The bicycle challenge in DMLA, where validation means correct modeling

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Dynamic Multi-Layer Algebra

- Core (the “HW”) – Data structure
  - Based on Abstract State Machines
  - Data structure and management
  - 4-tuple \( \{X_{ID}, X_{Meta}, X_{values}, X_{Attributes}\} \)

- Bootstrap (the “operating system”)
  - Set of entities, enabler of modeling
  - Defines metamodeling foundation
  - Basic building blocks (modelling and operations)

- DMLAScript (the “programming language”)
  - The “sugar”
  - Higher abstraction level interface (no tuples)
  - Always compiled to entities
DMLA – Instantiation

- Fluid metamodeling (#Ulrich: RC1, RC2)
  - Intention: support stepwise, partial refinement
    - Concretization everything at once (a whole level) is rigid
  - Entities/attributes are instantiated individually
  - (Partial) Instantiation – mixture of
    - Concretization: the abstraction level is lowered
    - Cloning: the entity/feature remains intact (#Ulrich RC7)
DMLA – Validated operations

• Goal: self validating bootstrap (without an external language)
  – Key: we need to *model the operations*
  – AST elements ➔ Bootstrap
  – Operation definitions are built from entities
    ➔ A high level script language (DMLAScript) was invented

• Validation formulae
  – *Alpha*: meta – instance (1:1, e.g. type)
  – *Beta*: meta – set of instances (1:n, e.g. cardinality)
  – *Gamma*: instance – whole model (1:*, e.g. uniqueness)
  – Entities can extend their formulae, but *validation is always enforced through the hierarchy up to the root element*
DMLA - slots

- Slots – features of entities
  - Constraints – reusable validation logic
    - Type, Cardinality (#Ulrich: RC3)
    - Operation signature
    - Must-Fill-Once
    - Extendable and fully modeled validation (e.g. filtered cardinality)
  - ComplexEntity.Children
    - Universal type, unlimited cardinality
    - The source of adding new features
Slots

**BicycleEntity: ComplexEntity**

*Children: ComplexEntity.Children {T: $Base, C: 0..*}*

**Component: BicycleEntity**

*Children: ComplexEntity.Children {T: $Base, C: 0..*}*

**Weight: ComplexEntity.Children {T: $Number, C: 1..1}**

**Configuration: BicycleEntity**

*Children: ComplexEntity.Children {T: $Base, C: 0..*}*

**Components: ComplexEntity.Children {T: $Component, C: 0..*}**
Inheritance “emulation”

**Component: BicycleEntity**
- Children: ComplexEntity.Children \{T: $Base, C: 0..*\}
- **Weight**: ComplexEntity.Children \{T: $Number, C: 0..*\}

**Frame: Component**
- Children: ComplexEntity.Children \{T: $Base, C: 0..*\}
- **Weight**: ComplexEntity.Children \{T: $Number, C: 0..*\}
- **Length**: ComplexEntity.Children \{T: $Number, C: 0..*\}

**Seat: Component**
- Children: ComplexEntity.Children \{T: $Base, C: 0..*\}
- **Weight**: ComplexEntity.Children \{T: $Number, C: 0..*\}
Gradual type constraints

**Configuration:** BicycleEntity

Children: ComplexEntity.Children \(\{T: \$\text{Base}, C: 0..*\}\)

**Components:** ComplexEntity.Children \(\{T: \$\text{Component}, C: 0..*\}\)

**Ncycle:** Configuration

Children: ComplexEntity.Children \(\{T: \$\text{Base}, C: 0..*\}\)

Components: ComplexEntity.Children \(\{T: \$\text{Component}, C: 0..*\}\)

**Fork:** Configuration.Components \(\{T: \$\text{Fork}, C: 1..1\}\)

**Seat:** Configuration.Components \(\{T: \$\text{Seat}, C: 1..3\}\)

**Wheel:** Configuration.Components \(\{T: \$\text{Wheel}, C: 1..2\}\)

Bicycle: Ncycle

Tandem: Ncycle

Unicycle: Ncycle
Gradual type constraints

Bicycle: NCycle

Children: ComplexEntity.Children {T: $Base, C: 0..*}
Components: ComplexEntity.Children {T: $Component, C: 0..*}
Fork: Ncycle.Fork {T: $Fork, C: 1..1}
Seat: Ncycle.Seat {T: $Seat, C: 1..1}

RaceBike: Bicycle

... 
Fork: Ncycle.Fork {T: $RaceFork, C: 1..1}
...

ProRaceBike: RaceBike

... 
Fork: RaceBike.Fork {T: $ProRaceFork, C: 1..1}
...

ChallengerA2XL: ProRaceBike

... 
Fork: ProRaceBike.Fork {T: $RocketA1XL, C: 1..1}
...
Concrete objects

- What does “physical object” mean?
  - You can touch it?
  - Can you touch a concrete bike, or only its components?
  - Is a concrete bicycle without wheels still a bike? Do the wheels still belong to the bike?
  - Serial number of components are unique – but this stands only for concrete components
Concrete objects

• Concrete objects
  – All primitive slots are filled with a value
  – All non-primitive slots have a concrete value
  – Has no more “free” slots

• Human + DMLA validation
  – Flag-driven validation
  – Concreteness is “claimed”
  – The statement is validated by DMLA
Derived attributes – built-in calculations

• Get average sales price of a
  – ...concrete model
  – ...a category of models
  – ...a type of bicycle

• Why do not we use the instantiation chain?

• Calculation = built-in operation
  – Added on a higher level (Bicycle)
  – Executed on arbitrary level
operation Number ID::GetAverageActualSalesPriceMethod() 
{
    Number sum = 0; Number cnt = 0;
    forall(entity in GetAllEntities) {
        if (DerivesFrom($SellingAct, entity)) {
            if (GetAttributeValue(entity, $BicycleEntity.AbstractEntity)==null) {
                if (DerivesFrom(this, GetAttributeValue(entity, $SellingAct.SoldBicycle))) {
                    cnt = cnt + 1;
                    sum = sum + GetAttributeValue(entity, $SellingAct.SellingPrice);
                    // sum = sum + GetAttributeValue(entity, $Bicycle.SalesPrice);
                }
            }
        }
    }
    if (cnt > 0) return sum/cnt; else return 0;
}
Summary

• Thank you for the challenge!
• Solved (almost) all requirements in DMLA
  – Patterns were created during the solution
  – The approach may express more complex scenarios (e.g. complex cardinality)
• Currently working on...
  – VM over DMLA
  – New language over DMLAScript for domain modeling
  – Handle multiple inheritance (diamond pattern)
  – Incremental and parallel validation
Thank You & Any Questions?

Feel free to check the poster as well

Dynamic Multi-Layer Algebra

http://www.aut.bme.hu/Pages/Research/VMTS/DMLA

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