VHDL BEHAVIORAL MODEL

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ABSTARCT

The language constructs introduced so far allow hardware to be described at a relatively detailed level. Modeling a circuit with logic gates and continuous assignments reflects quite closely the logic structure of the circuit being modeled; however, these constructs do not provide the power of abstraction necessary for describing complex high level facets of a system. The procedural constructs described in this chapter are well suited to tackling problems such as describing a microprocessor or implementing complex timing checks. With the increasing complicacy of digital design, it has become vitally important to make wise design decisions early in a project. Designers need to be able to evaluate the trade-off of various architectures and algorithms before they decide on the optimum architecture and algorithm to device in hardware.

INTRODUCTION

The behavioral approach to systems theory and control theory was began in the late 70's by J. C. Williams as a result of resolving inconsistencies present in classical approaches based on state-space, transfer function, and convolution representations. This approach is also motivated by the aim of obtaining a general framework for system analysis and control that respects the underlying physics.

The main object in the behavioral setting is the behavior --- the set of all signals compatible with the system. An important feature of the behavioral approach is that it does not distinguish a priority between input and output variables. Apart from putting system theory and control on a rigorous basis, the behavioral approach unified the existing approaches and brought new results on controllability for nD systems, control via interconnection, and system identification.

in the behavioral setting, a dynamical system is a triple

$$\Sigma = (\mathbb{T}, \mathbb{W}, \mathcal{B})$$

Where

- $\mathbb{T} \subseteq \mathbb{R}$ is the "time set" --- the time instances over which the system evolves,
- $\mathbb{W}$ is the "signal space" --- the set in which the variables whose time evolution is modeled take on their values, and
- $\mathcal{B} \subseteq \mathbb{W}^{\mathbb{T}}$ the "behavior" --- the set of signals that are compatible with the laws of the system ($\mathbb{W}^{\mathbb{T}}$ Denotes the set of all signals, i.e., functions from $\mathbb{T}$ into $\mathbb{W}$).

$w \in \mathcal{B}$ Means that w is a trajectory of the system, while $w \notin \mathcal{B}$ means that the laws of the system forbid the trajectory w to happen. Before the phenomenon is modeled, every signal in $\mathbb{W}^{\mathbb{T}}$ is deemed possible, while after modeling, only the outcomes in $\mathcal{B}$ remain as possibilities.

Special cases:

- $\mathbb{T} = \mathbb{R}$ --- continuous-time systems
- $\mathbb{T} = \mathbb{Z}$ --- discrete-time systems
- $\mathbb{W} = \mathbb{R}^q$ --- most physical systems
- $\mathbb{W}$ a finite set --- discrete event systems

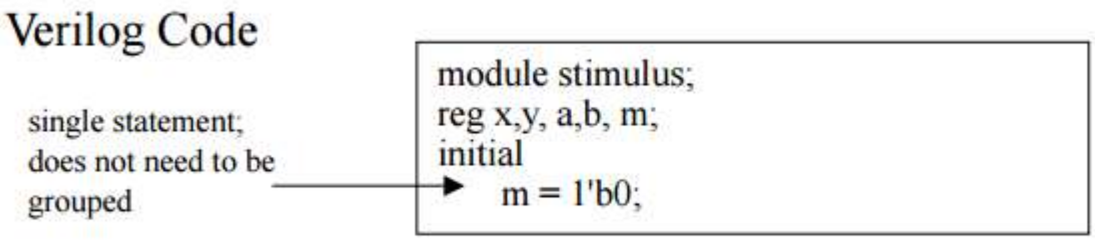
STRUCTURE PROCEDURES

There are two structure procedure statements: always and initial. These statements are the most basic statements in behavioral modeling. All other behavioral statements can appear only inside these structured procedure statements.

INITIAL STATEMENT

All statements inside an initial statement constitute an initial block. An initial block starts at time 0, and executes exactly once during a simulation, and then does not execute again. If there are multiple initial blocks, each block starts to execute concurrently at time 0.

Ex1. Initial statement program



LINEAR TIME-INVARIANT

System properties are defined in terms of the behavior. The system $\Sigma = (\mathbb{T}, \mathbb{W}, \mathcal{B})$ is said to be

- "linear" if $\mathbb{W}$ is a vector space and $\mathcal{B}$ is a linear subspace of $\mathbb{W}^{\mathbb{T}}$,
- "time-invariant" if the time set consists of the real or natural numbers and

  $\sigma^t \mathcal{B} \subseteq \mathcal{B}$ for all $t \in \mathbb{T}$,

  where σ^t denotes the t-shift, defined by

  $$\sigma^t(f)(t') := f(t' + t).$$

In these definitions linearity articulates the superposition law, while time-invariance articulates that the time-shift of a legal trajectory is in its turn a legal trajectory.

A "linear time-invariant differential system" is a dynamical system $\Sigma = (\mathbb{R}, \mathbb{R}^q, \mathcal{B})$ whose behavior $\mathcal{B}$ is the solution set of a system of constant coefficient linear ordinary differential equations $R(d/dt)w = 0$, where R is a matrix of polynomials with real coefficients. The coefficients of R are the parameters of the model. In order to define the corresponding behavior, we need to specify when we consider a signal $w : \mathbb{R} \to \mathbb{R}^q$ to be a solution of $R(d/dt)w = 0$. For ease of exposition, often infinite differentiable solutions are considered. There are other possibilities, as taking distributional solutions, or solutions in $\mathcal{L}^{\text{local}}(\mathbb{R}, \mathbb{R}^q)$, and with the ordinary differential equations interpreted in the sense of distributions. The behavior defined is

$$\mathcal{B} = \{w \in \mathcal{C}^\infty(\mathbb{R}, \mathbb{R}^q) \mid R(d/dt)w(t) = 0 \text{ for all } t \in \mathbb{R}\}.$$

This particular way of representing the system is called "kernel representation" of the corresponding dynamical system. There are many other useful representations of the same behavior, including transfer function, state space, and convolution.

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