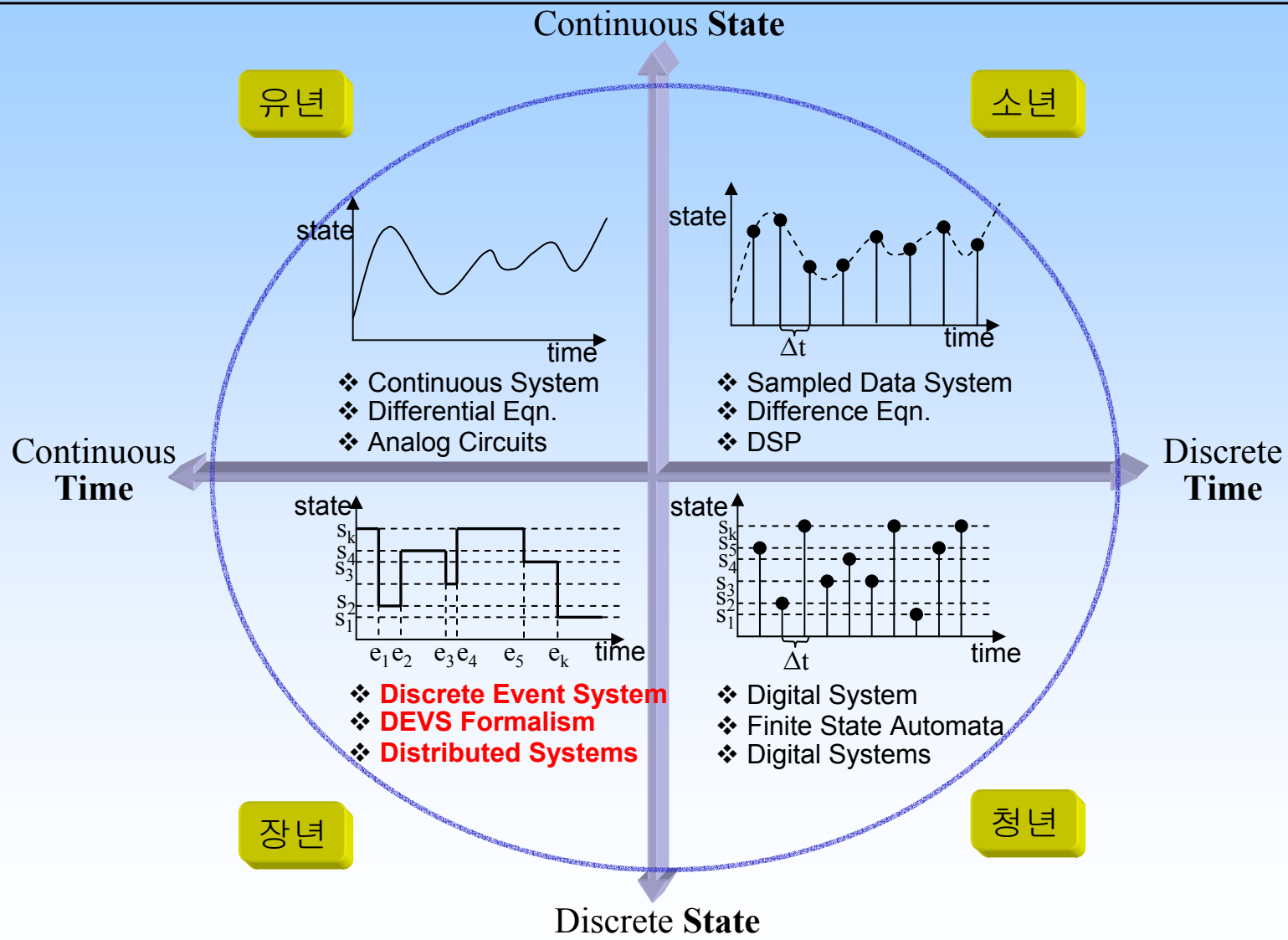
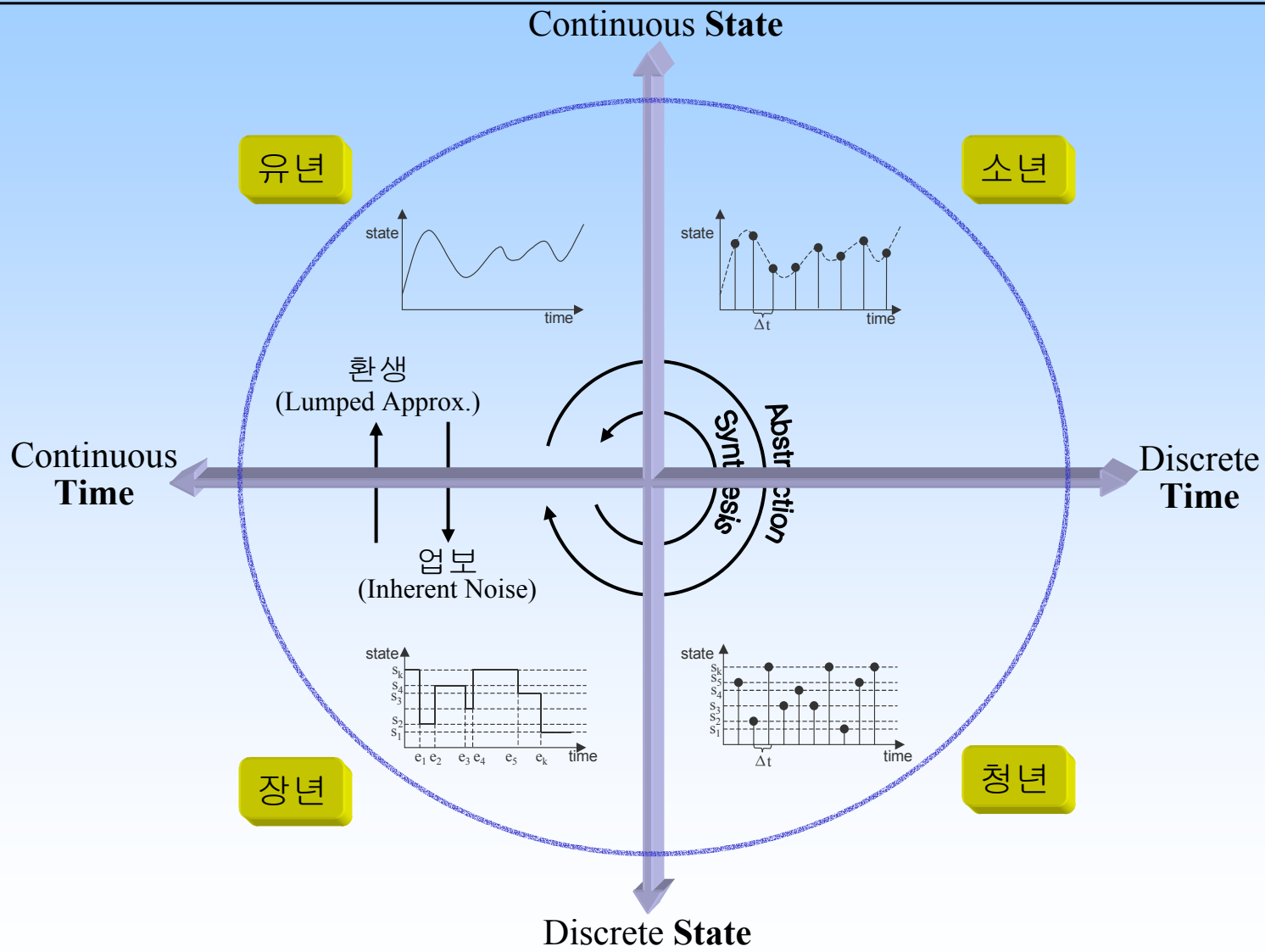


System Taxonomy: Multi-level Abstraction

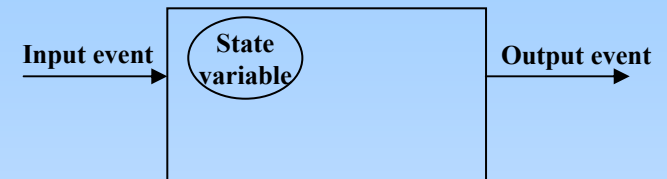


Chain of Abstraction Levels



◆ DES representation

- ❖ Input event
 - ❖ Output event
 - ❖ State variable
- } **Finite set of discrete variables**



◆ DES Modeling

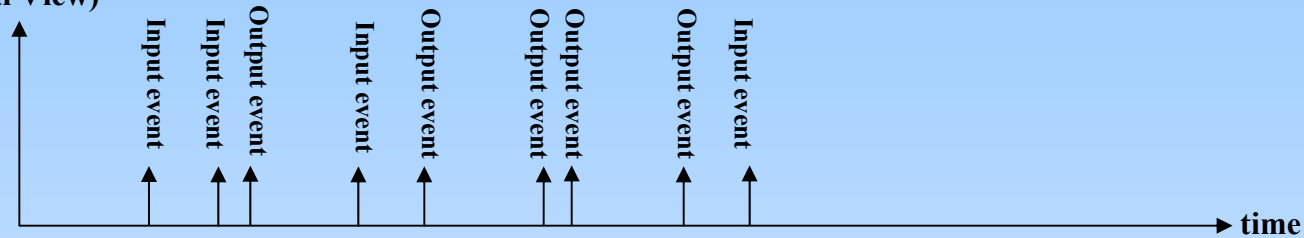
- ❖ Transition of system state caused by input/output events
- ❖ Event Occurrence Time
 - Input (External) event : time of randomly arrived external stimulus (eg: call arrived)
 - Output (Internal) event : time scheduled to complete a specified job (eg: call completion)
- ❖ State Transition
 - Change of state only at time of internal or external events
 - State variables are constant between events (piecewise constant)

◆ DES Example

- ❖ Computer system (above OS level)
- ❖ Manufacturing system
- ❖ War game
- ❖ Communication network (above data link layer)
- ❖ Traffic system

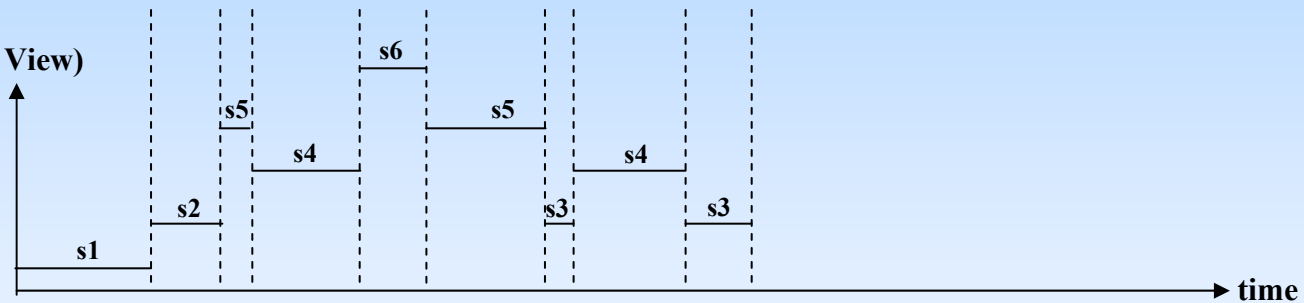
Dynamics of DES and Generality

Event (External View)



- ★ Note: 1. Time between events are random → Random Interval Time
- 2. Order of occurrence of input/output events is random

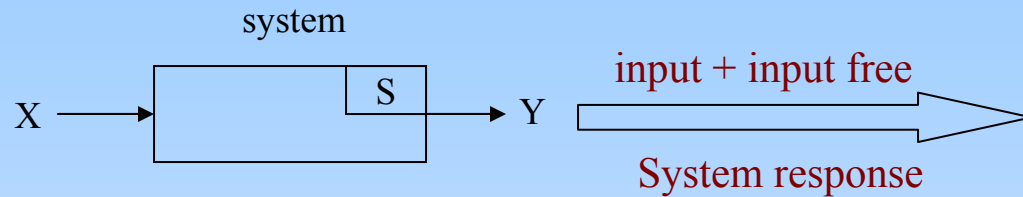
State (Internal View)



- ★ Terminology Comparison: Generality of Input/Output and system components

Communication Network	FMS
Messages	Parts
Node	Workstation
Packet	Automatic Guided Vehicles
Virtual Circuit	Route
Token	Fixture
Communication Link	Material Handling System

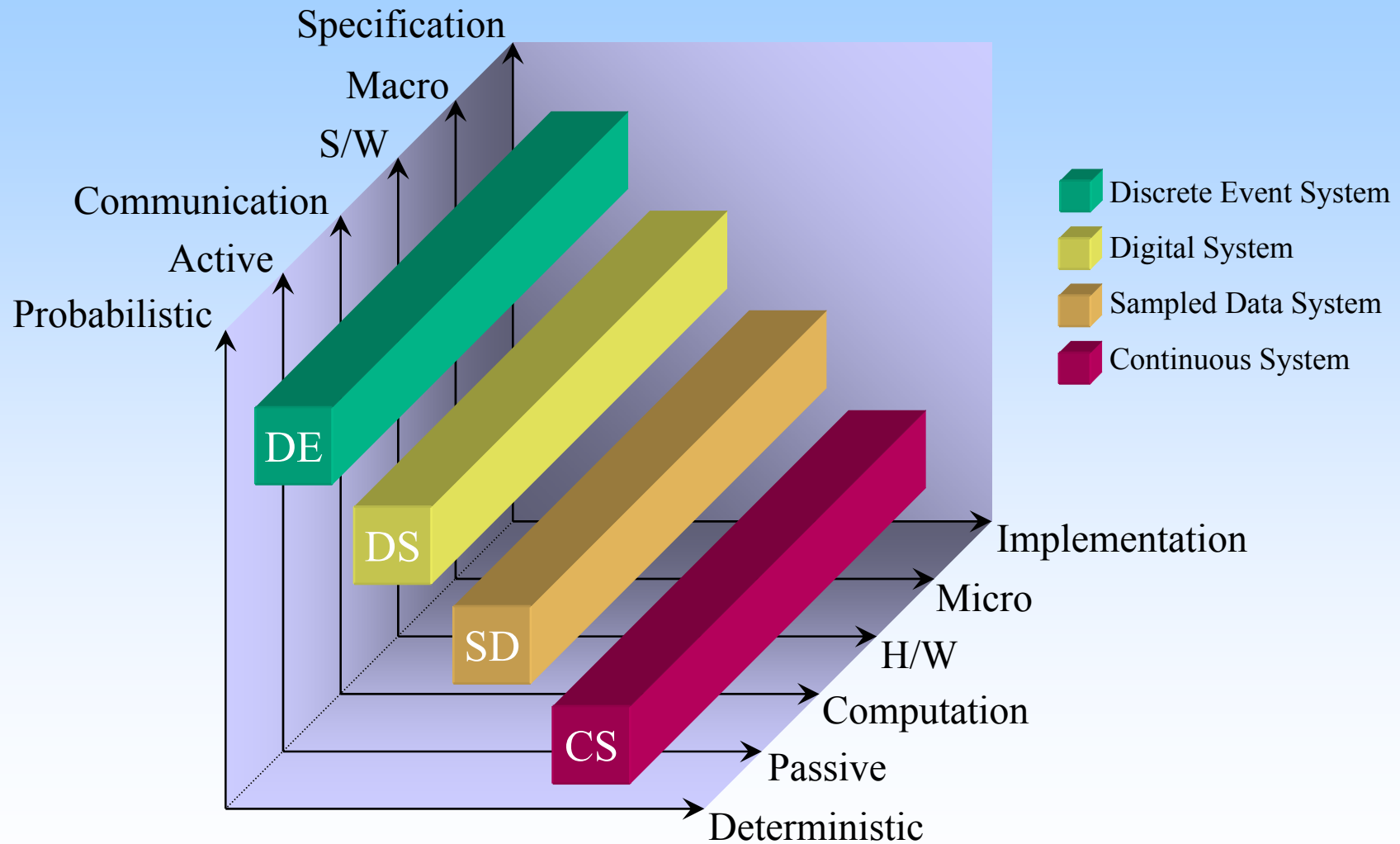
System Model = Math Representation of System Dynamics 5 of 10



Input free: state + output
 +
Input: state + output

	State transition and output	State/output equation
Continuous system		$dQ/dt = f(Q, X) = \mathbf{A}Q + \mathbf{B}X$ $Y = g(Q, X) = \mathbf{C}Q + \mathbf{D}X$
Discrete event system		$\delta_{w/o-in}: Q \rightarrow Q; \delta_{w-in}: Q \times X \rightarrow Q$ $\delta = \langle \delta_{w/o-in}, \delta_{w-in} \rangle$ $y = \lambda(Q)$

Characteristics of Abstraction Levels



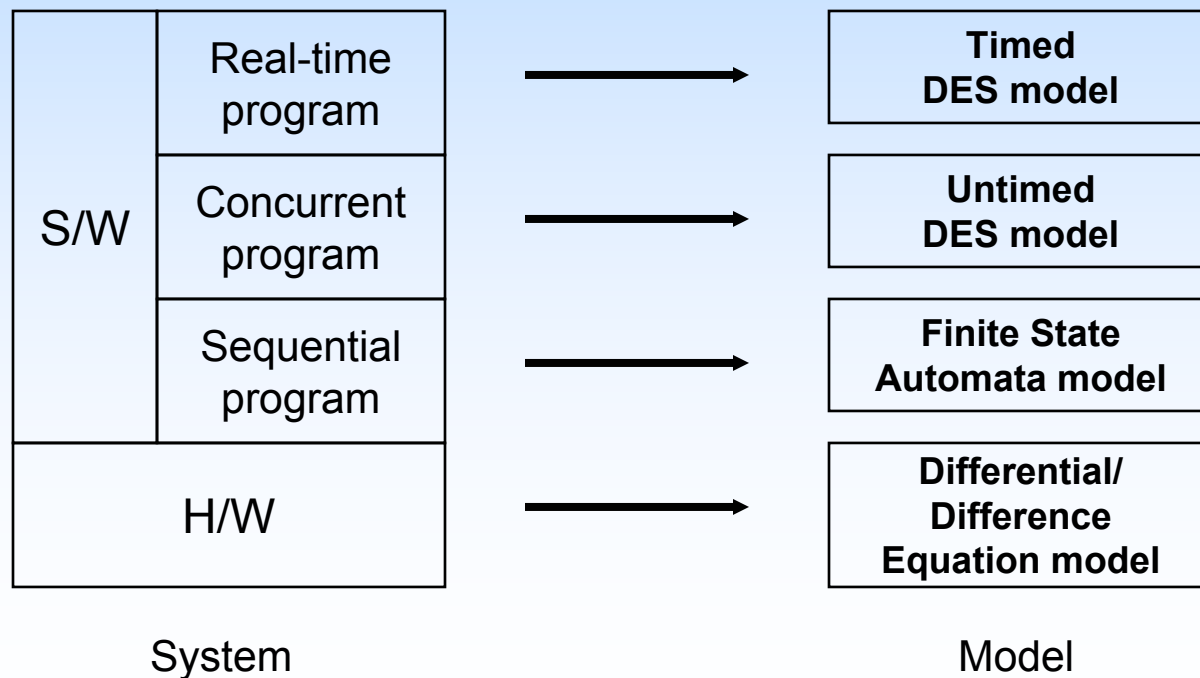
◆ Timed/Untimed DES

❖ Timed DES = Time specified DES

- Time between state transition is specified
- Objective: Time related performance analysis using timed event sequences

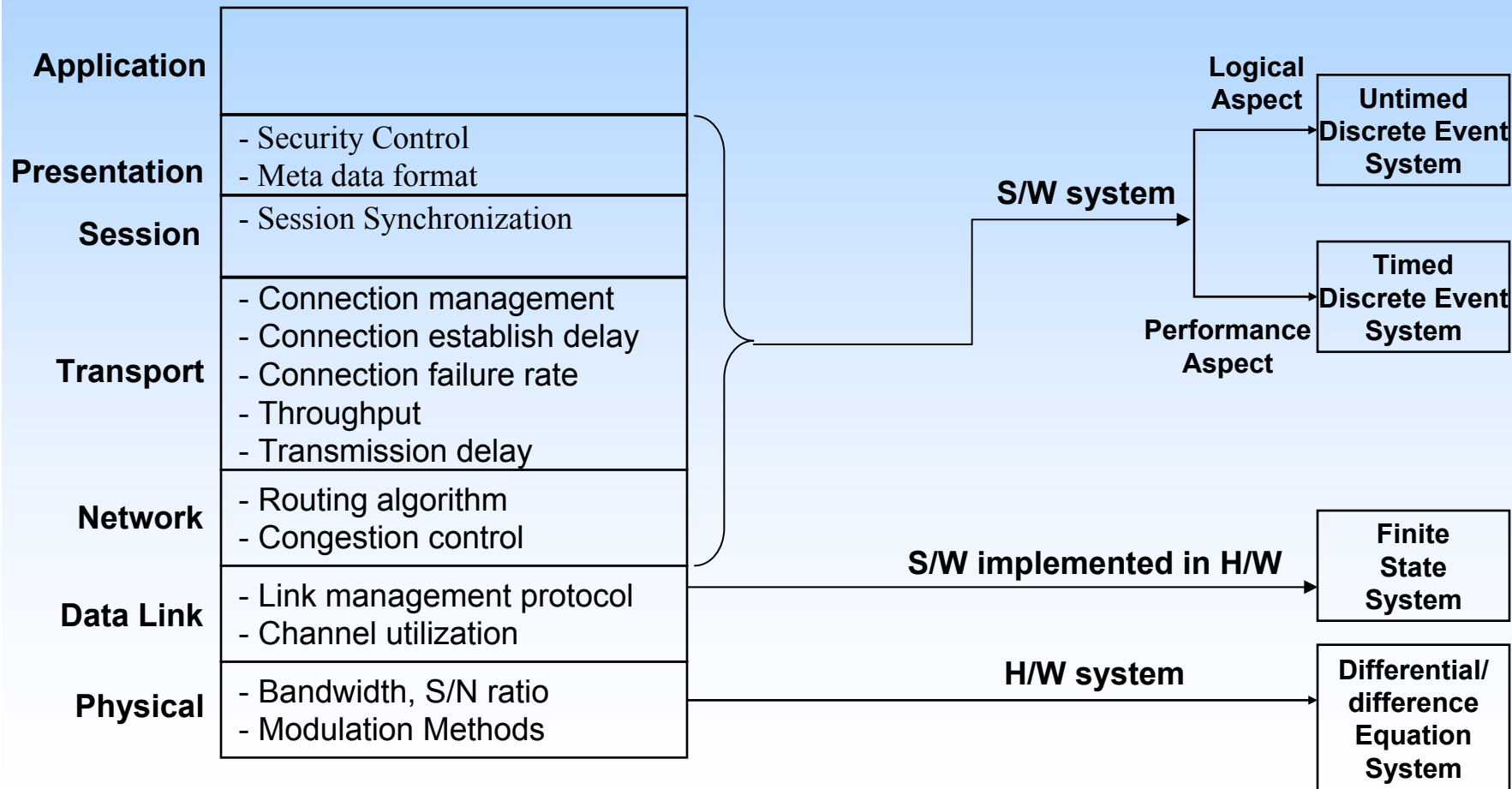
❖ Untimed DES = Time unspecified DES

- Time between state transition is not specified
- Objective: Correctness analysis using untimed event sequences



Protocol System in Layered(Hierarchical) Structure

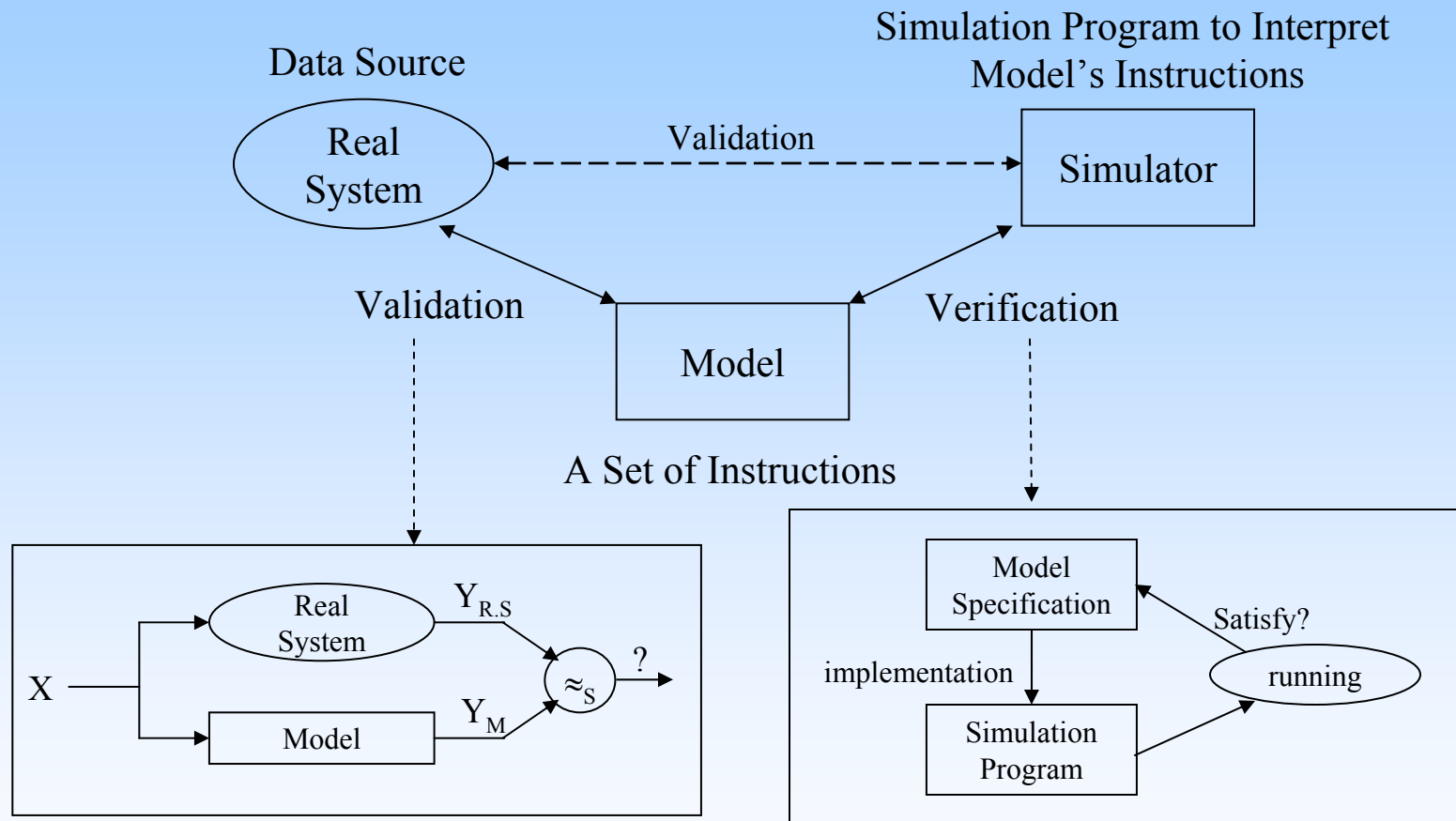
Functions in different layers



Terminology Comparison

Scenario Terms	Programming Terms	Modeling/Simulation Terms
Scenario	Module	Model
{ Attributes Attributes Updating Rule	{ Const + Data Operation	{ Parameter + State Variables State Transition Equation/Function
Scenario Construction	Programming	Modeling
Scenario Execution	Program Execution	Simulation
Scenario Verification	Program Debugging	Model Verification
Scenario Test	Program Test	Model Validation
Scenario Evaluation	Complexity Analysis	Performance Measurement

Three Entities in Modeling Simulation



Validation against Data Satisfying Objectives
 → Data Collection Cost (eg: weapon system)
 vs. Model Accuracy

Automatic Tool Desirable
 → Simulator Development Time
 vs. Verification Cost