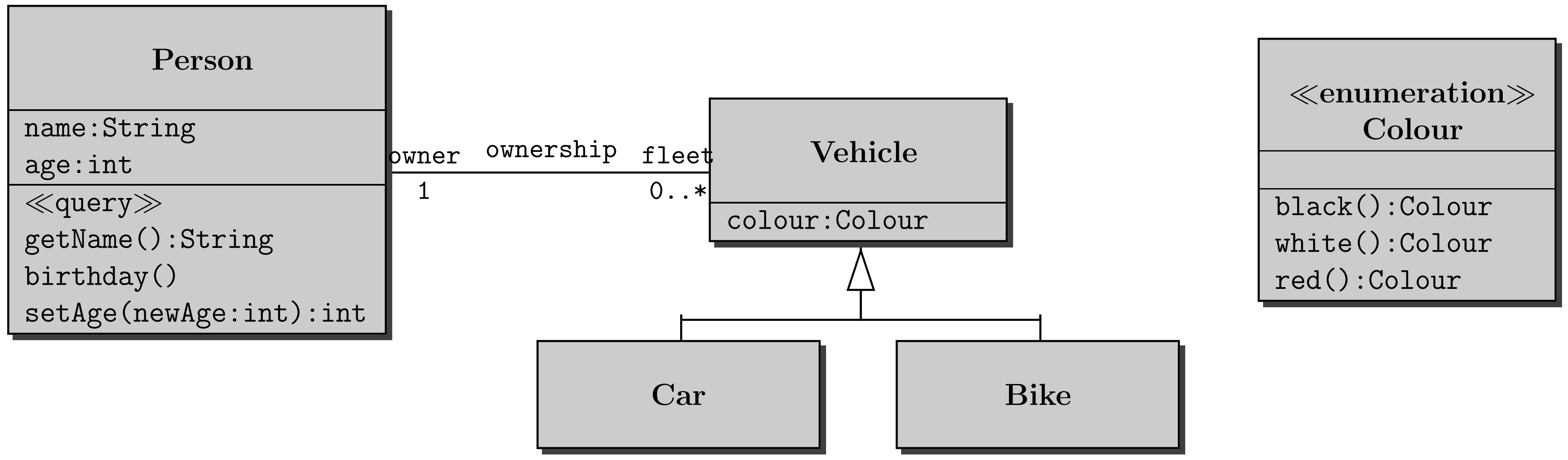


“Nobody has more than 3 vehicles”:

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

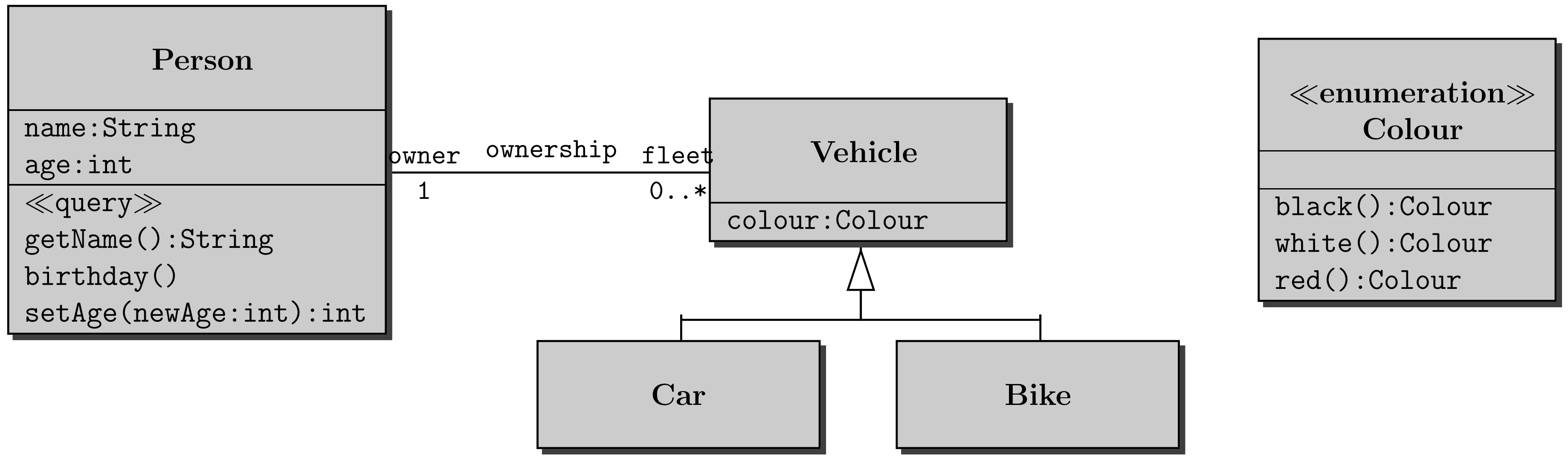
or change multiplicity

Some OCL examples II



“All cars of a person are black”:

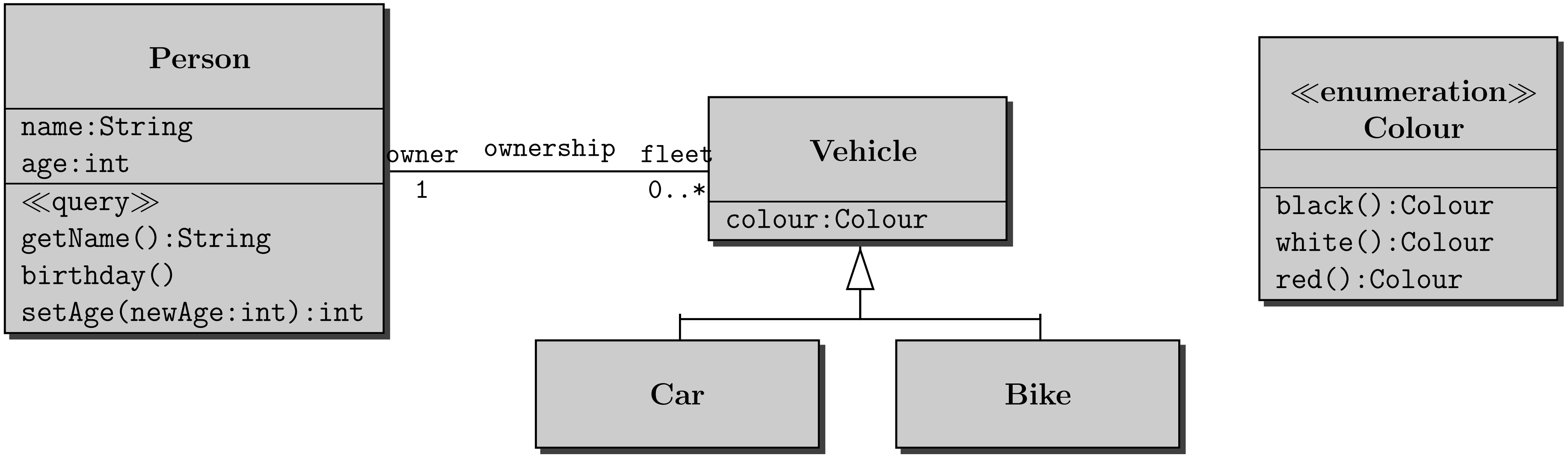
Some OCL examples II



“All cars of a person are black”:

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

Some OCL examples II

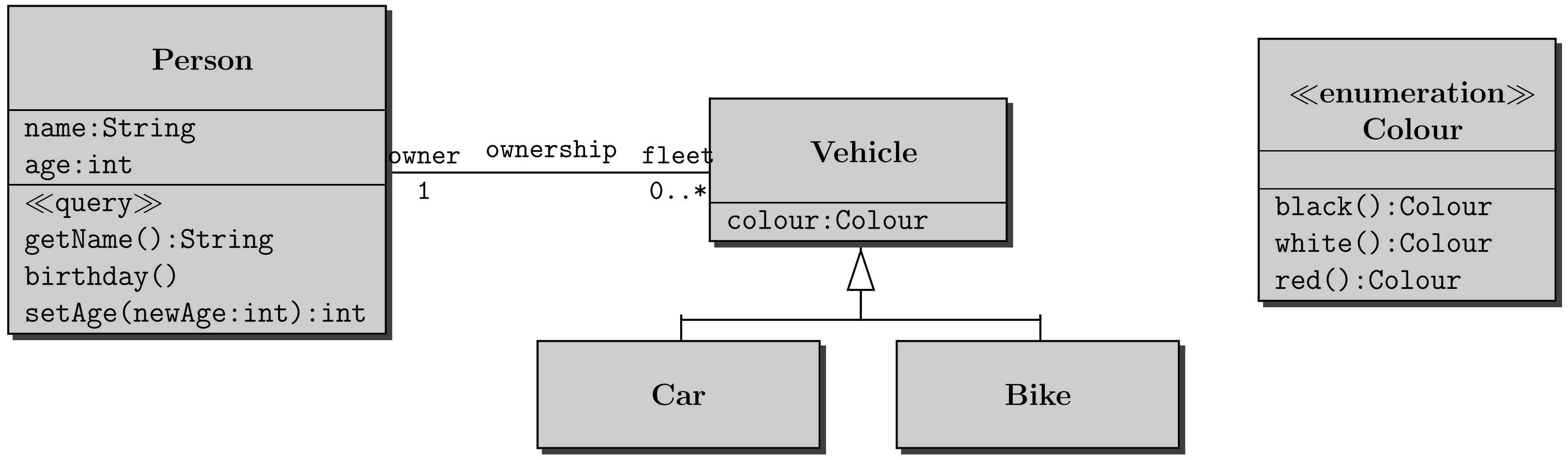


“All cars of a person are black”:

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

“Nobody has more than 3 black vehicles”:

Some OCL examples II



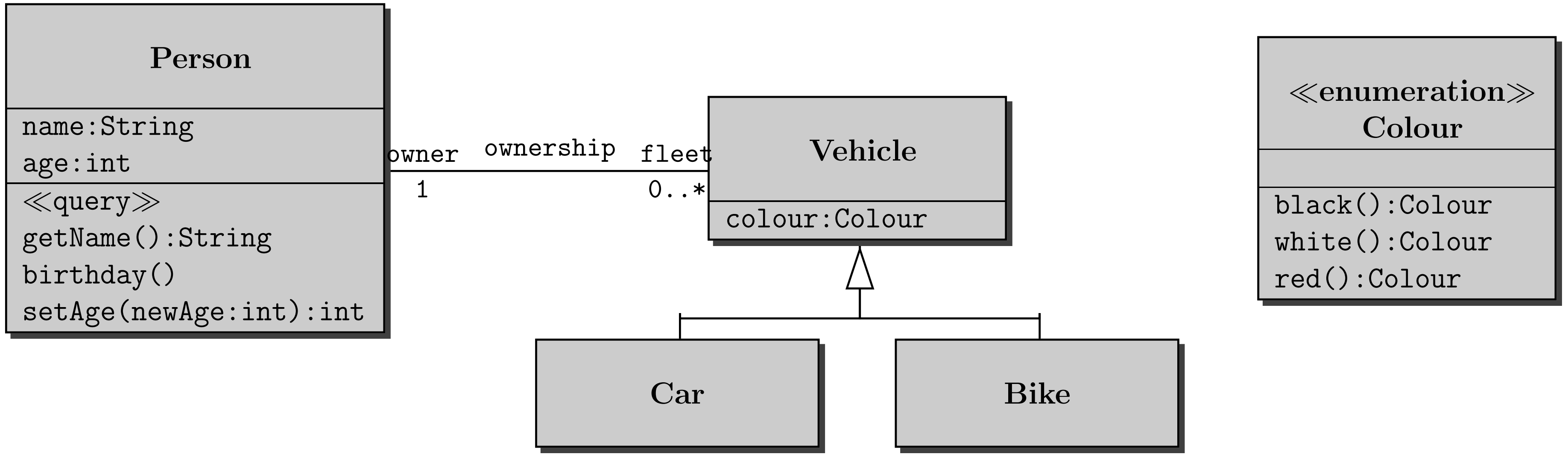
“All cars of a person are black”:

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

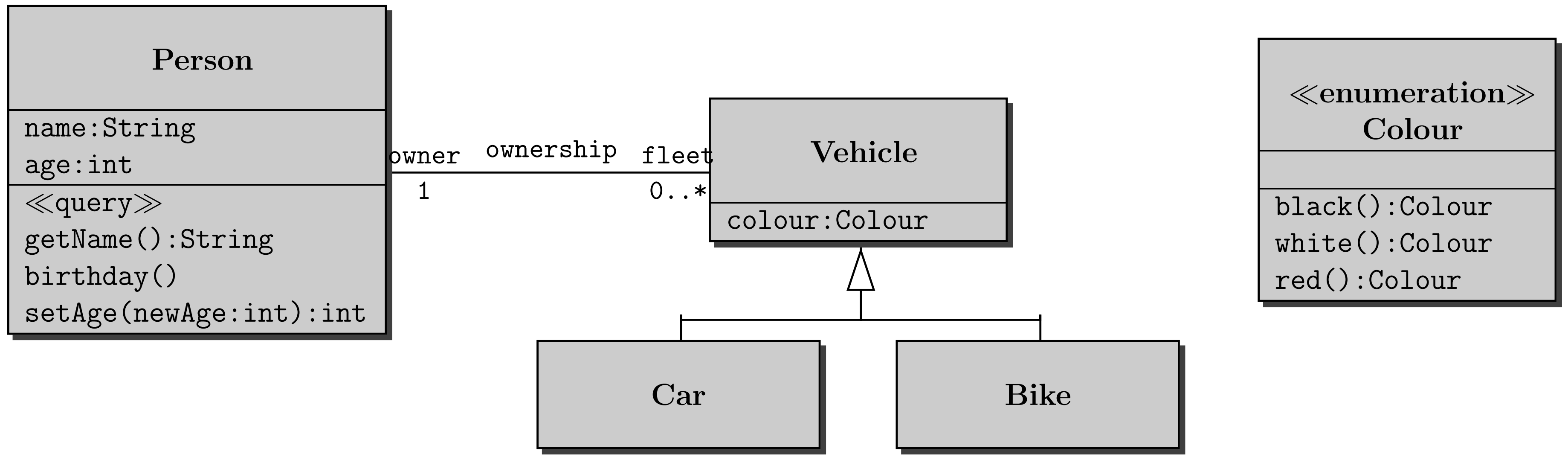
Some OCL examples III — iterate



What does this mean?

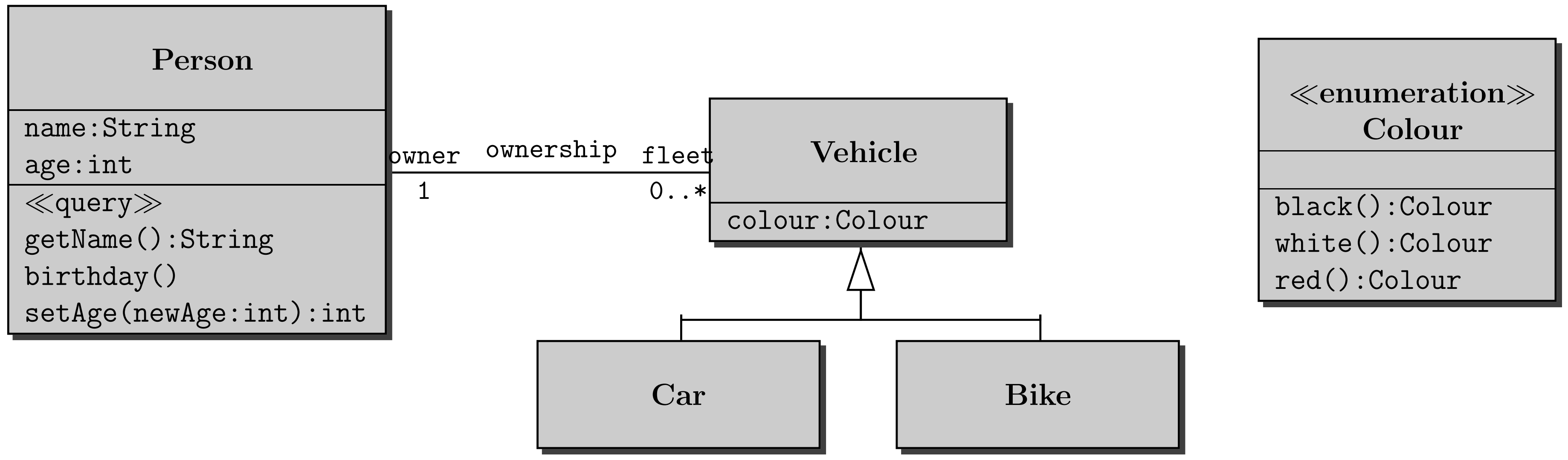
```
context   Person
inv:      self.fleet–>iterate(v; acc:Integer=0
                         | if (v.colour=#black)
                         then acc + 1 else acc endif) <=3
```

Some OCL examples IV — oclIsKindOf



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

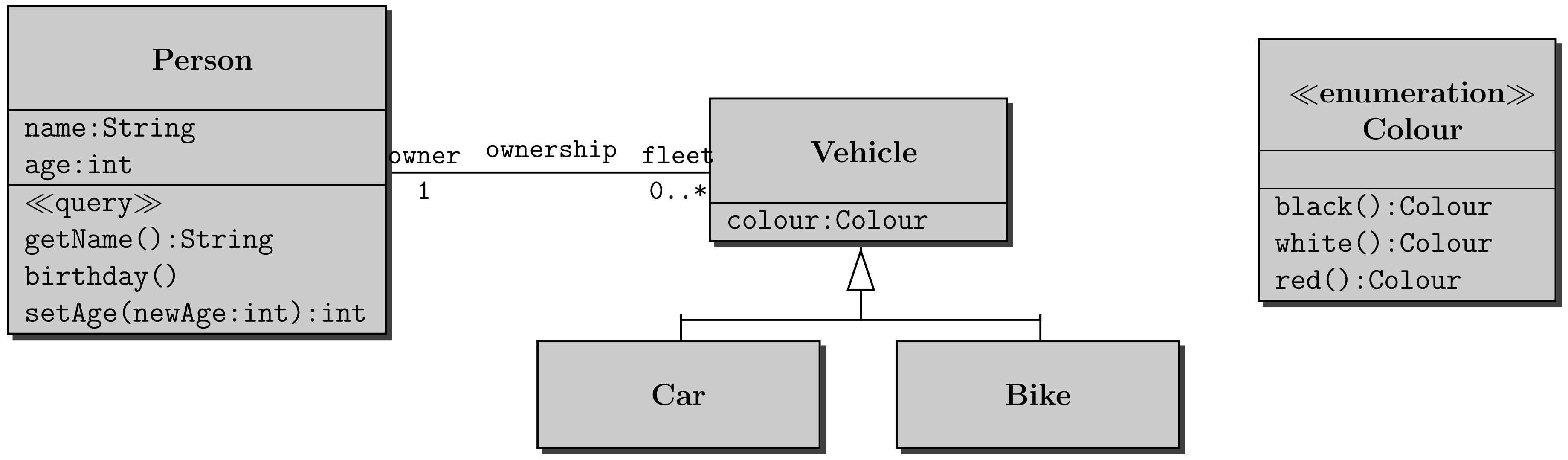
Some OCL examples IV — oclIsKindOf



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

“A person younger than 18 owns no cars.”

Some OCL examples IV — oclIsKindOf

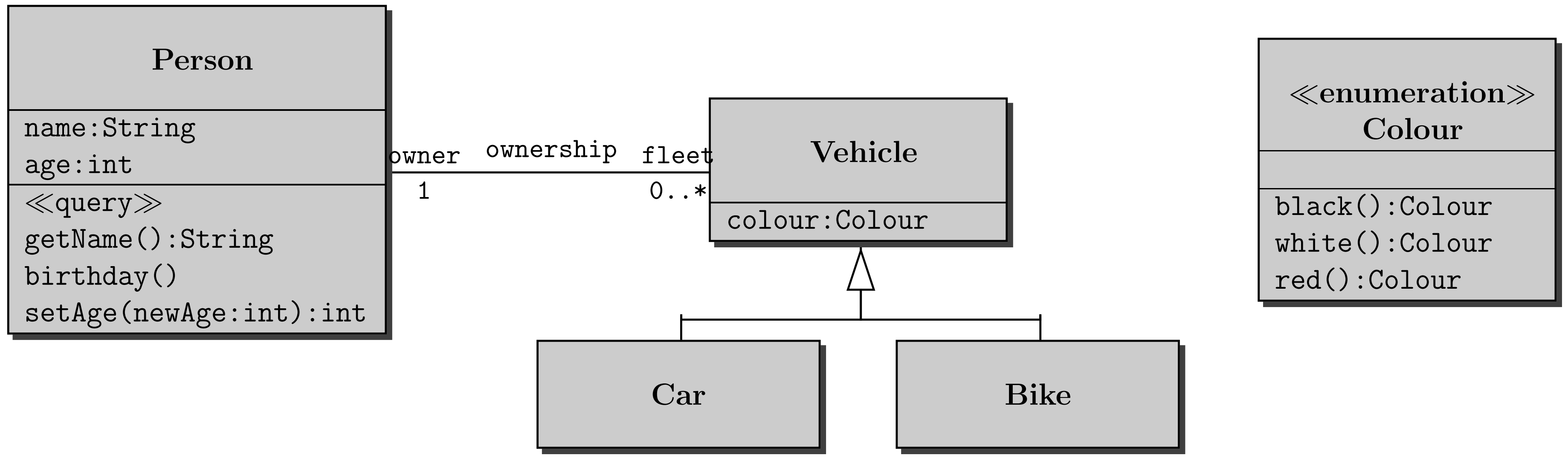


context Person
inv: age<18 implies self.fleet–>forAll(v | not v.oclIsKindOf(Car))

"A person younger than 18 owns no cars."

"self" can be omitted.

Some OCL examples IV — oclIsKindOf



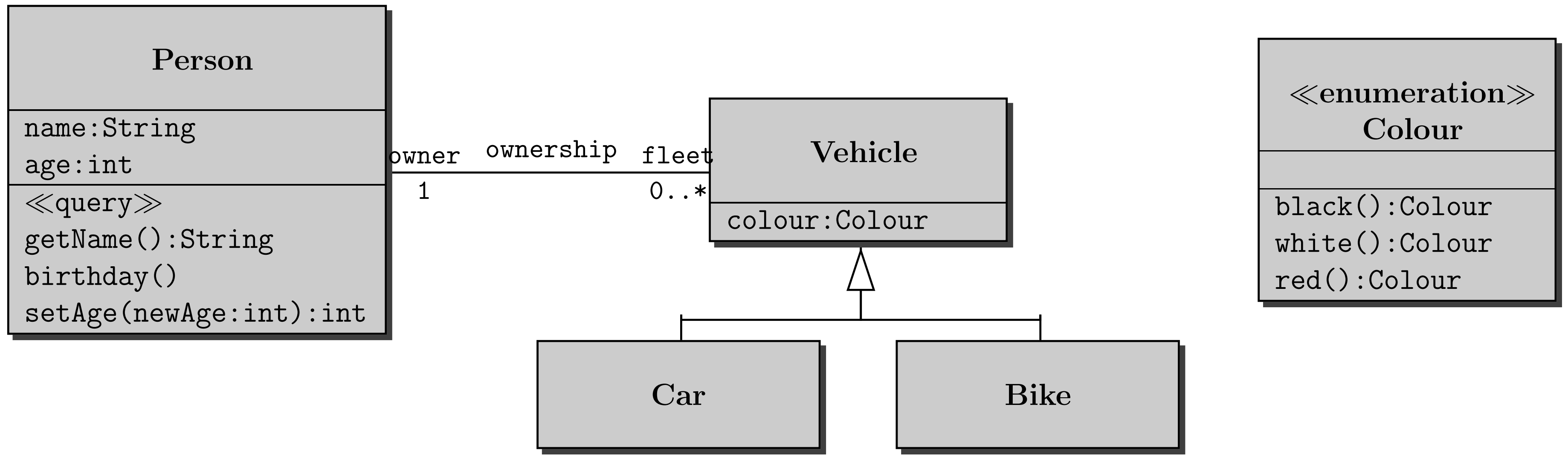
context **Person**
inv: **age<18 implies self.fleet–>forAll(v | not v.oclIsKindOf(Car))**

“A person younger than 18 owns no cars.”

“self” can be omitted.

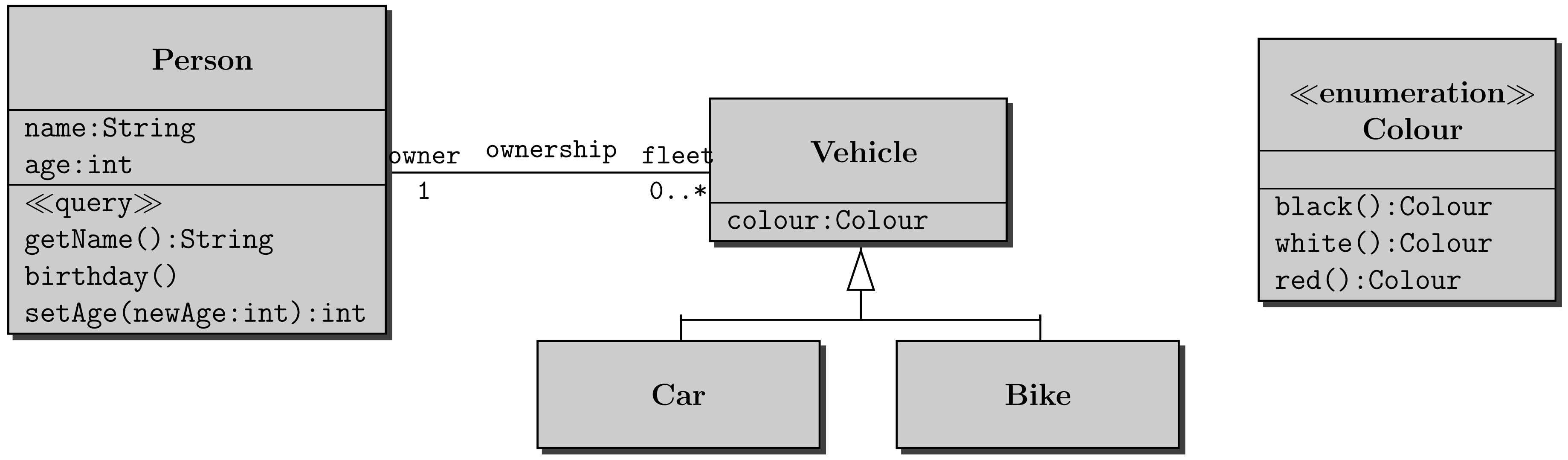
Logical Junctors: and, or, not, implies, if...then...else...endif, =

Some OCL examples V — allInstances



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

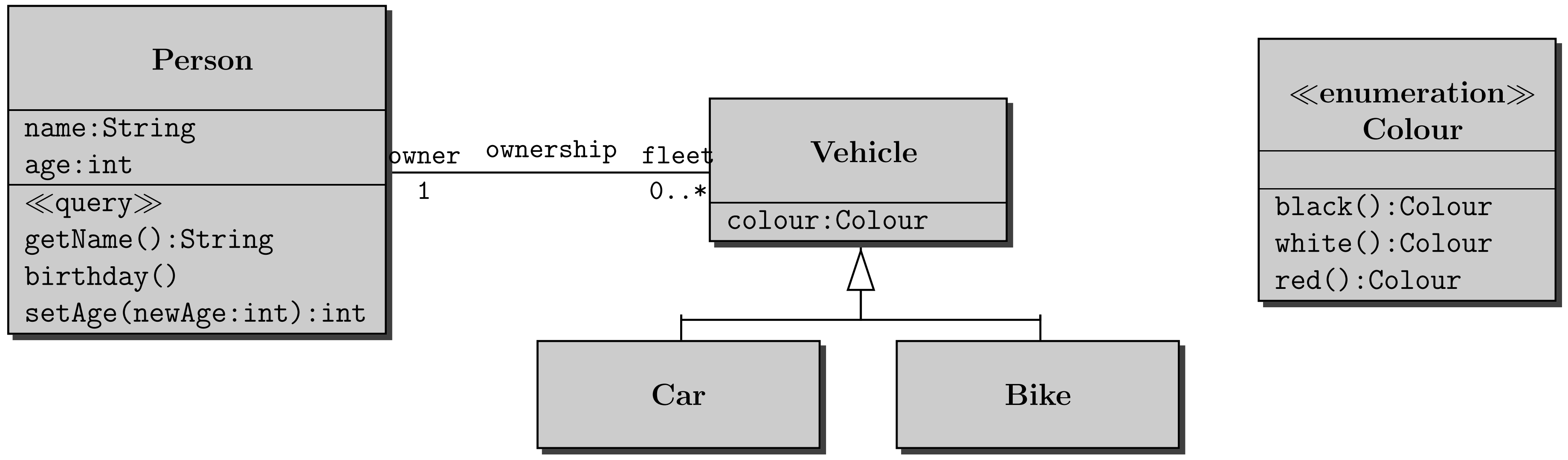
Some OCL examples V — allInstances



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

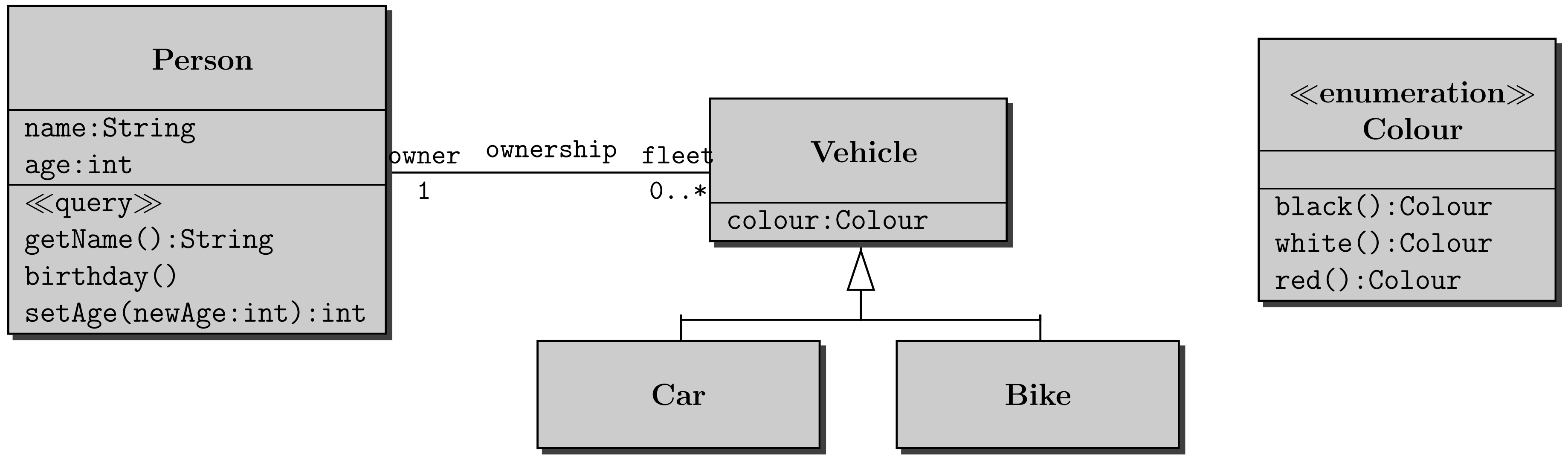
“There is a red car.”

OCL pre-/post conditions — Examples



So far only considered class invariants.

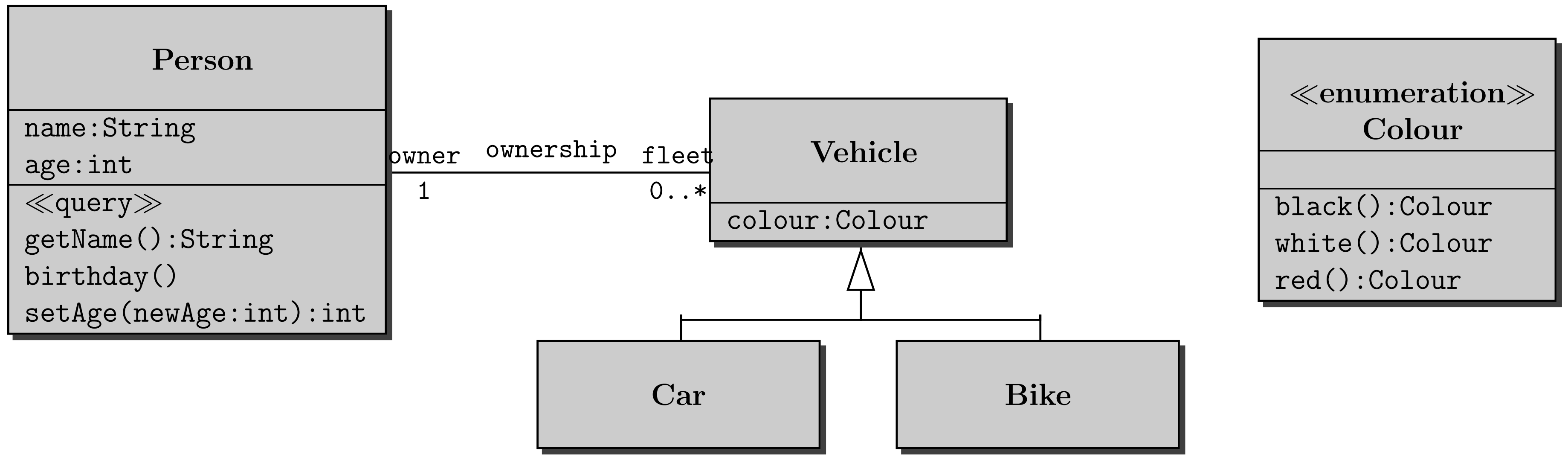
OCL pre-/post conditions — Examples



So far only considered class invariants.

OCL can also specify operations:

OCL pre-/post conditions — Examples



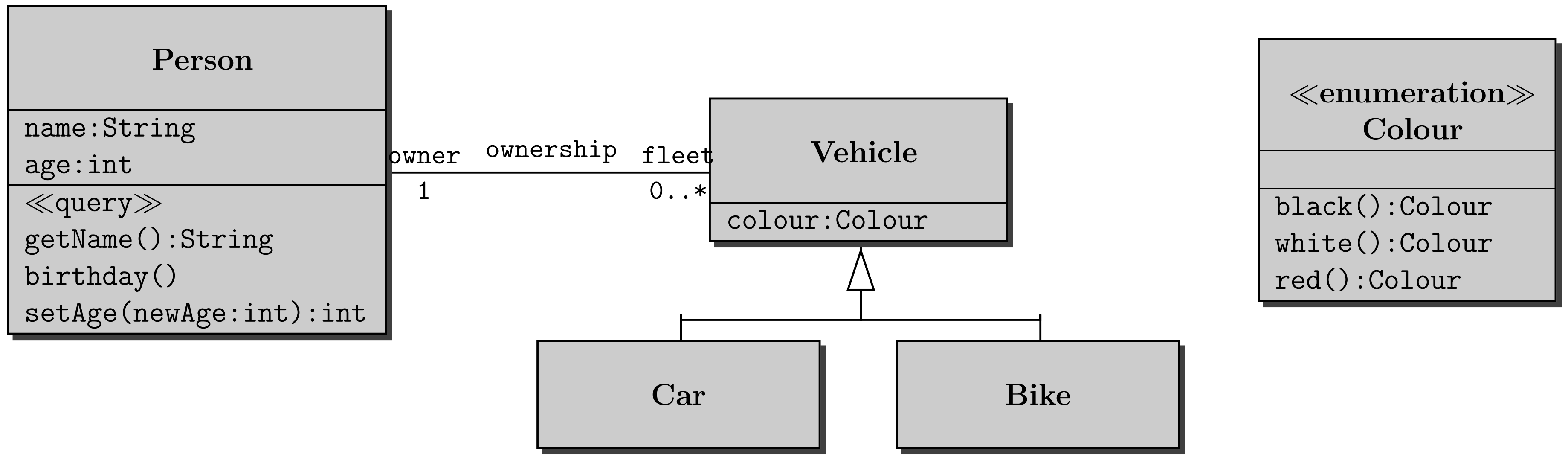
So far only considered class invariants.

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
```

OCL pre-/post conditions — Examples



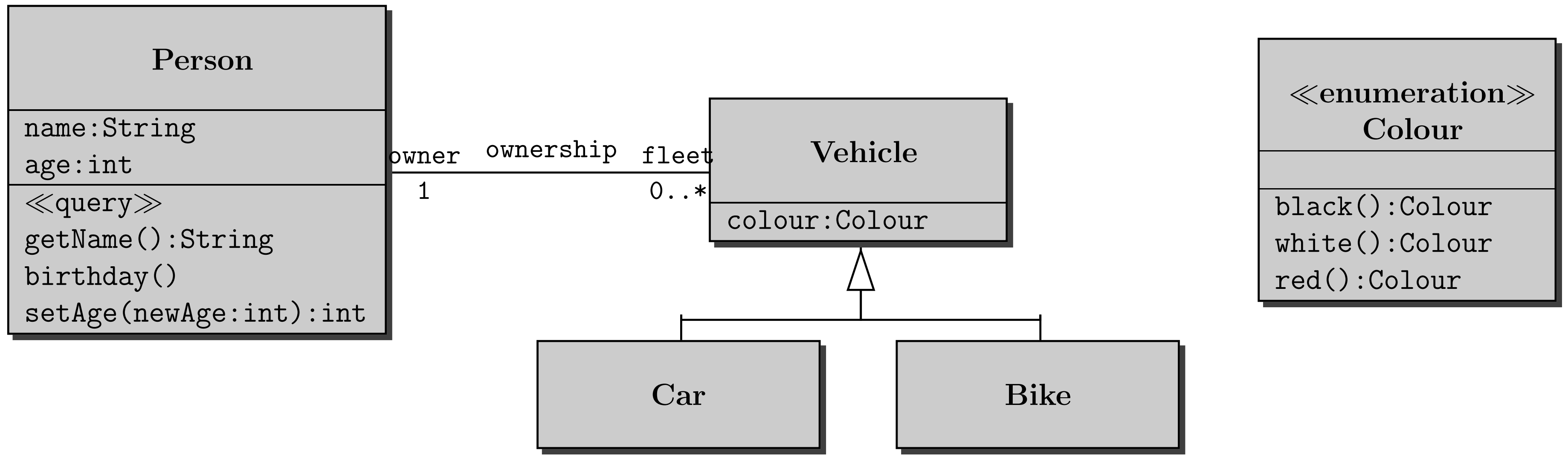
So far only considered class invariants.

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



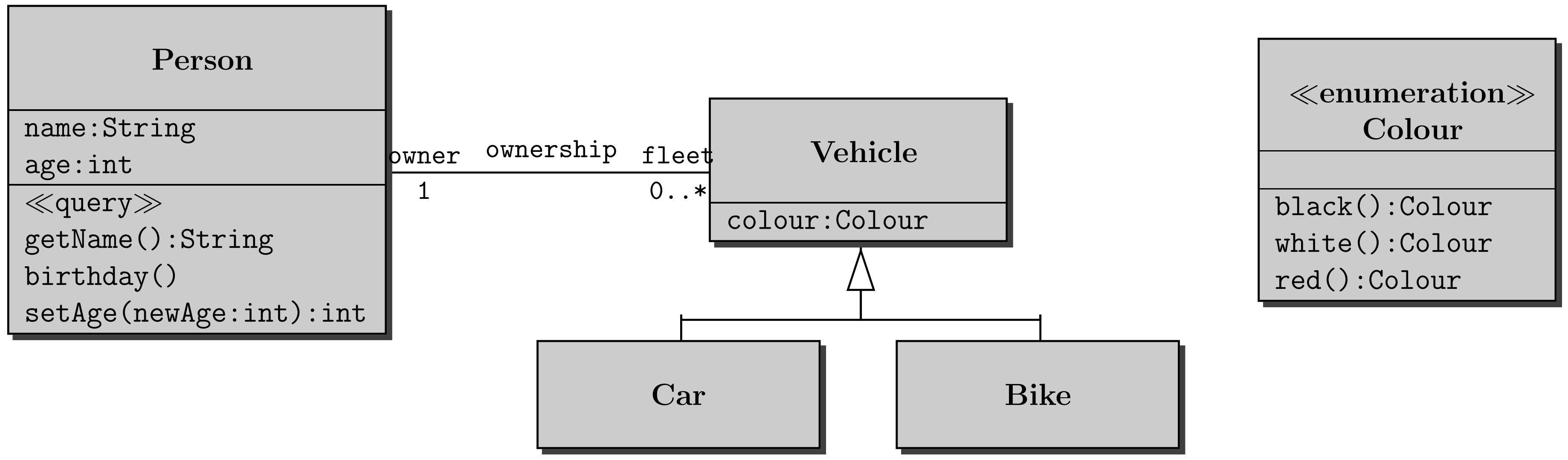
So far only considered class invariants.

OCL can also specify operations:

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

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

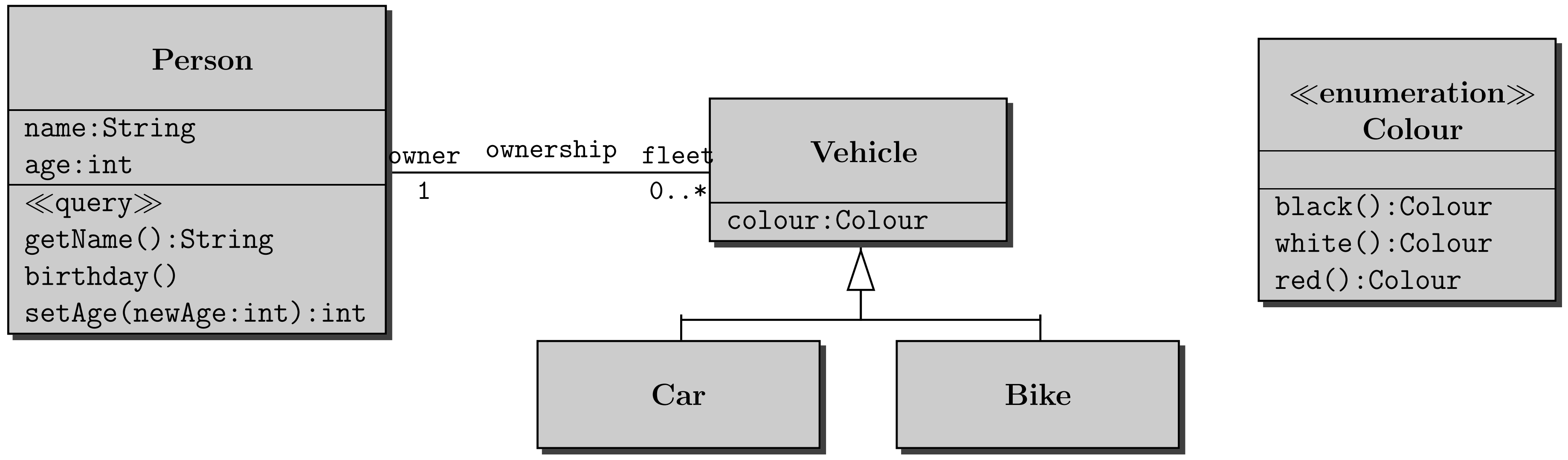
Queries



Special to OCL are operations with a ≪query≫ stereotype:

Only these operations can be used within an OCL expression.

Queries



Special to OCL are operations with a ≪query≫ stereotype:

Only these operations can be used within an OCL expression.

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

```
context   Person
inv:      self.getName() = name
```

OCL Basics

- OCL is used to specify invariants of objects and pre- and post conditions of operations. Makes UML (class) diagrams more precise.

OCL Basics

- OCL is used to specify invariants of objects and pre- and post conditions of operations. Makes UML (class) diagrams more precise.
- OCL expressions use vocabulary of UML class diagram.

OCL Basics

- OCL is used to specify invariants of objects and pre- and post conditions of operations. Makes UML (class) diagrams more precise.
- OCL expressions use vocabulary of UML class diagram.
- OCL attribute accesses “navigate” through UML class diagram.

OCL Basics

- OCL is used to specify invariants of objects and pre- and post conditions of operations. Makes UML (class) diagrams more precise.
- OCL expressions use vocabulary of UML class diagram.
- OCL attribute accesses “navigate” through UML class diagram.
- “context” specifies about which elements we are talking.

OCL Basics

- OCL is used to specify invariants of objects and pre- and post conditions of operations. Makes UML (class) diagrams more precise.
- 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

OCL Basics (cont.)

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

  Operations on collections: –>

  Example operations: select, forAll, iterate

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

OCL Basics (cont.)

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

  Operations on collections: –>

  Example operations: select, forAll, iterate

- "iterate" can simulate all other operations on collections.

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

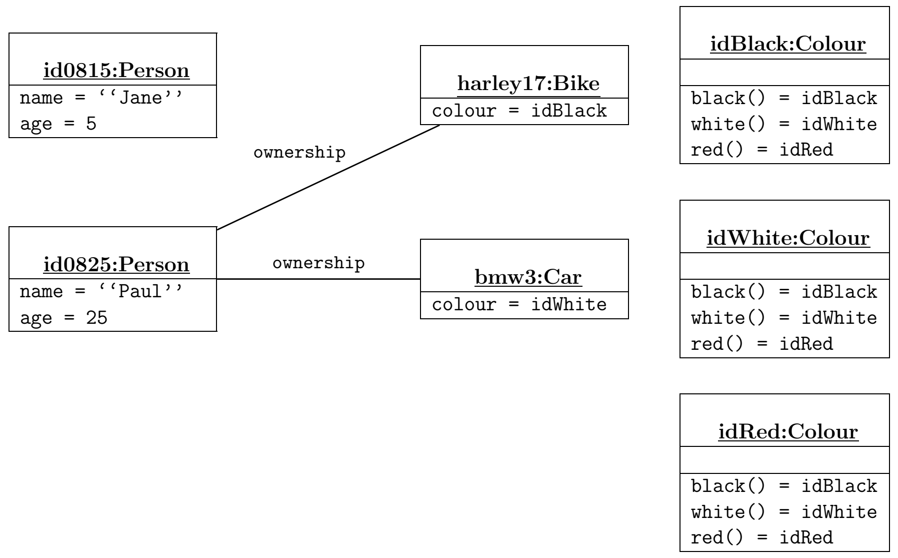
OCL in TogetherCC/KeY

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

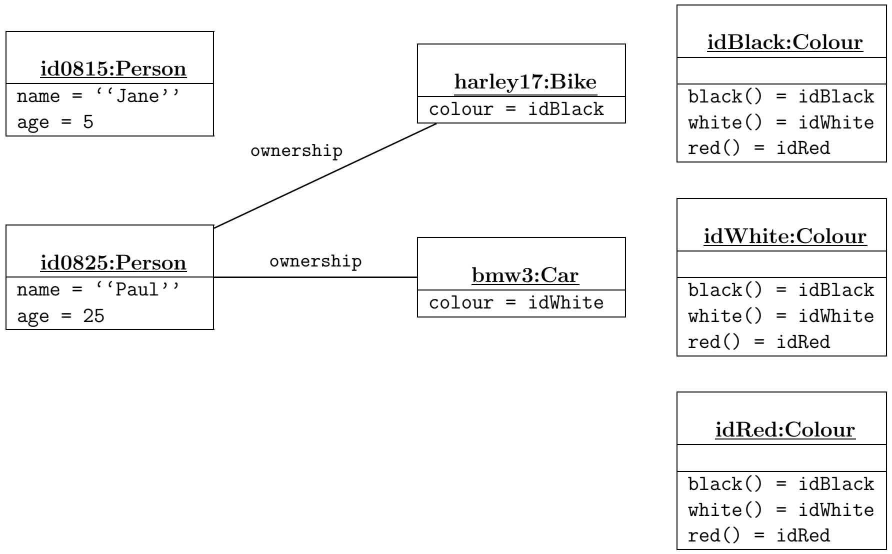
With the KeY extensions to TogetherCC syntax (type) checks of OCL constraints are possible.

System state

System state

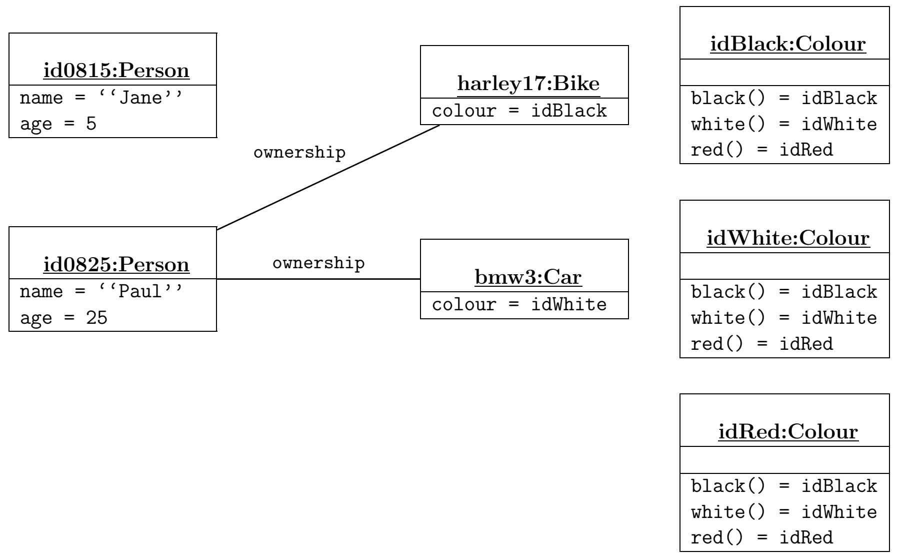


System state



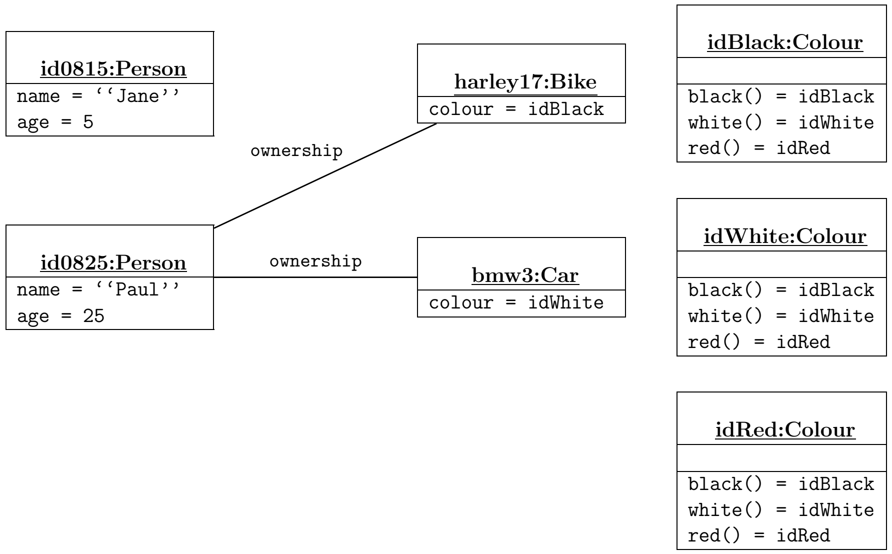
context **Vehicle**
inv: **self.owner.age $>=$ 18**

System state



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

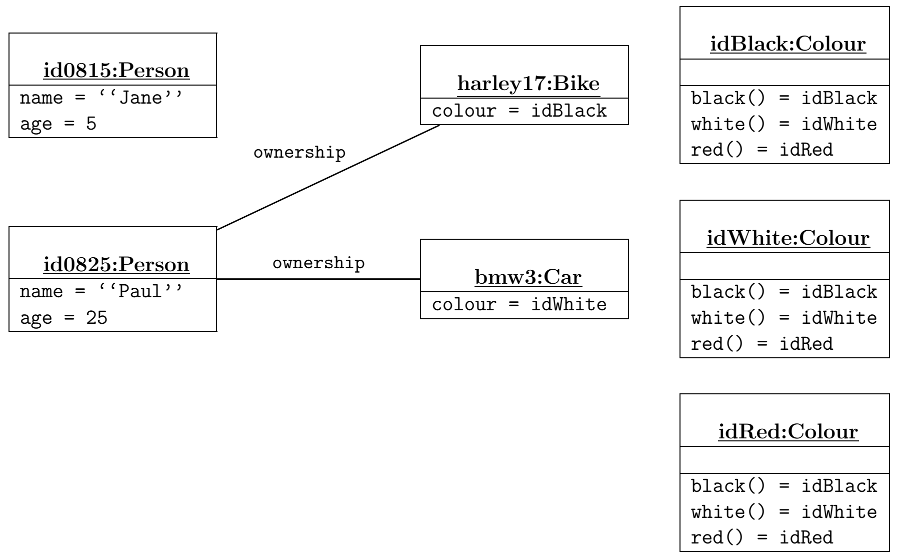
System state



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

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

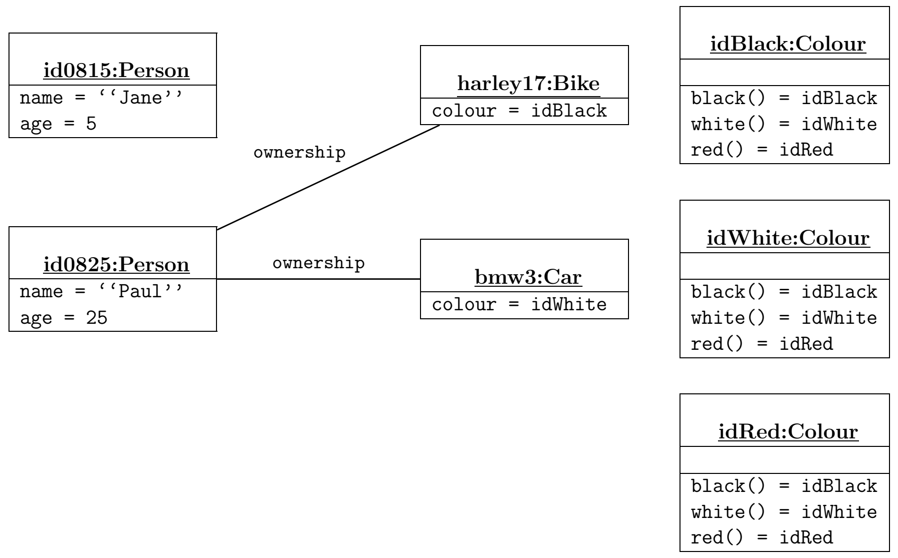
System state



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

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

System state

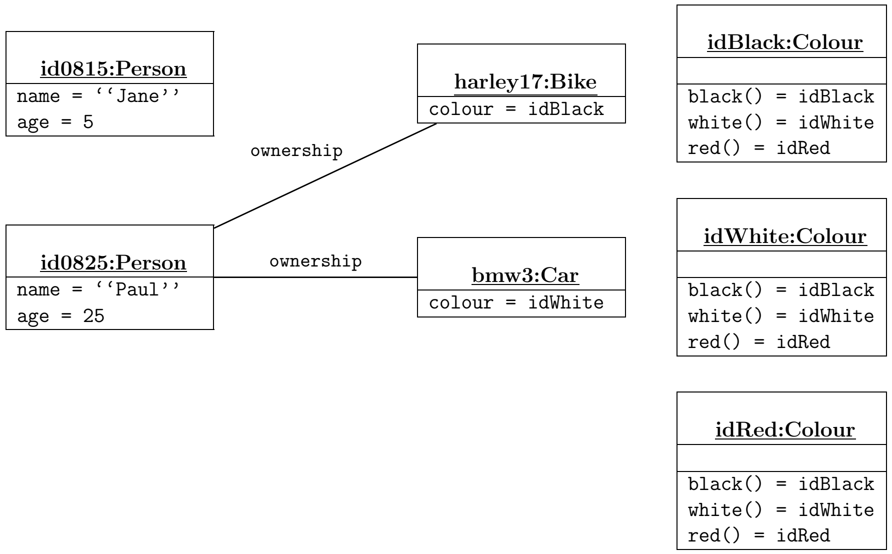


context **Vehicle**
inv: **self.owner.age $>=$ 18** ✓

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

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

System state

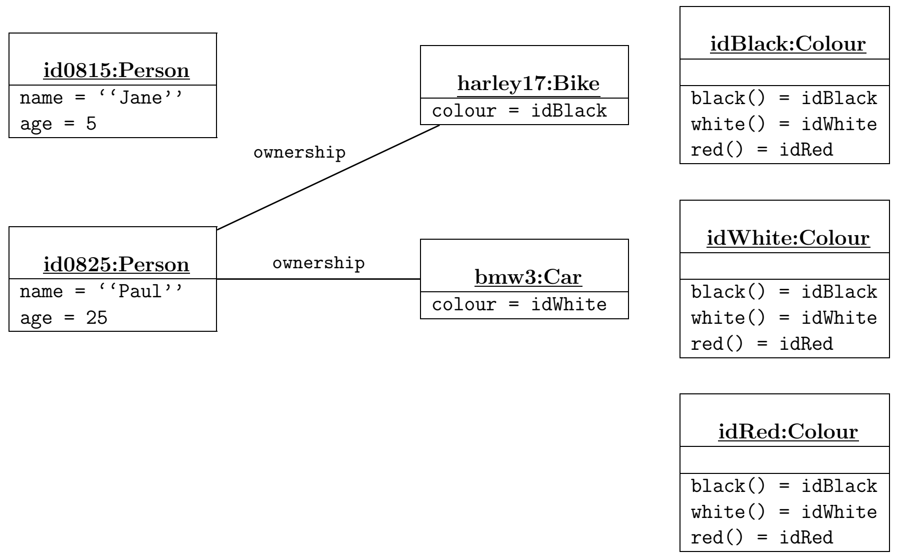


context **Vehicle**
inv: **self.owner.age $>=$ 18** ✓

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

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

System state

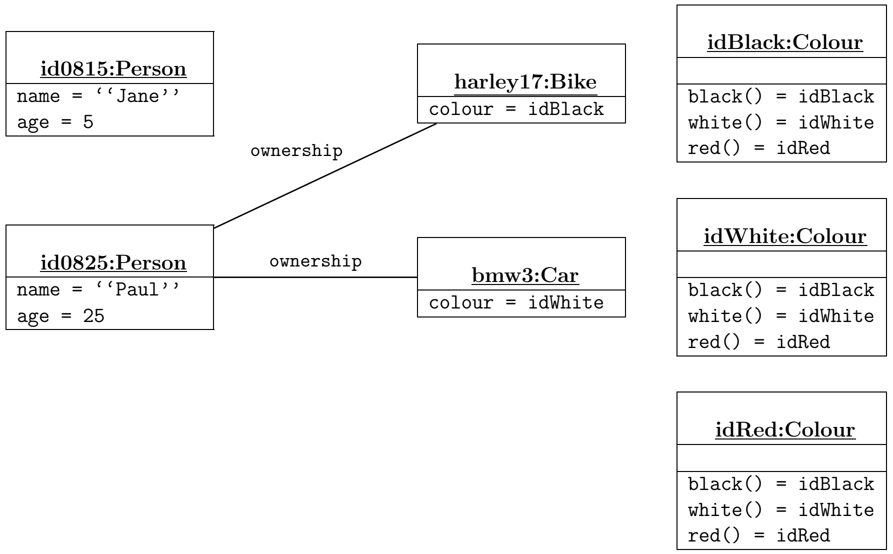


context Vehicle
inv: self.owner.age $>=$ 18 ✓

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

context Person
inv: self.fleet–$>$select(v | v.colour = #black)–$>$size $<=$ 3 ✓
inv: Car.allInstances()–$>$exists(c | c.colour=#red)

System state



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

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

context **Person**
inv: **self.fleet–>select(v | v.colour = #black)–>size $<=$ 3** ✓
inv: **Car.allInstances()–>exists(c | c.colour=#red)** ☒