Object Constraint Language 1

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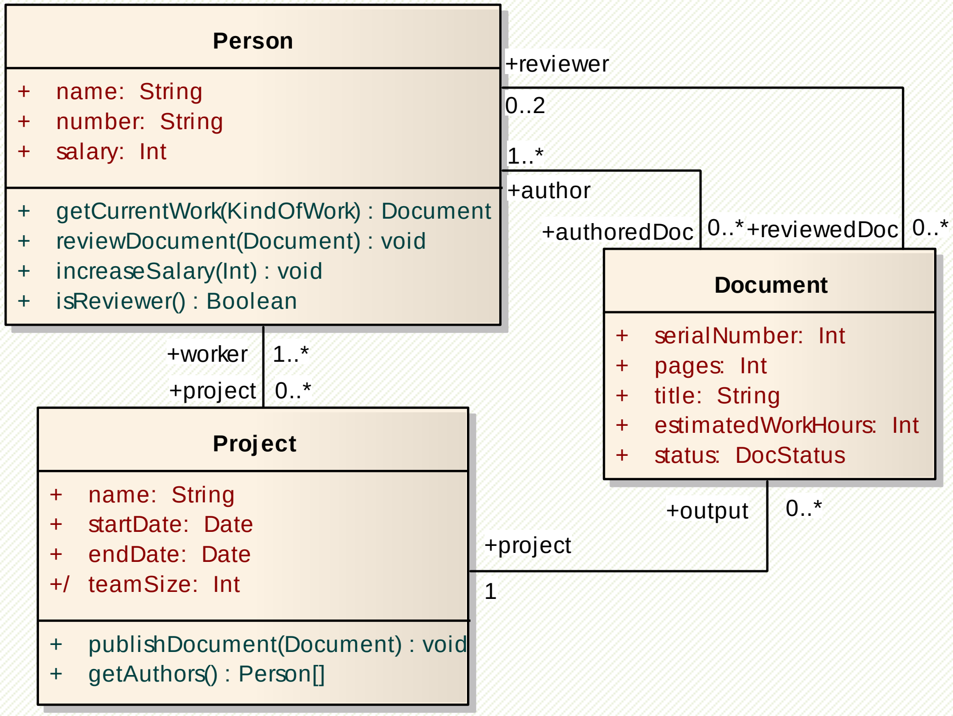
Incompleteness and Ambiguities

- UML (class) schemas typically do not provide all relevant details (e.g., constraints, pre-conditions, post-conditions)
- more information is required, it can be specified in a form of
  - notes/documentation in natural language
    - ambiguities but easy to understand by average business people or software engineers
  - formal languages
    - unambiguous but usable only to persons with strong mathematical background

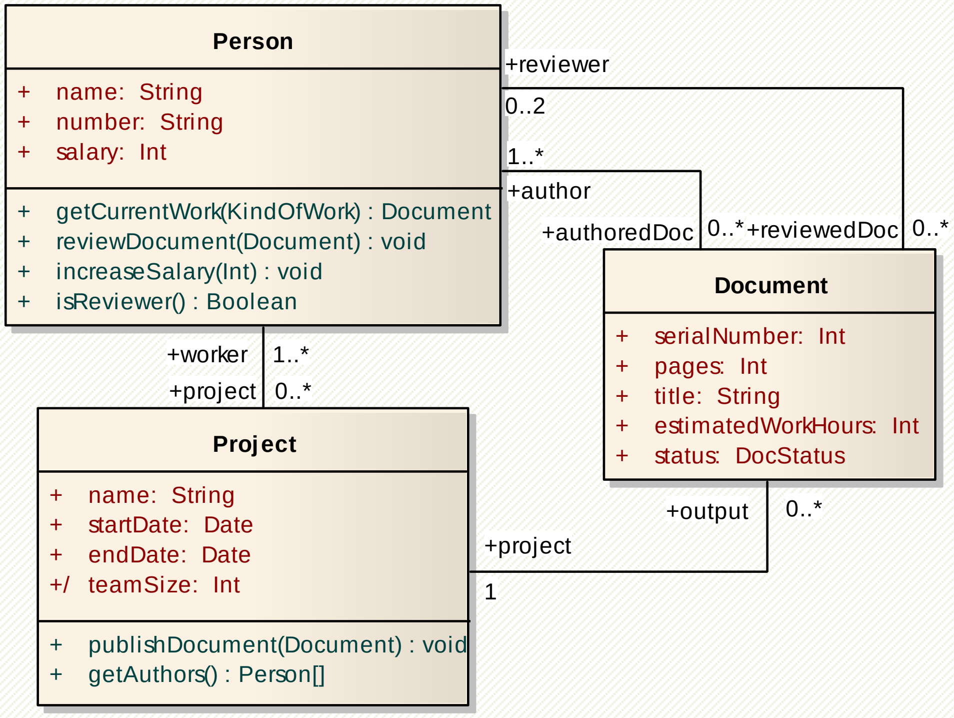
Incompleteness and Ambiguities

- What is on your mind when you see this UML class diagram? I.e.:
  - What constraints apply?
  - What constraints are already unambiguously expressed in the diagram?
  - What constraints are not expressed?
    - How would you express them?



Incompleteness and Ambiguities

- The start date of a project must be before the end date.
- A document with less than 8 estimated working hours can not have more than 1 author.
- A person can be either an author or reviewer of a single document but not both.
- A person can be an author of a document only if that document is an output of his or her project.
- The serial number of a document must be unique in a project.
- A document can be published only when it is finished.



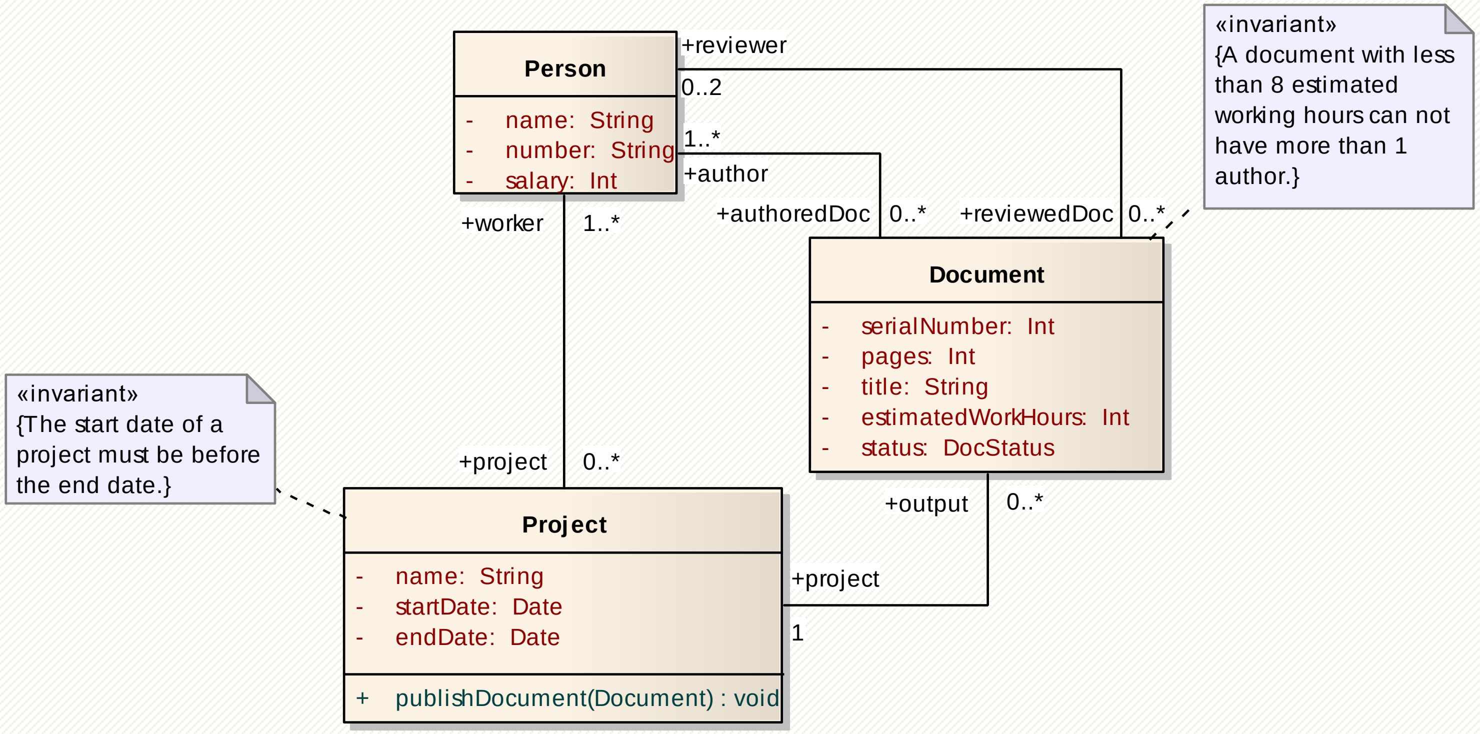
Constraints in UML

- UML constraint is a condition or restriction attached to one or more elements expressed in a natural language or machine readable notation
  - boolean expression that restricts the extension of the associated elements beyond what is imposed by the other UML constructs applied to that elements

Constraint Formal Model

- constraint context
  - the constraint is evaluated in a given context
  - determines when the constraint is evaluated
    - e.g., operation pre and post conditions
- constrained elements
  - all elements constrained by the constraint
- name
  - optional

Constraints in UML – Example



Object Constraint Language (OCL)

- not a procedural language
  - specification and declarative language
- extension to UML
- strongly typed language
  - types defined by UML diagrams
  - predefined types:
    - Integer, Boolean, String, Real, UnlimitedInteger
    - Set, OrderedSet, Bag, Sequence
- functional language
  - no side effects

Kinds of Expressions

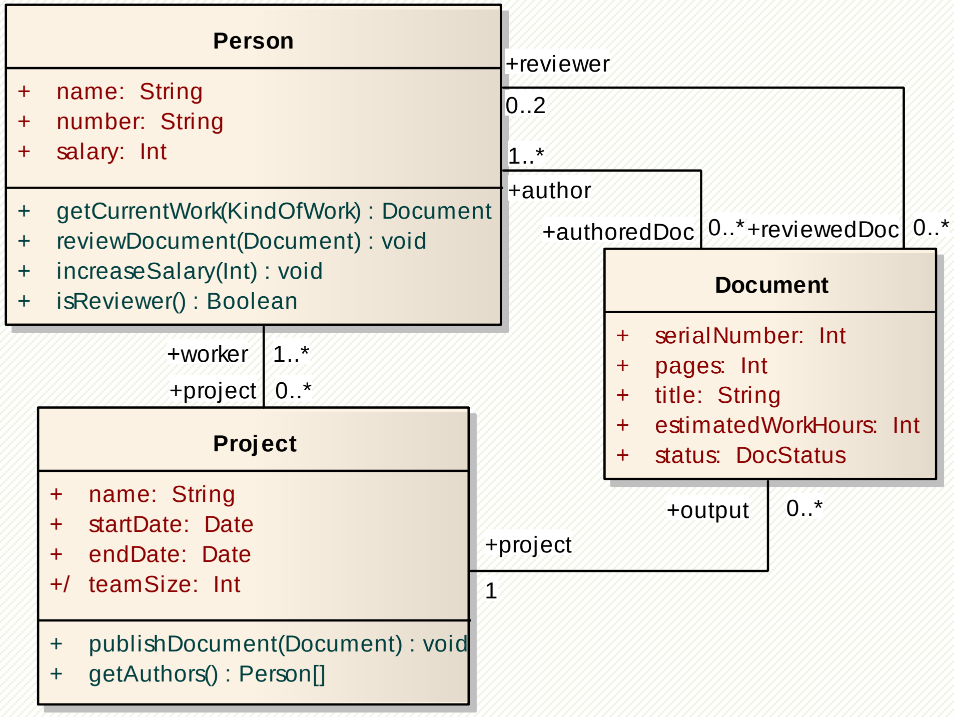
- initial values
- derivation rules
- operation pre-conditions, post-conditions, bodies
- invariants

Initial Values

```
context TypeName::PropertyName: Type
init: -- Expression representing the initial value
```

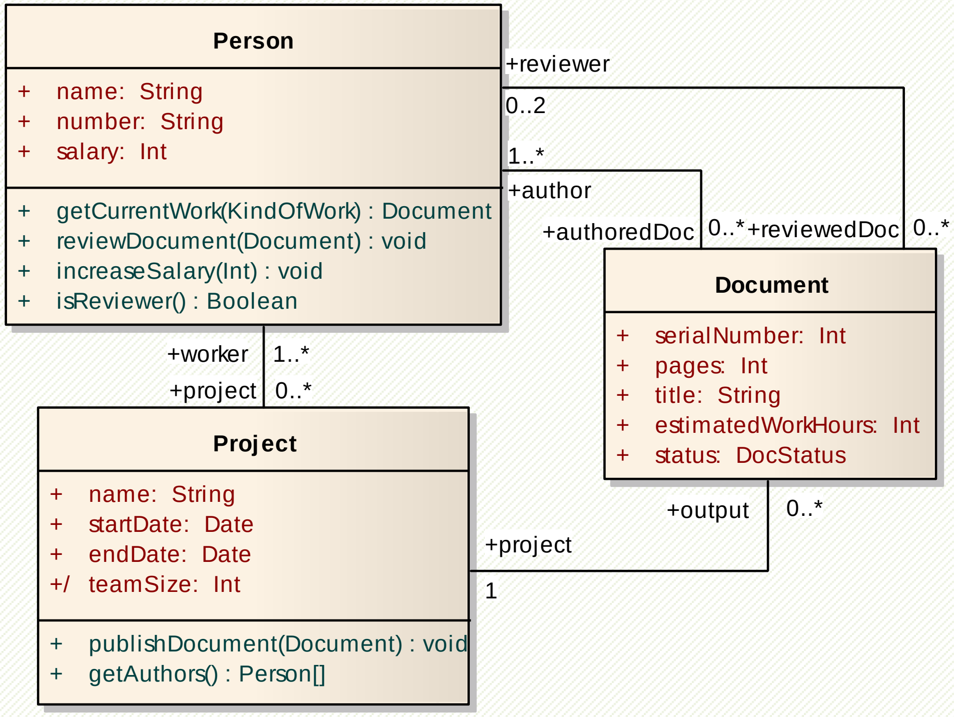
- declares that the initial value of `TypeName::PropertyName` is equal to the value of the `Expression`
  - the initial value is the value being assigned at the moment of the creation
  - the type of the initial value must conform to `Type`
- `PropertyName` is an attribute or association end
  - if attribute then it must be owned by `TypeName`
  - if association end then it must be owned by `TypeName`, or `TypeName` must be the context of `PropertyName`
- NOTE: What is *context*?

Initial Values



```
context Document::status
init: DocStatus::New
```

Initial Values



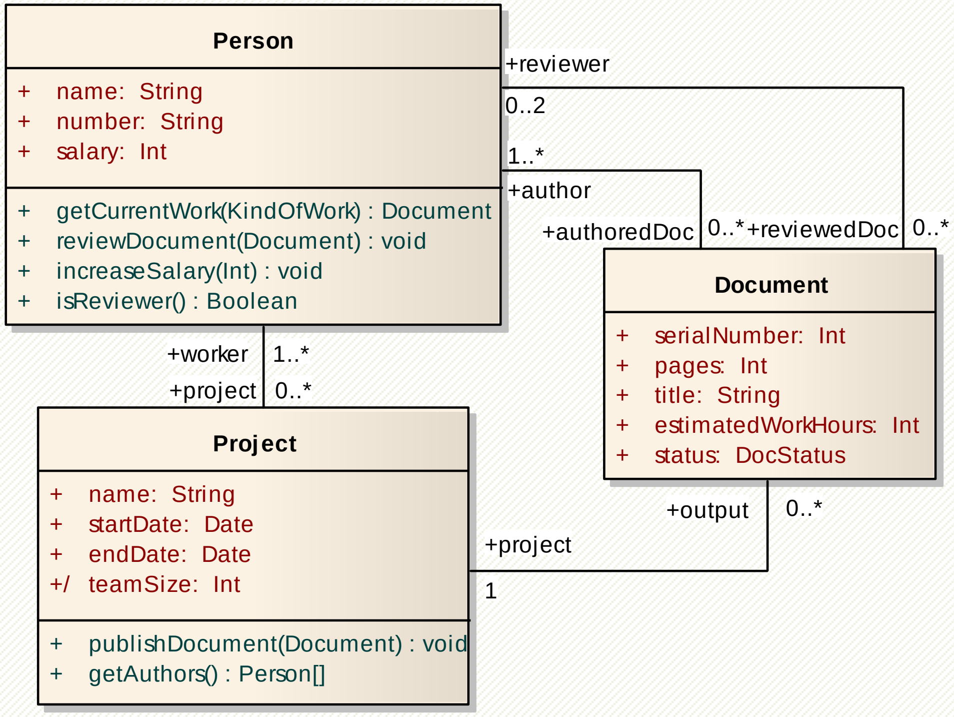
```
context Project::output : Set(Document)
init: Set{}
```

Derivation Rules

```
context TypeName::PropertyName: Type
derive: -- Expression representing the derivation rule
```

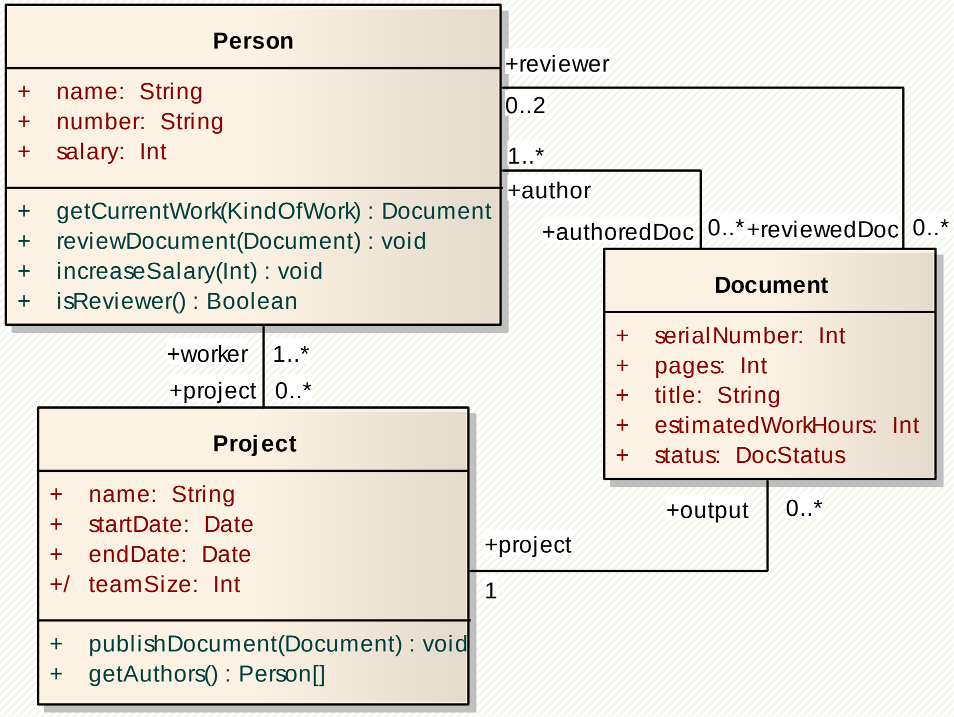
- declares that the value of `TypeName::PropertyName` should always be equal to the value of the `Expression`
  - the derivation rule is a kind of invariant
  - the type of the derived value must conform to `Type`
- `PropertyName` is an attribute or association end
  - if attribute then it must be owned by `TypeName`
  - if association end then it must be owned by `TypeName`, or `TypeName` must be the context of `PropertyName`

Derivation Rules



```
context Project::teamSize
derive: self.worker->size()
```

Derivation Rules



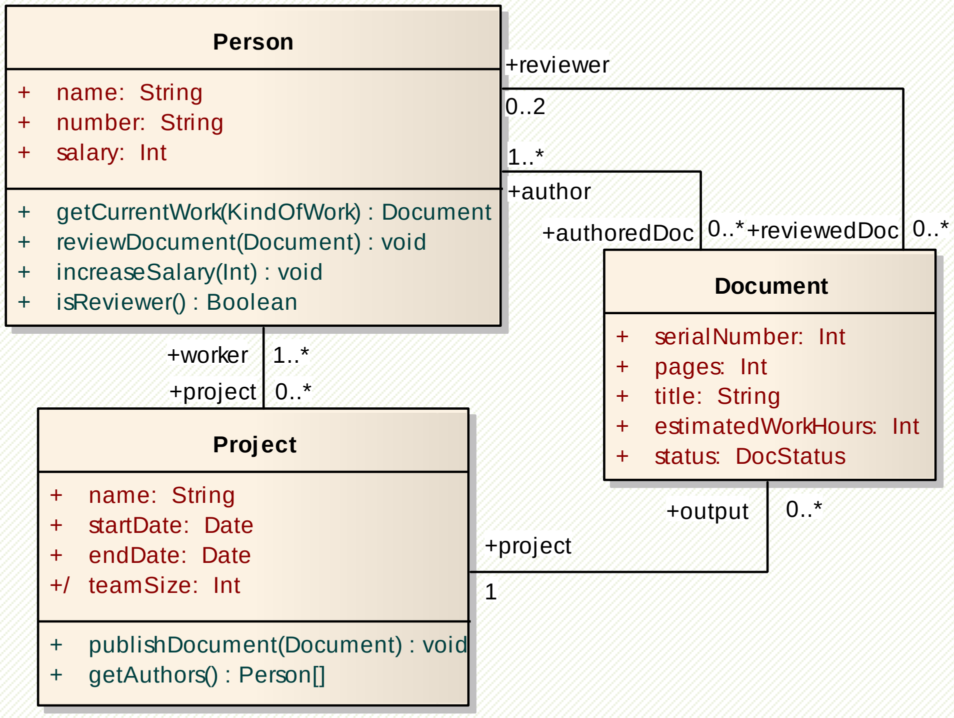
```
context Project::currentReviewer : Set(Person)
derive: output->select(status = DocStatus::Review)
                                               .reviewer->asSet()
```

Operation Pre- and Post-conditions

```
context TypeName::OperName(p1 : Type1, ...): ReturnType
pre: -- pre-condition Expression
post: -- post-condition Expression
```

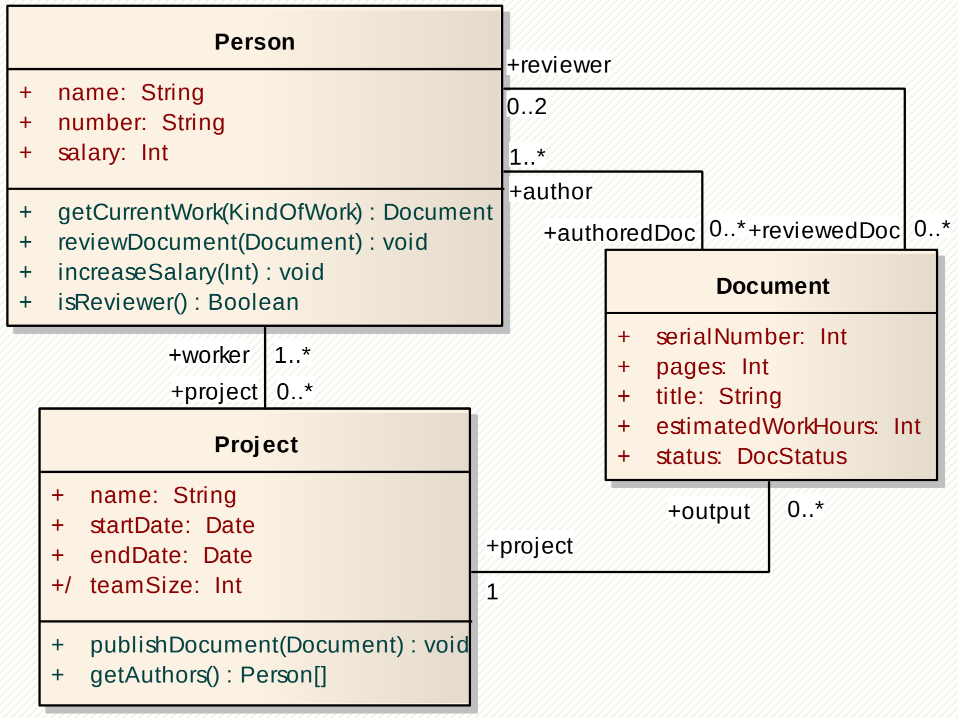
- pre-condition must be true when the operation starts its execution
  - otherwise the operation will not be executed
- post-condition must be true when the operation ends its execution
  - otherwise the operation has not executed correctly
  - `result` – reserved word representing the result of executing the operation
  - `@pre` – reserved property suffix representing the previous value of the property

Operation Pre- and Post-conditions



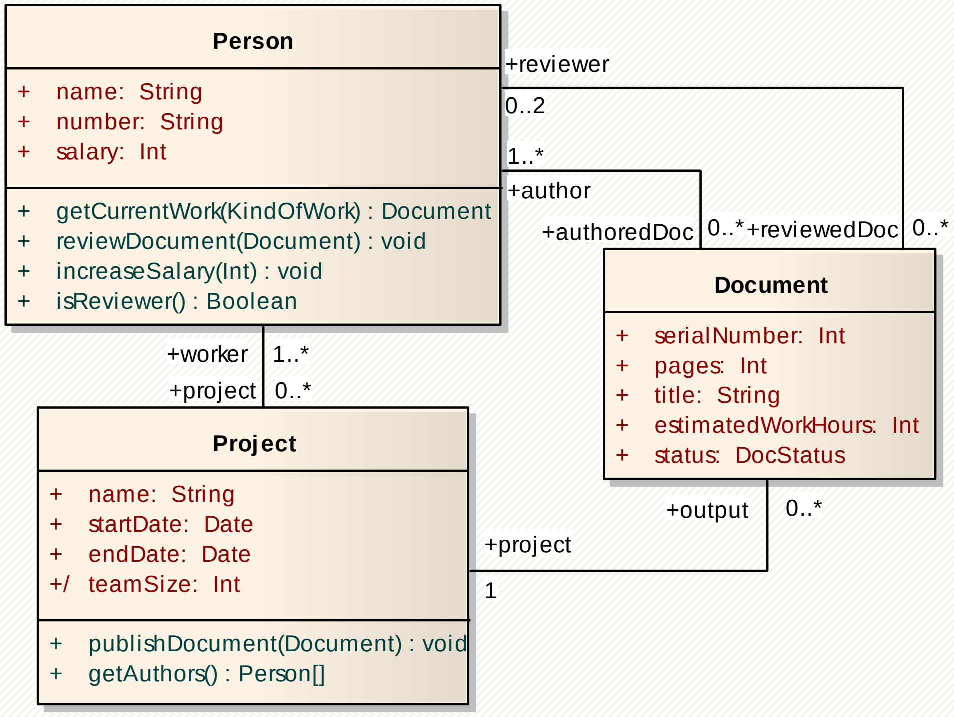
```
context Project::publishDocument(d:Document)
pre:   self.output->includes(d) and
       d.status = DocStatus::Finished
post:  d.status = DocStatus::Published
```

Operation Pre- and Post-conditions



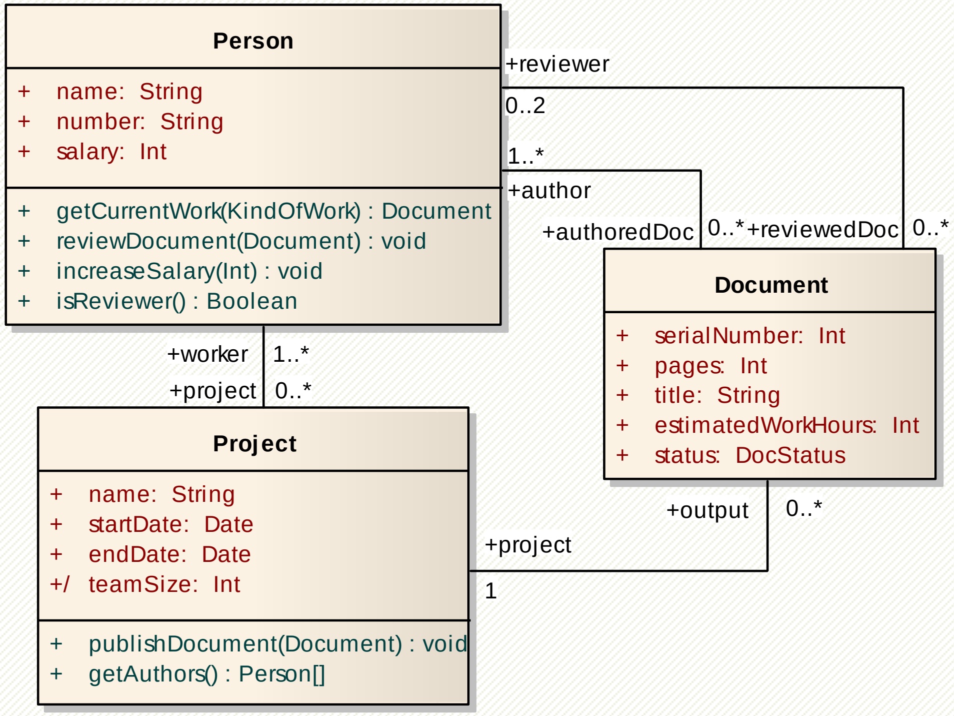
```
context Person::reviewDocument(d:Document)
pre:   self.reviewedDoc->excludes(d) and
       self.project.output->includes(d) and
       d.status = DocStatus::ToReview and d.reviewer->size()<2
post:  self.reviewedDoc->includes(d) and
       d.status = DocStatus::UnderReview
```

Operation Pre- and Post-conditions



```
context Person::increaseSalary(s:Integer): void
pre:  -- none
post: salary = salary@pre + s
```

Operation Pre- and Post-conditions



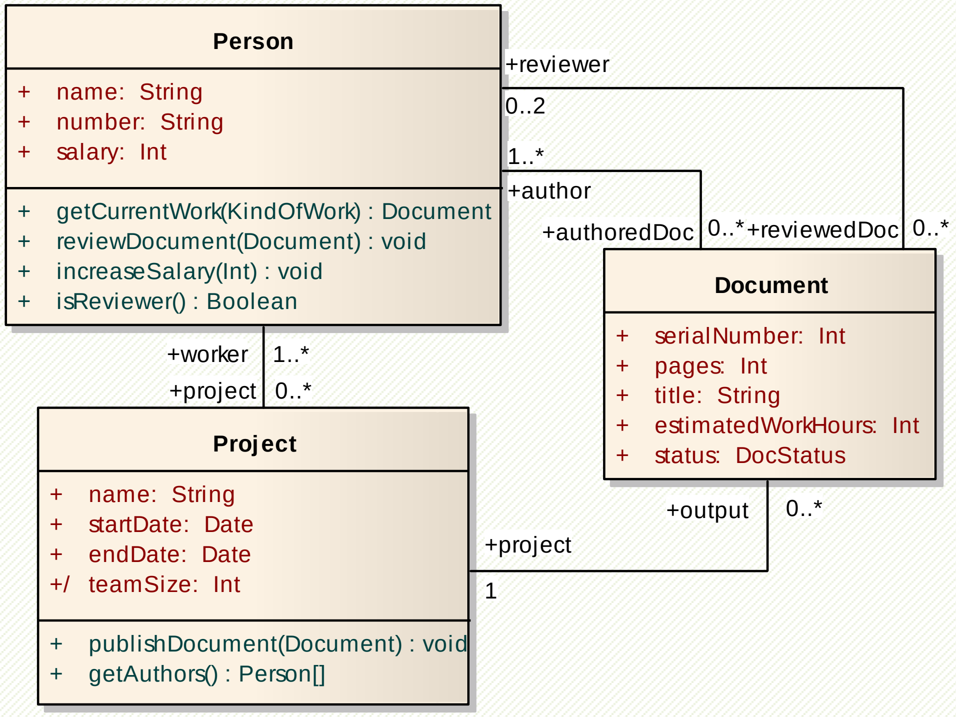
```
context Person::isReviewer(): Boolean
pre:  -- none
post: result = (self.reviewedDoc->size() > 0)
```

Operation Bodies

```
context TypeName::OperName(p1 : Type1, ...):
ReturnType
body: -- body Expression
```

- query operations can be fully declared by specifying their result in a single expression
  - query operation = does not have any side effect, no change to the extension

Operation Bodies



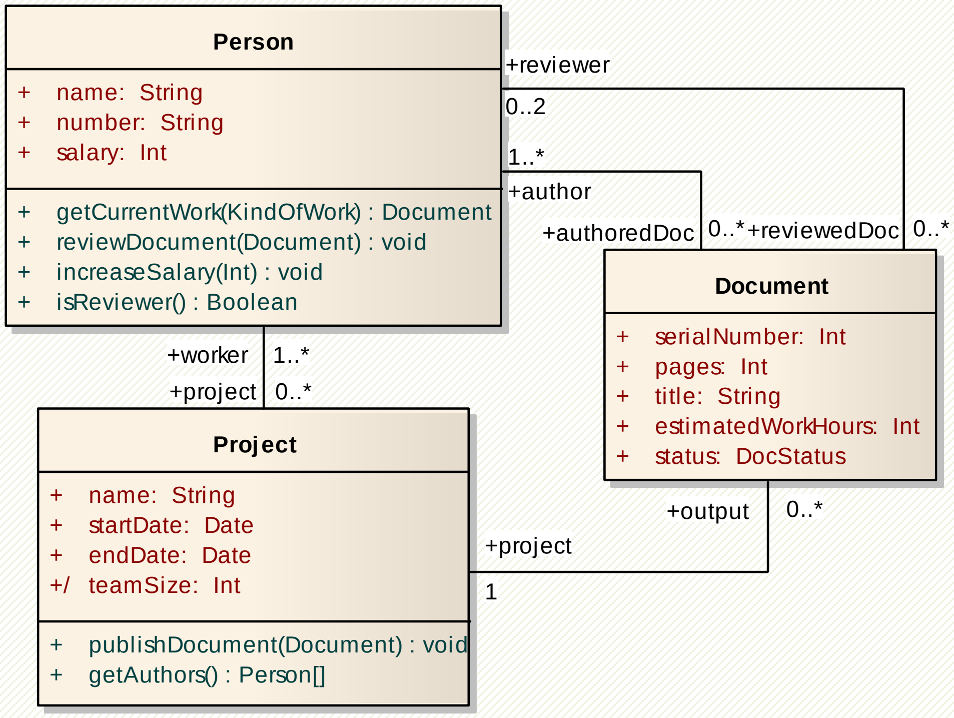
```
context Person::getCurrentWork(k: KindOfWork) : Set(Document)
body: if k = KindOfWork::Writting
      then self.authoredDoc->select(status =
                                      DocStatus::InProgress
      else self.reviewedDoc->select(status =
                                      DocStatus::Review)
```

Invariants

```
context TypeName
inv: -- invariant Expression
```

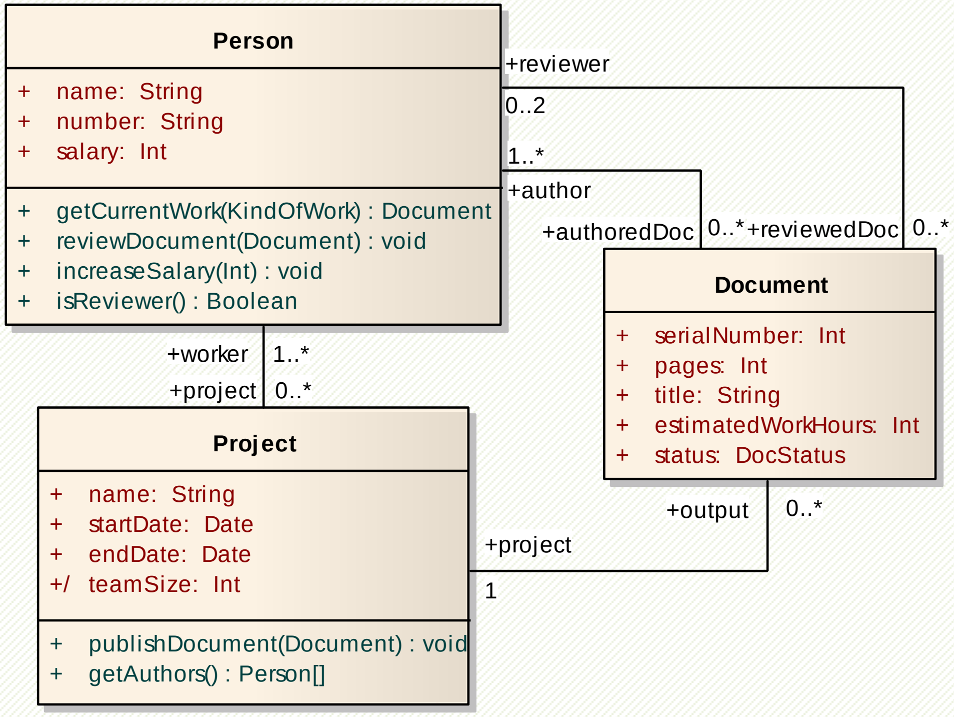
- invariant declares a condition which must be true upon completion of the constructor and completion of every public operation
- not necessarily true during the execution of the operations

Invariants



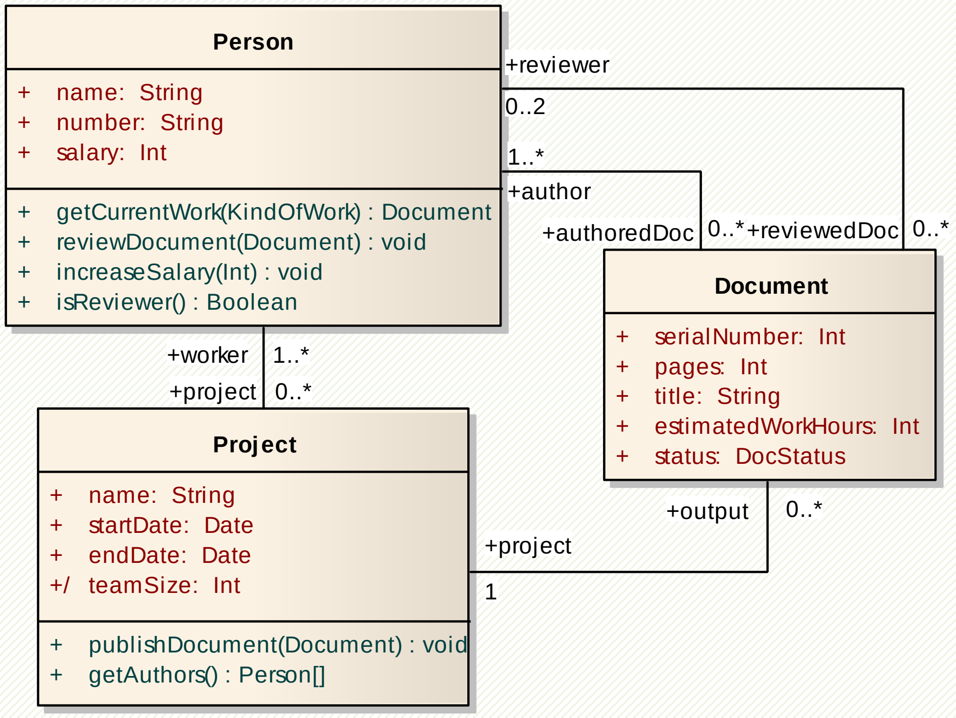
```
context Project
inv:  self.startDate->isBefore(endDate)
```

Invariants



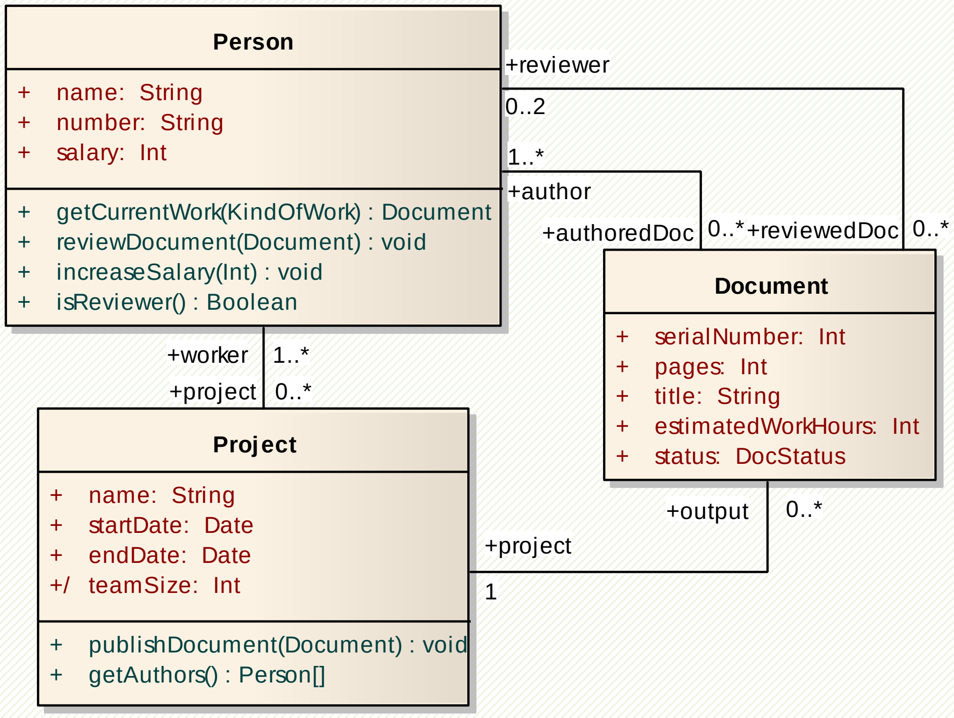
```
context Document
inv: self.estimatedWorkHours <= 8 implies self.author->size()<=1
```

Invariants



```
context Person
inv: self.authoredDoc->excludesAll(self.reviewedDoc)
```

Invariants



```
context Person
inv: self.authoredDoc.project
       ->excludesAll(self.reviewedDoc.project)
```