The bicycle challenge in DMLA, where validation means correct modeling

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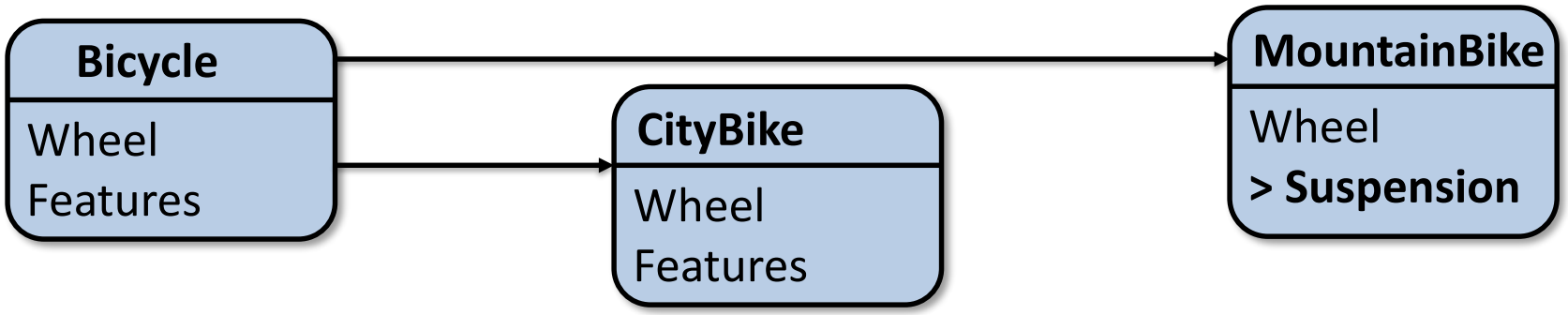
Dynamic Multi-Layer Algebra

- 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

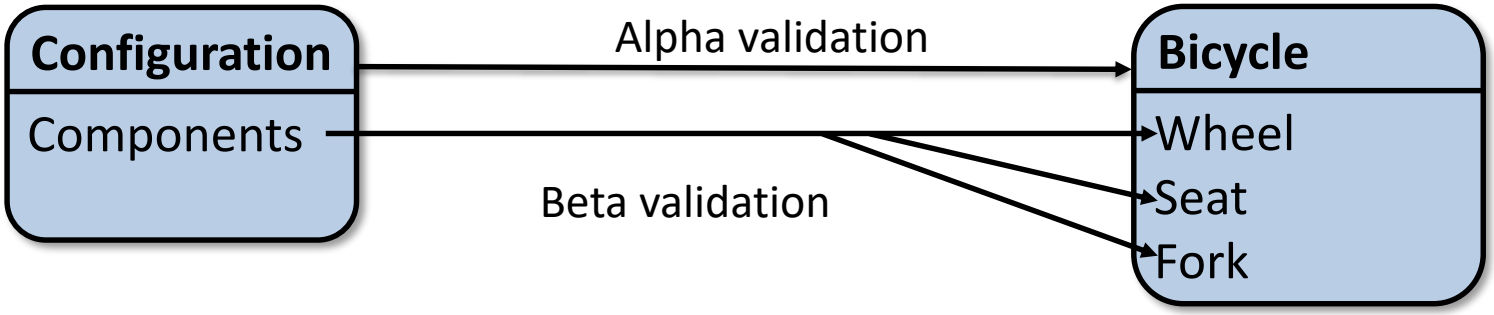
DMLA – Instantiation

- 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

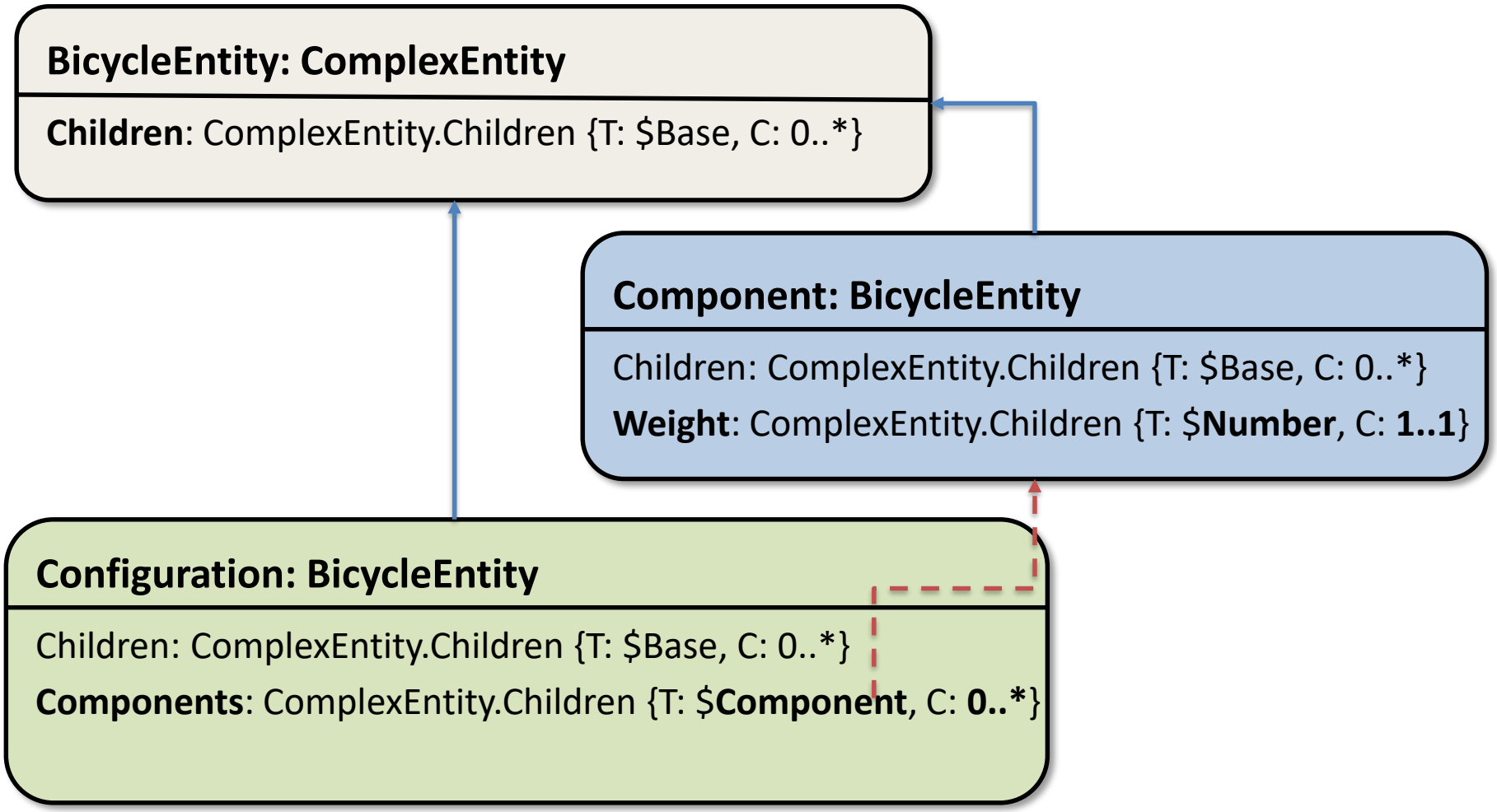
- Goal: self validating bootstrap (without an external language)
  - Key: we need to *model the operations*
  - AST elements → Bootstrap
  - Operation definitions are built from entities
    → A high level script language (DMLAScript) was invented
- Validation formulae
  - *Alpha*: meta – instance (1:1, 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*



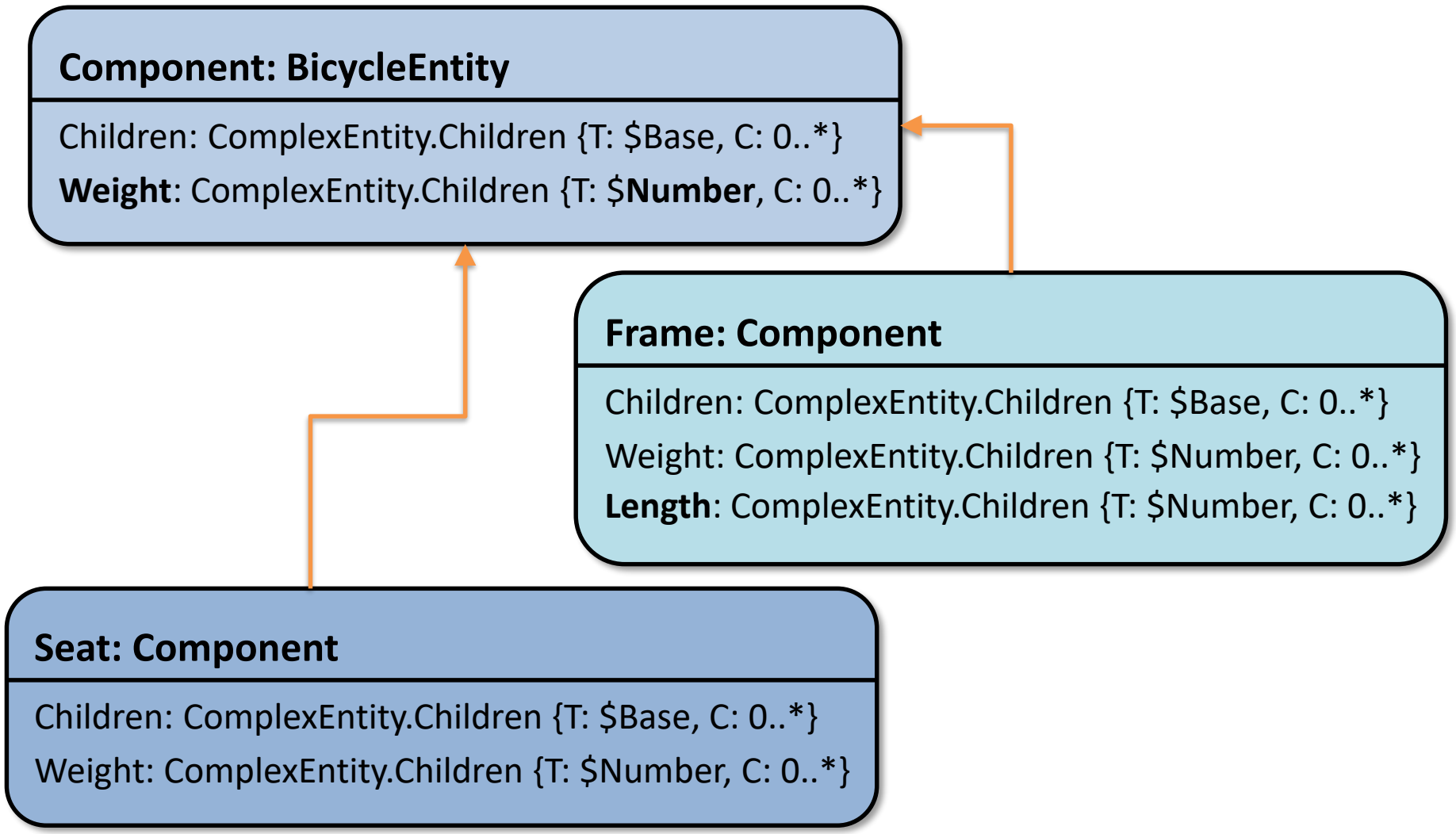
DMLA - slots

- 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

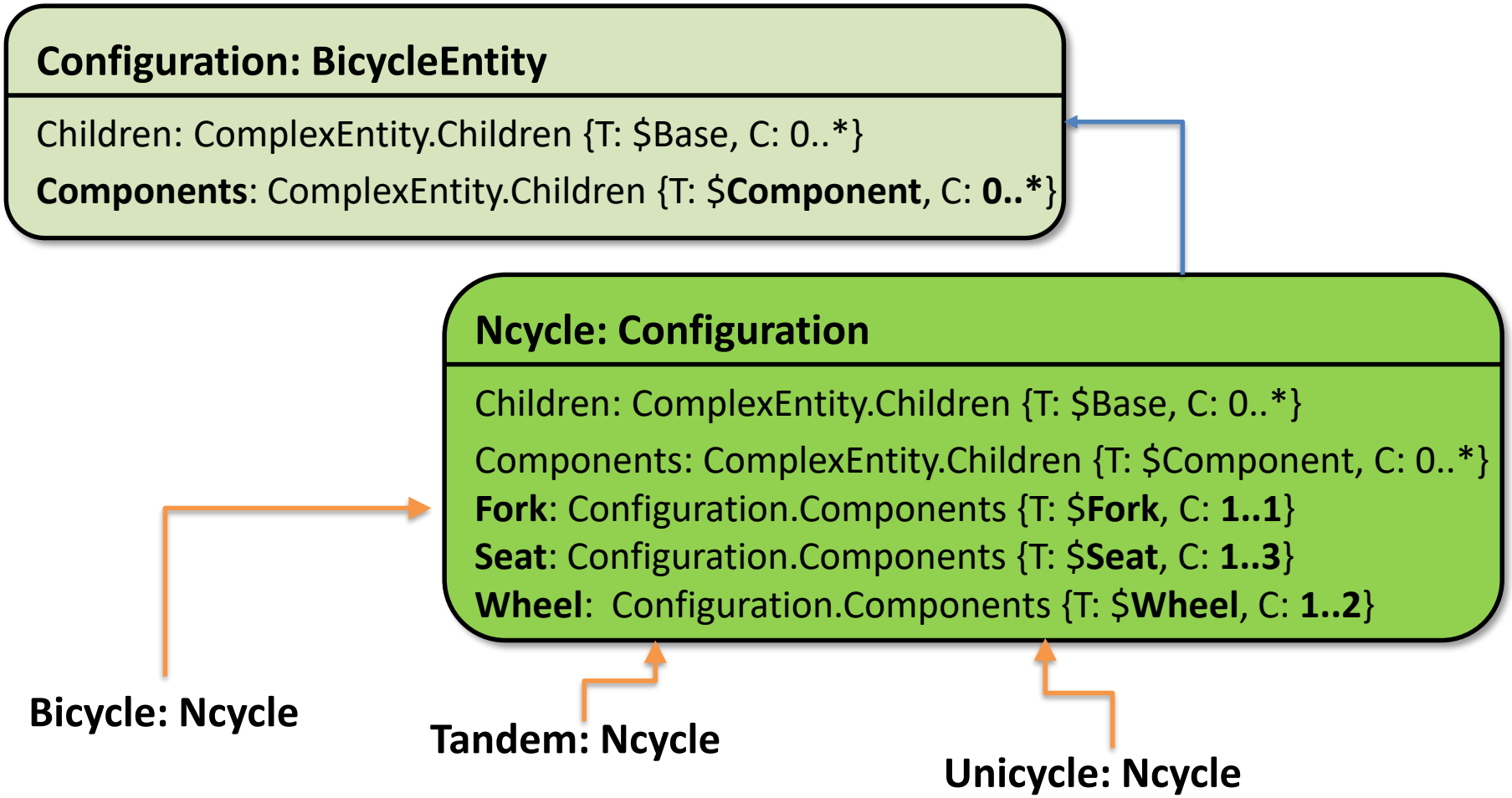
Slots


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..*}

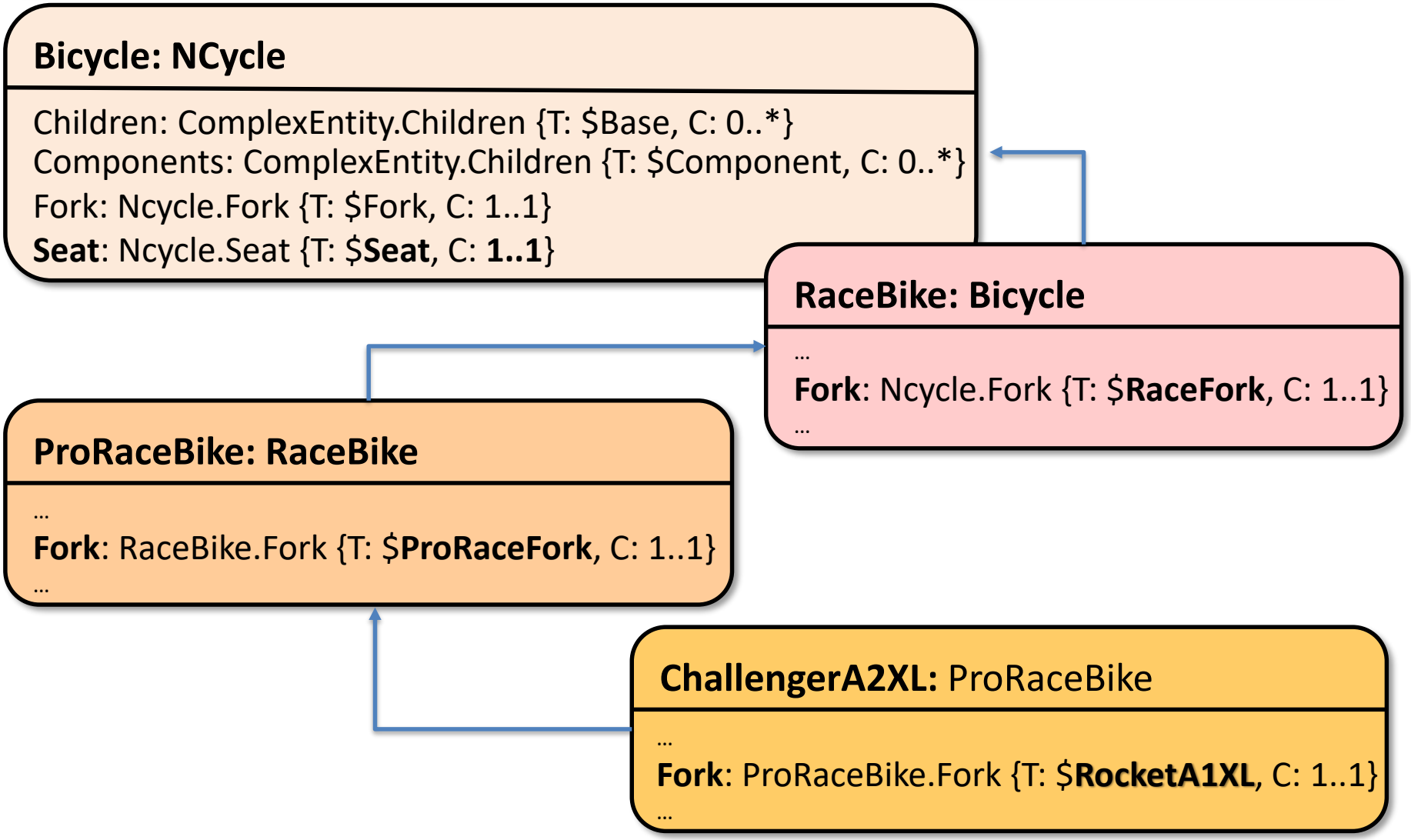
Inheritance “emulation”



Gradual type constraints



Gradual type constraints



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

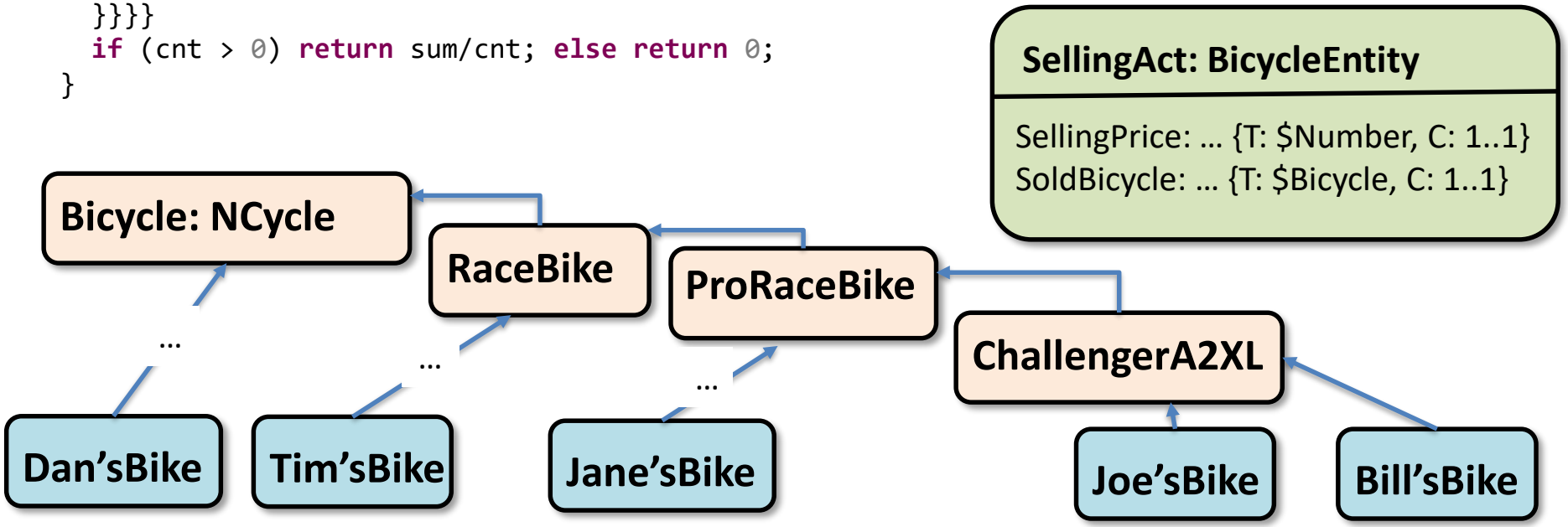
- Concrete objects
  - All primitive slots are filled with a value
  - All non-primitive slots have a concrete value
  - Has no more “free” slots
- Human + DMLA validation
  - Flag-driven validation
  - Concreteness is “claimed”
  - The statement is validated by DMLA

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

Derived attributes – built-in calculations

```
operation Number ID::GetAvarageActualSalesPriceMethod()
{
 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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