A Foundation for Multi-Level Modelling

Tony Clark[1]
Cesar Gonzalez-Perez[2]
Brian Henderson-Sellers[3]

[1]Middlesex University, UK

[2]Institute of Heritage Sciences Santiago de Compostela, Spain

[3]University of Technology, Sydney, Australia

September 28, 2014

Motivation

- System Modelling is used in many industries.
- One-size modelling technology does not fit all.
- Move towards domain-specificity.
- No consensus on meta-technology.
- Require a foundation for *specifying* languages.
- Strict meta-modelling is too restrictive.
- Proposals for power-types and clabjects.

Motivation

- System Modelling is used in many industries.
- One-size modelling technology does not fit all.
- Move towards domain-specificity.
- No consensus on meta-technology.
- Require a foundation for *specifying* languages.
- Strict meta-modelling is too restrictive.
- Proposals for power-types and clabjects.

Motivation

- System Modelling is used in many industries.
- One-size modelling technology does not fit all.
- Move towards domain-specificity.
- No consensus on meta-technology.
- Require a foundation for *specifying* languages.
- Strict meta-modelling is too restrictive.
- Proposals for power-types and clabjects.

Motivation

- System Modelling is used in many industries.
- One-size modelling technology does not fit all.
- Move towards domain-specificity.
- No consensus on meta-technology.
- Require a foundation for *specifying* languages.
- Strict meta-modelling is too restrictive.
- Proposals for power-types and clabjects.

Motivation

- System Modelling is used in many industries.
- One-size modelling technology does not fit all.
- Move towards domain-specificity.
- No consensus on meta-technology.
- Require a foundation for *specifying* languages.
- Strict meta-modelling is too restrictive.
- Proposals for power-types and clabjects.

Motivation

- System Modelling is used in many industries.
- One-size modelling technology does not fit all.
- Move towards domain-specificity.
- No consensus on meta-technology.
- Require a foundation for *specifying* languages.
- Strict meta-modelling is too restrictive.
- Proposals for power-types and clabjects.

Motivation

- System Modelling is used in many industries.
- One-size modelling technology does not fit all.
- Move towards domain-specificity.
- No consensus on meta-technology.
- Require a foundation for *specifying* languages.
- Strict meta-modelling is too restrictive.
- Proposals for power-types and clabjects.

Technology Requirements

- Meta-circularity: it is a self-describing language, semantics is part of a language definition, arbitrary levels - *fractal*.
- Uniformity: tools run over multiple levels, different languages can be integrated (where meaningful).
- Extensibility: modular language definitions.
- Views: syntax can be domain specific.

Technology Requirements

- Meta-circularity: it is a self-describing language, semantics is part of a language definition, arbitrary levels - *fractal*.
- Uniformity: tools run over multiple levels, different languages can be integrated (where meaningful).
- Extensibility: modular language definitions.
- Views: syntax can be domain specific.

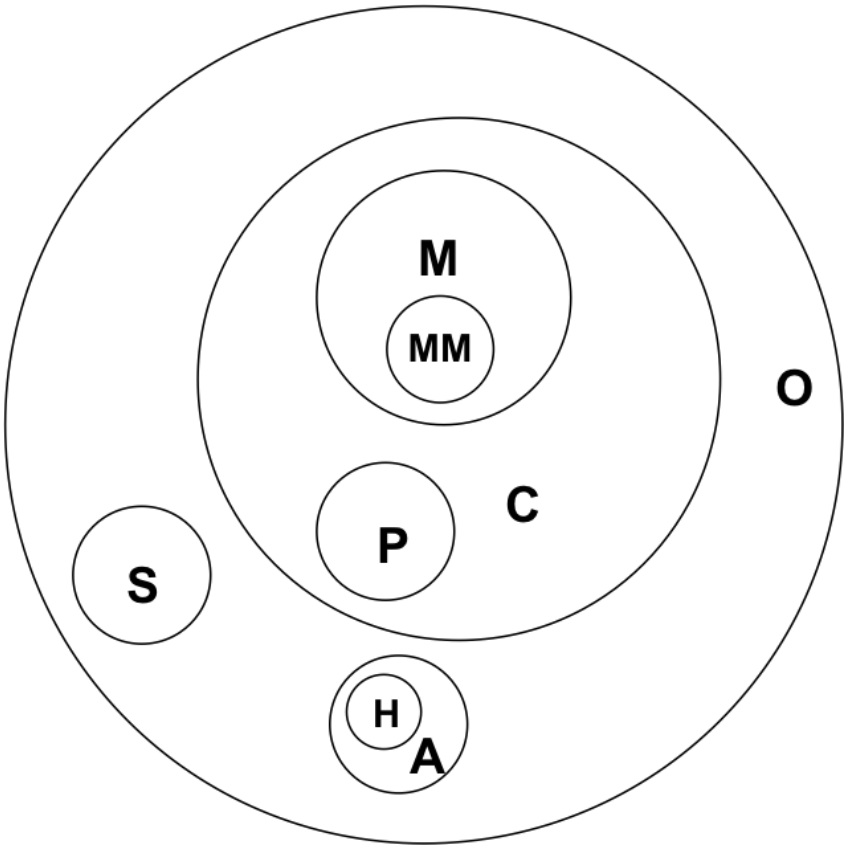
Technology Requirements

- Meta-circularity: it is a self-describing language, semantics is part of a language definition, arbitrary levels - *fractal*.
- Uniformity: tools run over multiple levels, different languages can be integrated (where meaningful).
- Extensibility: modular language definitions.
- Views: syntax can be domain specific.

Technology Requirements

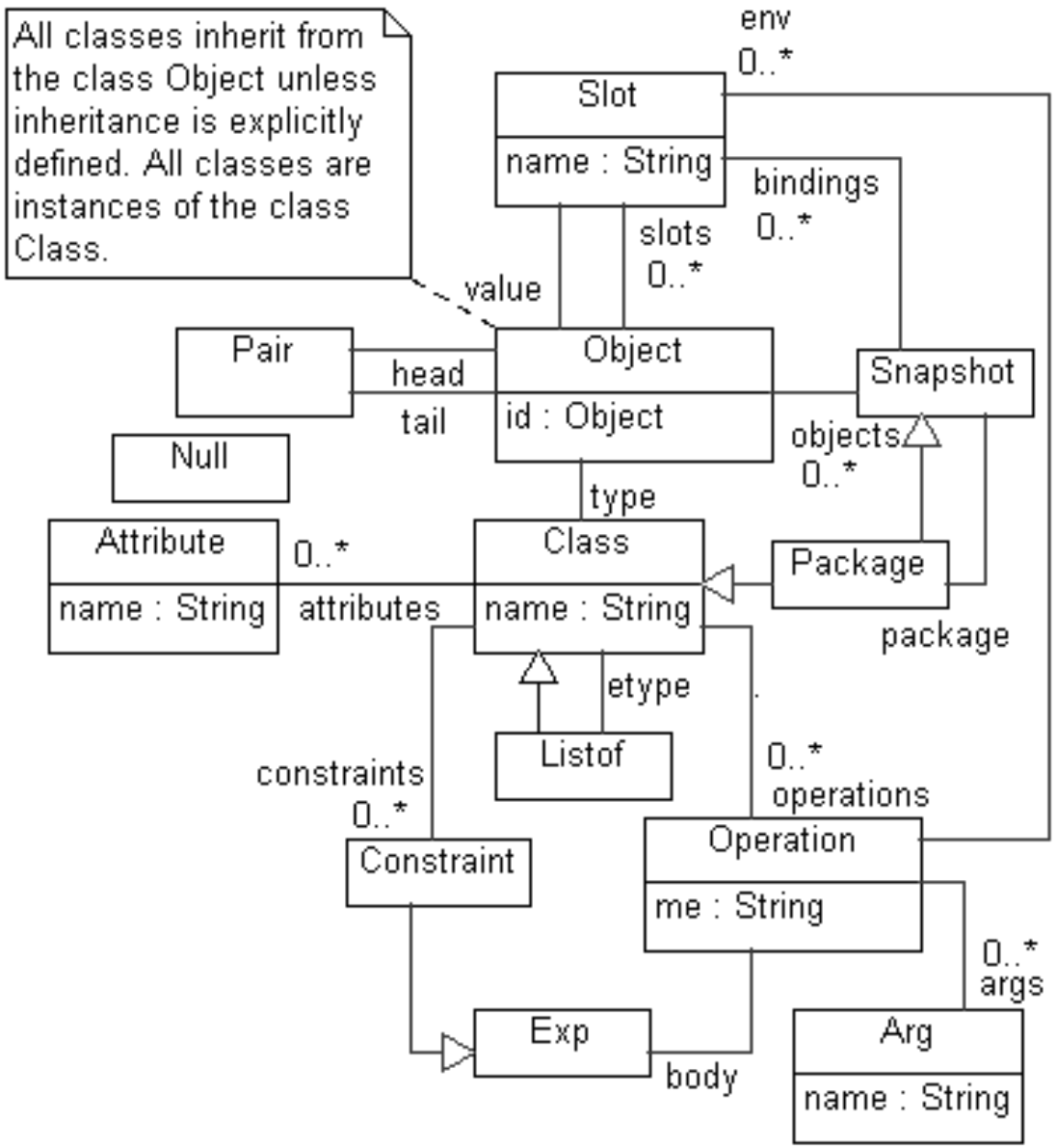
- Meta-circularity: it is a self-describing language, semantics is part of a language definition, arbitrary levels - *fractal*.
- Uniformity: tools run over multiple levels, different languages can be integrated (where meaningful).
- Extensibility: modular language definitions.
- Views: syntax can be domain specific.

Claim: Everything is an Object

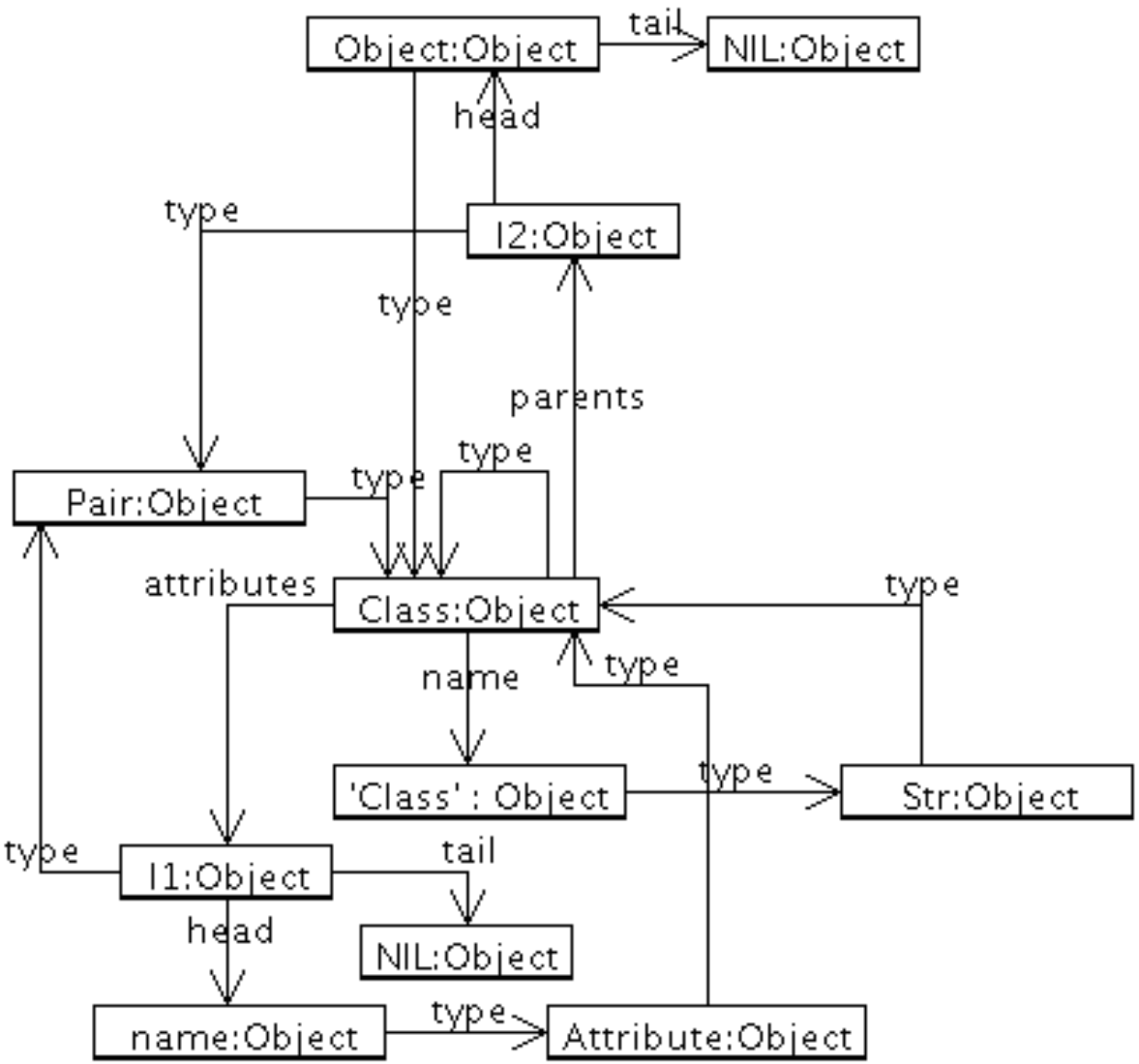


- O = Objects
- C = Classes
- M = Meta-classes
- MM = Meta-Meta-classes
- P = Packages
- S = Snapshots
- A = Animals
- H = Herbivores

A Meta-Modelling Kernel



A Meta-Modelling Kernel Without the Goggles



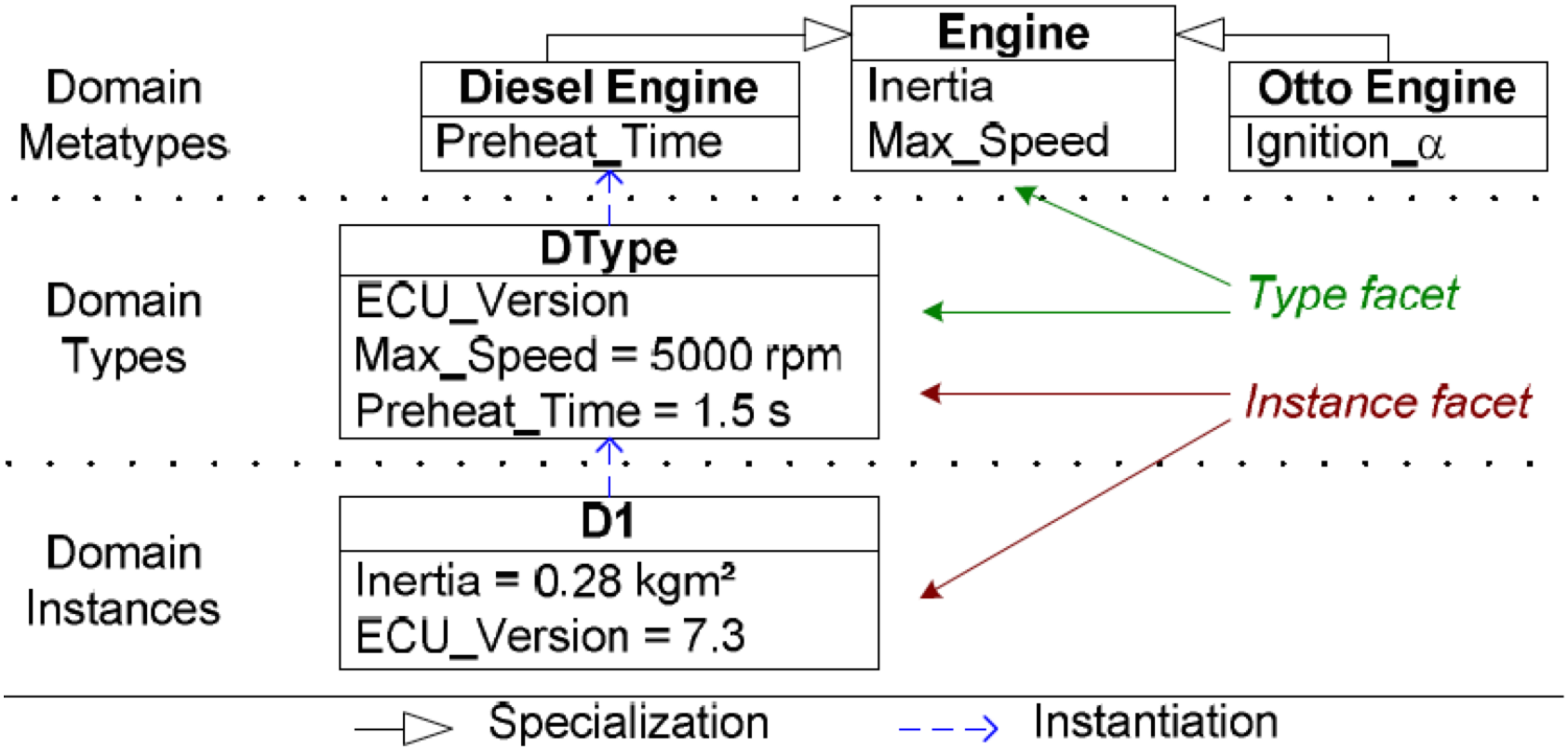
Self Description

```
class Class {
 name        : Str;
 supers      : [Class];
 attributes  : [Attribute];
 operations  : [Binding];
 constraints : [Constraint]
 operations {
  supers() = [self]+[c | p ← supers; c ← p.supers()].remDups()
  ⇑(c) = supers().∋(c)
  atts() =  [a | c ← supers(),a ← c.attributes]
  ops()  =  [b | c ← supers(),b ← c.operations]
  cond() =  [a | c ← supers(),a ← c.constraints]
  ::(n,d) = atts().⇐(λ(n′ ↦ a)n′=n,λ(n ↦ a)a,
            ops().⇐(λ(n′ ↦ o)n′=n,λ(n ↦ o)o,d))
  ?(o) = o.type.⇑(self) and
   atts().∀(λ(a)o.slots.∃(λ(s) s.name = a.name and
                               a.type.?(s.value))) and
    cond().∀(λ(c) c.eval([self ↦ o] +
     [s.name ↦ s.value | s ← o.slots]))
 }
}
```

Self Description

```
class Object {
 id     : Object;
 type   : Class;
 slots  : [Slot]
 constraints { type.?(self) }
 operations {
  dot(n) = slots.⇐(λ(n' ↦ _) n=n',λ(_ ↦ v) v,error)
  send(n,args) =
   type.ops().⇐(λ(n' ↦ (Operation)[args ↦ args'])
    n=n' and #args = #args',
    λ(_ ↦ f) f.invoke(self,args),
    error)
 }
}
```

Validation: Language Definition and Use



From: Thomas Aschauer, Gerd Dauenhauer, and Wolfgang Pree. Representation and traversal of large clabject models. In Model Driven Engineering Languages and Systems, pages 17–31. Springer, 2009.

Language Definition

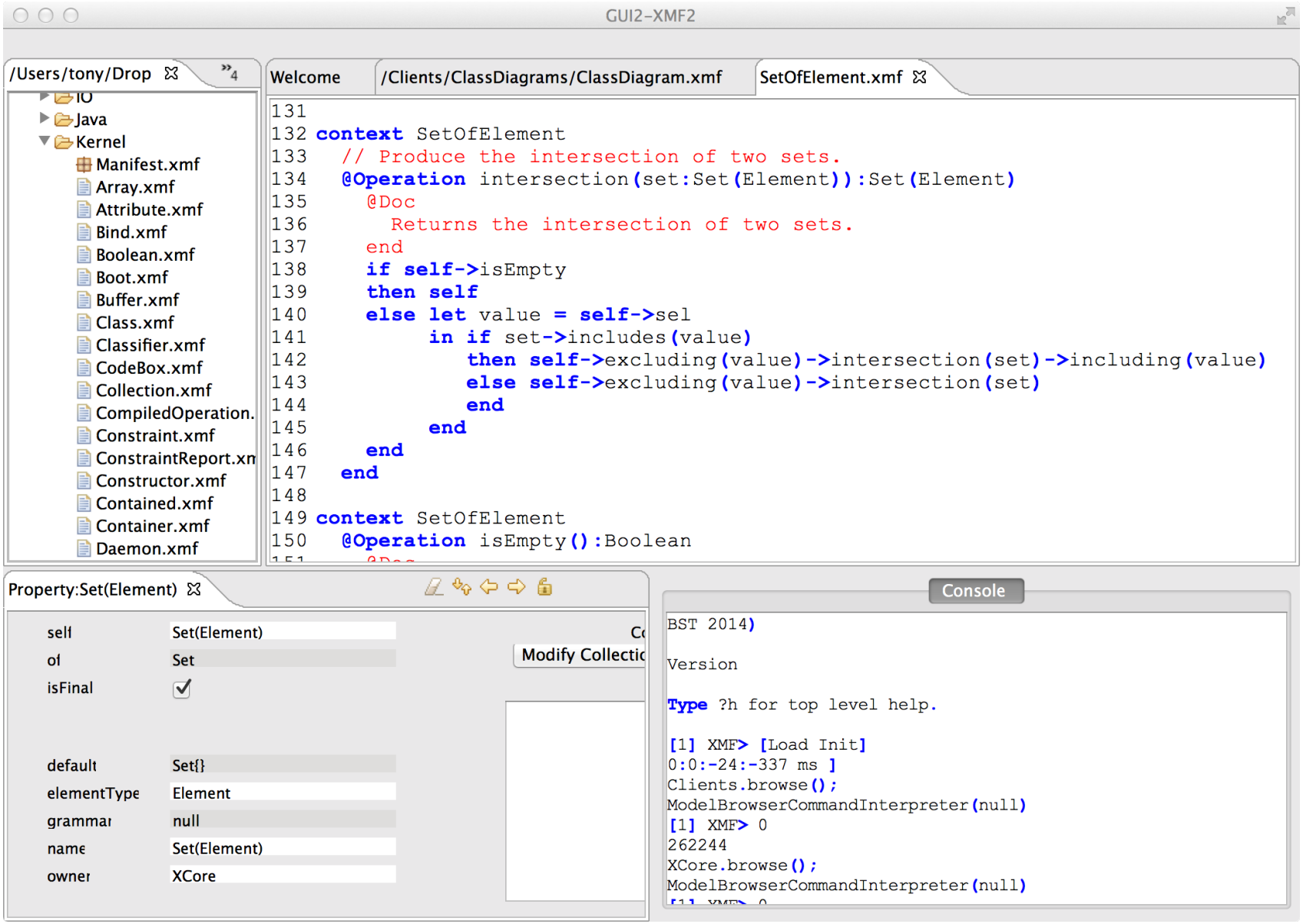
```
package CKernel:Kernel extends Kernel {
 class CAtt extends Attribute {
  level:Integer;
 }
 class CClass extends Class {
  operations {
   atts() = catts(1,self)
   catts(n,c=(_,c)[]) = []
   catts(n,c) =
     [a | a ← c.atts(),
          ?a.type=CAtt,a.level=n] +
     catts(n+1,c.type)
  }
  constraints {atts.∀(λ(a)a.type=CAtt)}
 }
}

snapshot DomainInstances:DomainTypes {
 (DType)[inertia ↦ 0.28;ECU_version ↦ 7.3]
}
```

Language Use

```
package DomainMetaTypes:CKernel  {
 class Engine:CClass extends CClass {
  inertia[2]:Float;
  max_speed[1]:Integer
 }
 class DieselEngine:CClass extends Engine {
  preheat_time[1]:Float
 }
 class OttoEngine:CClass extends Engine {
  ignition_alpha[1]:Float
 }
}
package DomainTypes:DomainMetaTypes {
 class DType:DieselEngine {
  ECU_version[1]:Float;
  max_speed=5000;
  preheat_time=1.5
 }
}
```

Validation: Practicality



Conclusion

- Proposal is for a self-describing, fractal, specification language for modelling languages.
- Does not suffer from limitations of strict modelling.
- Can specify other proposals such as clabjects, power-types.
- Can form the basis of a practical tool (with extensions).

Conclusion

- Proposal is for a self-describing, fractal, specification language for modelling languages.
- Does not suffer from limitations of strict modelling.
- Can specify other proposals such as clabjects, power-types.
- Can form the basis of a practical tool (with extensions).

Conclusion

- Proposal is for a self-describing, fractal, specification language for modelling languages.
- Does not suffer from limitations of strict modelling.
- Can specify other proposals such as clabjects, power-types.
- Can form the basis of a practical tool (with extensions).

Conclusion

- Proposal is for a self-describing, fractal, specification language for modelling languages.
- Does not suffer from limitations of strict modelling.
- Can specify other proposals such as clabjects, power-types.
- Can form the basis of a practical tool (with extensions).