DEVS Formalism for Discrete Event System Modeling and Simulation

Bernard P. Zeigler

AI & Simulation Group
Dept. of Electrical and Computer Engineering
University of Arizona

DEVS (Discrete Event System Specification)

is a **Modelling Formalism**

with **sound DEDS semantics**

founded on **System-theoretic basis**

is **universal for DEDS formalisms**
extends to continuous case

implemented in **Simulation Environment**

for **complex systems with intelligent components**

has associated **Simulation Engine Architectures**

for **sequential**
or **parallel / distributed platforms**

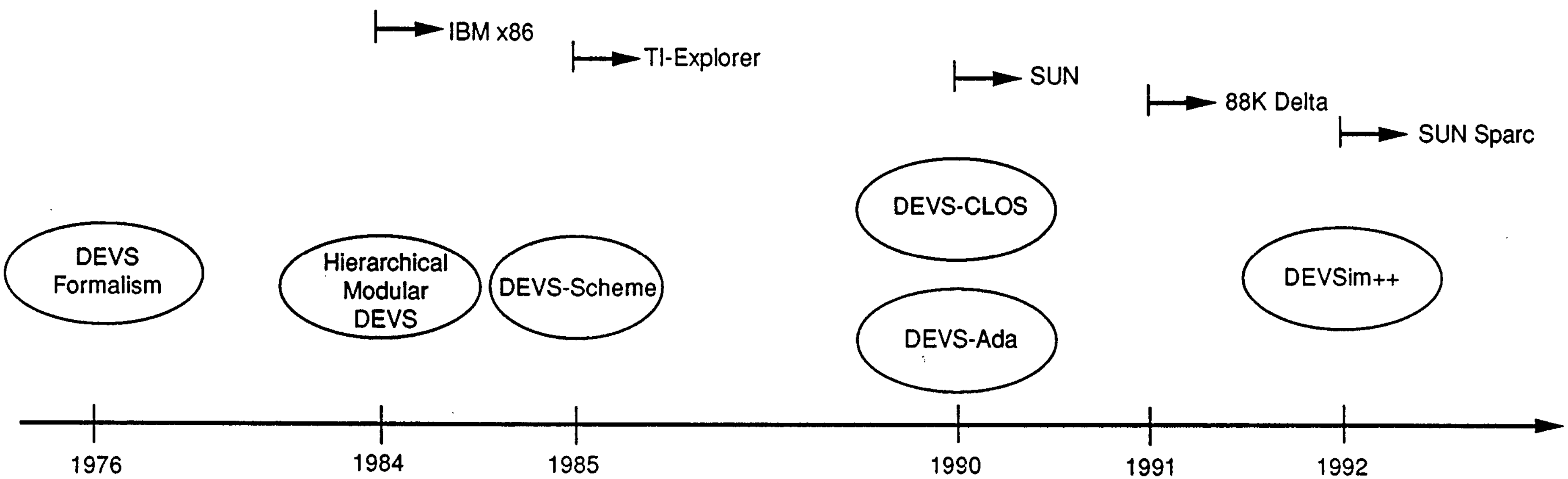


Figure. Evolution of DEVS

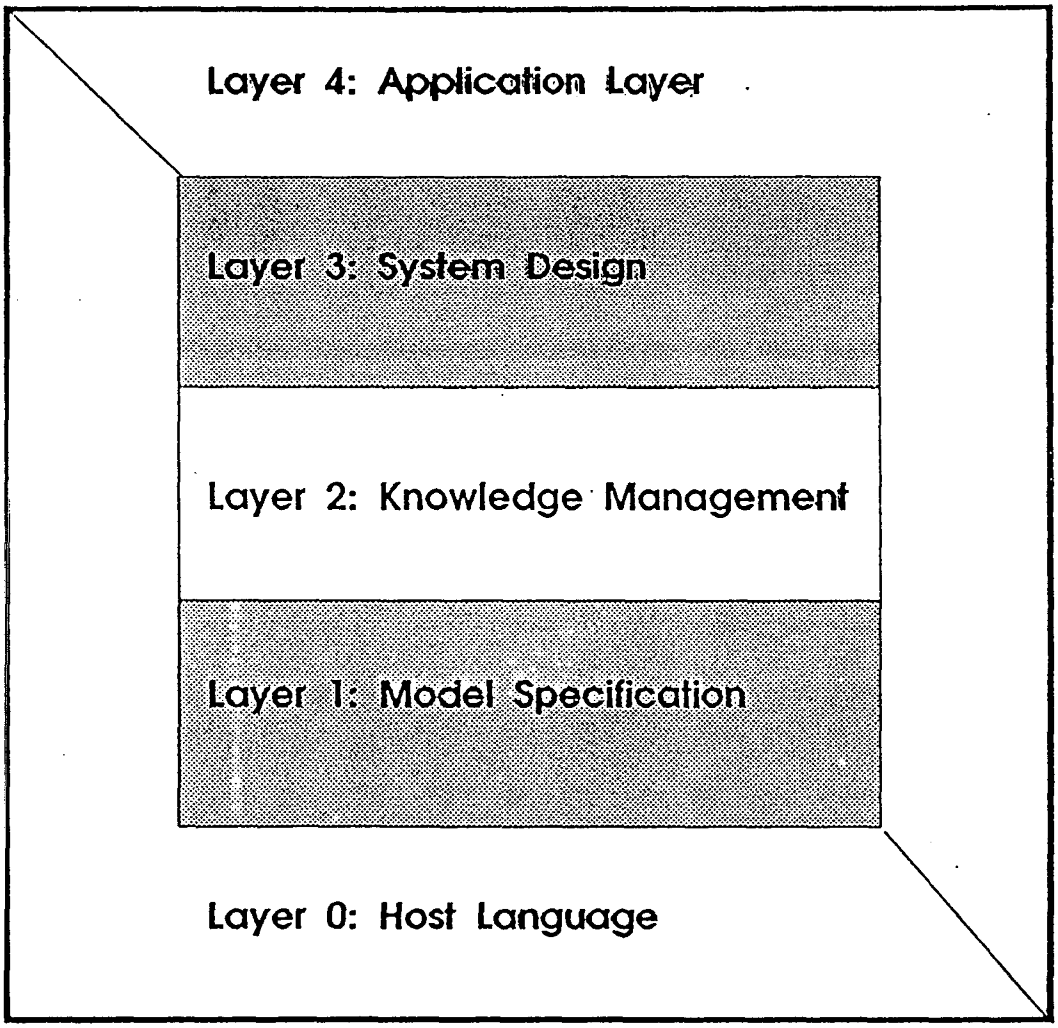
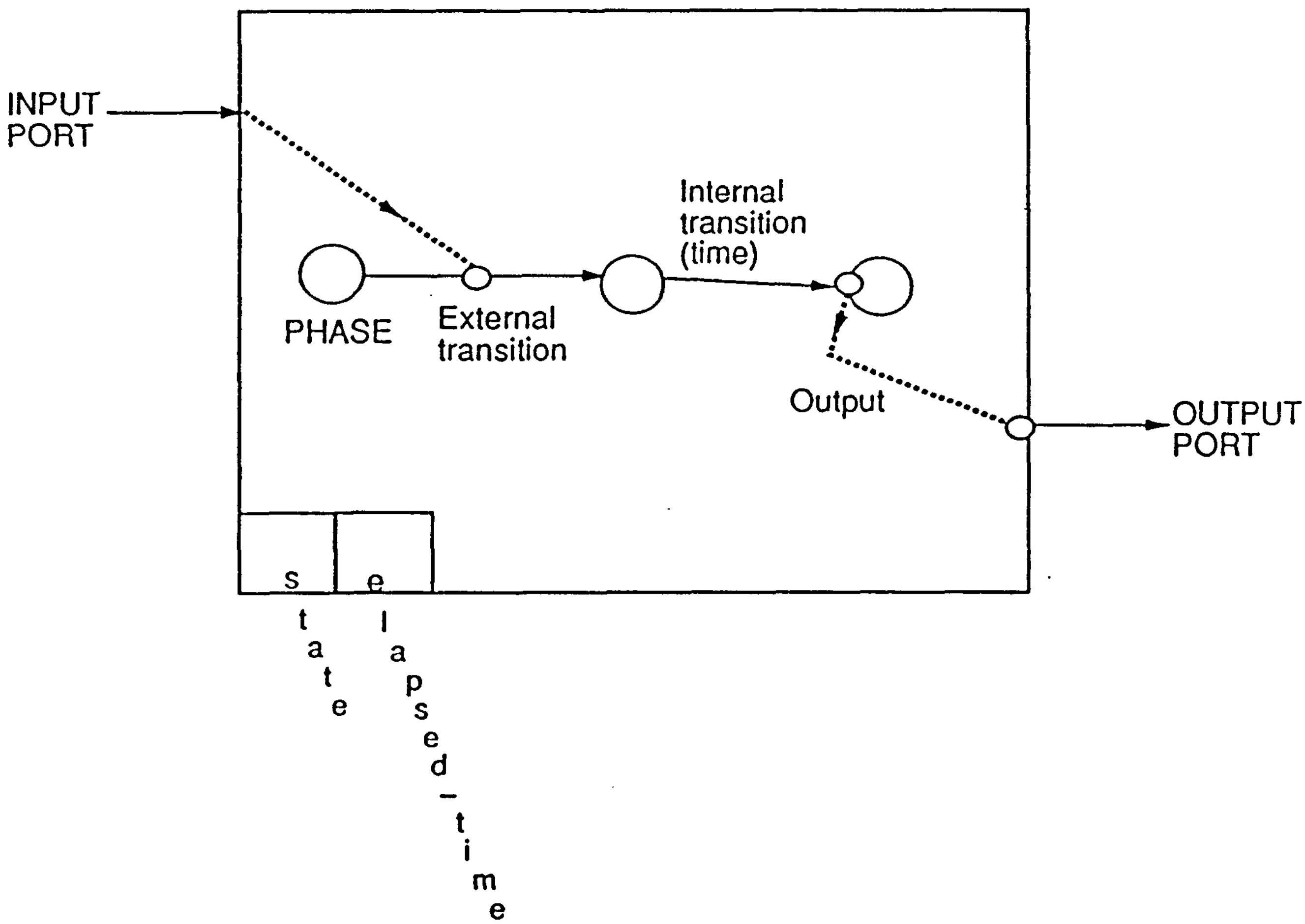
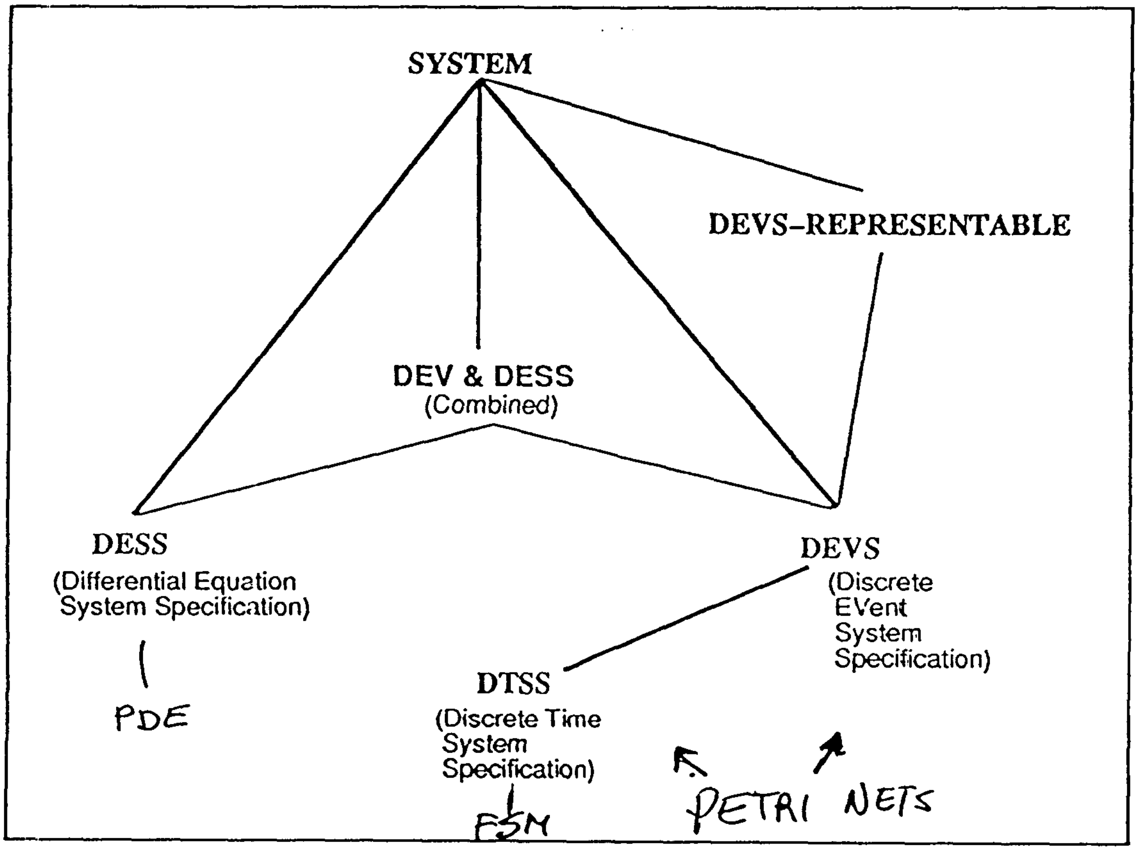


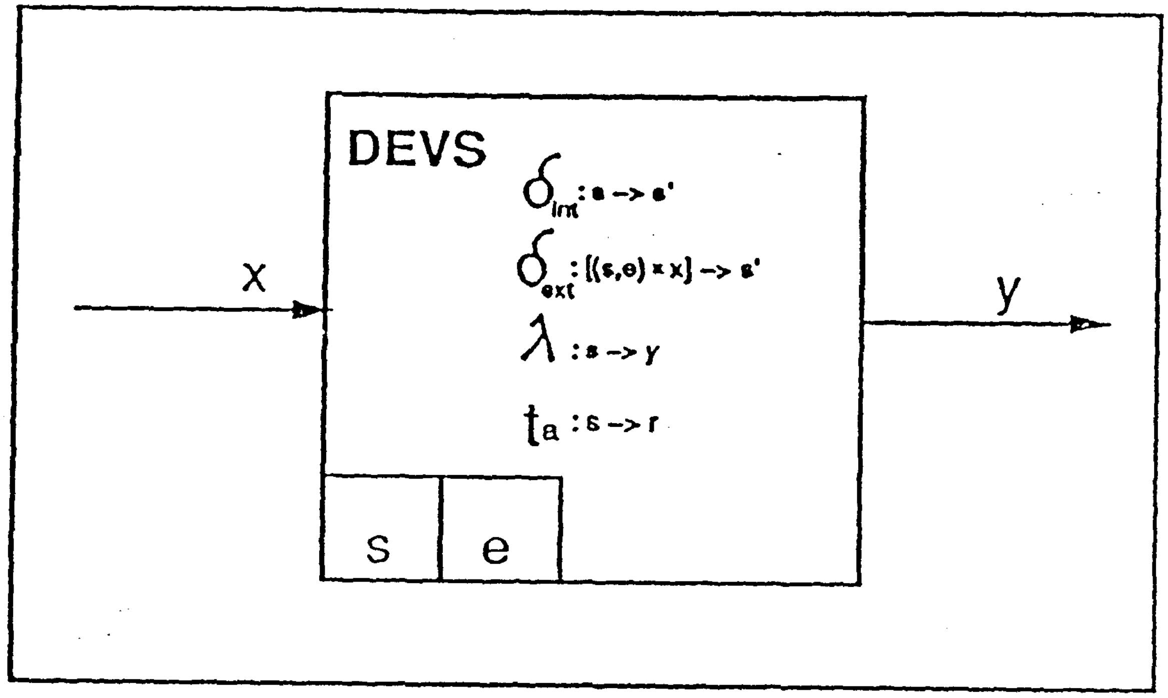
Figure 3: The Reference Model

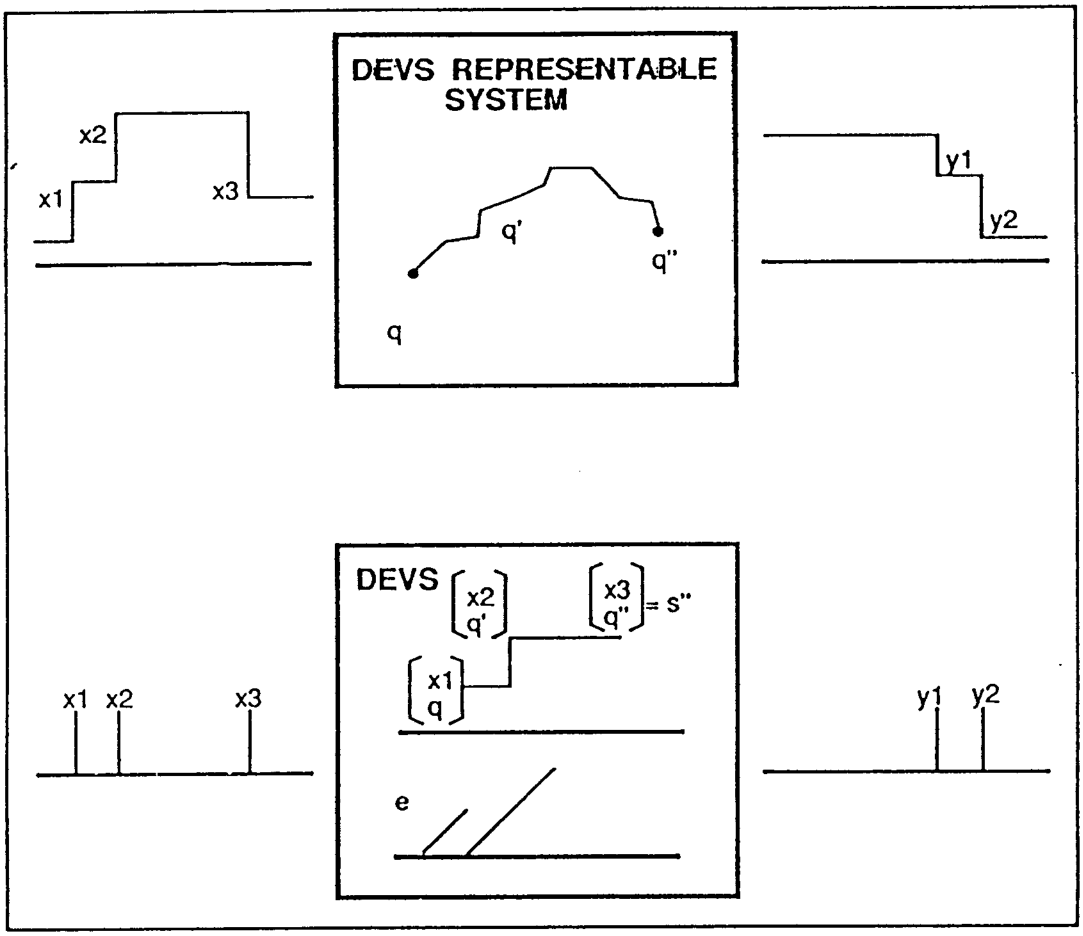
ATOMIC MODEL

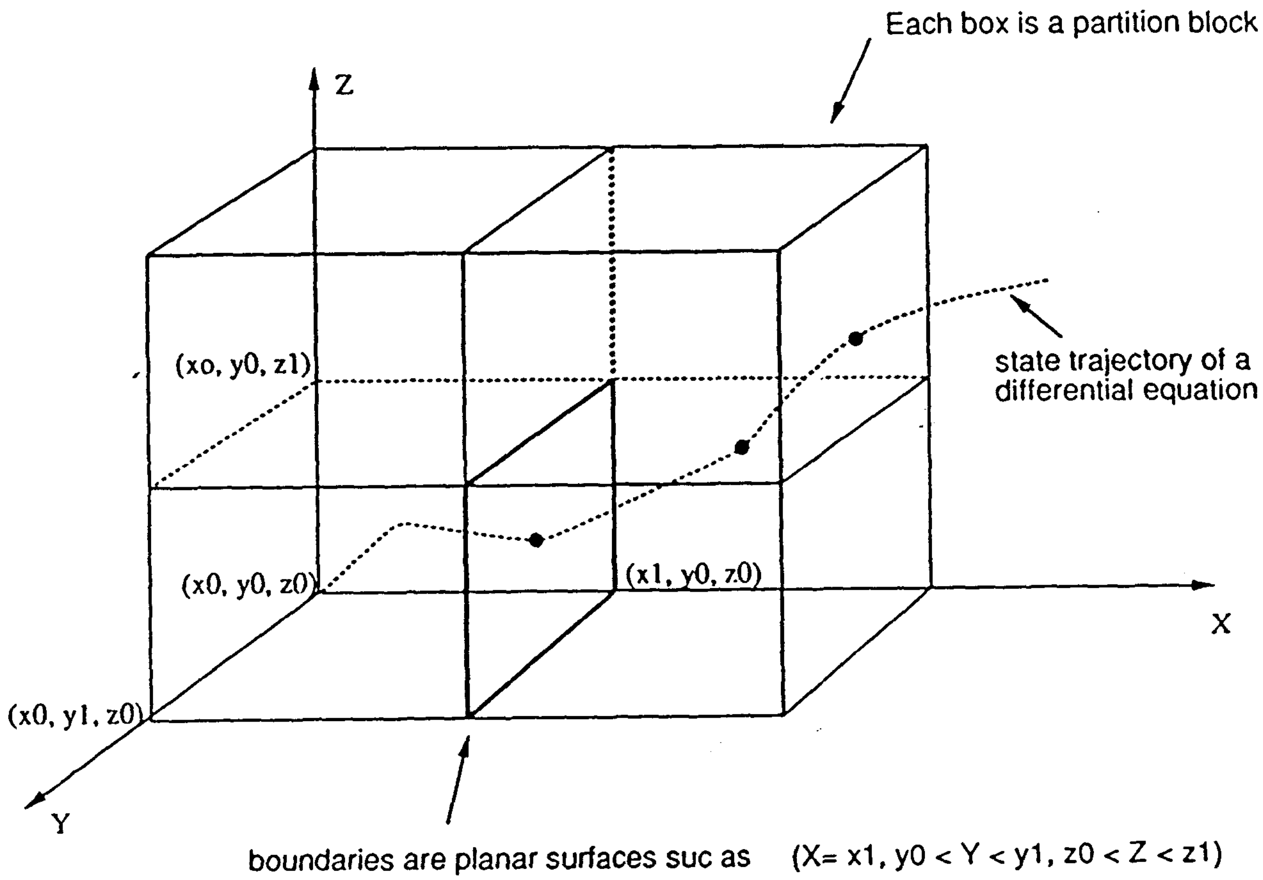
State Diagram Conventions




SYSTEM
DEVS–REPRESENTABLE
DEV & DESS
(Combined)
DESS
(Differential Equation
System Specification)
PDE
DEVS
(Discrete
EVent
System
Specification)
DTSS
(Discrete Time
System
Specification)
FSM
PETRI NETS


DEVS
x
y
s
e


x1
x2
x3
DEVS REPRESENTABLE SYSTEM
q
q'
q''
y1
y2
DEVS
x1 q
x2 q'
x3 q'' = s''
e
x1 x2 x3
y1 y2



Each box is a partition block
Z
(xo, y0, z1)
state trajectory of a differential equation
(x0, y0, z0)
(x1, y0, z0)
X
(x0, y1, z0)
Y
boundaries are planar surfaces suc as (X= x1, y0 < Y < y1, z0 < Z < z1)

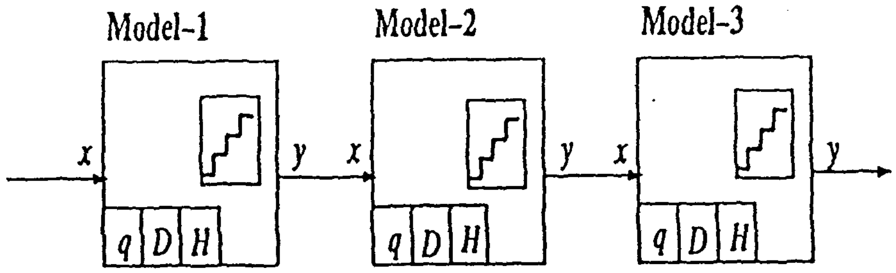


Figure 3.1: The integrator models

$$q(t) = \int x(t)\, dt$$

where $q(t)$ is the state variable and $x(t)$ is the input. The output is the state after having been quantized i.e.

$$y(t) = D \times \left[Integer\ Round \left(\frac{q(t)}{D} \right) \right]$$

where $y(t)$ is output, and D is the quantizer size.

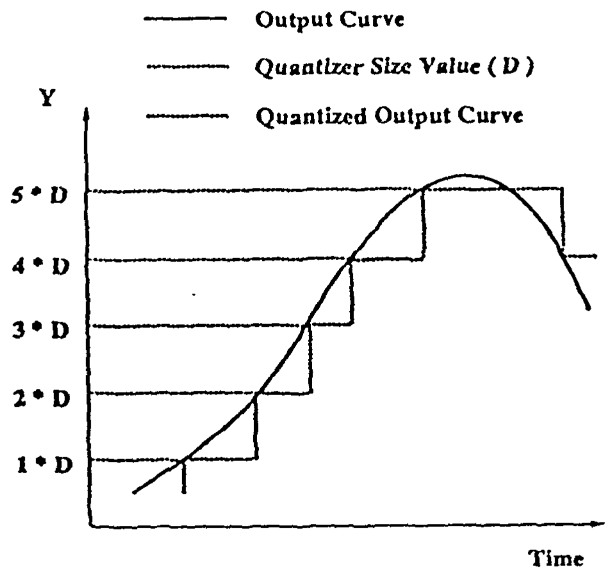
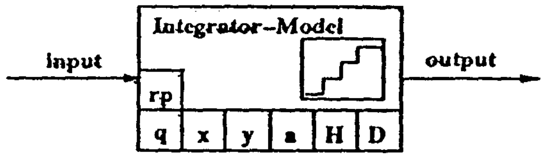


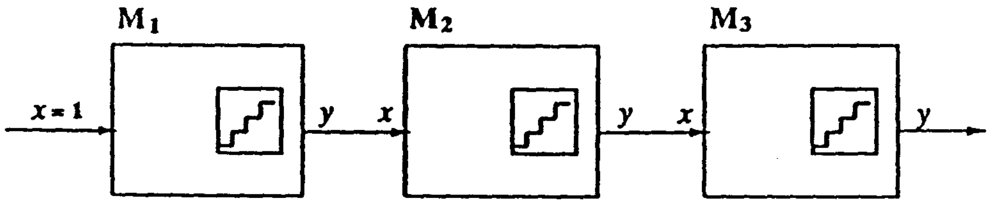
Figure 3.2: Quantized output

sparseness of DICS can be described as:

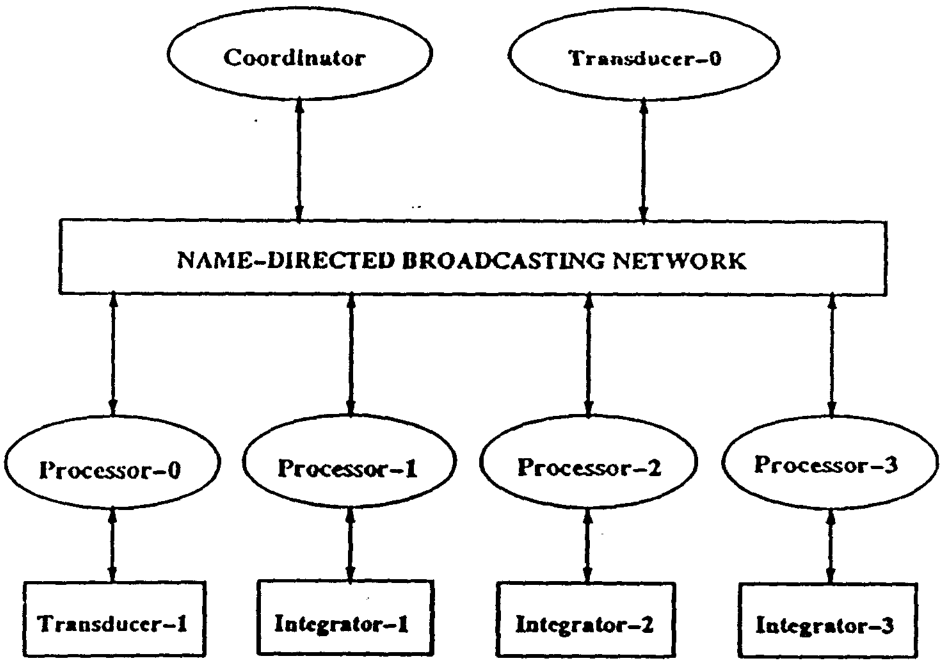
$$Sparseness = \frac{D}{U}$$



(a) Integrator atomic model port and state variables



(b) An open loop of coupling of DICS



(c) Corresponding distributed simulation environment

Figure 6.1: An open loop coupling

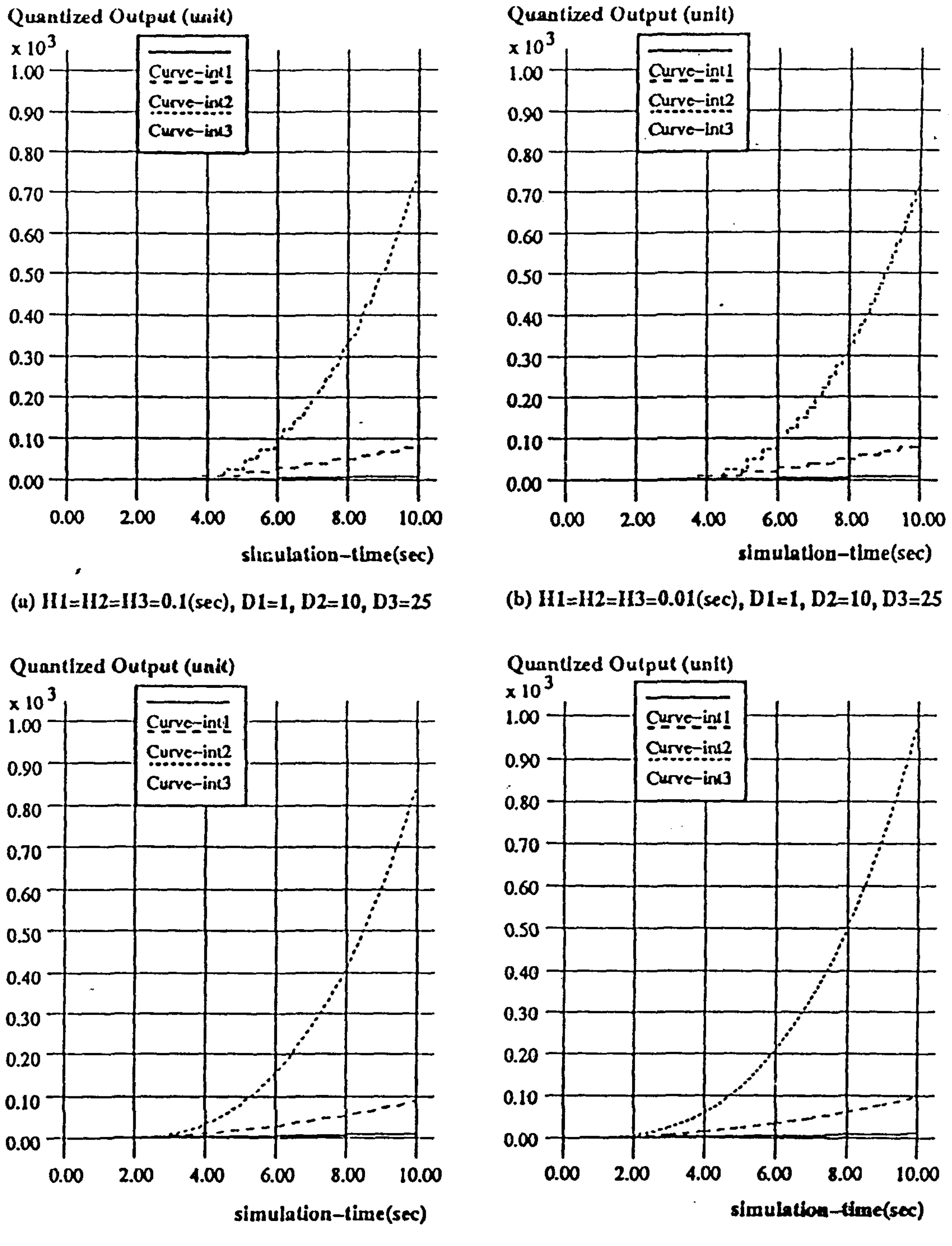
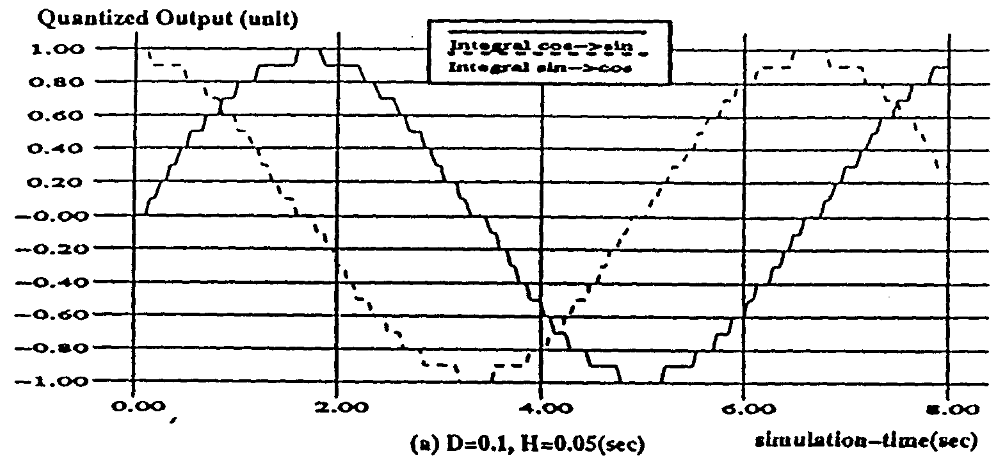
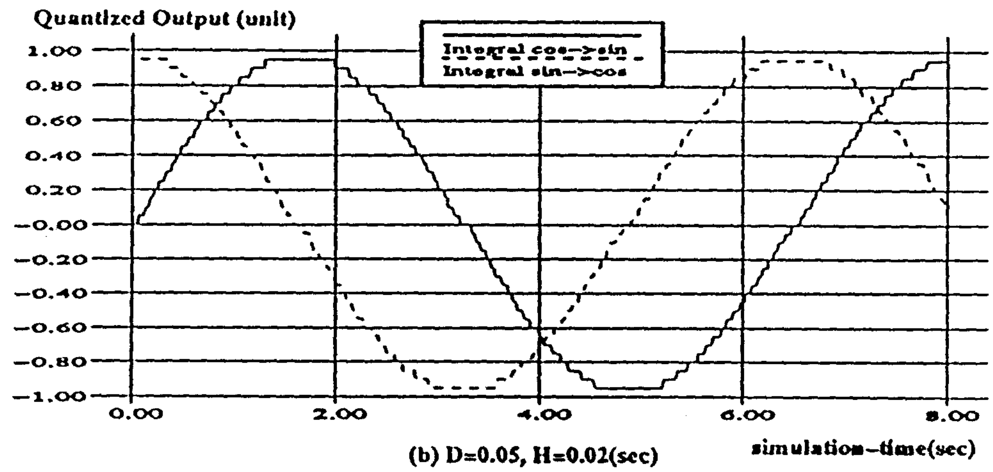


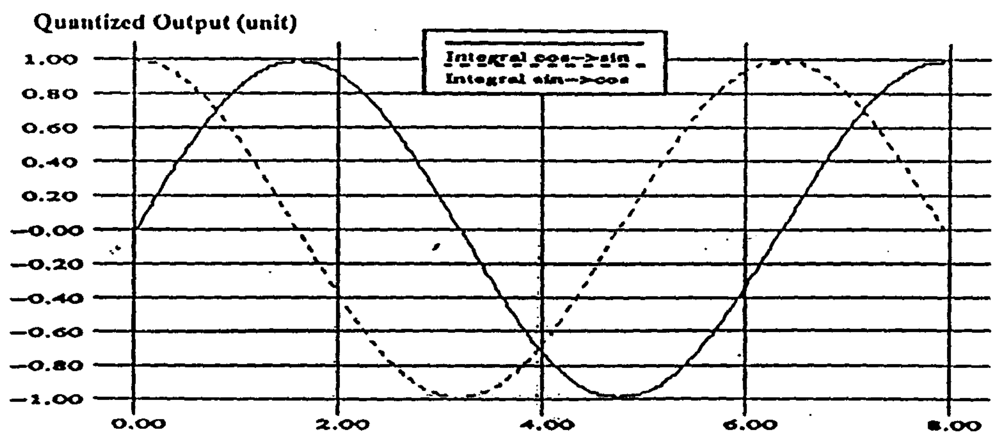
Figure 6.2: Simulation results of the open loop coupling



(a) D=0.1, H=0.05(sec)



(b) D=0.05, H=0.02(sec)



(c) D=0.02, H=0.01(sec)

Figure 6.4: Simulation results of the closed loop coupling

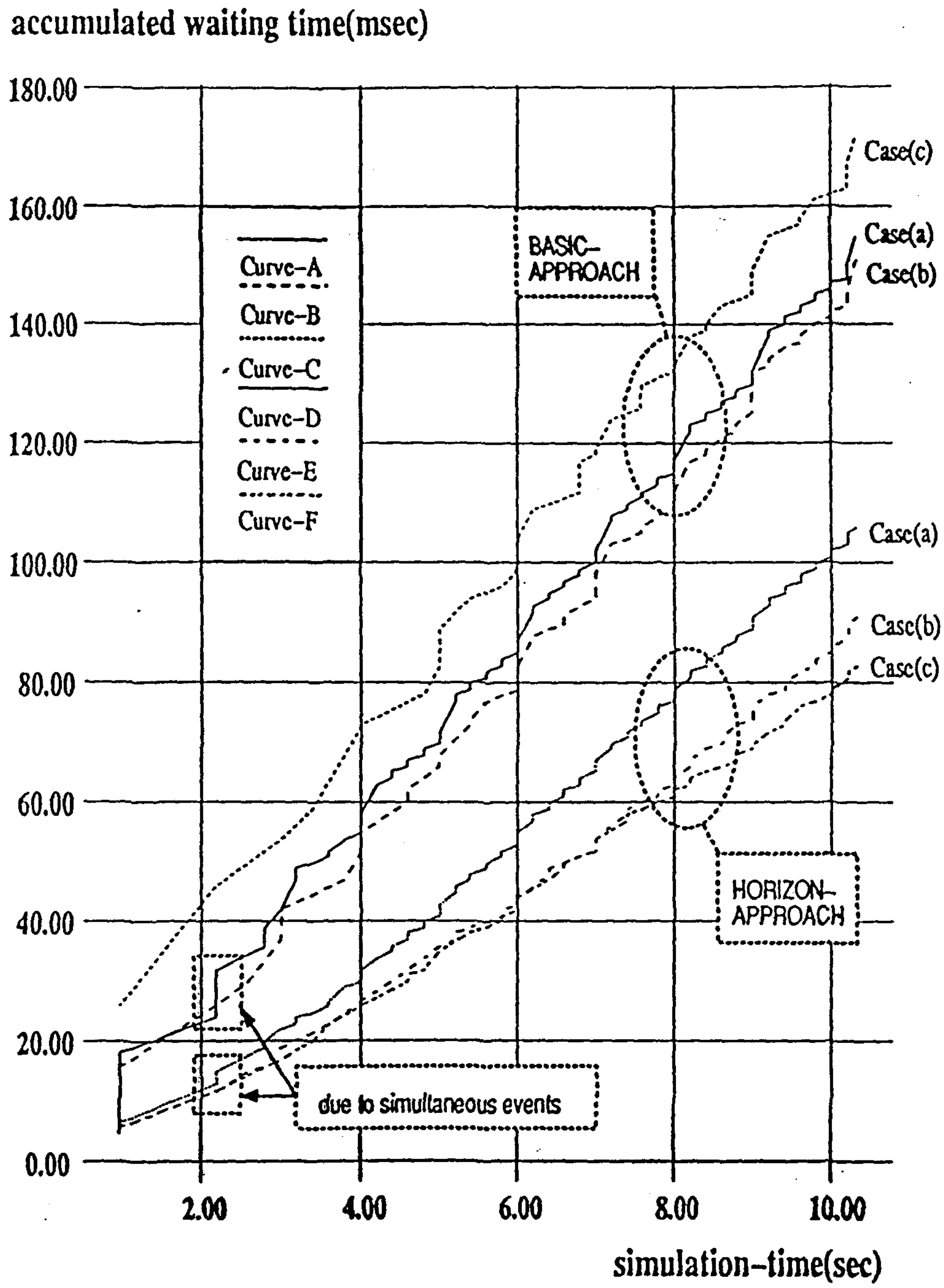
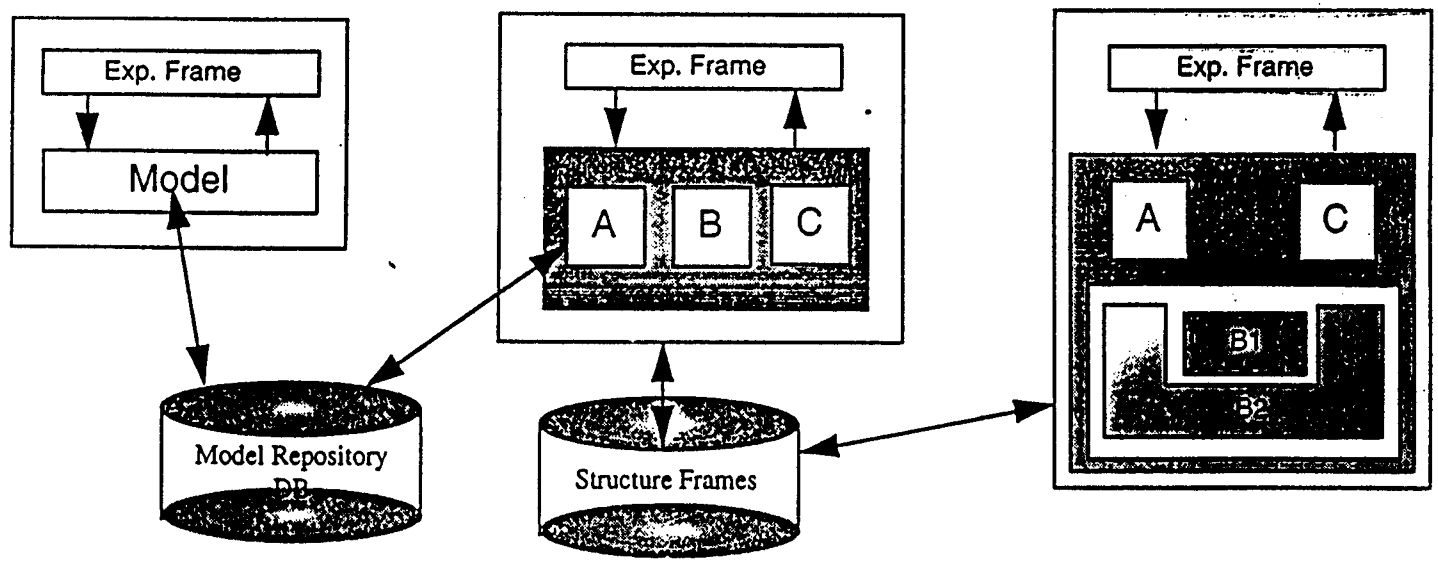


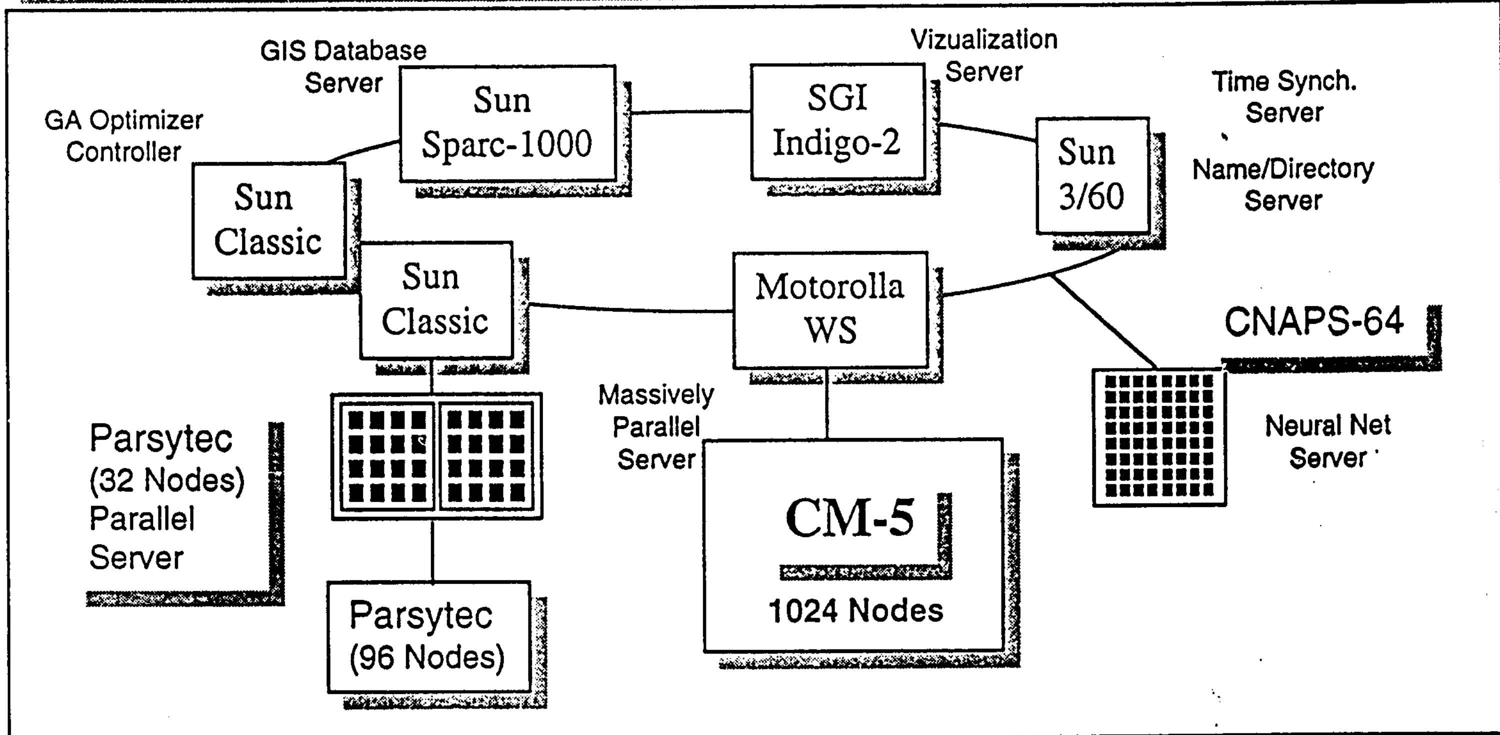
Figure 6.5: Accumulated waiting time with varied quantizer size D_i in two algorithms

MultiResolution MultiFormalism Modeling

A model repository consisting of models with multiple components at different levels of *abstraction* expressed in *diverse formalisms.*

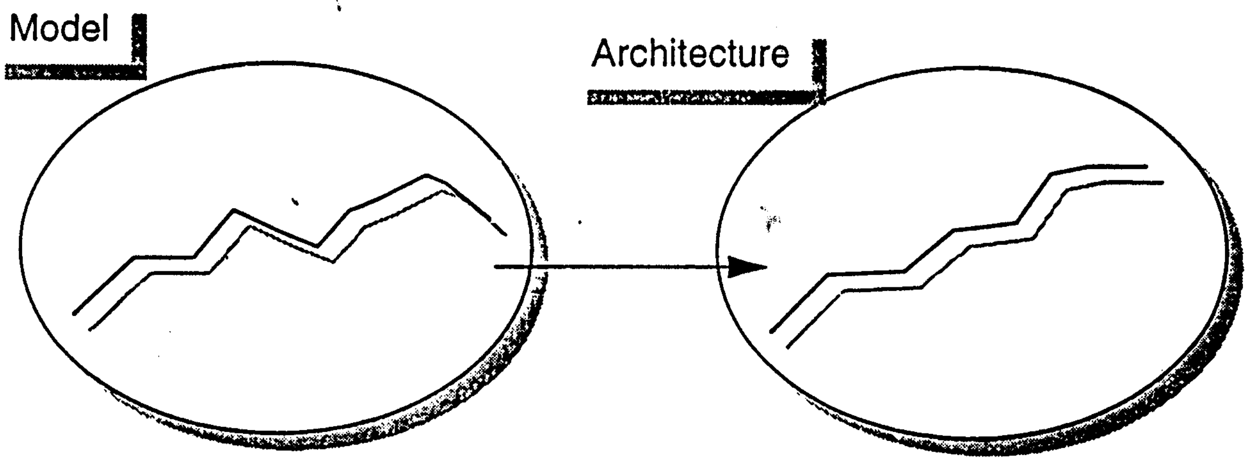


Distributed Heterogeneous Computing Environment for MultiResolition MultiFormalism Modeling

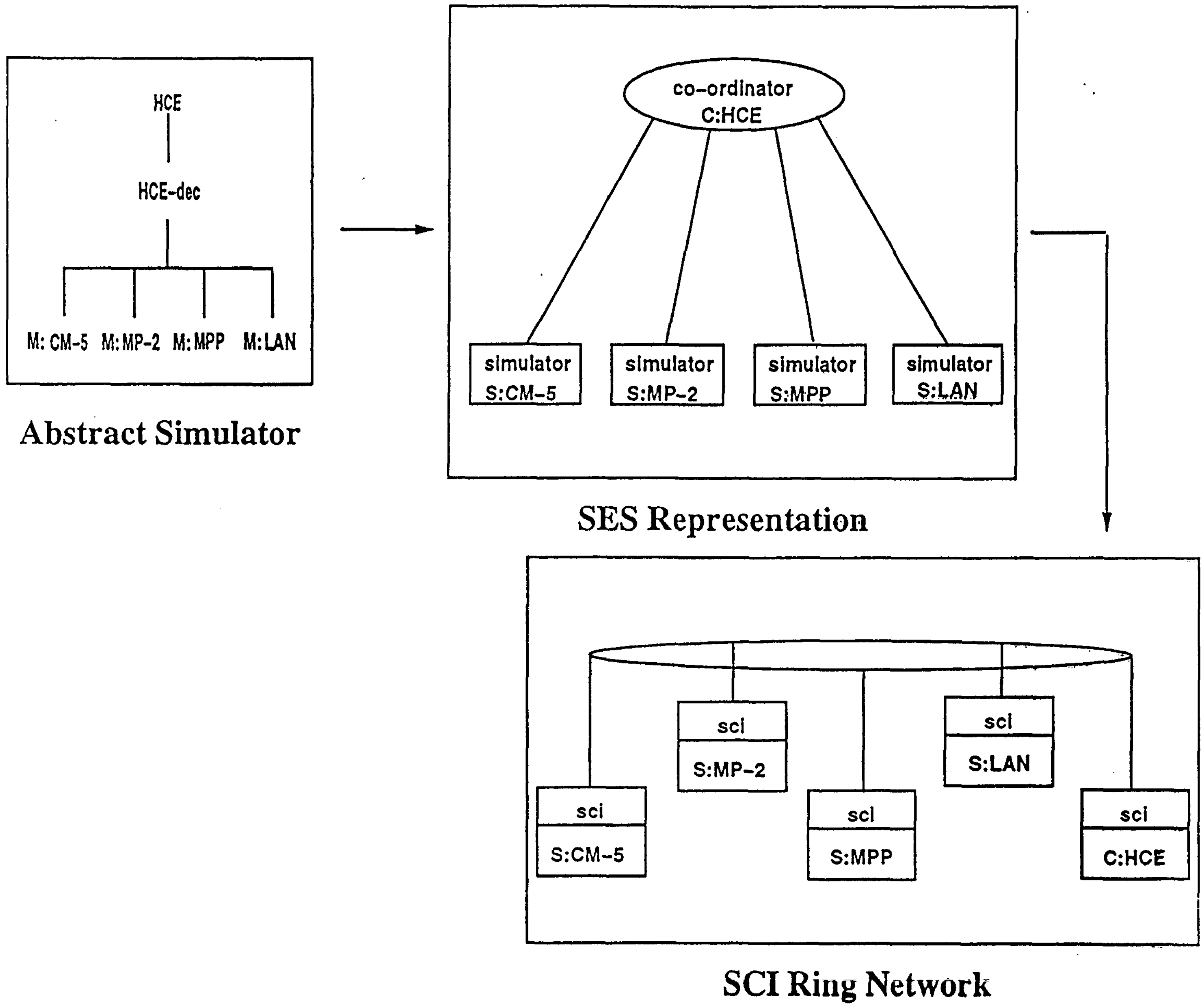


Hierarchical Expandability

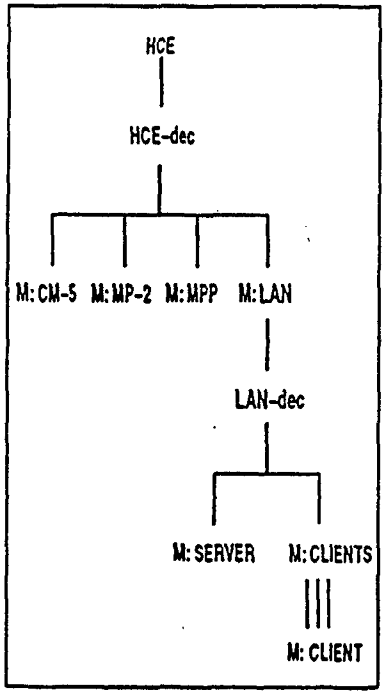
Enables the architecture (hardware & software) to co-evolve with the model for maximum exploitation of computing resources .

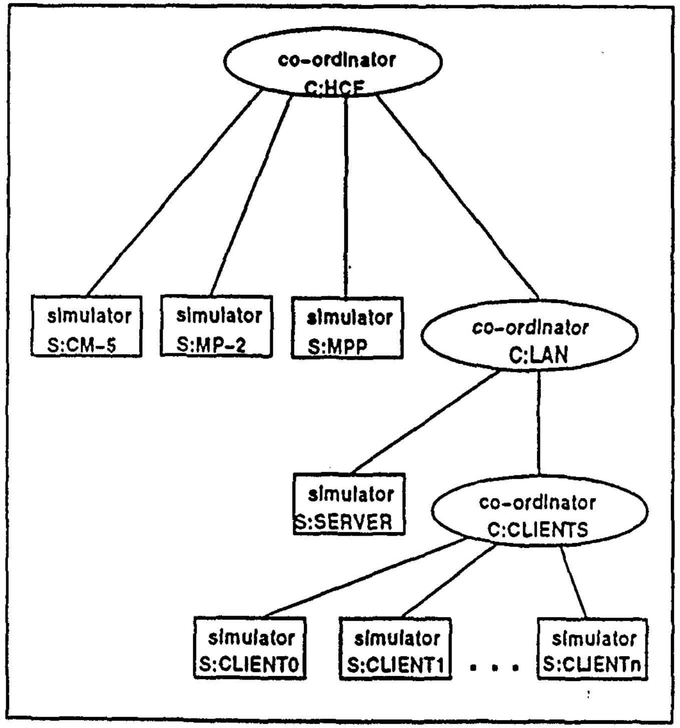


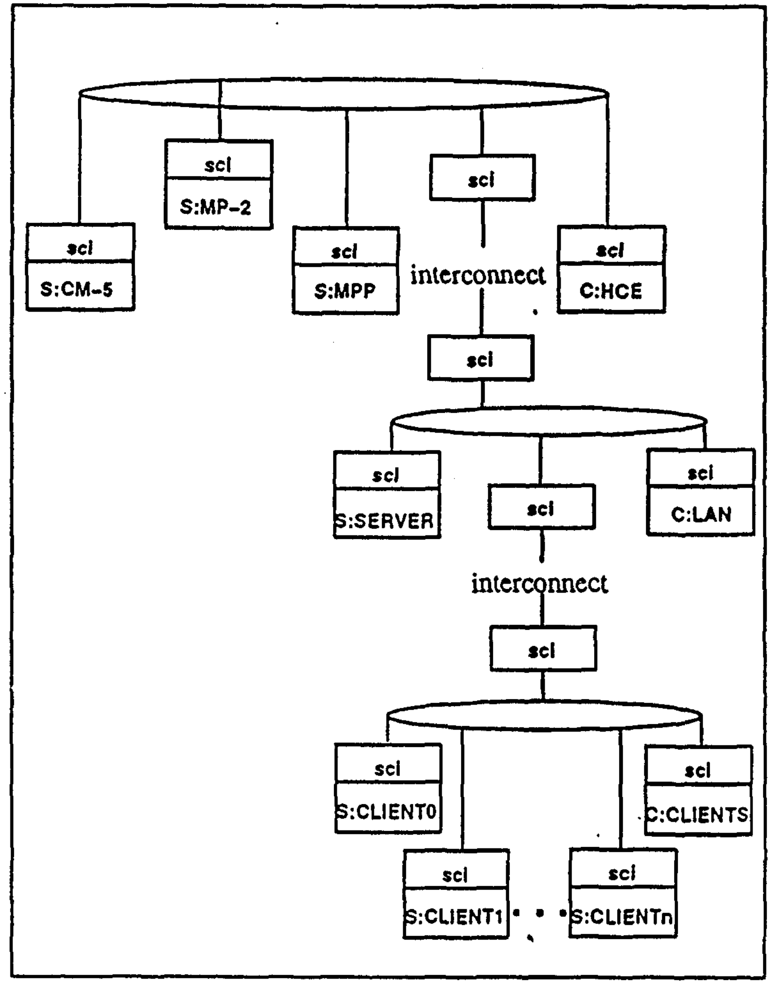
Hierarchical Expansion – I

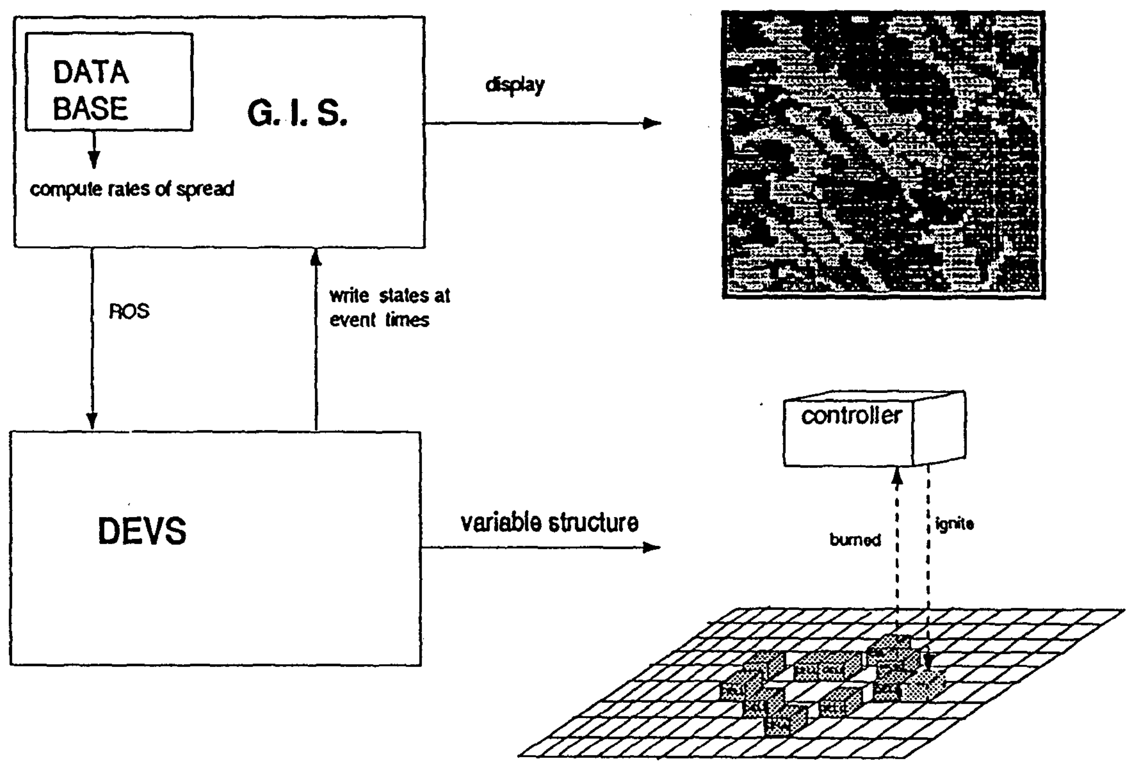


Hierarchical Expansion – II

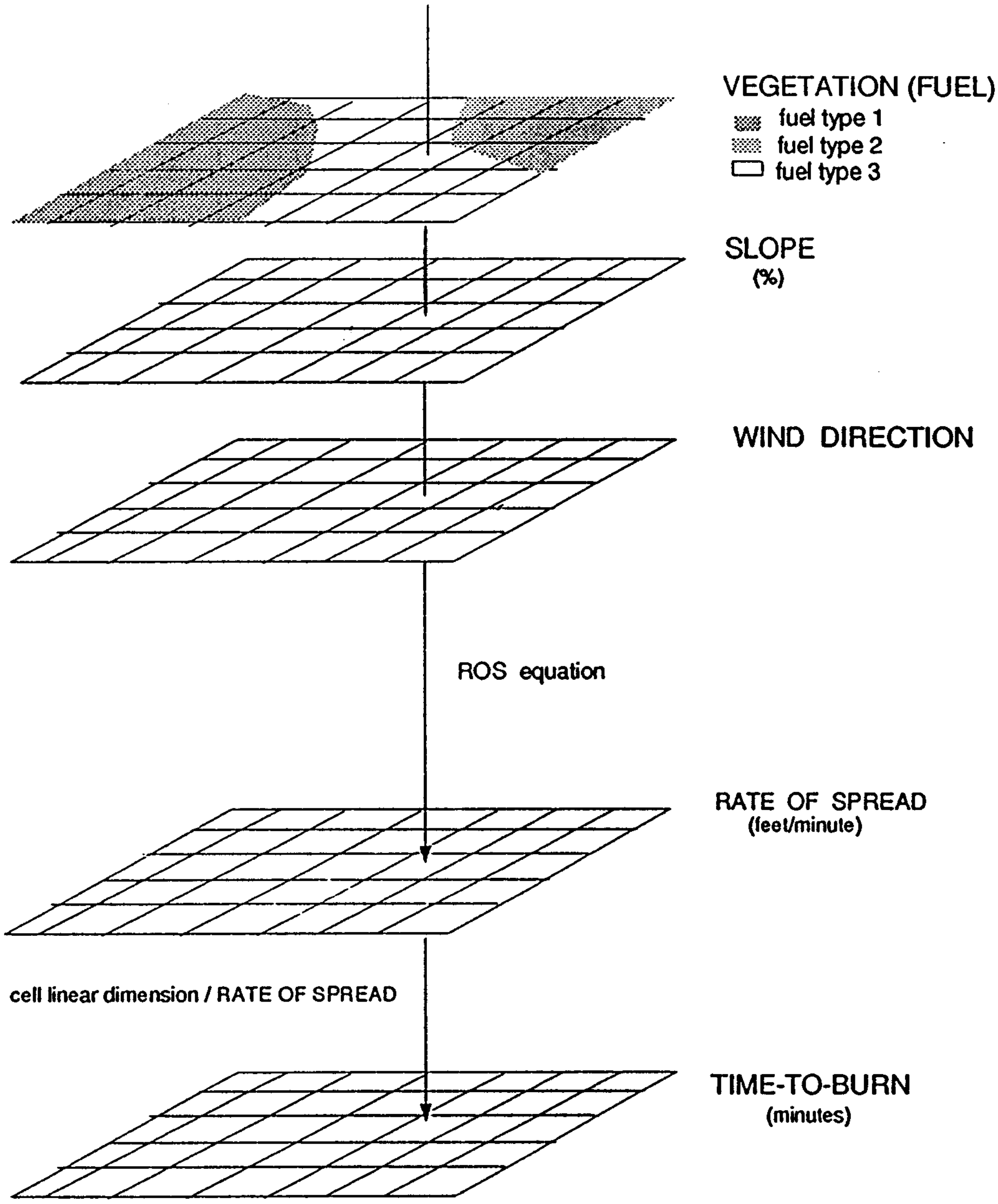







DATA
BASE
G. I. S.
compute rates of spread
display
ROS
write states at
event times
DEVS
variable structure
controller
burned
ignite

MAP LAYERS:


VEGETATION (FUEL)
fuel type 1
fuel type 2
fuel type 3
SLOPE
(%)
WIND DIRECTION
ROS equation
RATE OF SPREAD
(feet/minute)
cell linear dimension / RATE OF SPREAD
TIME-TO-BURN
(minutes)

TIME = 202

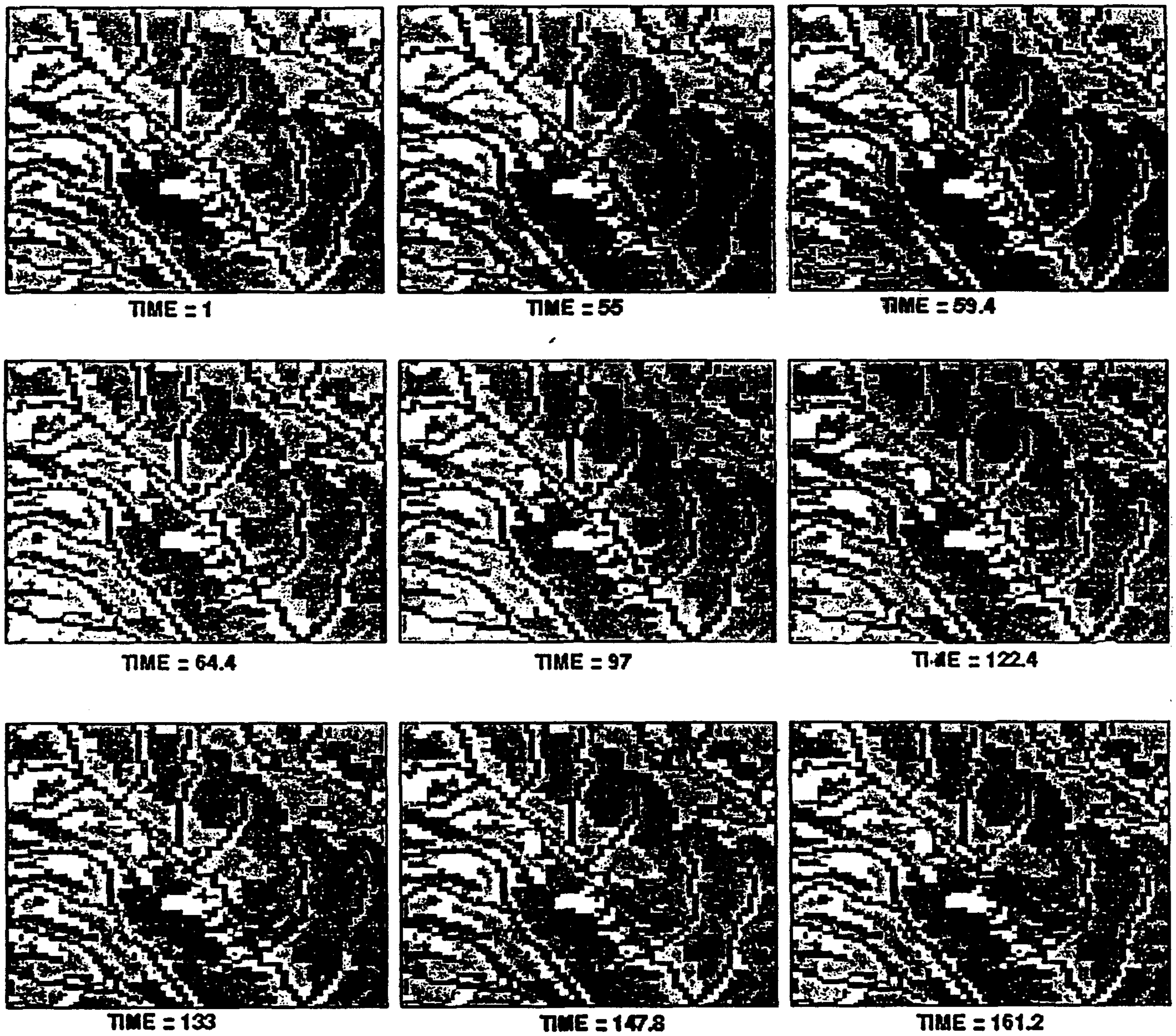
TIME = 205.16

TIME = 206.43

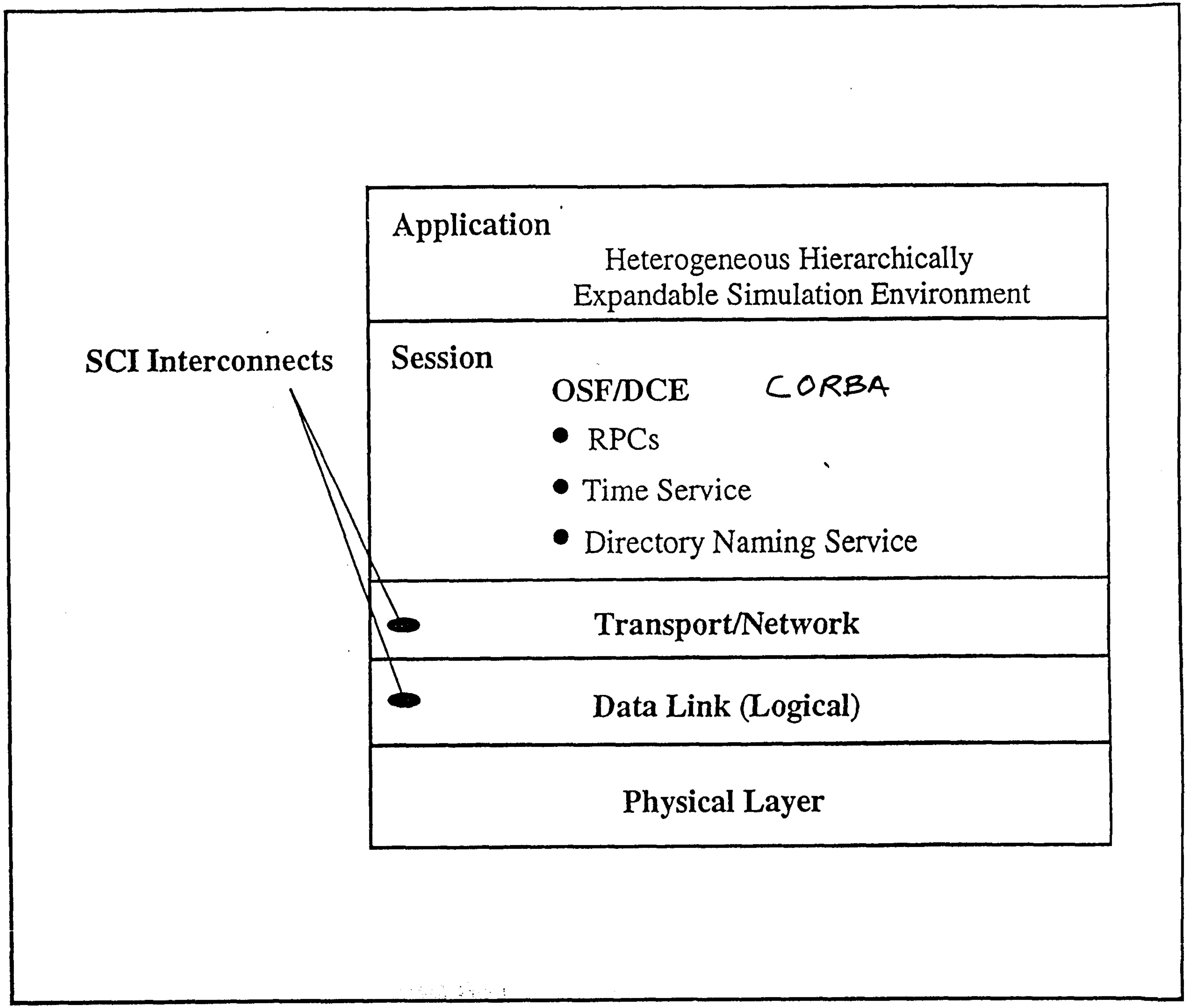
TIME = 207.98

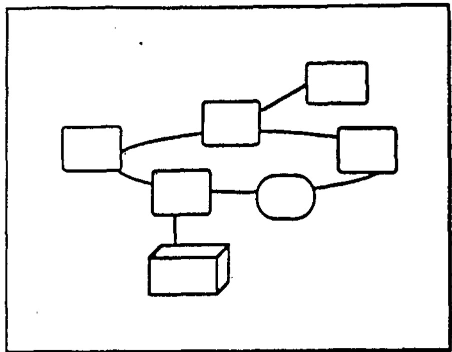
TIME = 208.12

TIME = 209.88



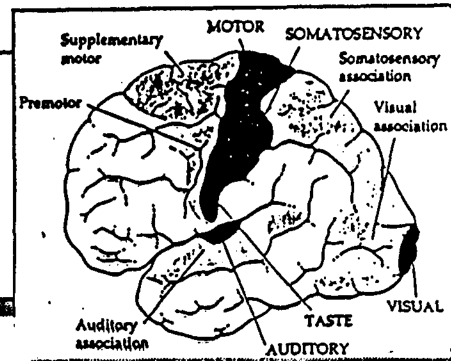
harvested areas, slash left on site
pinyon-juniper
ponderosa pine
douglas fir
combustible shrubs in stream lines


SCI Interconnects
Application
Heterogeneous Hierarchically
Expandable Simulation Environment
Session
OSF/DCE
CORBA
RPCs
Time Service
Directory Naming Service
Transport/Network
Data Link (Logical)
Physical Layer



Systems Challenge: Characterize

Intelligent Computing Environments



- *Heterogeneity:*
  - * Specialization for local efficiency
  - * General purpose for flexibility
- *Parallel/Distributed:*
  - * Memory
  - * Processing
- *Resource Orchestration:*
  - * Flexible for overall high performance
  - * Attention to urgent demands
  - * Adaptable to changing environments
- *Synchronicity:*
  - * Time service to reduce coordination overhead
  - * Enable coherent activity binding
- *Hierarchical Expandability:*
  - * Name service
  - * Reconfigurable interconnects