Lecture 4 – System Specification

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Lecture 4: Outline

- **System specification**
  - Essential issues
  - Specification modeling guidelines
  - C-to-SpecC recoding

- **Design example**
  - SUSAN edge detection specification
System Specification

- **System behavior**
  - Specification model

- **System constraints**
  - Non-functional requirements

**Essential Issues in Specification**

- **An Example ...**

  - Proposed by the project team
  - Product specification
  - Product design by senior analyst
  - Product after implementation
  - Product after acceptance by user
  - What the user wanted

*Source: unknown author. Courtesy of: R. Doemer*
**Specification Model**

- **Functional and executable**
  - “golden model” (first functional model in the design flow)
  - all other models will be derived from and compared to this one

- **High abstraction level**
  - no implementation details
  - unrestricted exploration of design space

- **Separation of communication and computation**
  - channels and behaviors

- **Pure functional**
  - no structural information

- **No timing**
  - exception: timing constraints

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**Specification Model**

- **Top-level Main behavior**
  - Test bench
    - Stimulus provides test vectors
    - Monitor observes and checks outputs
      - no restrictions in syntax and semantics (no synthesis)
  - Design under test (DUT)
    - restricted by syntax and semantic rules (synthesis!)
Specification Modeling Guidelines

- **Computation: Behaviors**
  - Hierarchy: explicit concurrency, state transitions, ...
  - Granularity: leaf behaviors = smallest indivisible units
  - Encapsulation: localization, explicit dependencies
  - Concurrency: explicitly specified (par, pipe, fsm, seq, ...)
  - Time: un-timed, partial ordering

- **Communication: Channels**
  - Semantics: abstract communication, synchronization (standard channel library)
  - Dependencies: explicit data dependency, partial ordering, port connectivity

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**Example rules for SoC Environment (SCE)**

- **Clean behavioral hierarchy**
  - hierarchical behaviors: no code other than seq, par, pipe, fsm statements
  - leaf behaviors: no SpecC code (pure ANSI-C code only)

- **Clean communication**
  - point-to-point communication via standard channels: c_handshake, c_semaphore, c_double_handshake, c_queue (typed or untyped)
  - ports of plain ANSI C type or interface type, no pointers!
  - port maps to local variables or ports only

**Detailed rules for SoC Environment**

"SCE Specification Model Reference Manual,“
by A. Gerstlauer, R. Doemer, CECS, UC Irvine, April 2005
Specification Modeling Guidelines

- **C code conversion to SpecC**
  - Functions become behaviors or channels
  - Functional hierarchy becomes behavioral hierarchy
    - Clean behavioral hierarchy required
    - if-then-else structure becomes FSM
    - while/for/do loops become FSM
- **Explicitly specify potential parallelism**
  - Task and data parallelism
- **Explicitly specify communication**
  - Avoid global variables
  - Use local variables and ports (signals, wires)
  - Use standard channels
- **Data types**
  - Avoid pointers, use arrays instead
  - Use explicit SpecC data types if suitable
  - Floating-point to fixed-point conversion

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Image Edge Detection

- **Identifying points at which the brightness changes sharply**
  - Capture important events and changes

- **Edge sources (brightness changes)**
  - Discontinuities in depth
  - Discontinuities in surface orientation, and material properties
  - Variations in scene illumination

- **Application**
  - Computer vision
    - Industrial robots, autonomous vehicles or mobile robots, medical image analysis, etc.
  - Machine vision
    - Quality assurance, sorting, material handling, robot guidance, and optical gauging

- **Smallest Univalue Segment Assimilating Nucleus (SUSAN)**
  - Edge detection, corner detection and image noise reduction

Susan Edge Detector Specification

![Diagram of Susan Edge Detector Specification](image)
Lecture 4: Summary

• **System specification**
  • Specification modeling guidelines
    – Testbench setup
    – Hierarchy, concurrency, communication
  • Unambiguous, formal definition
    – Intended system behavior
    – Analysis and synthesis

➢ How to capture concurrency, order, time, …?
  ➢ Models of Computation!

• **Design example**
  • SUSAN

➢ Specification development in Lab 1