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Software Radio Modeling Language: A Domain-Specific Modeling Environment for designing Signal Analyzers

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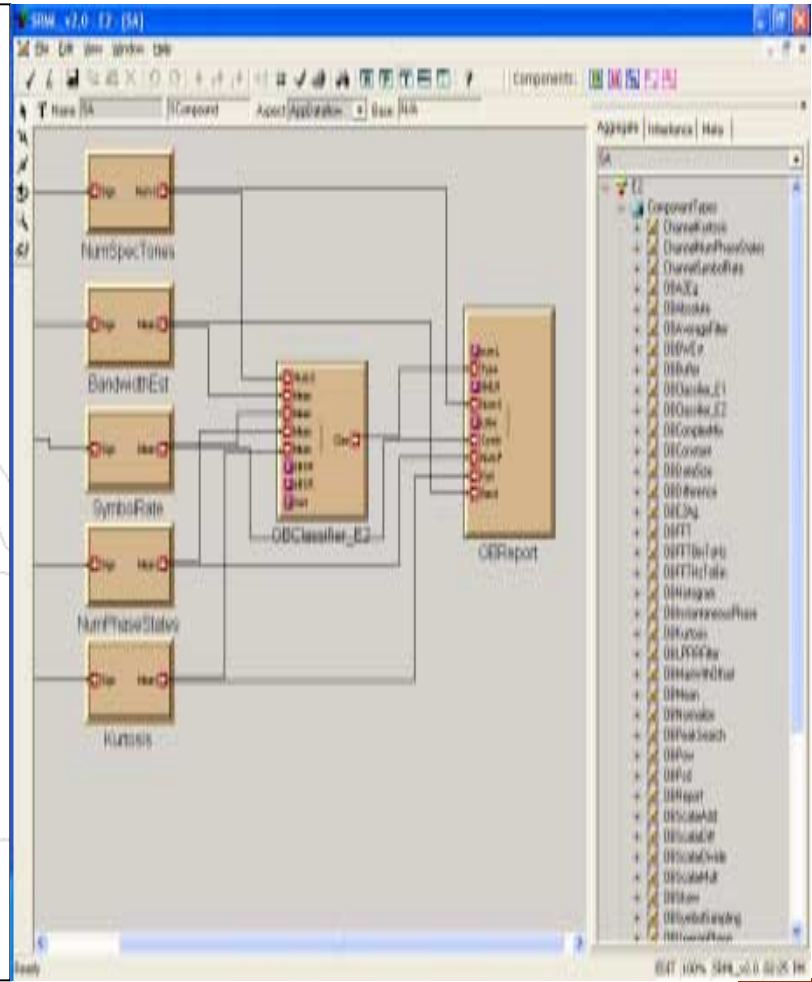
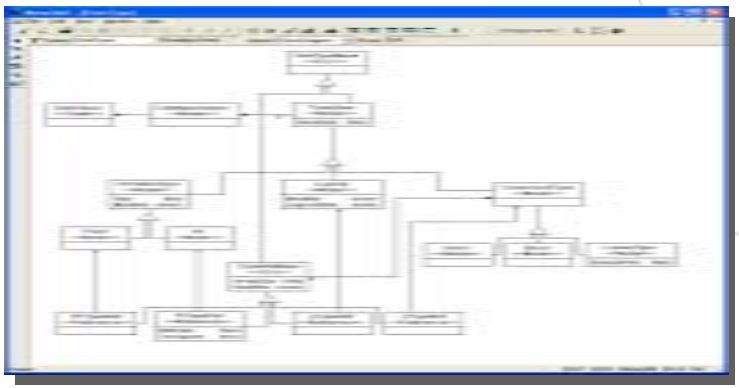
What is SRML?

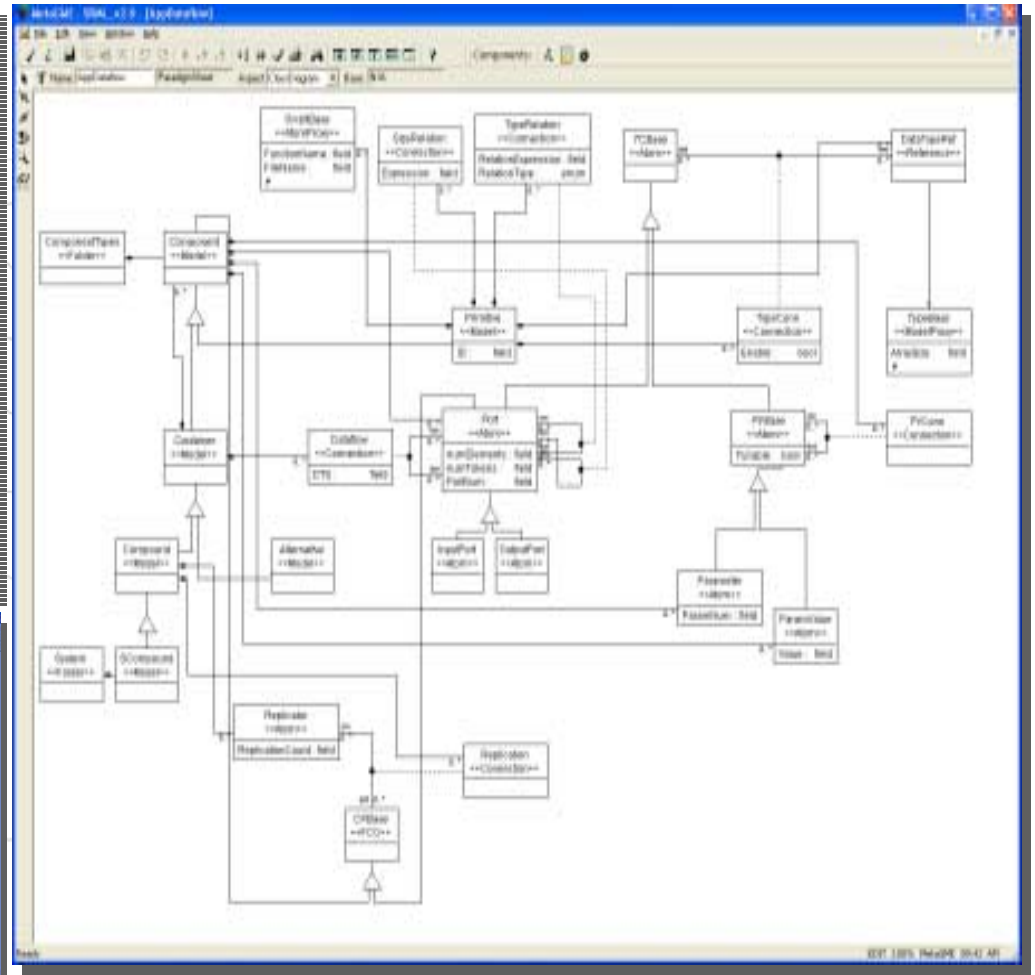
- SRML is a graphical modeling language for specifying signal processing applications
- The goal is to reduce design cycles by generating code from models
- Features
  - Type hierarchy and Instances
  - Generative Modeling
  - Strong Data-Typing
  - Well-formedness checked by online constraint checker
  - Usability/utility plug-ins
  - Multiple Computation Model
  - Model optimization by graph refactoring



Key Modeling Concepts

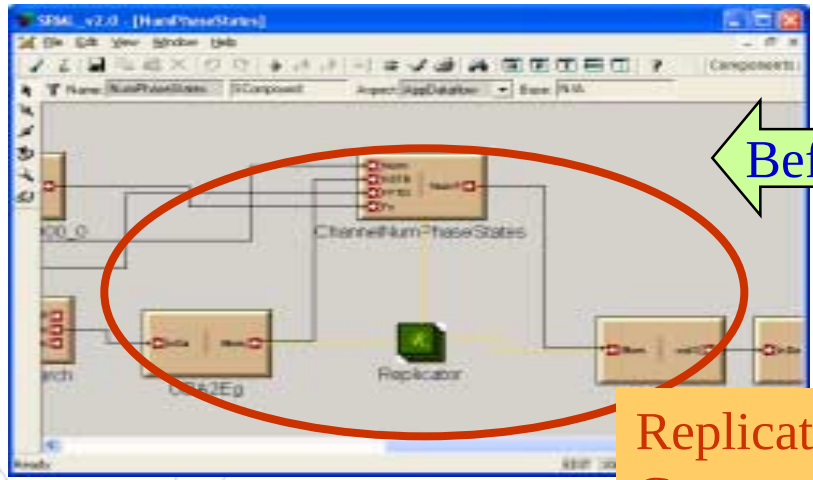
- Data-Type Modeling
- Component Types Modeling
  - Typed ports, type/size relations between ports
  - Component core and interface mapping System modeling
  - Hierarchical dataflow w/ Component Instances

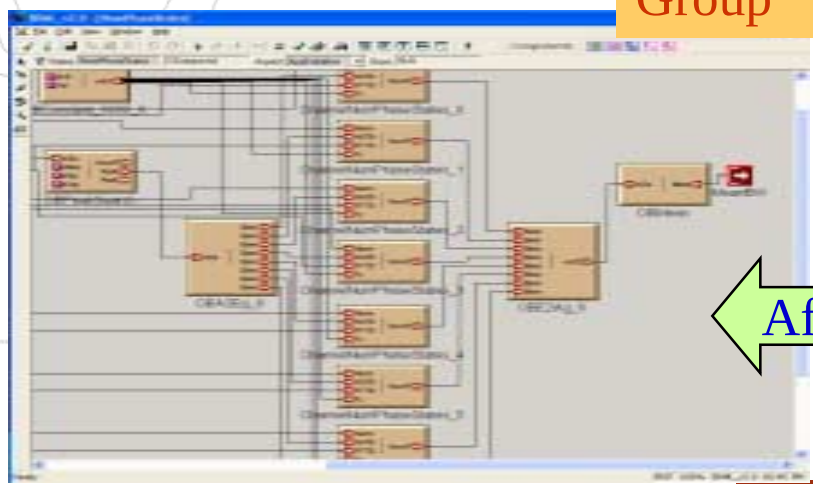




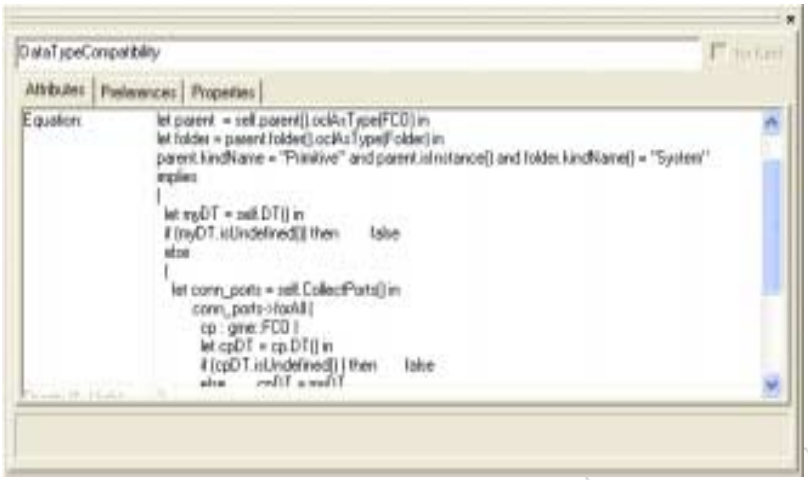
Generative Modeling

- Compact/Scalable representation of repetitive structures
- Replication groups defined by connecting ports and models with a replicator object
- Replication Plug-in elaborates models with replicator constructs

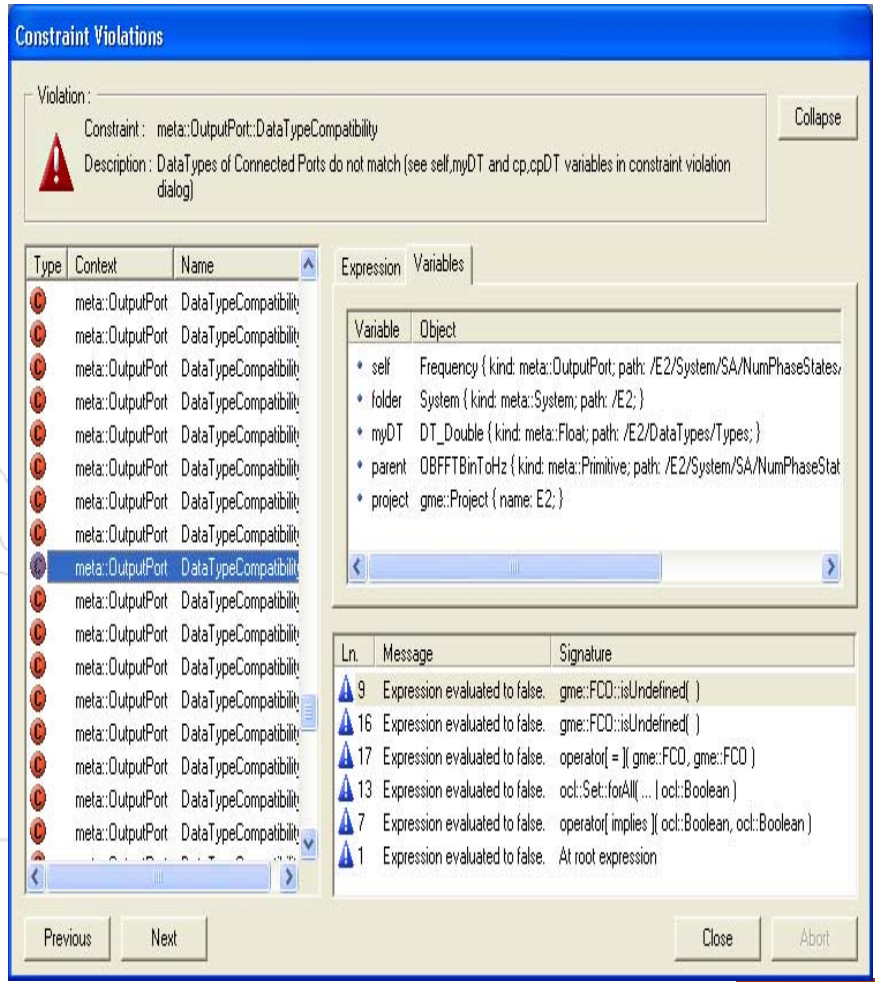




Type-Checking

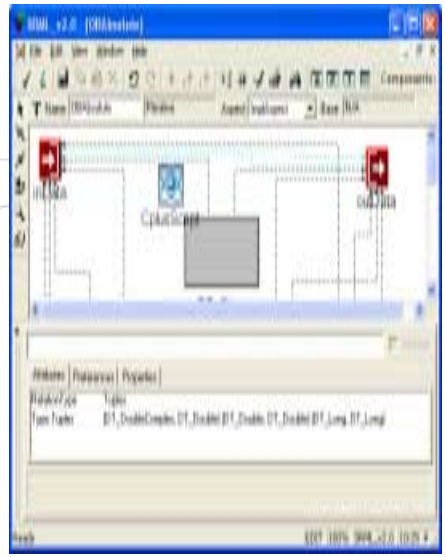


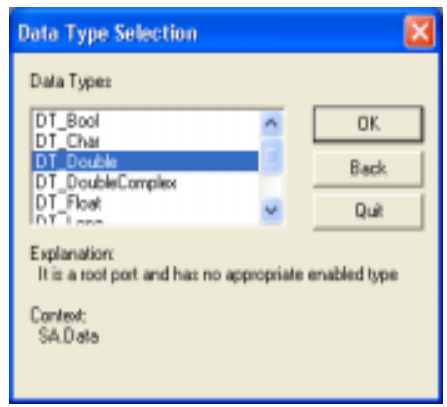
- OCL constraints for checking type compatibility between connected ports
- Constraint-checker offers advanced debugging support for detecting constraint failure location



Auto-Type Assignment

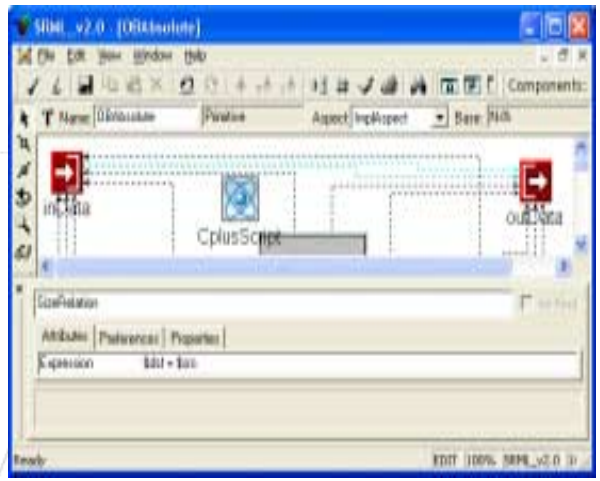
- Component Type Models allow assigning multiple types for ports - supporting type-polymorphism within models
- Component Type Models contains type relations between ports as
  - Identical || Tuples $[(t_a,t_x),(t_b,t_y),\ldots]$
- A single type must be selected in component instances for SA configuration synthesis
- Plug-in automatically assigns types based on type-relations and user-inputs

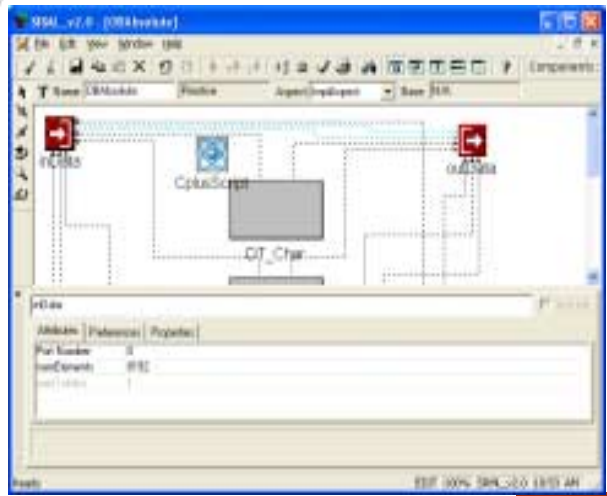




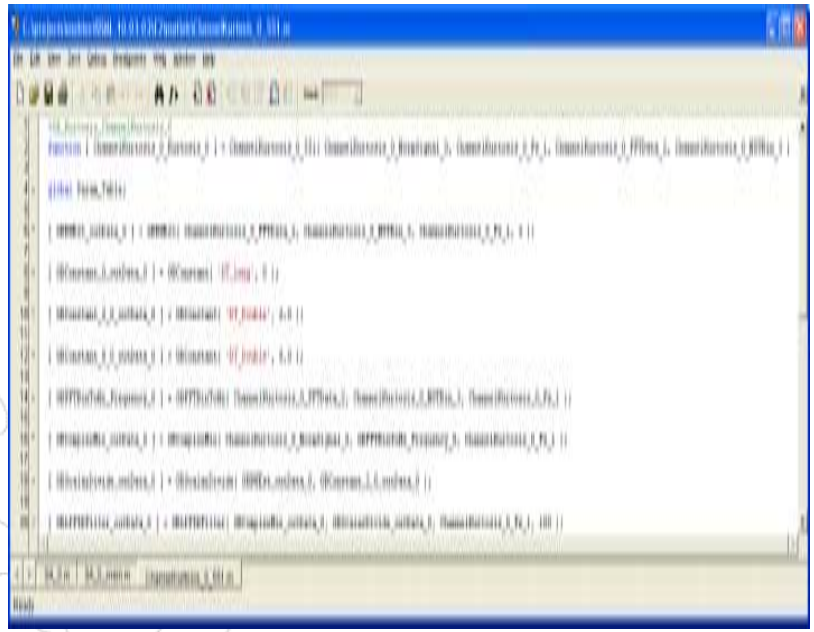
Auto-Size Assignment

- Component ports have attributes for size of data-packets
- Component types allow modeling of size relations between component ports
  - arithmetic expressions over $dst and $src
- Plug-in automatically assigns sizes for component instances based on size-relations and user-inputs





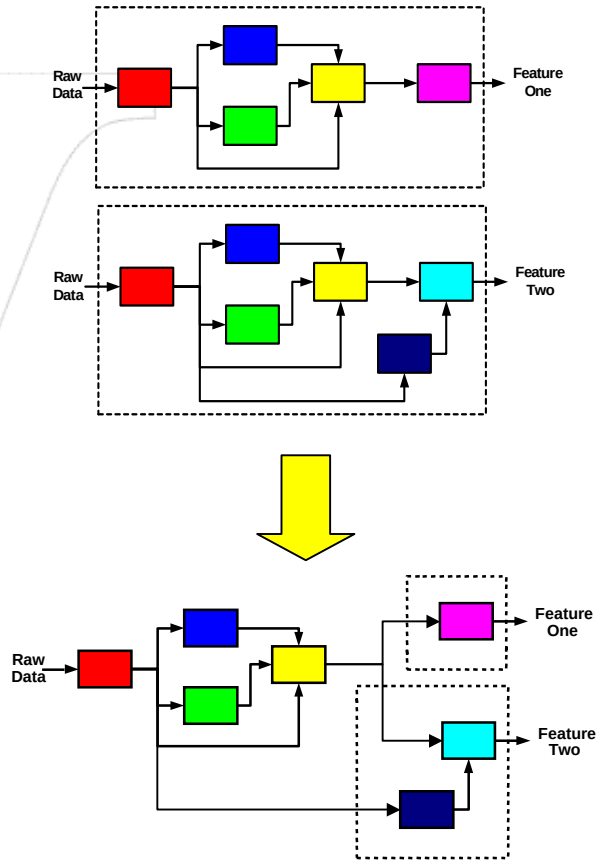
Code generation



- SA-XML Config Generation
  - Optional SDF schedule generation (SwRI contrib.)
- Generate Wrappers
  - Matlab Code Generation (Generates accessors for tunable parameters)
  - C++ wrapper code for Component Cores

Common Sub-Graph Elimination

- Removal of redundant computations from signal flow graph
- Must take into account both structure and parameter values
- Algorithm is an adaptation of the Value Numbering compiler optimization technique
- Overall latency improved 2.27x / 56.0% in experiments using SwRI Signal Analyzer experimental runtime platform



Key Accomplishments

- Precise, well-defined modeling language defined with meta-models and OCL-constraints
- Scalability/Reuse with Types-Instances and Generative Modeling
- High-degree of usability with convenience plug-ins (type-size assignment, replicator)
- Facilitate Deployment Analysis, Optimization, and Generation (code generation, CSGE)