AdaCore
The GNAT Pro Company

GeneAuto for Ada and SPARK

A verifying model compiler

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Model Compilers: State-of-the-Art

- **Traditional model compiler**
  - Rarely added value (model = graphical coding)
- **Properties verifiable at model level**
  - Show they hold at source level: qualified code generator
  - Show they hold in the executable: compiler qualification kit
  - Assume they are respected during execution
- **Properties *non*-verifiable at model level**
  - Platform-dependent properties (overflows, stack size, wcet, …)
  - No feedback in the model

Verifying Model Compilers: High-level Vision

- **Properties for an intermediate representation**
  - Formal semantics
  - Executable semantics
  - Show properties are formally preserved
  - Complement V&V activities

- **Our first experiment: Simulink**
  - Need open technology to rely on: GeneAuto
  - Emphasis on the intermediate representation for:
    - Correctness (property preservation + complement V&V)
    - Efficiency
    - Traceability (model→source & source→object)

SPARK: target language of GeneAuto/Ada

```
package My_Block
--# own Input_Ports, Output_Ports, Is_Initialized;
is
   procedure Initialize;
   --# global out Is_Initialized;
   --# post Is_Initialized;

   procedure Pass_Data (D : Data);
   --# global out Input_Ports;
   --# pre Is_Initialized;
   --# derives Input_Ports from D;

   procedure Compute;
   --# global in Input_Ports; out Output_Ports;
   --# pre Is_Initialized;
   --# derives Output_Ports from Input_Ports;
```

Data/Information flow contract
Statically proved pre/post condition

Require the Block to be initialized

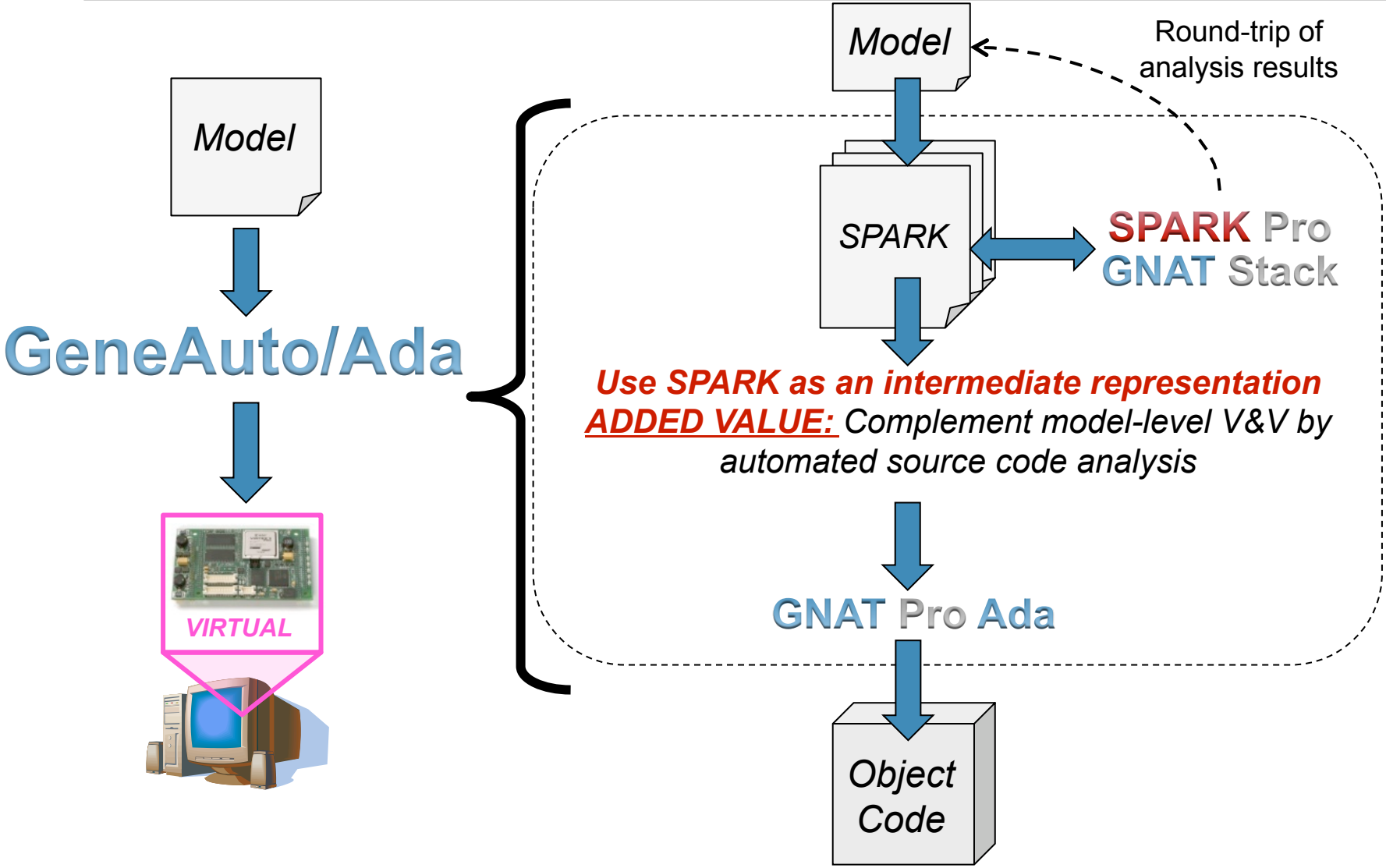
State that the value of input ports depends from the parameter D

GeneAuto/Ada: a Verifying Model Compiler (I)

- **What we can *formally prove* with SPARK**
  - Absence of run-time errors:
    - Overflows, underflows
    - Array-out-of-bounds
    - Data/Information flow errors (uninitialized variables, ineffective statements, …)
  - Partial correctness
    - Hoare-like pre/post conditions

- **Major advantages:**
  - Model translation is *formally* void of errors
  - The *formal representation (in SPARK)* is *executable* and *efficient*

GeneAuto/Ada: a Verifying Model Compiler (II)



A typical day in GeneAuto/Ada...

This is the C code we generate:
how would the SPARK version look like?

This is the corresponding SPARK code. I've found:
- Possible source of overflow
- Unused parameters
- Access to uninitialized variables
- ...

Yep, you're right. We discovered:
- A problem in GeneAuto requirements
- A problem in GeneAuto implementation
- A limit in model-level verification

Qualifying GeneAuto/Ada

- **We considered OpenOffice… for almost 3 full minutes…**

- **We needed:**
  - Agile framework supporting distributed artifacts manipulation
  - Easy revision control (at least 4 developers)
  - Tracking of:
    - Actions!
    - Approved requirements
    - Implemented requirements
    - Open questions
  - Traceability evidence

FitNesse: a Prototypal Qualifying Machine

- **A qualifying machine:**
  - Infrastructure keeping track of each atomic action
  - Analyze artifacts deployment/history to discover:
    - Workflow was (not) followed
    - Traceability problems
  - Agile user interface (possibly web-based)

- **Our current choice: FitNesse**
  - A tool for test-driven development (agile paradigm)
  - Slightly modified to better fit our needs

FitNesse: a Prototypal Qualifying Machine (II)

Artifact Editing & Action tracking

Managing Open Questions

Future Directions

- **Increase the number of supported blocks**
- **Pursuing the verifying model compiler vision**
- **Investigate integration with UML, SysML, MARTE/AADL**
- **Improve qualifying machine**
- **Opening the project: Open-DO**
- **Business model (OPEES)**