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Applying MDD, Generative Programming, and Agile Software Techniques to the SDR Domain

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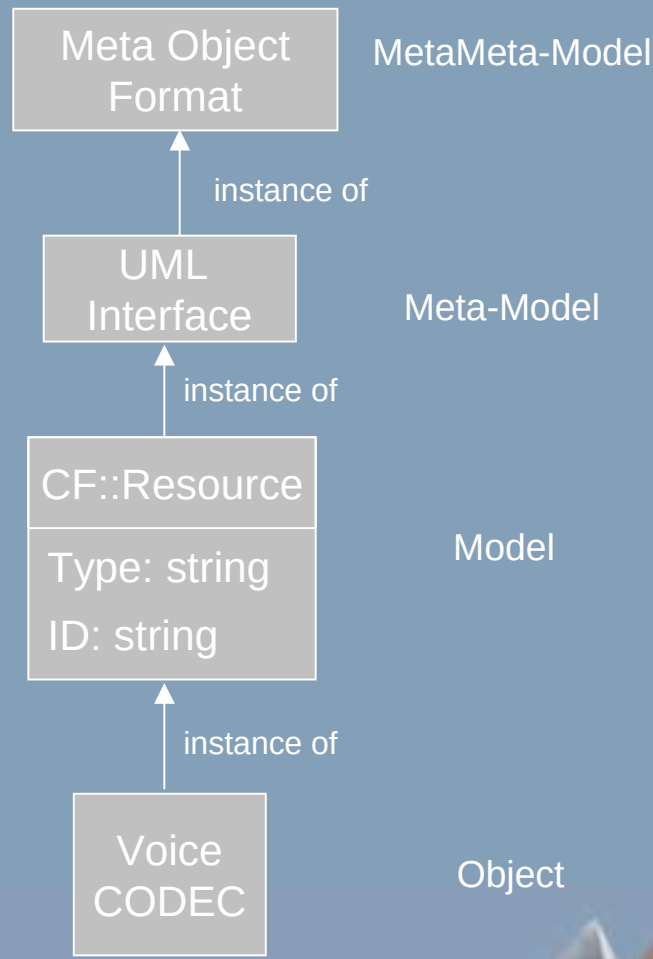
Dominick Paniscotti
Bruce Trask
Angel Roman
Vikram Bhanot

What is a Domain Specific Language?

- In order to understand DSLs, one must understand levels of modeling
- DSLs are defined using Meta-Models
- Meta-Models are defined using even higher level modes

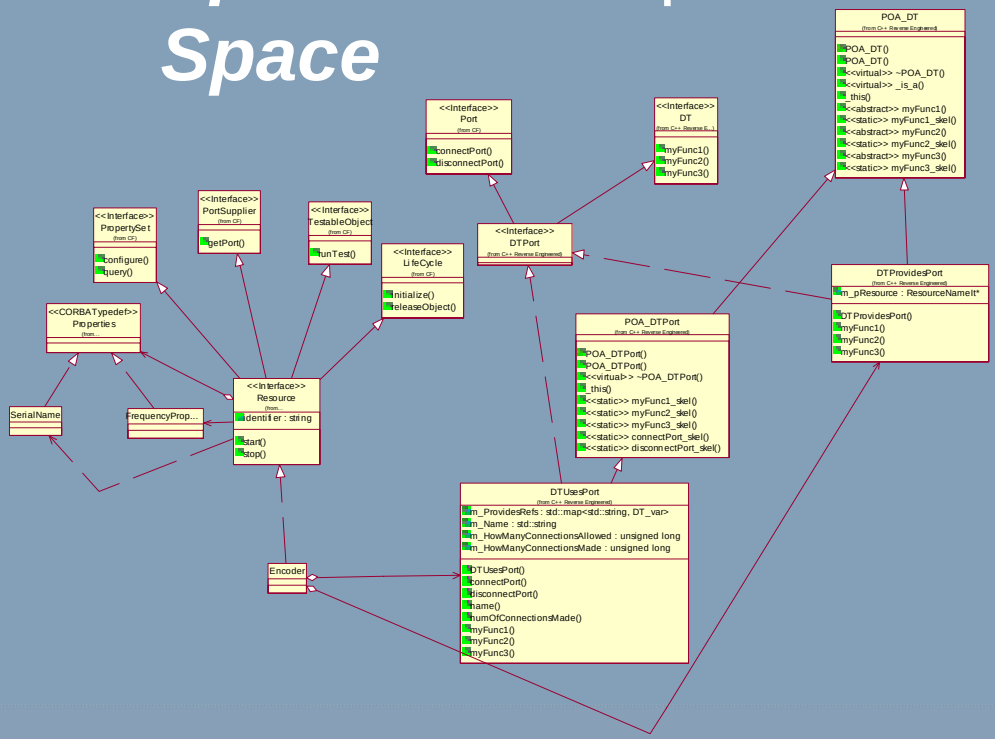
So, a Domain Specific Language is…

- A language targeted to a particular problem
  - Such as Software Radios
- Not a general purpose language aimed at any kind of problem
  - Such as UML



Domain Specific Modeling

- DSLs allow simplified modeling in the ***Problem Space*** vs. complex modeling ***in the Solution Space***



Solution Space Modeling *Problem Space Modeling*

Single CF::Resource with 2 Port and 2 Properties

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Model Driven Software Development

- ***Model Driven Development***
  - Models are used to express the design of a system
  - Models are transformed to create implementations
- Model Driven approaches combined with ***Generative Programming*** technologies allow developers to ***"create designs that write code"***
- Developers use ***Domain Specific Languages*** and ***Models*** to ***efficiently and automatically map to platform-specific technologies***
- Model Driven approaches allow us to effectively and practically move from making one-time concrete systems to ***families of systems***
  - Since the meta-models capture the system family rules

Model Driven Software Development

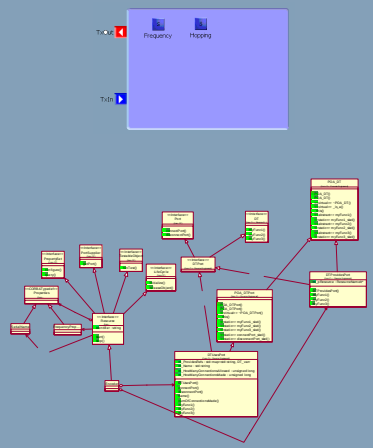
- Allows developers to ***weave various aspects*** of the solution domain together automatically
- Increases ***productivity and correctness*** in complex systems by ***simplifying*** development
- Puts tools in the hands of developers so they can properly ***capture the commonalities and variabilities*** of their domain
- Captures the "***sweet-spot" of many areas of software development***
  - Including modeling, code generation, coding, testing
  - Could program in assembly or C++, what is the best combination of software tools to get the job done and done correctly
- Supports the creation of development ***processes*** for the domain
  - Explain exactly what is meant here
- Supports the creation of ***Domain Specific Tools***
- These Tools further ***eliminate the complexities associated with development*** in a particular domain

Levels of Abstraction

Less Flexible

Flexibility

More Flexible



Higher Order Languages

Assembly

Opcodes

Custom Hardware

More Productive

Productivity

Less Productive

Generative Programming

- The process of moving from a higher level abstraction to a lower level abstraction *automatically*
- Specification of transformation rules support this paradigm

  e.g. C++ to Assembly to Opcodes.
- Domain Specific Models and Languages work in concert with generative technologies
  - The whole is the worth more than the sum of the parts
- Thereby increasing the productivity

To summarize…

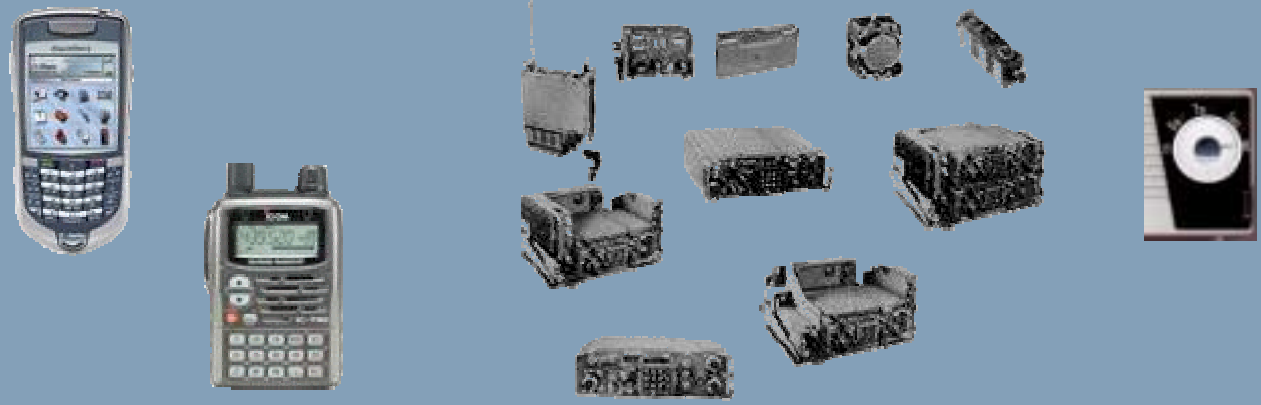
- Model driven development defines higher levels of domain specific abstractions and combines these with generators that automatically transform these abstractions to lower level ***executable*** artifacts
- An Engineering Trade-Off
  - Sacrificing flexibility for productivity
- Not a value judgment
  - Its payback is in the cost reduction found in developing ***Families Of Systems*** vs. Single Concrete System

Families Of Systems

- Focus on System Families allows one to identify the commonalities and variablities found across family members
- And develop DSLs to:
  - ***Factor out*** common behavior into paramaterizable abstractions
  - Provide ***extension mechanisms*** to incorporate variation points found across family members
- And further develop generators to synthesize concrete functionality for a particular family member

Radio Families

Radio Family Members



- ***Commonalities***
  - Properties
  - Tests
  - Life Cycle
  - Communications Path
  - Deployment
  - Functionality (Routing, Networking)
  - Basic architecture
- ***Variabilities***
  - Functionality
  - RF or SiS characteristics
  - Processing Elements (HW)
  - Size weight and power constraints

What the SCA has done … and has not

- SCA isolated the commonalities and variabilities but did not provide a DSL in which to program these things
- Also no generators
- So to really complete the picture, need generators to handle practical use an to map against the variabilities
- The SCA provides the necessary abstraction and framework of patterns (Extension Object with component Configurator) as well as the deployment and configuration engine.
- What is needed now are the remaining artifacts to make this particular solution complete.

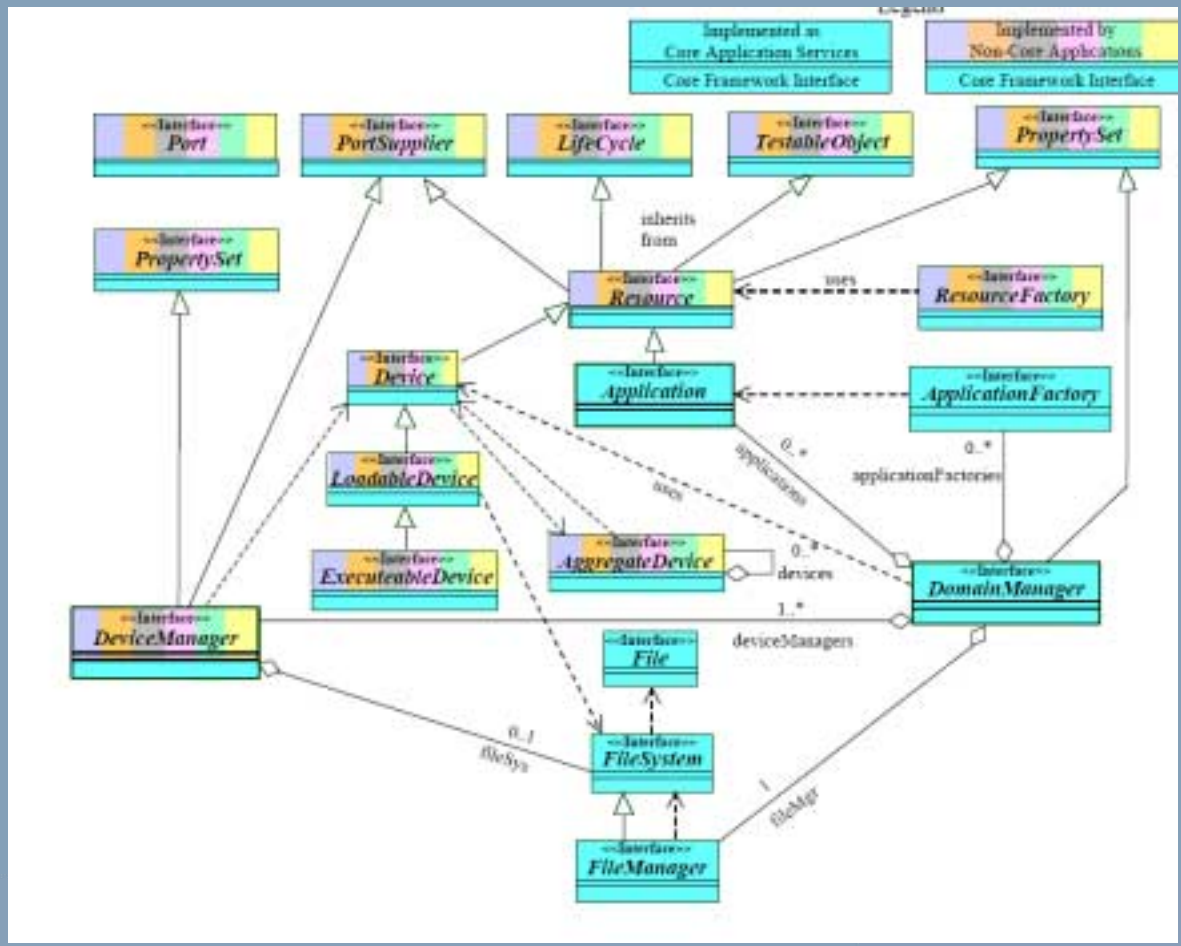
Providing the remaining steps

- Allow programmers to program in the higher order domain by
  - Providing a domain specific grammar
  - Graphical representations of this grammar
  - Automatic constraint engines to ensure the use of the grammar is correct
  - Automatic generations engines
    - transform the resulting model to various targets along varying dimensions
    - Weave together various complex aspects of the domain

The steps

In general	In our domain
Isolate the abstractions and how they work together	*The SCA*
Create a formalized grammar for these - DSL	*Create a formalize SCA meta-model*
Create a graphical representation of the grammar – GDSL	*Create a SCA specific graphical tool*
Provide domain-specific constraints – GDSCL, DSCL	*Program into the tool the constraints*
Attach generators for necessary transformations	*C++, C and VHDL generators*

The SCA



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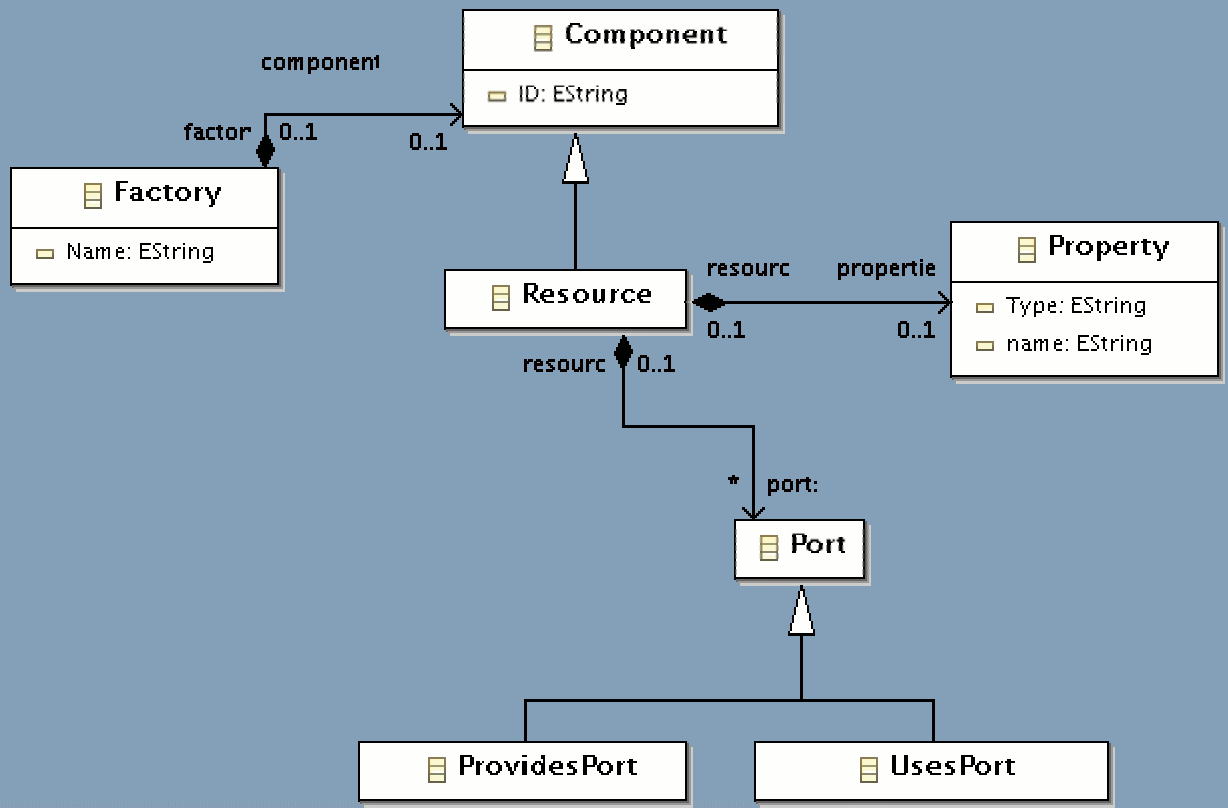
The Metamodel



Domain Specific Language

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<?xml version="1.0" encoding="ASCII"?>
<com.prismtech.spectra.sdr.sca2_2.models:Assembly
          xmi:version="2.0"
          xmlns:xmi="http://www.omg.org/XMI"
          xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
          xmlns:com.prismtech.spectra.sdr.sca2_2.models="http://com.prismtech.spectra.sdr.sca
2_2.models">

  <components Name="BitFlipper" organization="PrismTech" id="DCE:8f647411-91a1-4295-bbc6-
6d3eff4982f7">

    <ports xsi:type="com.prismtech.spectra.sdr.sca2_2.models:UsesPort"
                                        instanceName="TX" name="Data"/>

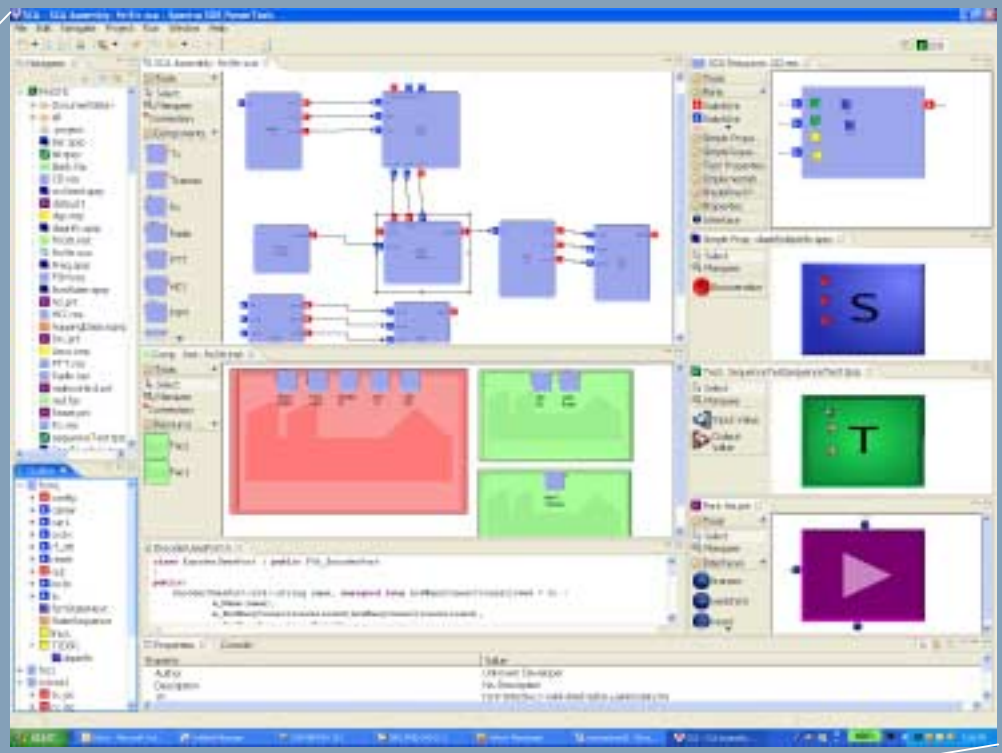
    <ports xsi:type="com.prismtech.spectra.sdr.sca2_2.models:ProvidesPort" instanceName="RX"
name="Data"/>

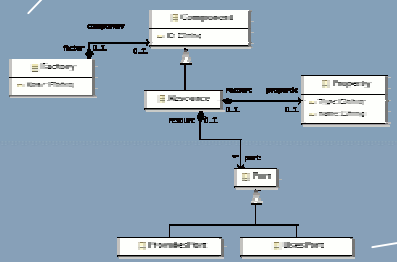
  </components>

</com.prismtech.spectra.sdr.sca2_2.models:Assembly>
```

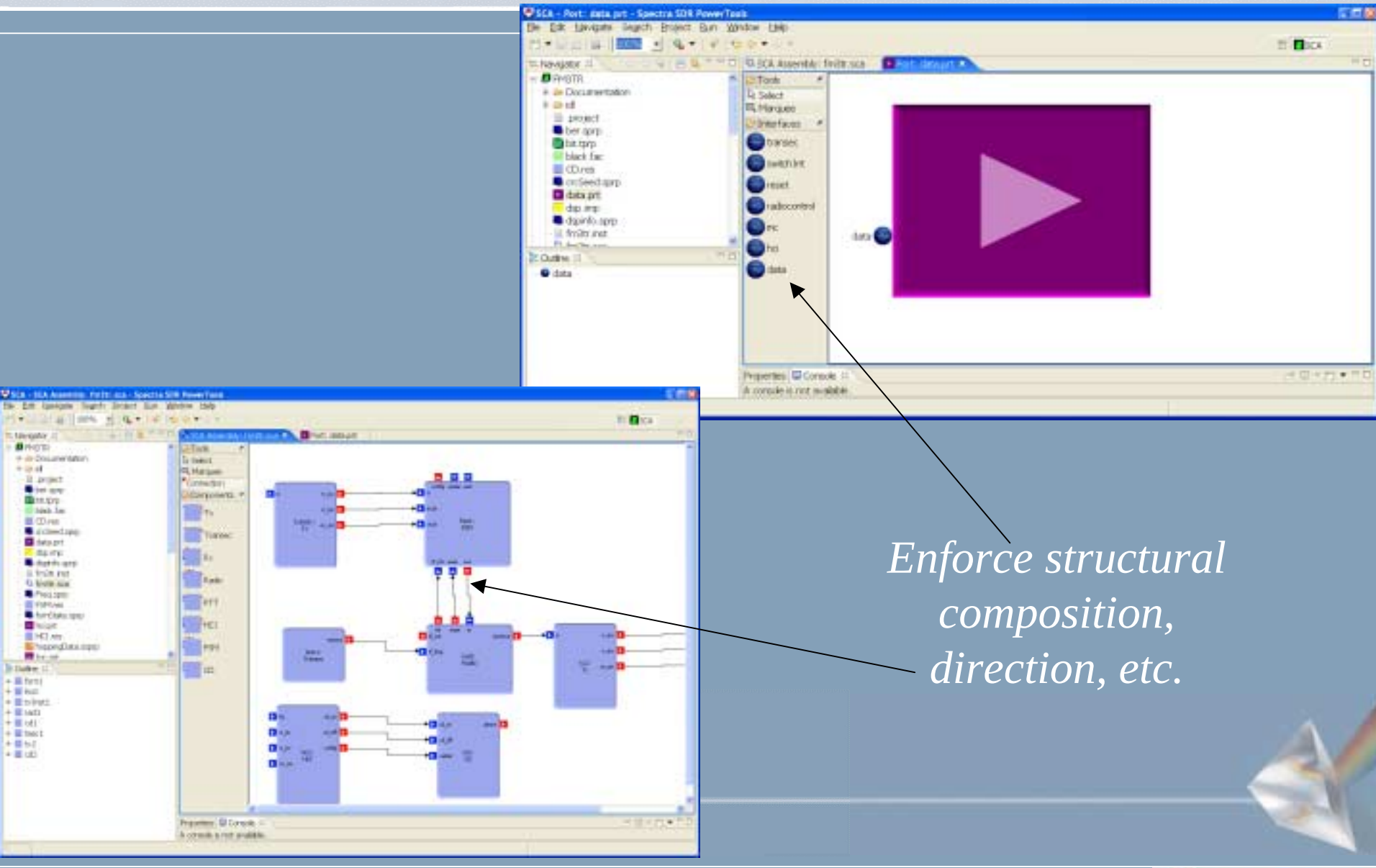
A Graphical Domain-Specific Language

Images, layout, organization based on meta-model





Domain-Specific Constraints

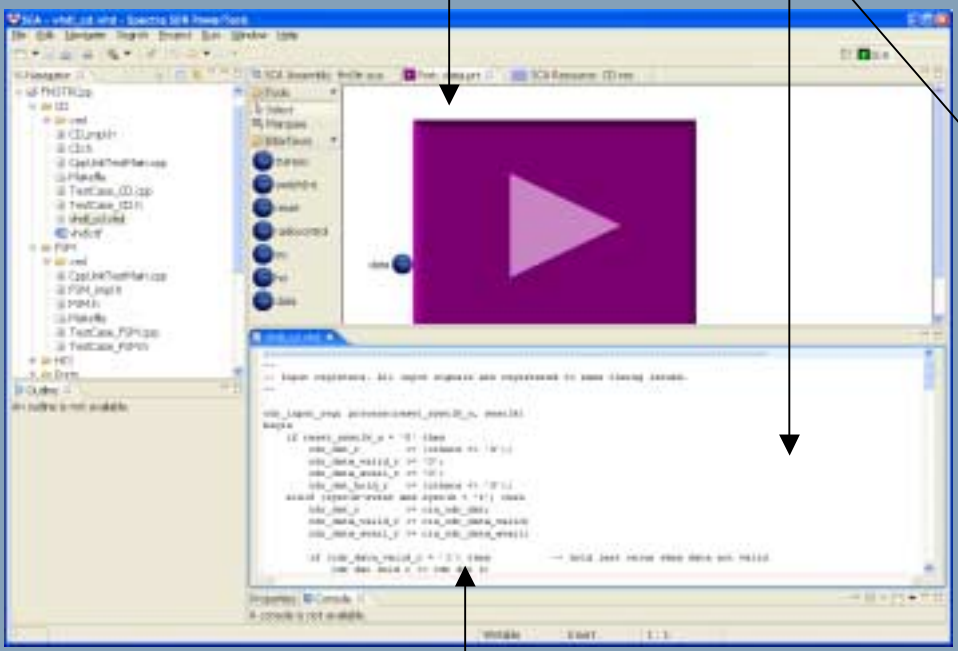


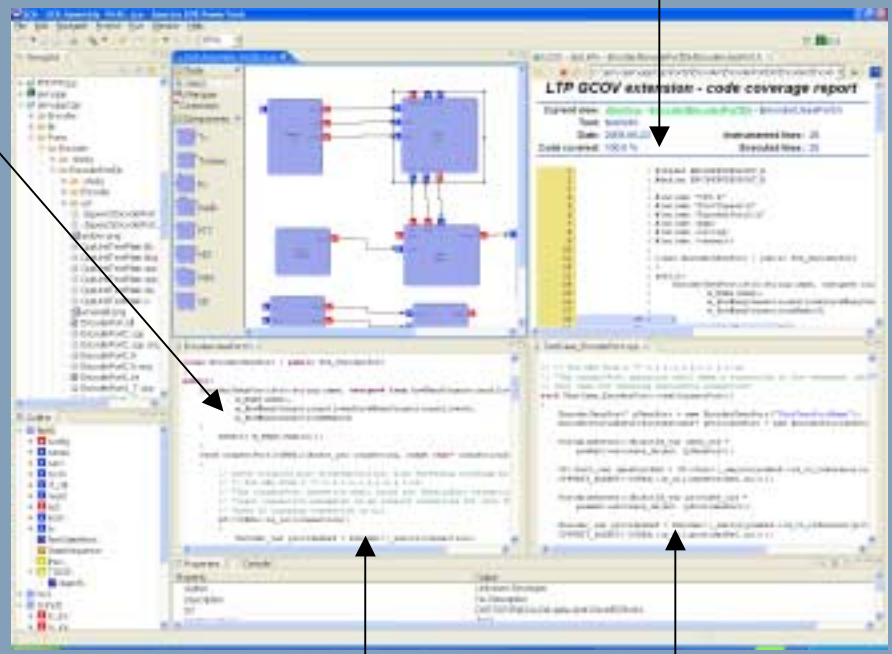
Enforce structural composition, direction, etc.

Generators

Translate from declarative to imperative

Code Coverage





VHDL

C++

Test Cases

The Benefits

- The SCA
  - portability
  - standardized development
- Meta-model – Domain Specific Language
  - more productivity
- GDSL
  - easy to use and communicate to others
- Constraints
  - left shift defects from run-time to modeling time
- Generators
  - Productivity
  - Correctness
  - Architectural consistency
  - Requirements traceability
  - Synchronization of software artifacts
    - e.g.documentation
  - Automated testing = increased robustness

Contact Info

Stop by our booth at this conference

www.prismtech.com

Dominick - dp@prismtech.com

Bruce – bt@prismtech.com