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Rich Meta Object Facility

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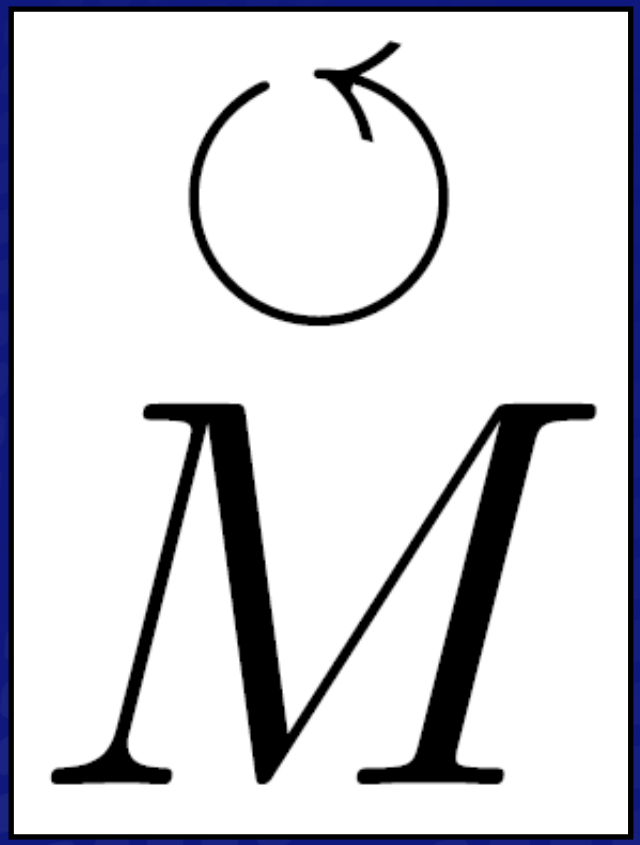
ICFEM 2008

October 27-31, 2008

Kitakyushu, Japan

Workshop UML&FM'08



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2 Where does this/do I come from?

- **Some Facts**

  OFFIS Institute for Information Technology
  (**O**ldenburger **F**orschungsinstitut **f**ür
  Informatik- Werkzeuge und **S**ysteme)

  - Founded 1991 as a not for profit organization
  - Closely related to University of Oldenburg
    - Sonderforschungsbereich: AVACS
      (Automatic Verification and Analysis of Complex Systems)
  - Members: State of Lower Saxony, University Oldenburg,
    Professors of IT and related studies
  - Department Transportation, Research Areas
    - Formal Verification & Safety Analysis
    - WCET Analysis
    - Human Centered Engineering
    - Cooperative Mobile Systems
    - *Process Analysis & Optimization*
  - OFFIS Service and Consulting
    - Testing (Automated Test Case Generation)

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3 MOF

- Some facts ...
  - MOF 2.0 developed January 2006 by the OMG
  - Differentiation in Essential und Complete MOF
  - Meta Language for UML2, SPEM, SysML
- What is MOF exactly?
  - Language to describe other languages (Syntax)
  - Natural language description of Behavior (e.g., operations)
  - With XMI possible to read/write models/meta-models with corresponding files directly downloadable from the OMG homepage
- Central Usage (right now): **Repository**
  - "Easy" to say an „a" is related to a „b" in a language „c" without
    - Parse Files (XML, XMI, Language Layer)
    - Implementing required data structures
  - Positive Project Experience

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4 RMOF

- MOF is not enough, why?
  - Not formal
  - No Algorithms
- Why is it interesting to formalize & enrich MOF?
  - Implementation → Formalization → Making decisions
    (e.g., Damm & Harel "LSCs: Breathing Life into Message Sequence Charts")
  - Are we making the „right" decisions?
  - Communicate & explore semantically different methodologies
    (e.g., "variable domains", concurrency, event queues)
  - Drawbacks of different formal methodologies:
    - Time-consuming to understand/apply
    - Different abstraction levels
    - Redundancy
    - No easy way to **integrate & explore** different approaches with all the positive effects of a MOF repository approach
  - → RMOF solves these problems

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5 RMOF in Short

- Formal Methodology
  - Close to MOF/UML2 Specification
    - Data structures compliant to EMOF / Layer1 to CMOF + Constraints
    - UML2 Enrichments to support Algorithms
  - (Flexible) Symbolic Transition System
- Algorithms
  - State Machines (SM)
    - With different degrees of concurrency (effect, transition, state machine)
    - (Synchronous) Operation calls
    - Constraint SMs
    - Derived Values SMs + Default Derived Union Computations
    - Oberserver SMs
  - Action Language (layer & collection type management, arithmetic operations, …)
- Implementation
  - Used Frameworks (Graphical Representation) vs. our Implementations (Simulation)
  - Layer composition, debugging

6 Formal RMOF::Syntax & Semantics

7.3.33-93 *NamedElement* = (Class,{(ownedAttribute, (name, qualifiedName, namespace)), (isAbstract, true), (generalization,{Element})}) is an element in a model that may have a name.

\+ name = (Property,{(aggregation, composite [at]), (type, Kernel::String), (lowerValue, "1 [prev. 0]"), (upperValue,"1")}) of the NamedElement.
Defined in: CoreAbstractionsNamespaces::NamedElement, Core::Basic::NamedElement, Core::Constructs::NamedElement

- $\underline{down} : \sum \overset{\circlearrowleft}{M} \times \overset{\circlearrowleft}{M} \times 2^N \rightarrow 2^N$ *determining the instance IDs of a set of IDs is defined as follows:*

$$down_{\overset{\circlearrowleft}{M},l.n}(N) := \begin{cases} \bigcup_{n.i \in l.n_i} \{n.i\} & if\ \exists l.n_i \in \overset{\circlearrowleft}{M} : l.n_i \dashrightarrow l.n \\ & \quad \wedge \bigcup_{n.i \in l.n_i} \{up(n.i)\} = N \\ \bot & else \end{cases}$$

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7 RMOF::Semantics::Symbolic Transition System

Definition 20 (System Semantics) *Let* $\overset{\circlearrowleft}{M}$ *be a system. The semantics of* $\overset{\circlearrowleft}{M}$ *is defined as:*

$$STS(\overset{\circlearrowleft}{M}) = (V, \Theta, \rho), \text{ where}$$

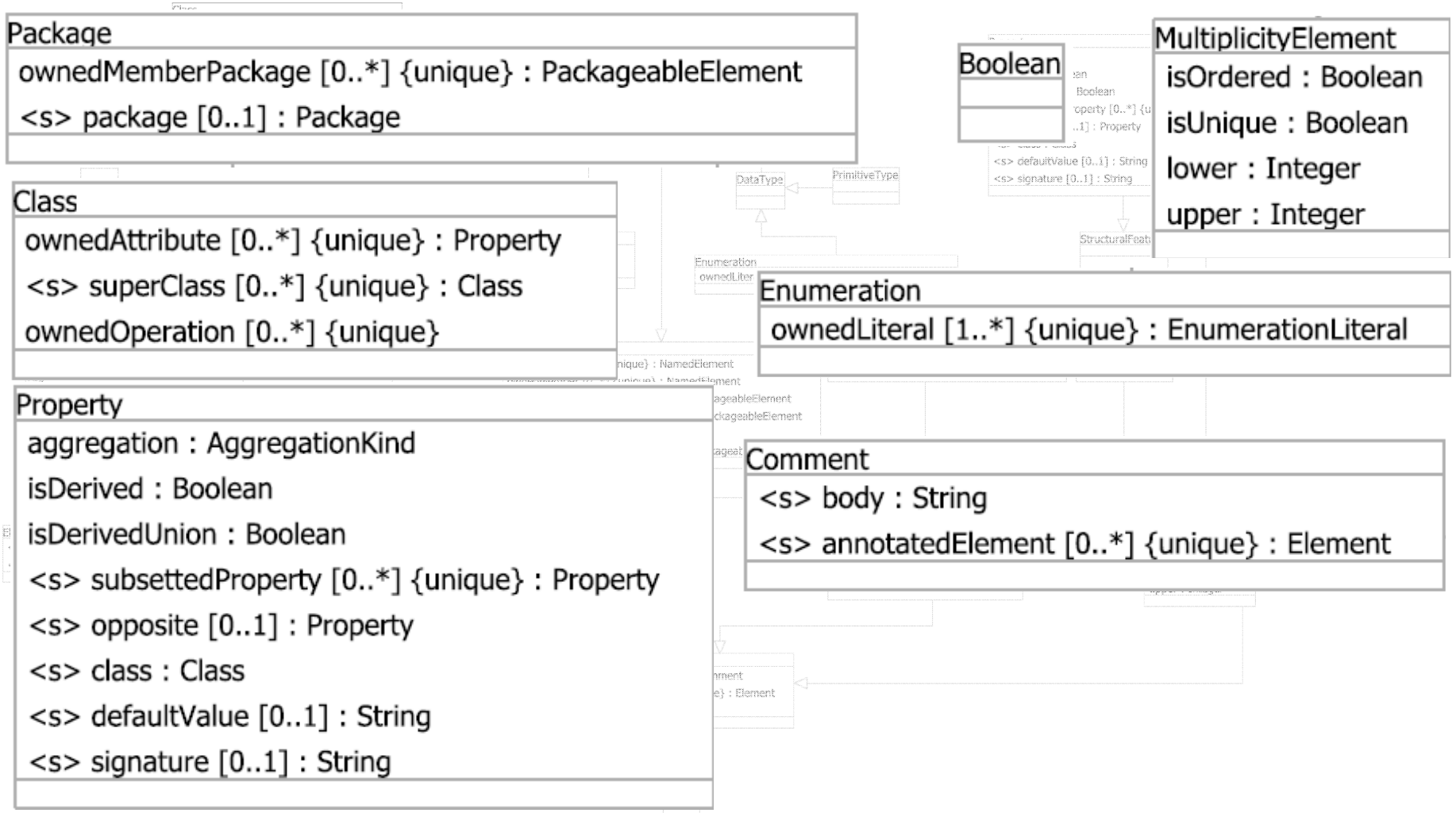
System Variables: $V := \{sc : \mathcal{T}_{sc}(\overset{\circlearrowleft}{M}), \overset{\circlearrowleft}{m}.c : Q, sysfail : \mathbb{B}\}.$

Initial condition: $\Theta := \overset{\circlearrowleft}{m}.c = q_0 \wedge sysfail = false$

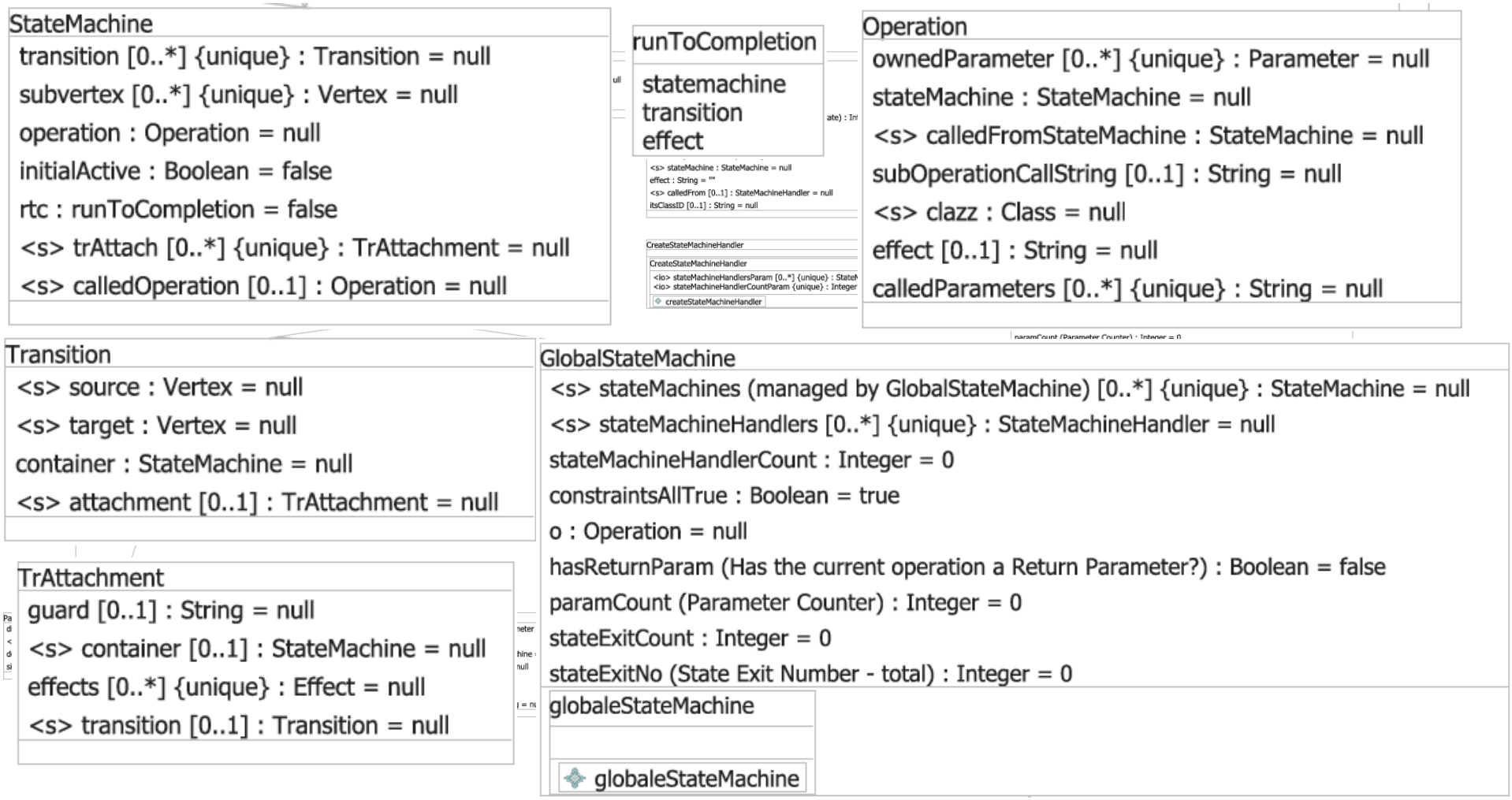
Transition relation: *The intermediate predicate* ρ_0 *composes the above introduced sub-predicates and additional conditions on their application within objects' life-cycle as follows:*

$$\begin{aligned}\rho_0 :=& (\neg sysfail \wedge \exists (q, \gamma, q') \in \overset{\circlearrowleft}{m}.tr : \overset{\circlearrowleft}{m}.c = q \wedge \overset{\circlearrowleft}{m}.c' := q' \\ & \wedge (\rho_{assign}(l) \vee \rho_{guard}(l)) \wedge q \neq q_x) \vee q = q_x\end{aligned}$$

8 RMOF::Data Structures for Data Structures



9 RMOF::Data Structures for Algorithms



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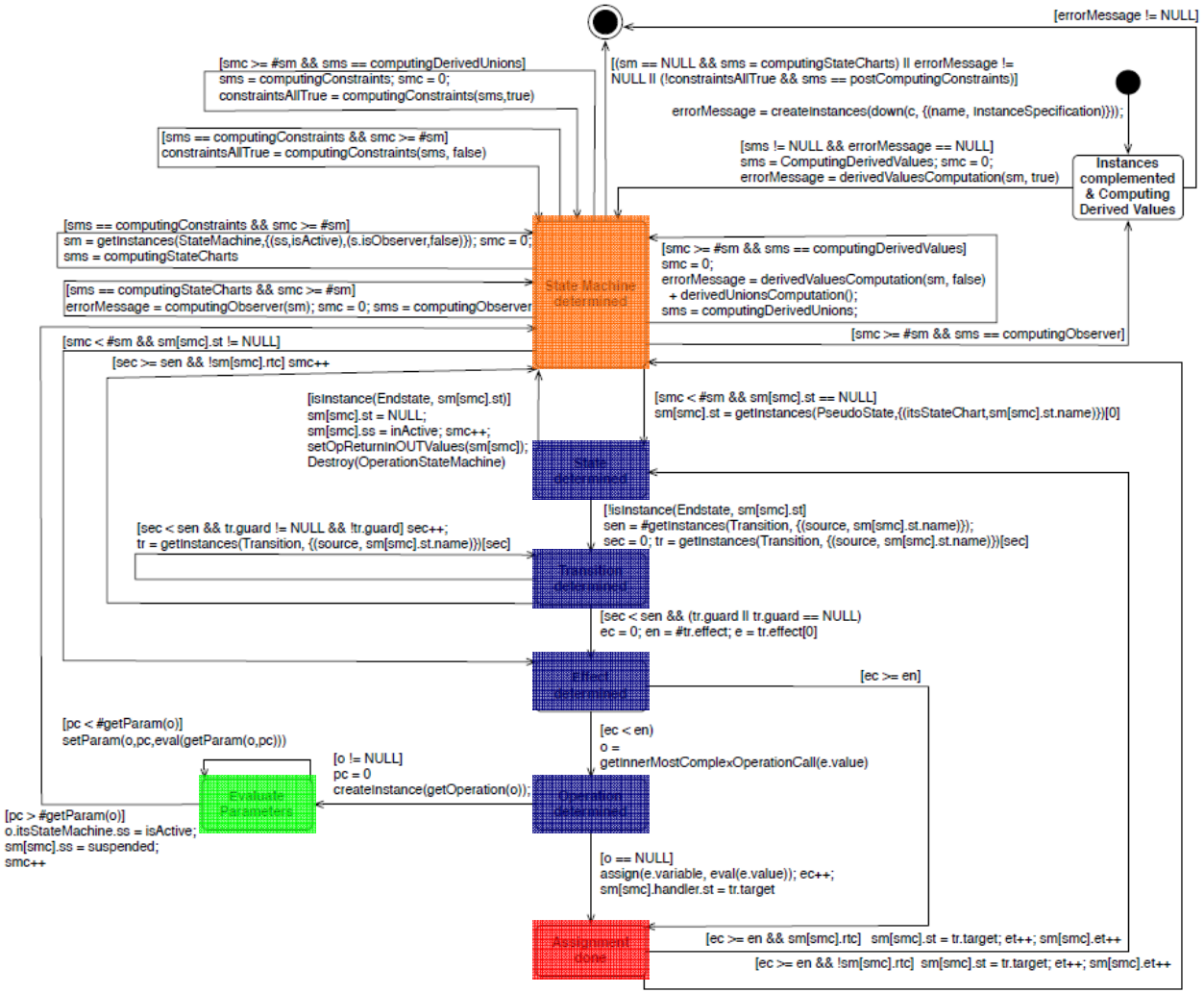
10 RMOF::Action Language

- Directly supported by the platform (on each layer) e.g.,
  - Layer Management
    - up()
    - down()
    - filter()
    - getObjectID()
    - read() & write() object attributes
    - add() & remove() objects

  e.g., filter(down(down(filter(up(*), {(name, StateMachine)}))), {(isActive, true)})
  - Navigation (e.g., a.b.c = 42)
  - Collection Type Management (set, bag, ordered set, sequence e.g., a.b[0].c[3] = 42, remove(s,e), a subBagOf b (flat or deep)
  - Arithmetic Operations (a+b*c = 24, if a = 2, b = 3, c = 4)
  - Simulation related (break(), wait())
  - Coloring of graphical objects
- … otherwise an Operation is called

11 RMOF::Global State Machine



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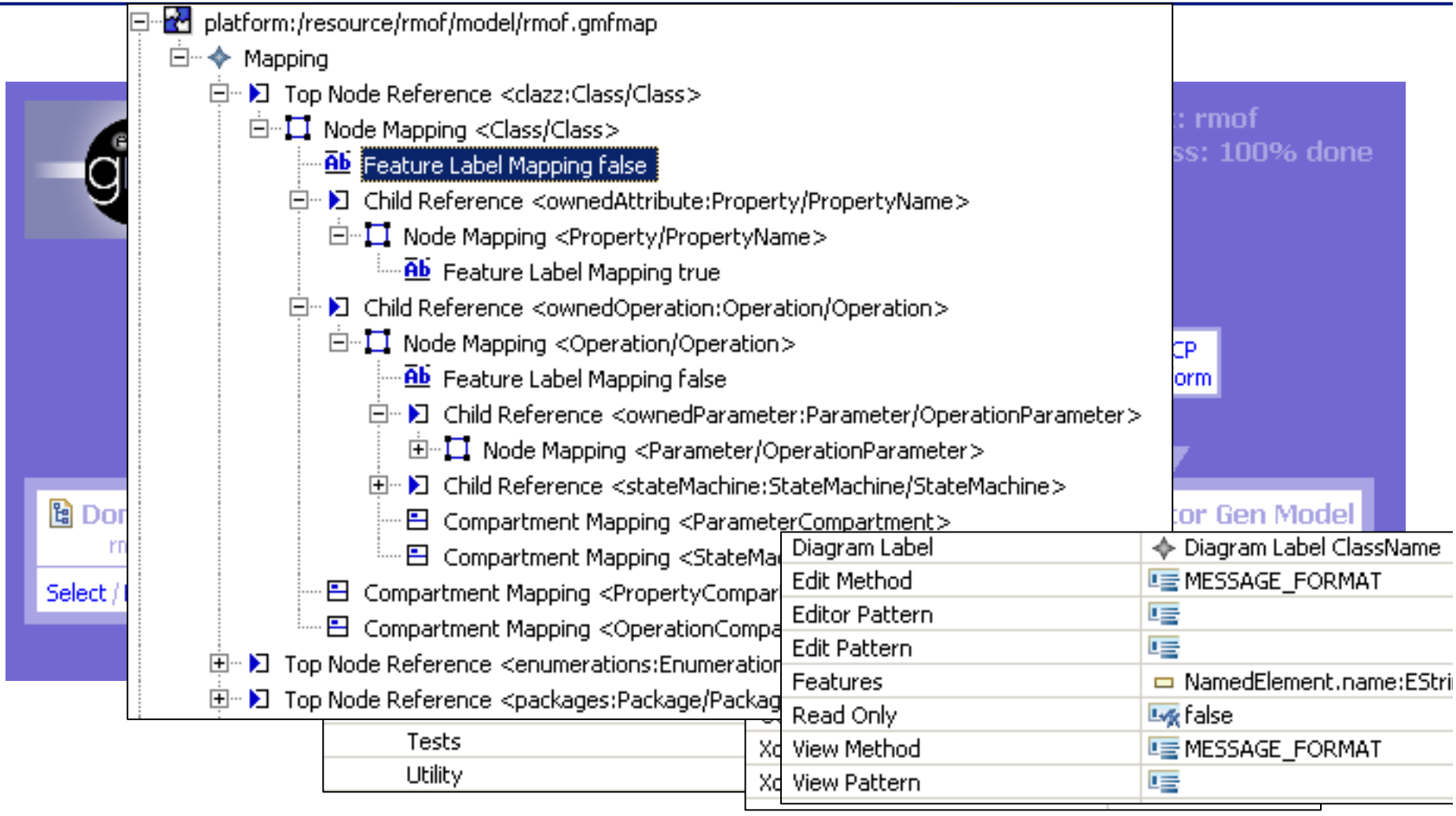
12 RMOF::Implementation:: emf & gmf



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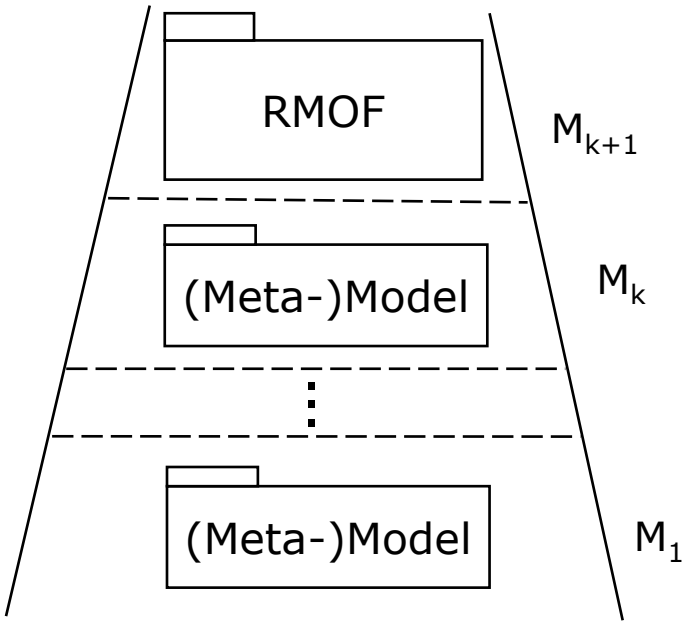
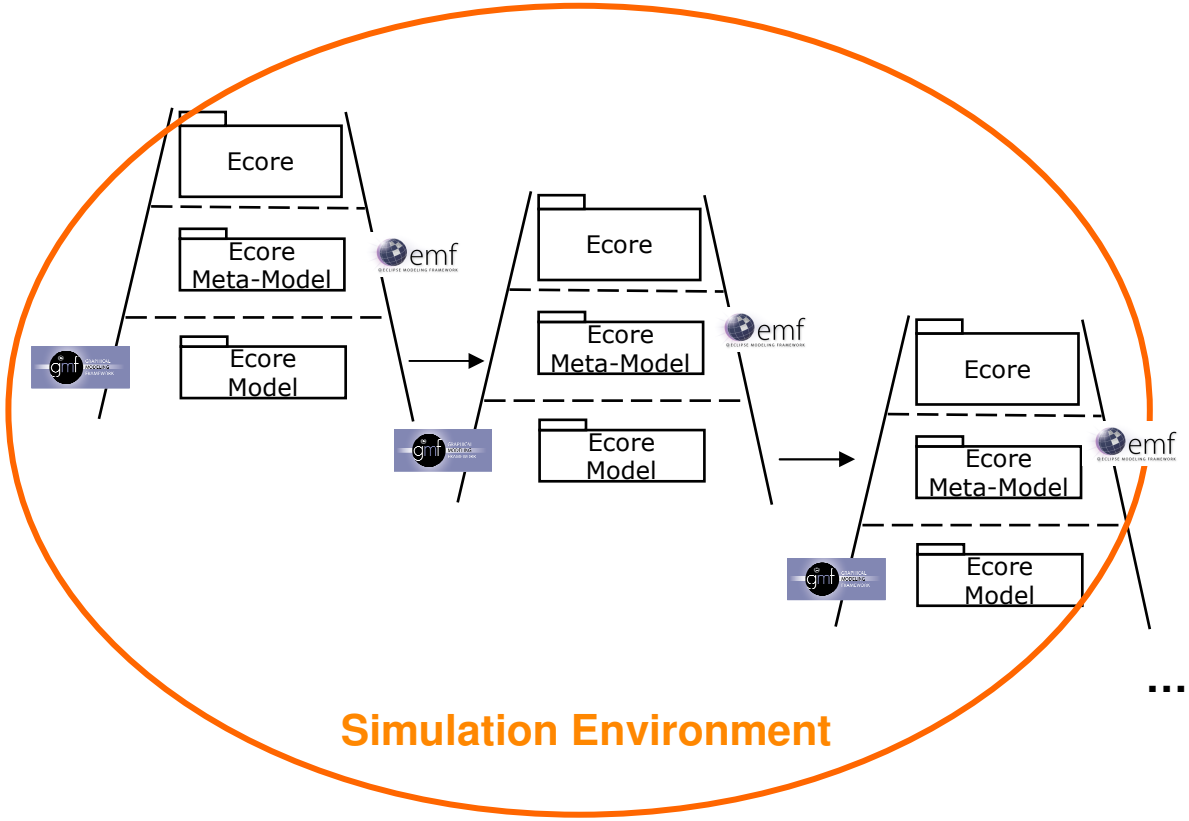
13 RMOF::Implementation

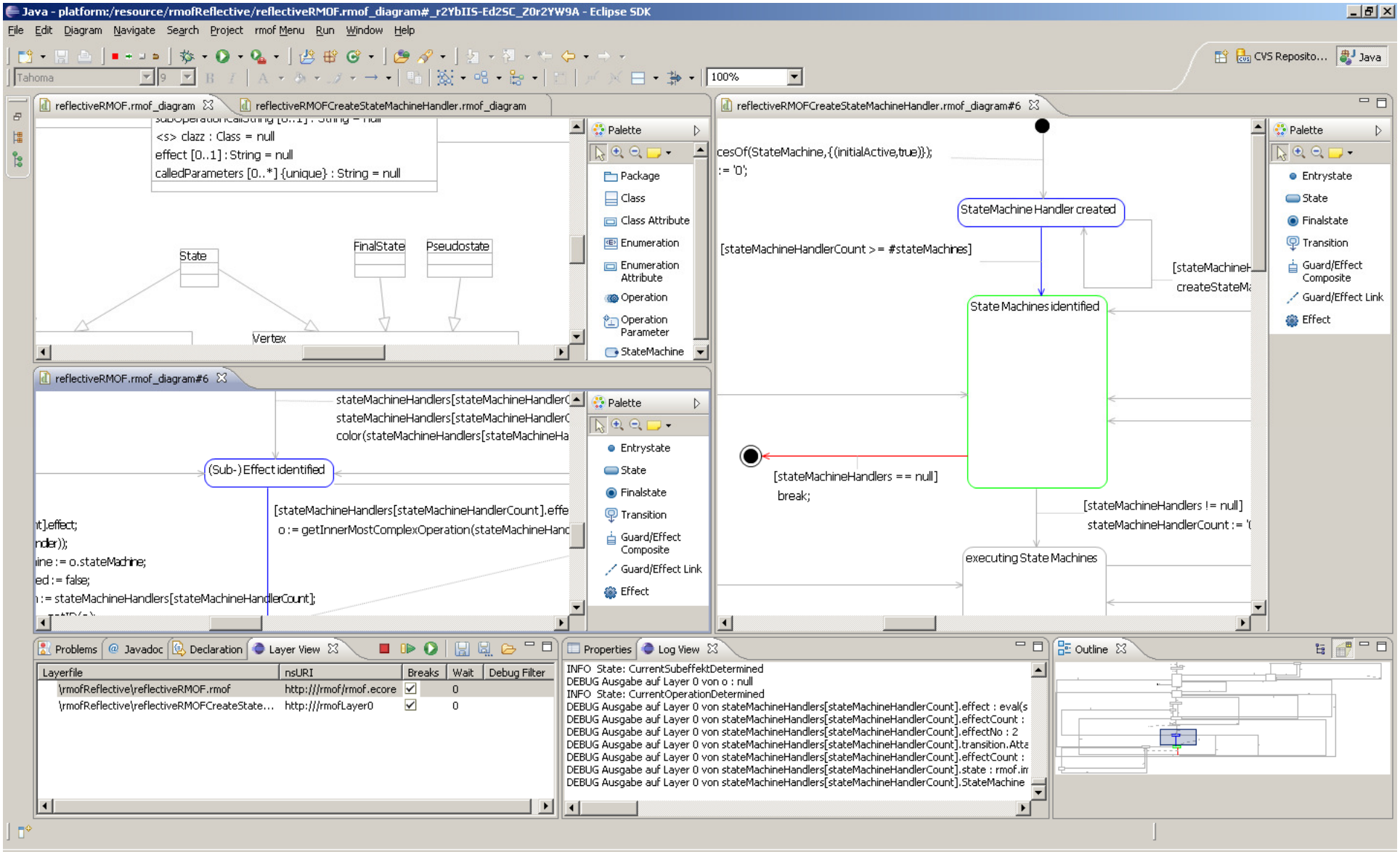
RMOF Specification



RMOF Implementation (based on EMF)



ICFEM'08::UML&FM'08::Rich Meta Object Facility



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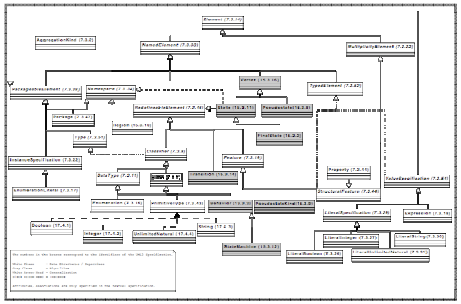
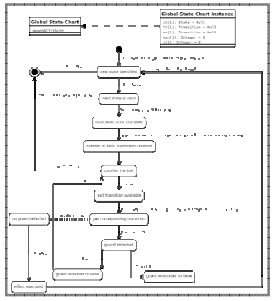
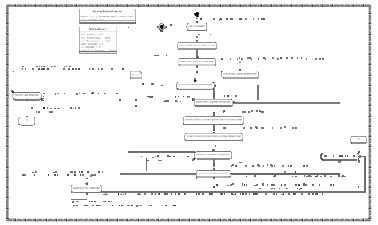
15 Example Instantiation / Instantiation plan

Data Structures Algorithms & …

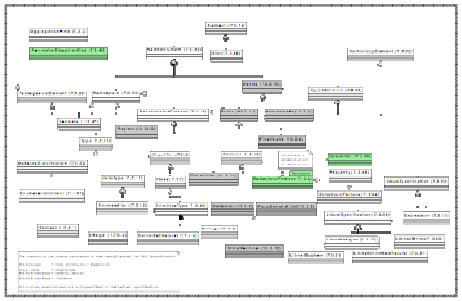
RMOF
Core Meta Model

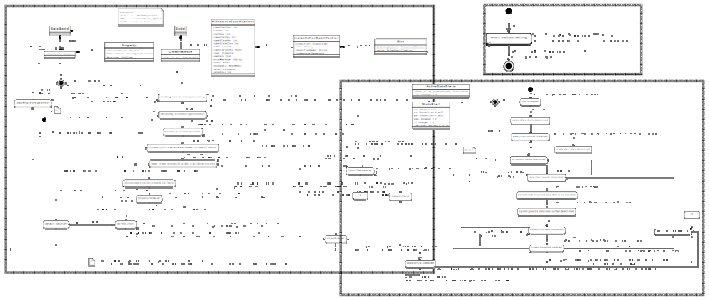




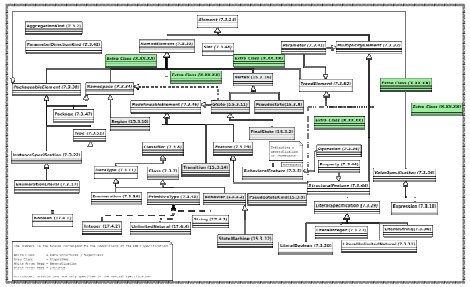


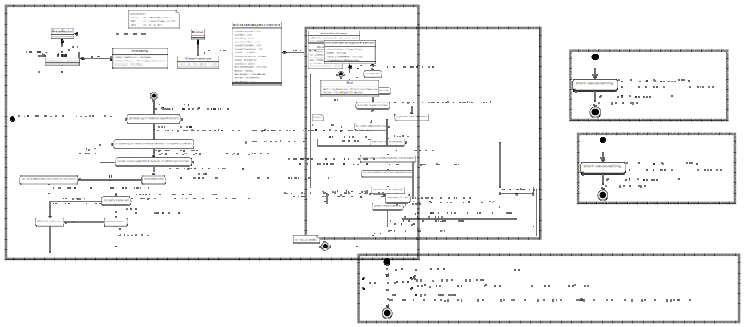
(CMOF Layer)





UML2, SPEM, SysML





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16 Summary

- RMOF Specification
  - Formal Variant of MOF
  - +Algorithms
    - (Simple) State Machines, supporting e.g., Operations, Constraints, Derived Value Computations with different degrees of concurrency
    - Action Language, supporting e.g., Layer & Collection Types Management, Simple Arithmetic Operations, Highlighting
- RMOF Implementation
  - Based on Java, Eclipse
    - EMF: Domain Model (Model Access, Persistence, Item Providers)
    - GMF: Graphical Representation
  - Enrichment to support arbitrary Modeling Layers
    - Layer Composition
    - Ecore/Genmodel Generation
  - Simulation Environment
    - Core Layer is RMOF triggered
    - Simulation/debug/… views

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17 Future Work

- Minor Editor Improvements
  - Edit support (e.g., hightlighting matching braces)
  - Only relevant editors pop-up during a simulation run
  - Speed things up
- Adding Modeling Layers
  - CMOF (Associations, Constraints, Derived Values)
  - UML2 (Class Diagrams, State Chart Diagrams, Activity Diagrams)
  - SPEM
- Adding Platform Bindings
  - Implementation: C++
  - Analysis: Symbolic (Model Checking), Heuristical & Statistical Analysis Methods
- Modell Import & Export (OMG XMI Metamodels)
- Extensions
  - Model Comparison/Search/Merge
  - Model Storage & Versioning (DB)
  - Distributed Modeling

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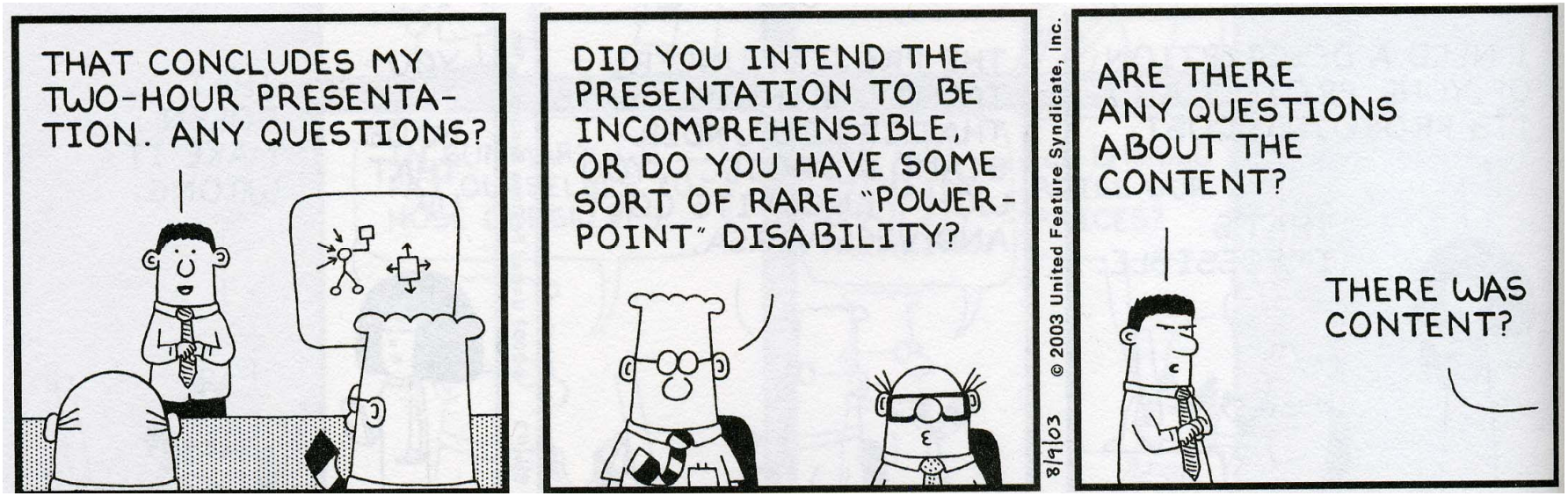
18 Thank you! Questions?



Complete specs/software please contact me:

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