19th International Workshop in OCL and Textual Modeling

Experimenting with functional features of the Object Constraint Language

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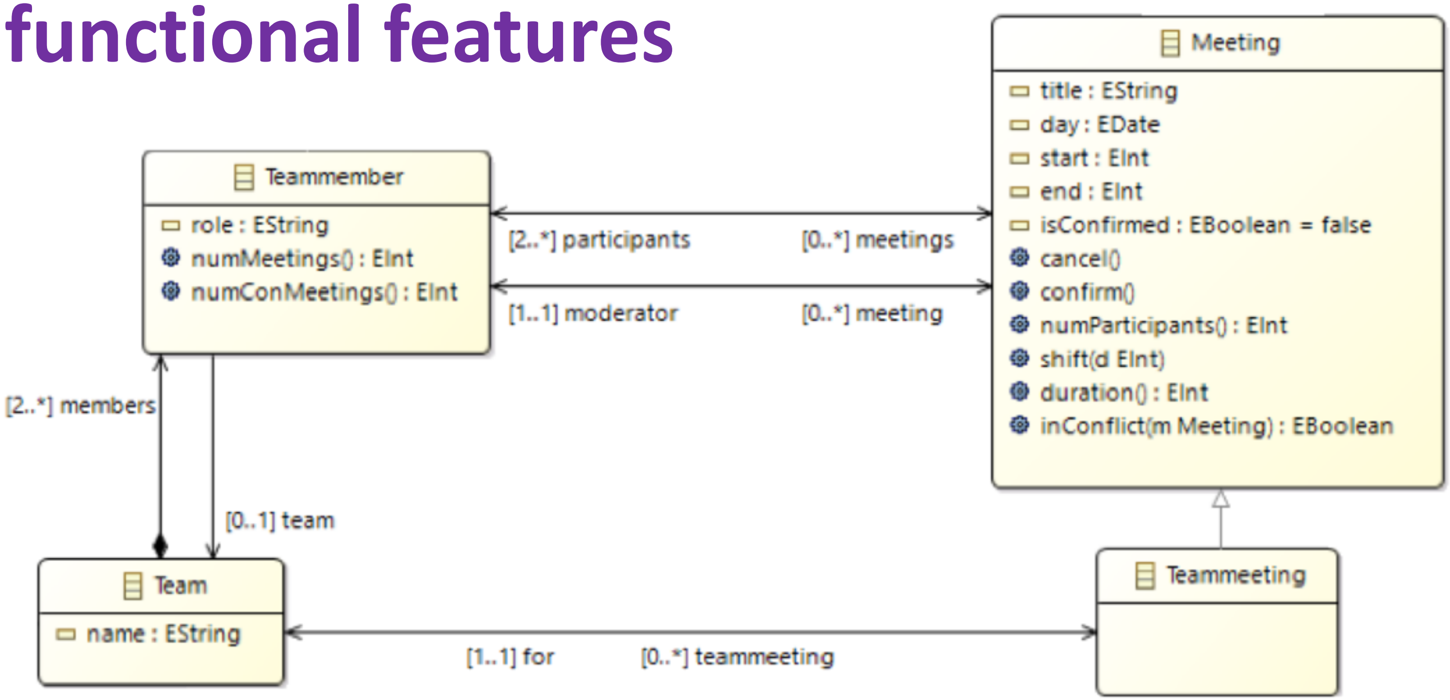
context

OCL combines model-oriented and functional features




```
-- A teammeeting has to be organized for a whole team
context Teammeeting inv:
   self.participants -> forAll(team = self.for)
```

context

we have explored a functional approach to support the construction of an OCL interpreter (for invariants)

- **a sandbox for experimentation**
- **an EDSL in Haskell + a tool Haskell OCL**
- **the functional infrastructure can be predefined and automatically generated**

D. Calegari and M. Viera, "On the functional interpretation of OCL," in *Proc. of the 16th Workshop on OCL and Textual Modelling*, ser. CEUR vol. 1756, pp. 33–48, 2016

G. Sintas, L. Vaz, D. Calegari, M. Viera. "Model-Driven Development of an Interpreter for the Object Constraint Language". Proc. CLEI 2018, IEEE: 120-128

objectives

experiment with functional features proposed by the scientific community (e.g., pattern matching, lazy evaluation, lambda abstractions, etc.)

how OCL interpretation benefits from such an encoding and its limitations

- **not focusing on proposing new features**
- **not on making any comparison w.r.t. technological support for the language**

interpretation of models & meta

metamodel and models are automatically translated to Haskell datatypes/values

```
data ModelElement      = ModelElement Int ModelElementChild
data ModelElementChild = PersonCh  Person | ...
data Person            = Person String Int String String (Maybe PersonCh)
data PersonCh          = TeammemberCh Teammember
data Teammember        = Teammember String [Int] [Int] [Int]
...
name :: Cast Model Person_ a => Val a -> OCL Model (Val String)
name a = upCast _Person a >>= pureOCL (\(Person x _ _ _ _) -> return (Val x))
```

Boilerplate code is defined to navigate through a model easily/uniformly

interpretation of invariants

invariants are automatically translated to Haskell functions mimicking its structure

```
-- A teammeeting has to be organized for a whole team
context Teammeeting inv:
   self.participants -> forAll(a | a.team = self.for)

invariant = context _TeamMeeting [inv] inv
self = ocl self |.| participants |->|
      forAll (\a -> ocl a |.| team |==| ocl self |.| for)
```

monad (OCL m a): computations within a model *m*, returning a value *a* (OCL four-valued logic)

the OCL library

it is predefined and provides an almost complete support for invariants and queries

	Haskell OCL	Eclipse OCL
OCL Constructs & Expressions		
`context` / `inv` (invariant condition and its context)	✓	✓
`init` (initial value of an attribute or association role)	✓	✓
`derive` (derived attribute or association role)	✗	✓
`def` (new attribute or query operation)	✓	✓
`package` (package to which OCL expressions belong)	~ [a]	✓
`self` (contextual instance)	✓	✓
`if-then-else` / `let-in` expressions	✓	✓
Navigation (through attributes, association ends, etc.)	~ [b]	✓
OCL Standard Library (types and operations)		
`Boolean/Integer/Real/String` types	✓	✓
`UnlimitedNatural` type	✗	✓
`OCLAny` type (supertype of all OCL types)	~ [c]	~
`OCLVoid` type (one single instance `undefined`)	~ [d]	✓
`Tuple` type	✓	✓
`Collection` types (`Set`, `OrderedSet`, `Bag`, and `Sequence`)	✓	✓
`Collection` operations	~ [e]	✓

Disclaimer

the following requires strong functional programming understanding

lets discuss some interesting findings and lessons learned from the experience

- functional support
- model-oriented vs functional
- monadic interpretation

functional support

functions are first-class citizens in Haskell

OCL defines something like functions (e.g., when defining a let expression)

collection operators use lambda abstractions e.g.,

```
reject p = select (notOCL . p)
```

functional support

what about higher-order functions?

```
-- the moderator is the one with highest priority
context Meeting inv:
let priority(Set(Teammember)) : Teammember = ... ,
    getModerator(m:Meeting,
       p:(Set(Teammember) -> Teammember))
       : Teammember = p(m.participants)
in self.moderator = getModerator(self, priority)
```

there are some problems, e.g., `flatten` is not easily supported when there are multi-type elements within the collection

functional support

is it feasible / valuable to have an extensive support for functions in OCL

model-oriented vs functional

hierarchical typing and identities introduce the main mismatch problems

some functional boilerplate can be generated to minimize the impact

```
name :: Cast Model Person_ a => Val a -> OCL Model (Val String)
name a = upCast _Person a >>= pureOCL (\(Person x _ _ _ _) -> return (Val x))
```

¿what about a multi-paradigm interpreter?

model-oriented vs functional

Sigma is an OCL EDSL implemented in Scala

since Scala is both functional and object-oriented, their embedding does not have to deal with mismatch problems

however, Sigma OCL expressions are not effect-free, and formal reasoning is much more difficult than in a purely functional approach

model-oriented vs functional

is it feasible / valuable to have a balance between model-oriented and functional interpretation for OCL

monadic interpretation

a `Reader` monad "silently" passes a model through the sequences of computations

```
invariant = context _TeamMeeting [inv] inv
self = ocl self |.| participants |->|
      forAll (\a -> ocl a |.| team |==| ocl self |.| for)
```

in some cases OCL could be benefited from the introduction of controlled side effects

monads can be composed for adding these behaviors in a modular way

monadic interpretation

`Error` monad represents computations which may fail or throw exceptions

```
type OCLError m a = ErrorT String (OCL m a)
invariant1 = context _Meeting [inv2]
inv2 self = do res <- ocl self |.| participants ...
               if res |==| oclVal True
               then return res
               else throwError ”There was an error”
```

`State` monad consumes a state and produce both a result and an updated state (e.g., a repaired model)

monadic interpretation

is it feasible / valuable to define a modular effects mechanism for OCL (e.g., inspired by monads and monad transformers)

conclusions & future work

we experimented with functional features proposed for OCL and provided a different perspective of OCL as a Haskell EDSL

the expressions and their interpretation are clean: modular, abstract and extensible

there are many challenges, e.g., laziness can improve performance but also adds memory overhead

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