SUAVE: Extending VHDL to Improve Modeling Support

Peter J. Ashenden
University of Adelaide

Philip A. Wilsey, Dale E. Martin
University of Cincinnati

This work was partially supported by Wright Laboratory
under USAF contract F33615-95-C-1638.

SUAVE

SAVANT and
University of
Adelaide
VHDL
Extensions

Outline

- Design Objectives
- Overview of Extensions
  - encapsulation
  - type derivation & inheritance
  - genericity
- What we have not done (yet)
  - entity/architecture inheritance
  - concurrency and communication

Design Objectives

- Support high-level modeling
  - improve encapsulation and information hiding
  - provide for hierarchies of abstraction
- Support re-use and incremental development
  - polymorphism, dynamic binding, type genericity
- Preserve capability for synthesis & other analysis
- Support hw/sw codesign
  - improved integration with programming languages

. . .

Design Objectives (cont)

- Refinement through elaboration of components
  - avoid repartitioning
- Preserve correctness of existing models
- Design principles from VHDL-93
  - preserve “conceptual integrity”

Overview of Extensions

- Borrow heavily from Ada-95
  - VHDL already has much in common with Ada
  - borrow encapsulation, information hiding, inheritance, genericity features
- Class-based *cf* programming by extension
  - class-based
    - replicates package features
    - choose one or the other, but not both!
  - programming by extension
    - integrates better with signal semantics

Encapsulation

- Strengthen existing package feature
  - used to define secure ADTs
- Package can have *visible part* and *private part*
- *Private type*
  - declare *partial view* in visible part
    - includes some contractual details
  - declare *full view* in private part
- Allow packages in any declarative region
  - local ADTs

Encapsulation Example

```
package complex_numbers is
    type complex is private;
    constant i : complex;
    function re ( C : complex ) return real;
    function im ( C : complex ) return real;
    function "abs" ( C : complex ) return real;
    function arg ( C : complex ) return real;
    function "+" ( L, R : complex ) return complex;
    function "–" ( L, R : complex ) return complex;
    . . .
private
    type complex is
        record
            re, im : real;
        end record complex;
end package complex_numbers;
```

Encapsulation Example (cont)

```
use complex_numbers.all;
signal a, b, sum : complex;
signal enable : bit;
. . .
sum <= a + b after 10 ns when enable = '1' else
        0.0 + 0.0*i after 10 ns;
```


Encapsulation: Contracts

- *Limited* private type
  - assignment not allowed, no predefined equality
  - use when deep copy/compare needed
- *Access* private type
  - needed if full view includes access types
  - can't be used for signals

Type Derivation and Classes

- Adopt from Ada-95:
  - tagged records
  - type derivation
    - type derived from tagged record can add elements
    - inherits primitive operations from parent type
    - can override/augment operations
  - class-wide types, class-wide operations
    - T'Class is hierarchy of types derived from T
    - dynamic dispatching
  - abstract type and operations
- Signals and dynamic variables can be class-wide

Type Derivation Example

```
type instruction is
    tagged record
        opcode : opcode_type;
    end record instruction;

function privileged ( instr : instruction;  mode : protection_mode )
                    return boolean;

procedure disassemble ( instr : instruction;  file output : text );

type ALU_instruction is new instruction with
    record
        destination, source_1, source_2 : register_number;
    end record ALU_instruction;

procedure disassemble ( instr : ALU_instruction;  file output : text );
```

Type Derivation Example (cont)

```
type memory_instruction is abstract new instruction with record
        base : register_number;
        offset : integer;
    end record memory_instruction;

function effective_address_of ( instr : memory_instruction ) return natural;

procedure perform_memory_transfer ( instr : memory_instruction ) is abstract;

type load_instruction is new memory_instruction with record
        destination : reg_number;
    end record load_instruction;

procedure perform_memory_transfer ( instr : load_instruction );

type store_instruction is new memory_instruction with record
        source : reg_number;
    end record store_instruction;

procedure perform_memory_transfer ( instr : store_instruction );
```


Type Derivation Example (cont)

```
procedure execute ( instr : instruction'class ) is
begin
    disassemble ( instr, trace_file );
    if privileged(instr) and execution_mode = user then
        handle_privilege_violation;
    else
        . . .
    end if;
end procedure execute;
```

```
entity instruction_reg is
    port ( load_enable : in bit;
           instr_in : in instruction'class;
           instr_out : out instruction'class );
end entity instruction_reg;
```

Interaction: Encapsulation and Derivation

- Adopt mechanisms from Ada-95
  - tagged private type
    - can be extended without revealing details of parent
  - private extension
    - concrete details of extension hidden
- See papers for examples