UML Diagrams: StateCharts The Dynamic Analysis Model

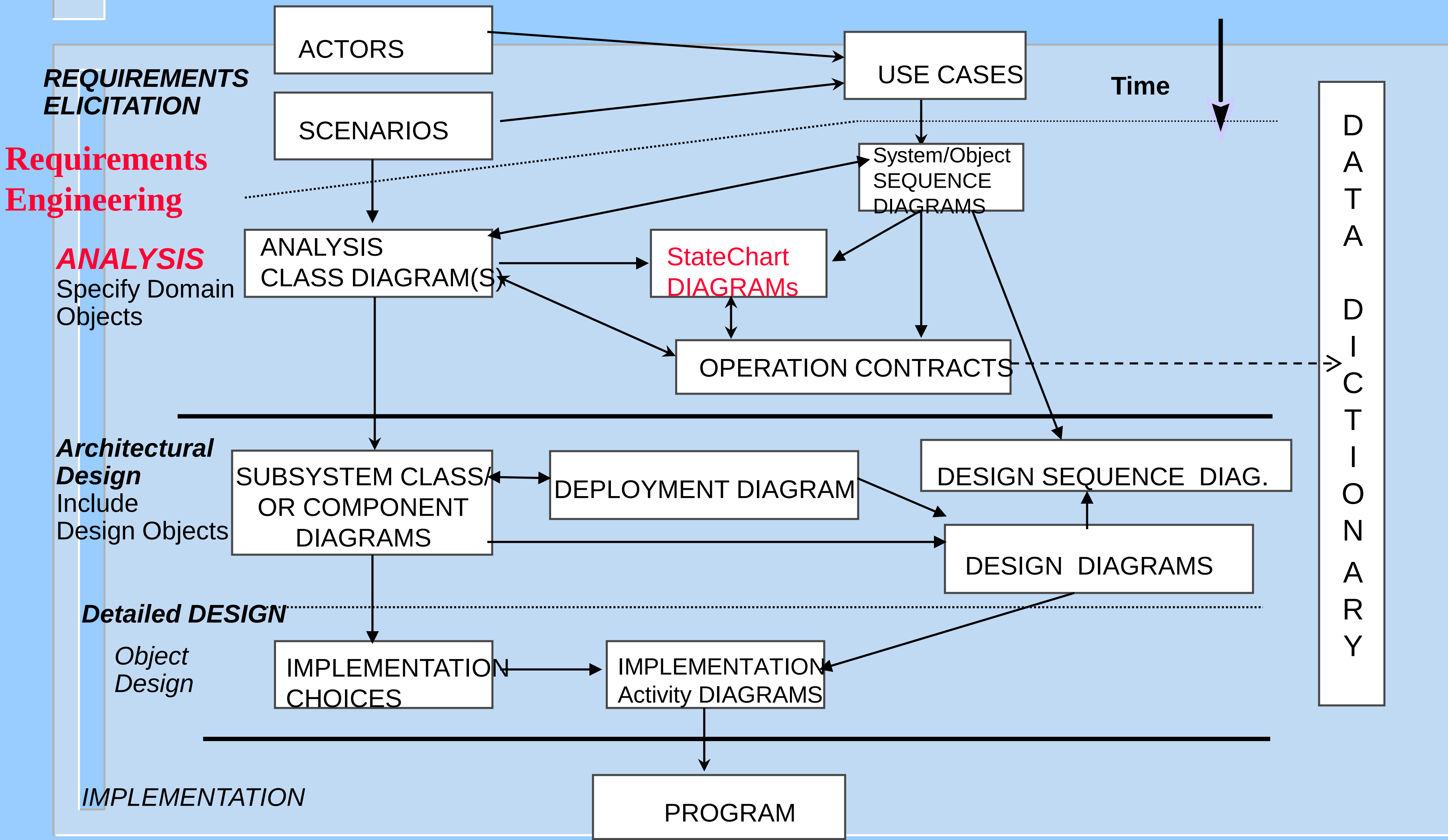
Instructor: Dr. Hany H. Ammar

Dept. of Computer Science and Electrical Engineering, WVU

outline

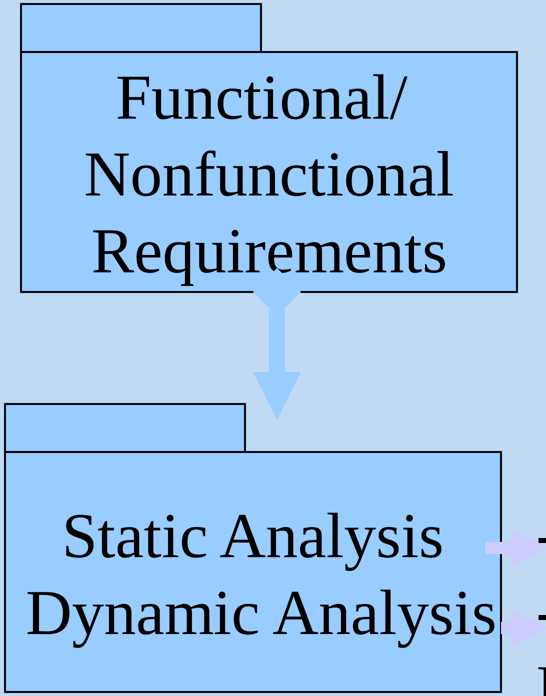
- UML Development - Overview
- The Requirements Model and the Analysis model
- The Analysis Model and the importance Statecharts
- Finite State Machines and Statecharts
- More on State Chart Elements
- Examples

UML Development - Overview



The Requirements Model and the Analysis Model

Requirements Elicitation Process



Use Case Diagrams/ Sequence Diagrams (the system level)

The Analysis Process

- Class Diagrams
- State Chart Diagrams/ Refined Sequence Diagrams (The object level)

outline

- UML Development - Overview
- The Requirements Model and the Analysis model
- The Analysis Model and the importance Statecharts
- Finite State Machines and Statecharts
- StateChart Elements
- Examples

The Analysis Model and the Importance of StateCharts

- StateCharts are particularly important for real-time systems,
- Control functions are typically activated at specific states of the system
- StateCharts model the dynamic behavior of an object (with multiple states of behavior) by showing the possible states that the object can be in (idle, busy, waiting for selection, timedout, processing_transactions, etc)

- In the analysis model a StateChart diagram is needed for each class of domain objects (including the system class) defined in the class diagram that has multiple states of behavior.

Recall the Banking System Example

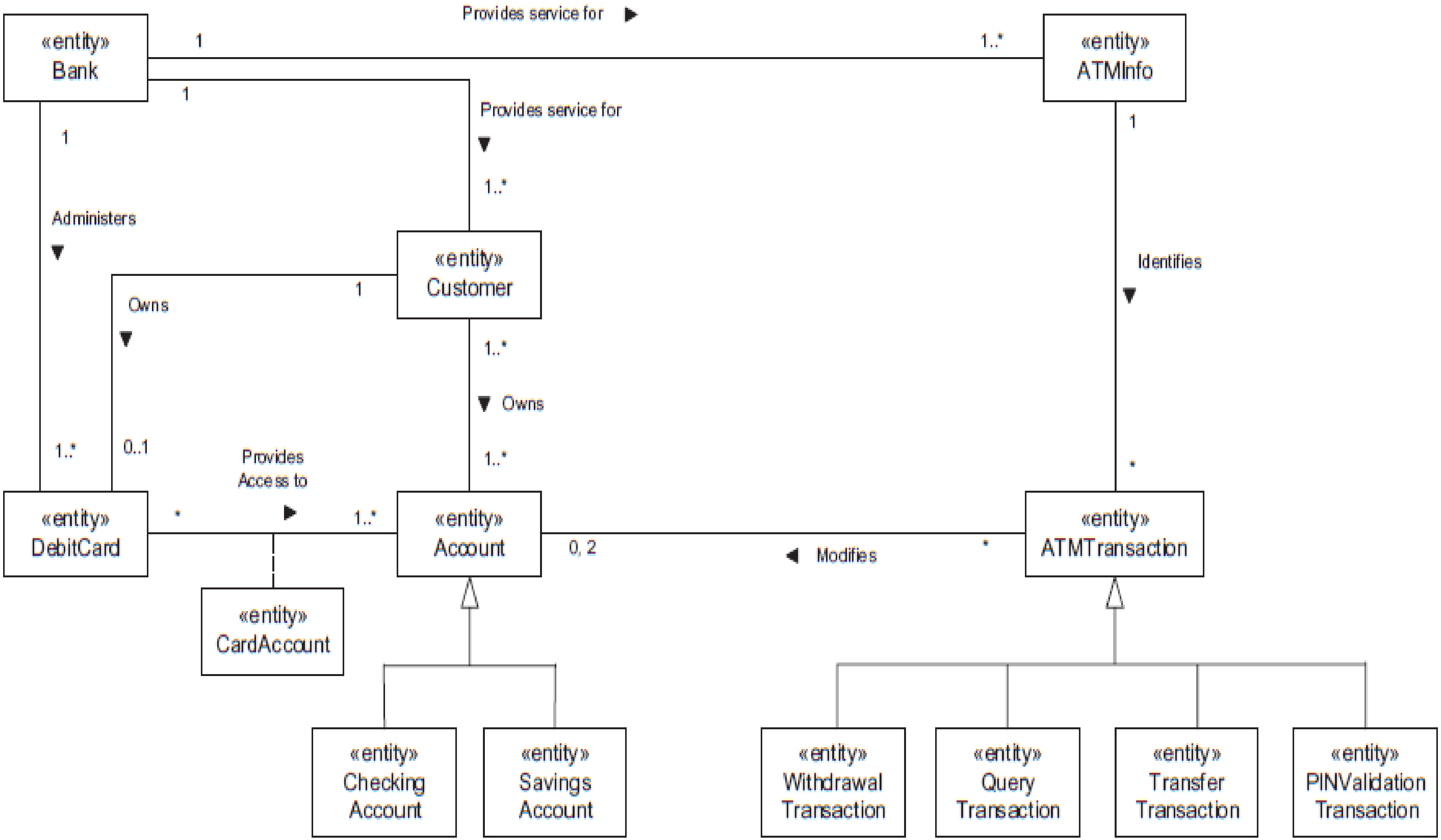


Figure 21.4. Conceptual static model for Banking System: entity classes

Example: StateChart for class Account in an ATM example

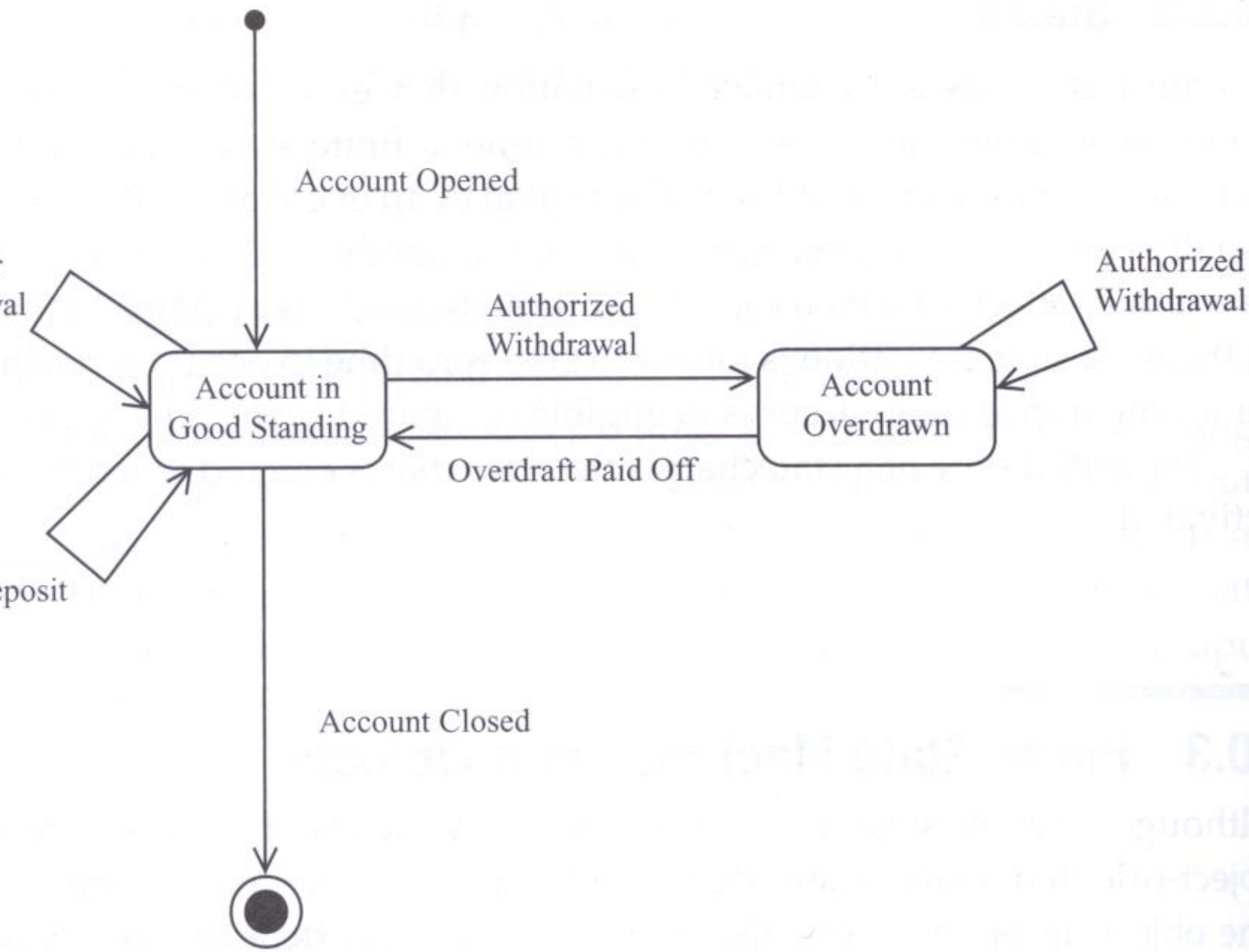


Figure 10.1 *Example of Account statechart*

Example: StateChart for the ATMControl class

What are the limitations of this Diagram?

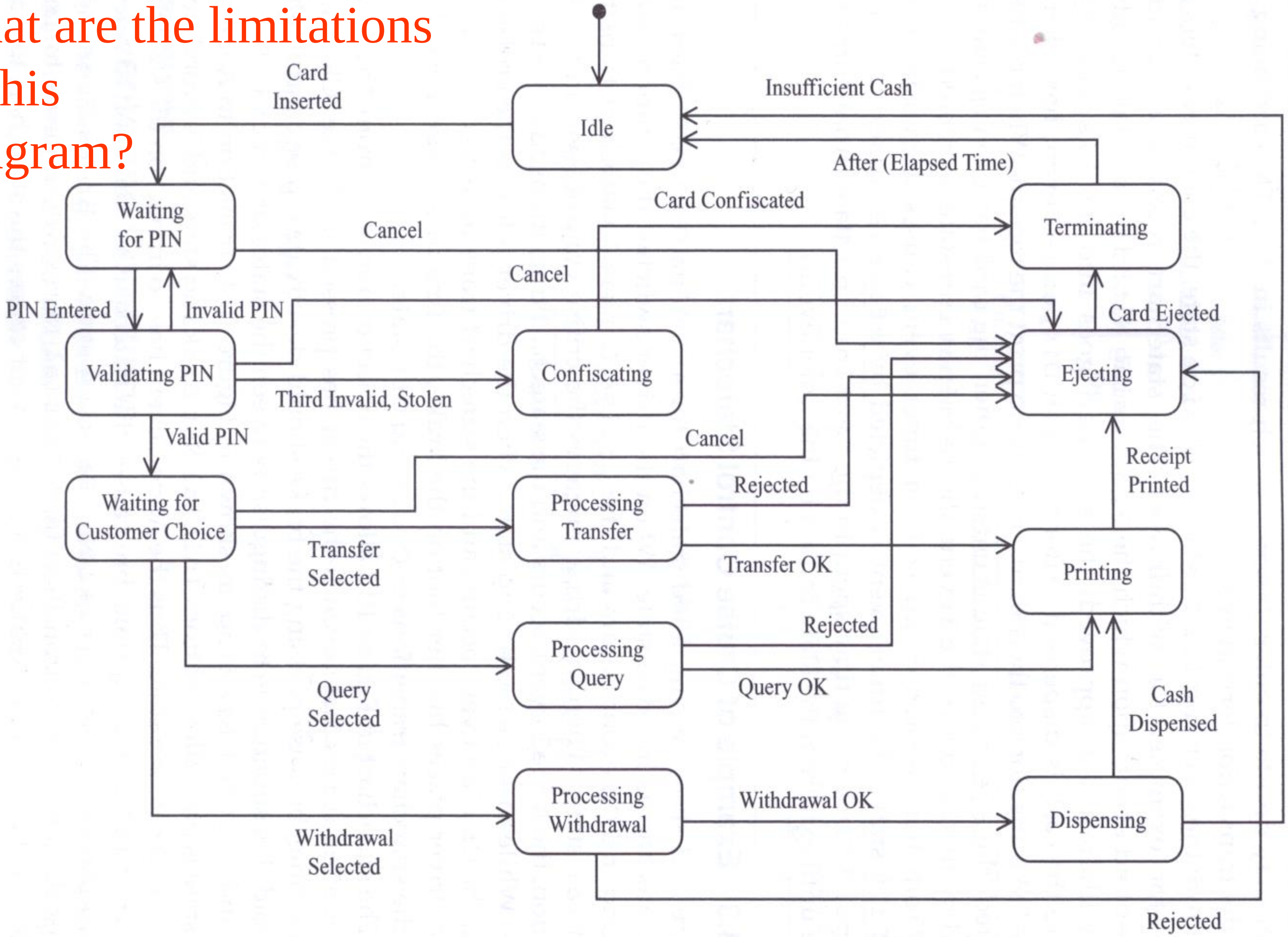


Figure 10.2 *Example of flat ATM statechart*

outline

- UML Development - Overview
- The Requirements Model and the Analysis model
- The Analysis Model and the importance Statecharts
- Finite State Machines and Statecharts
- StateChart Elements
- Examples

Finite State Machines and Statecharts

- Statechart Graphical representation of finite state machine–States are rounded boxes–Transitions are arcs
- Statechart relates events and states of a class of objects
  - •Event –Causes change of state Referred to as state transition
  - •State –A recognizable situation –Exists over an interval of time–Represents an interval between successive events

Finite State Machines (FSMs) and StateCharts (SCs)

- SCs are graphical representation of FSMs
- They can depict complex FSMs consisting of a hierarchy of state diagrams
- SCs consist of *states* and *transitions*
- A *state* depicts an actual state of behavior that an object can be in during its life time
- A *transition* from one state to another is caused by an *event* (e.g., user input, received a message from another object, etc)

StateChart Rules
States of an Object

- A recognizable situation
- Exists over an interval of time
- Represents an interval between successive events
- Can be a Macro state or a Micro state
- A Macro State is defined by another StateChart containing Macro and Micro states
- A Micro state is a primitive state not defined any Further

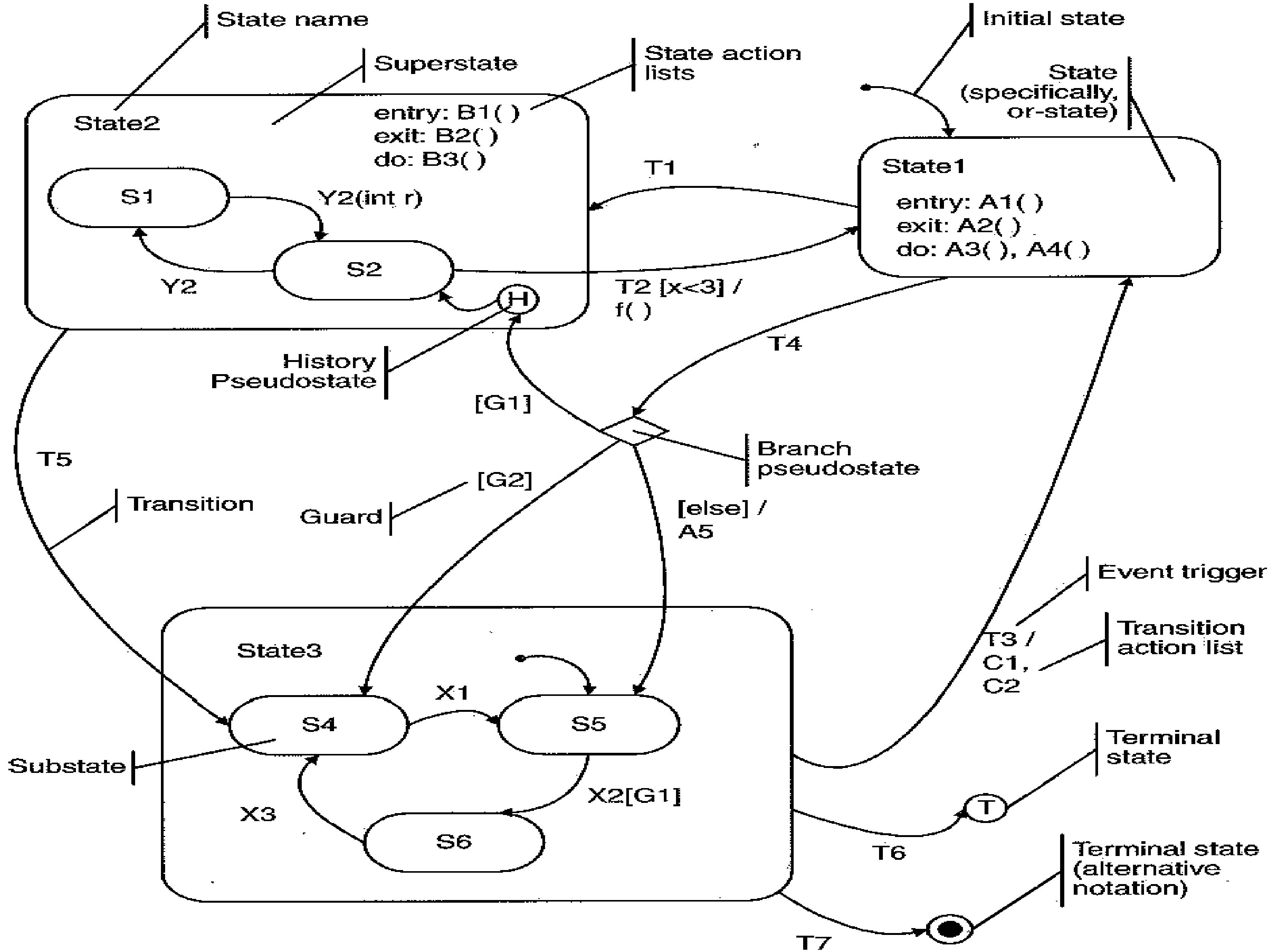


Figure 4-3: *Basic Statecharts*

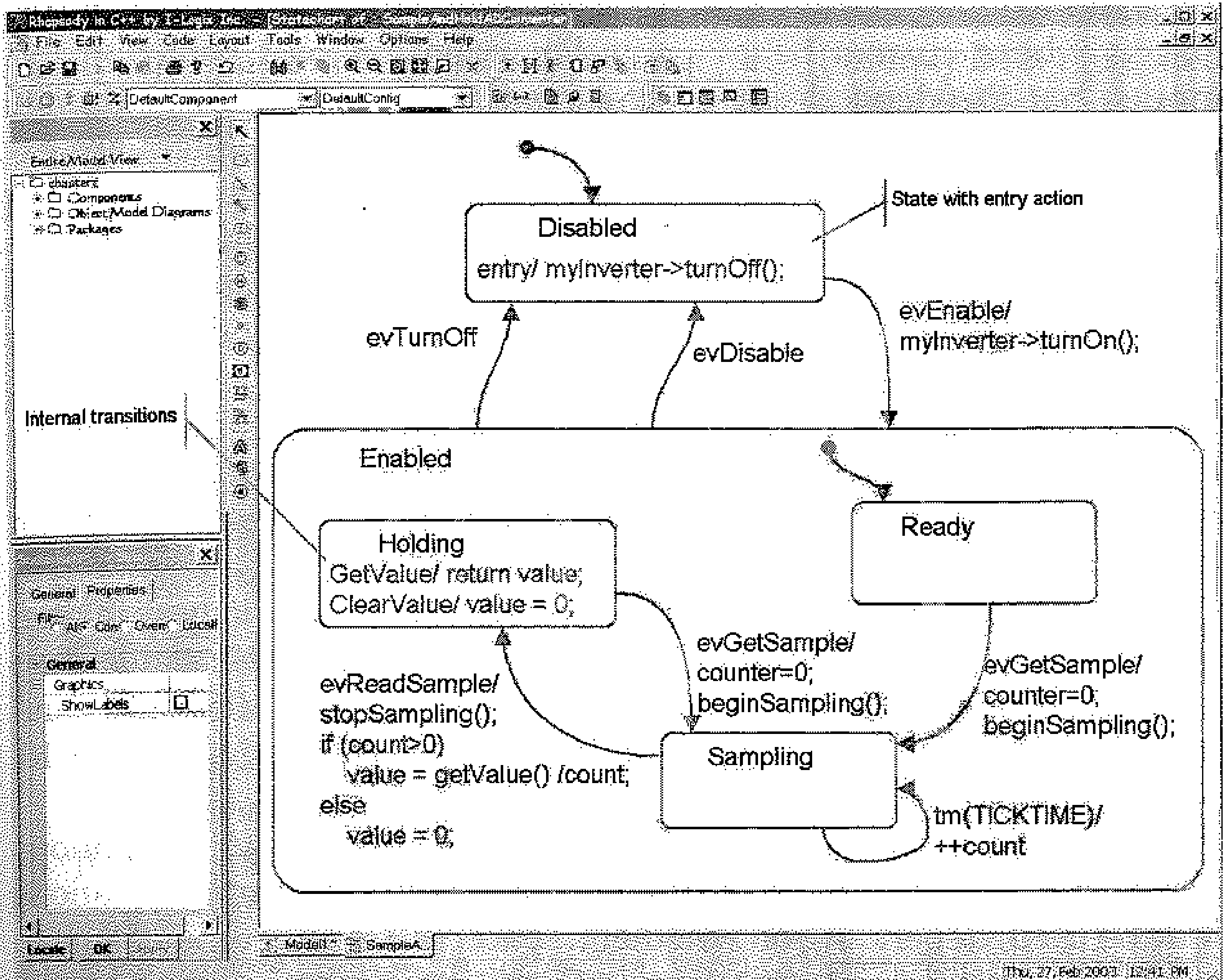


Figure 3-1: *State Machine for an Object*

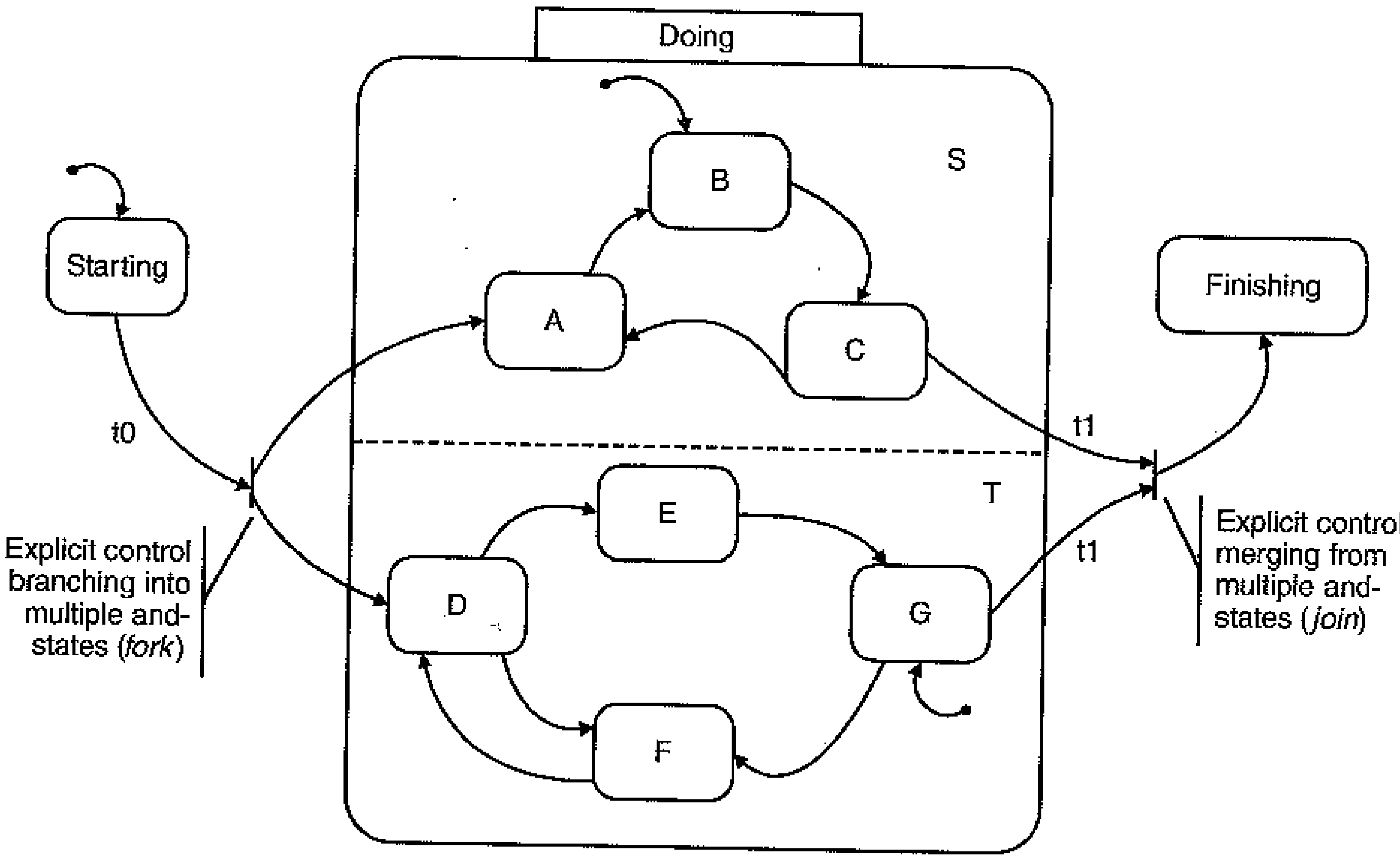


Figure 4-10: *Fork and Join*

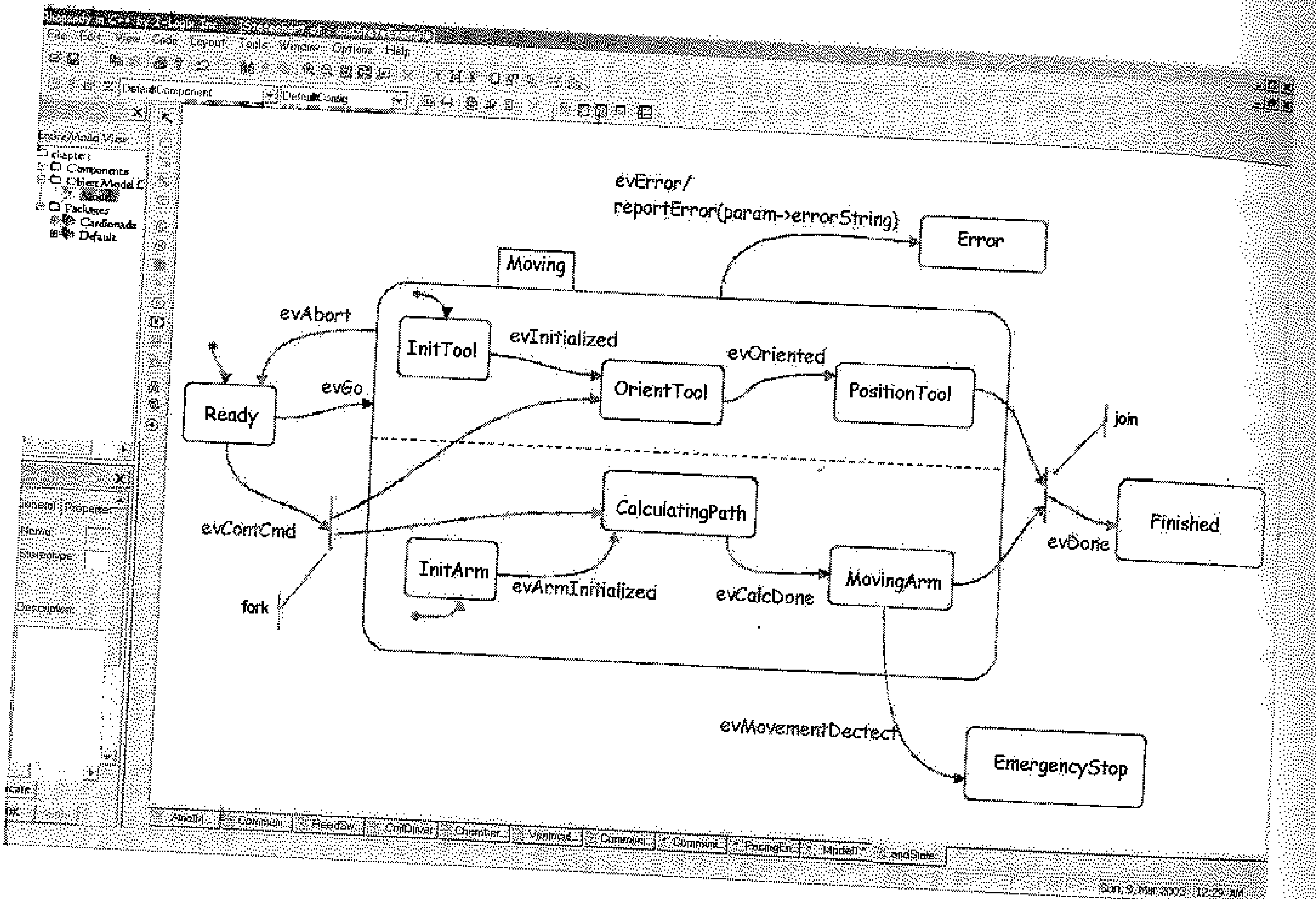


Figure 3-8: *Forks and Joins*

The History mark means subsequent entries are to the last active state

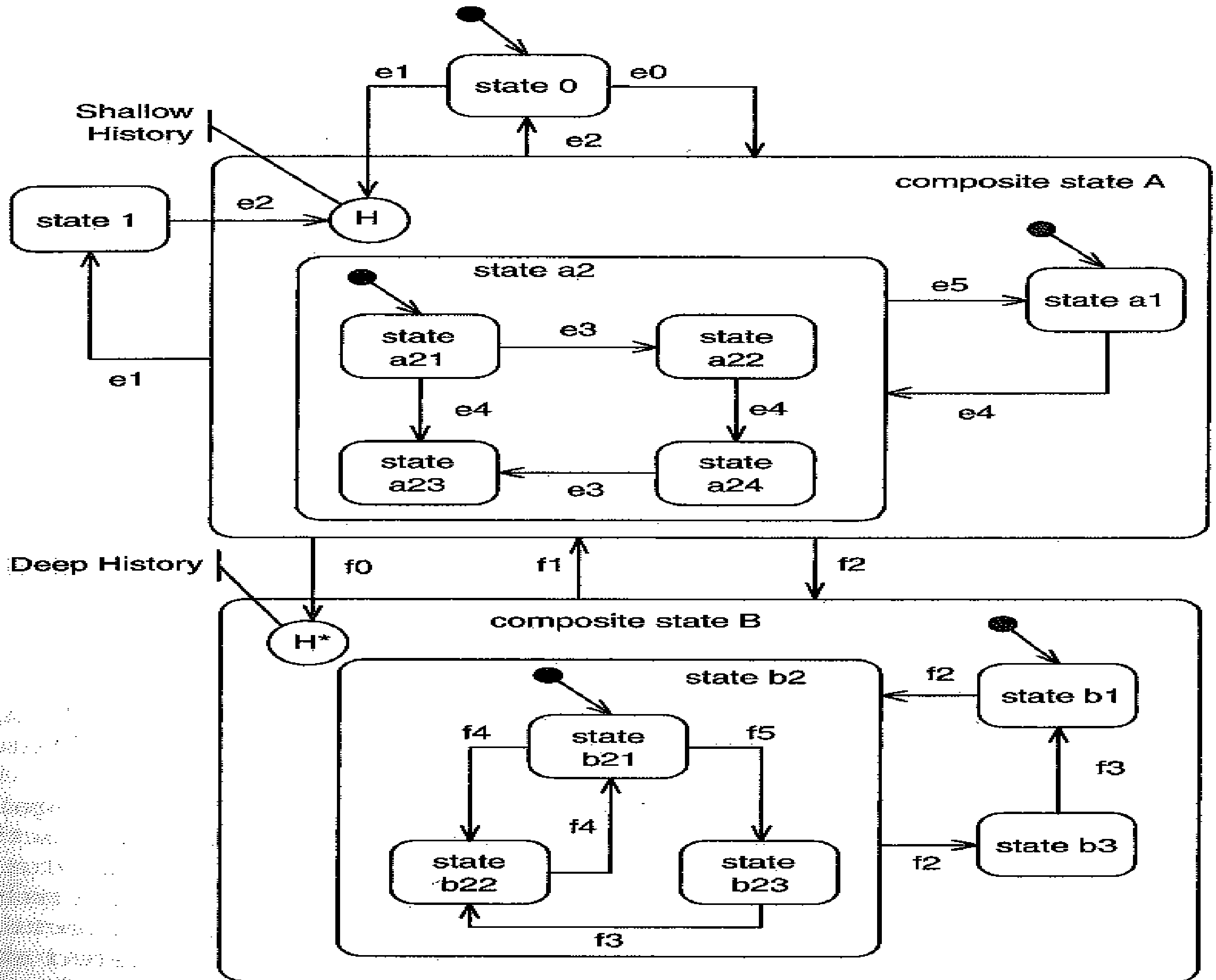


Figure 3-7: *History*

outline

- UML Development - Overview
- The Requirements Model and the Analysis model
- The Analysis Model and the importance Statecharts
- Finite State Machines and Statecharts
- More on State Chart Elements
  - Events, Conditions, Actions, and Activities
- Examples

Events

- Event–A discrete signal that happens at a point in time
  - –Also known as a stimulus
  - –Has no duration
- •Two events
  - –May logically depend on each other
  - –E.g, ATM Card inserted before Pin # entered
- •Two events
  - –May be independent of each other (they can occur independently)
  - –E.g., Cancel

Events and Conditions

- State transition label
  - Event [Condition]
- Condition is a Boolean function
  - Conditions are optional on statecharts
  - Condition is true for finite period of time
- When event occurs, condition must be *true* for state transition to occur.

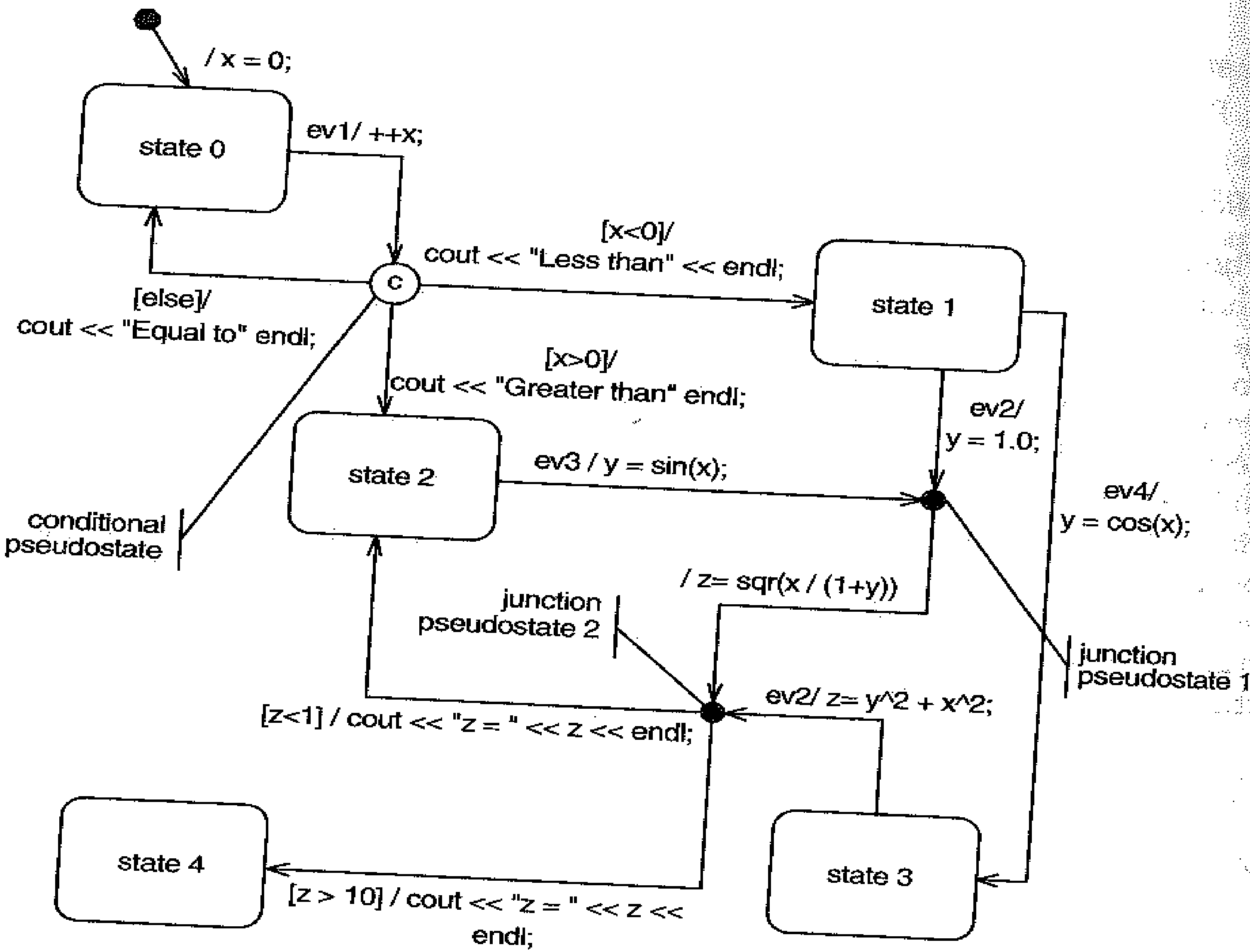


Figure 3-6: *Branches and Junctions*

Actions

- Can be defined as state transition label
  - Event / action(s)
  - Event [condition] / action(s)
- Actions
  - Executed as a result of state transition
  - Executes instantaneously at state transition
  - Terminates itself
- Entry Actions
  - Defined for a given state and executes on entry to this state from any state
- Exit Actions
  - Defined for a given state and executes on exit from this state to any state

Example: Actions and Conditions, Auto Cruise Controller

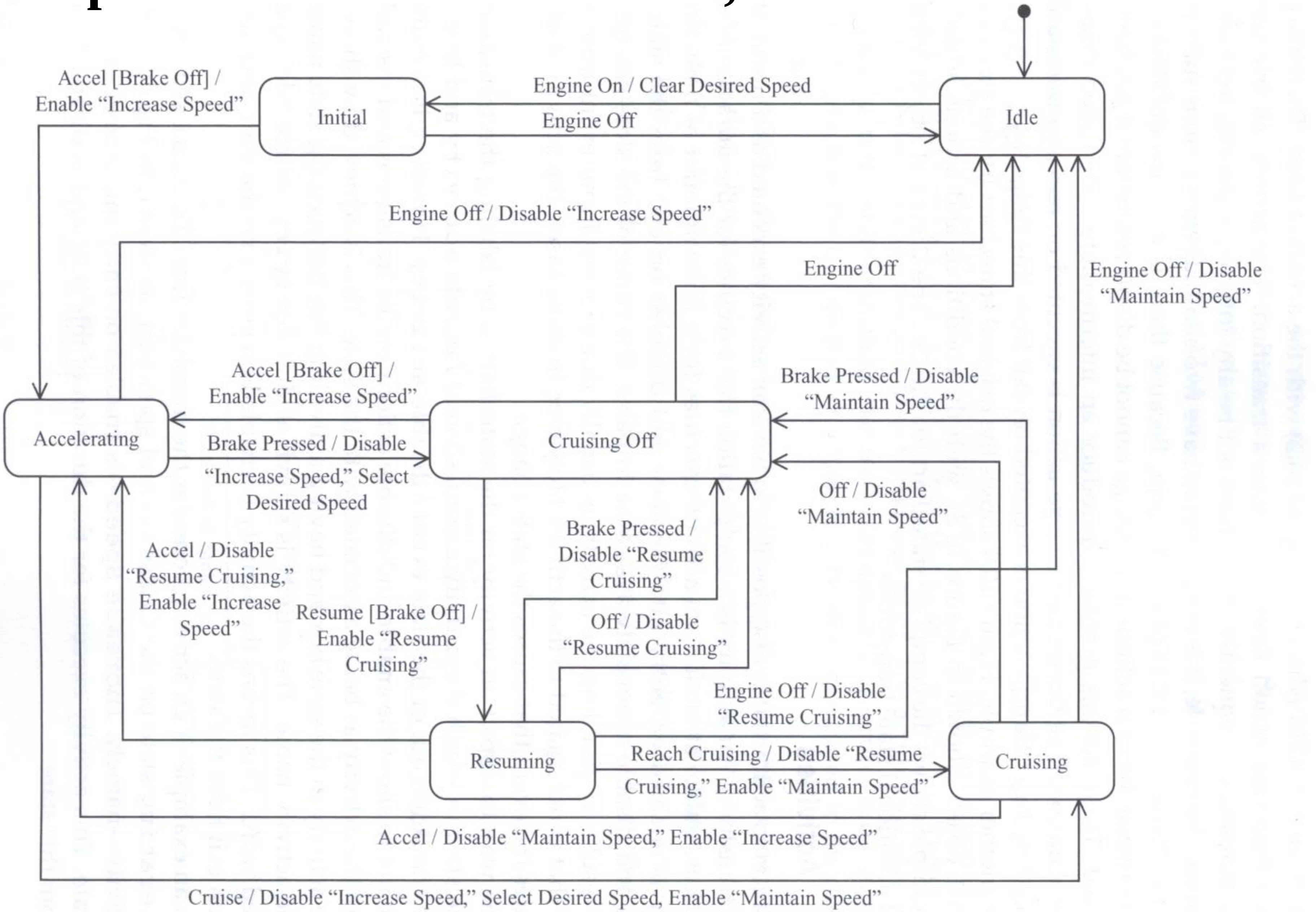


Figure 10.9 *Detailed Cruise Control statechart with actions and conditions*

Example: Entry Actions, execute on the entry to a state after a state transition

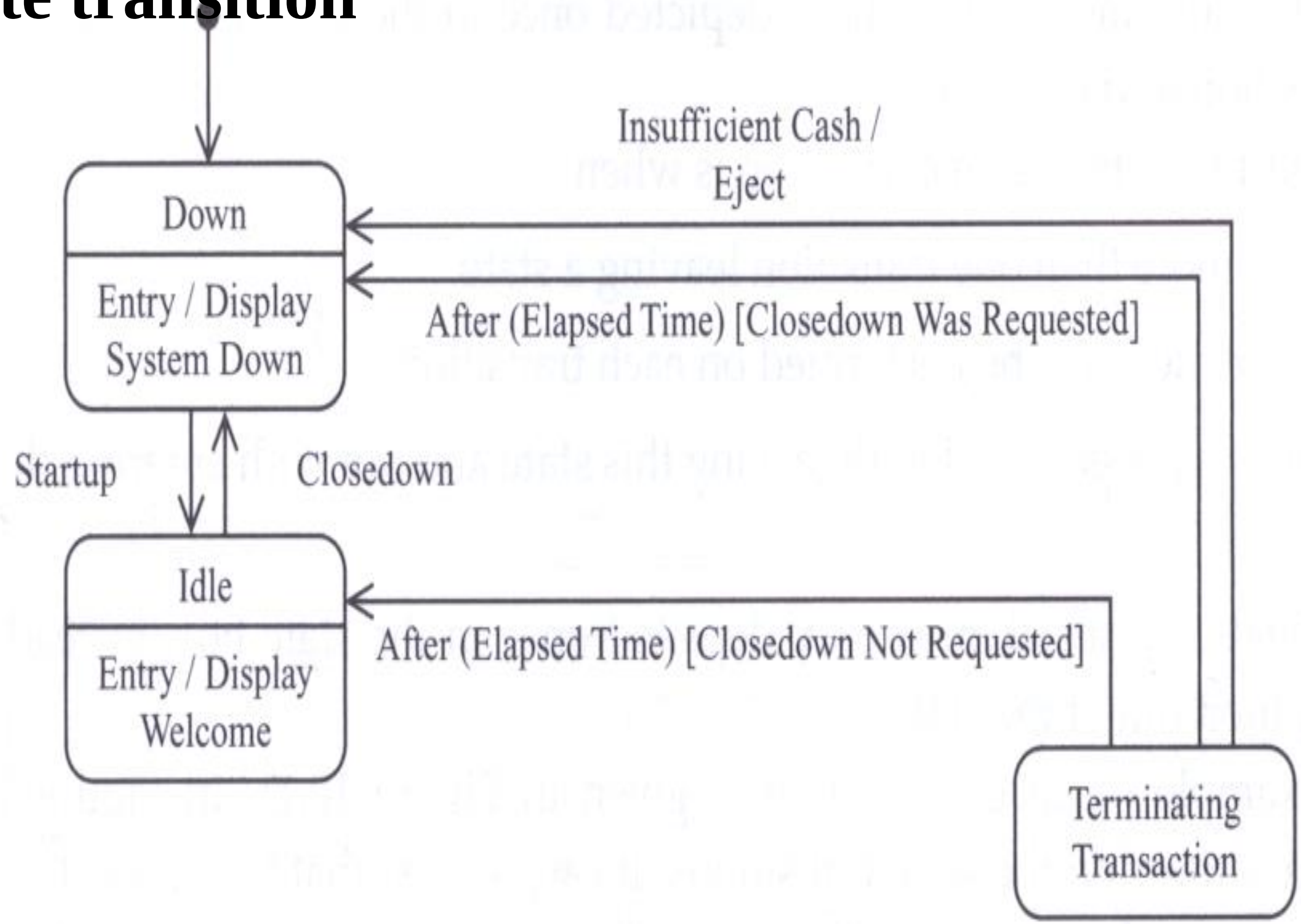


Figure 10.11b *Entry actions*

Figure 10.11 *Example of entry actions (continued)*

Example: Exit Actions

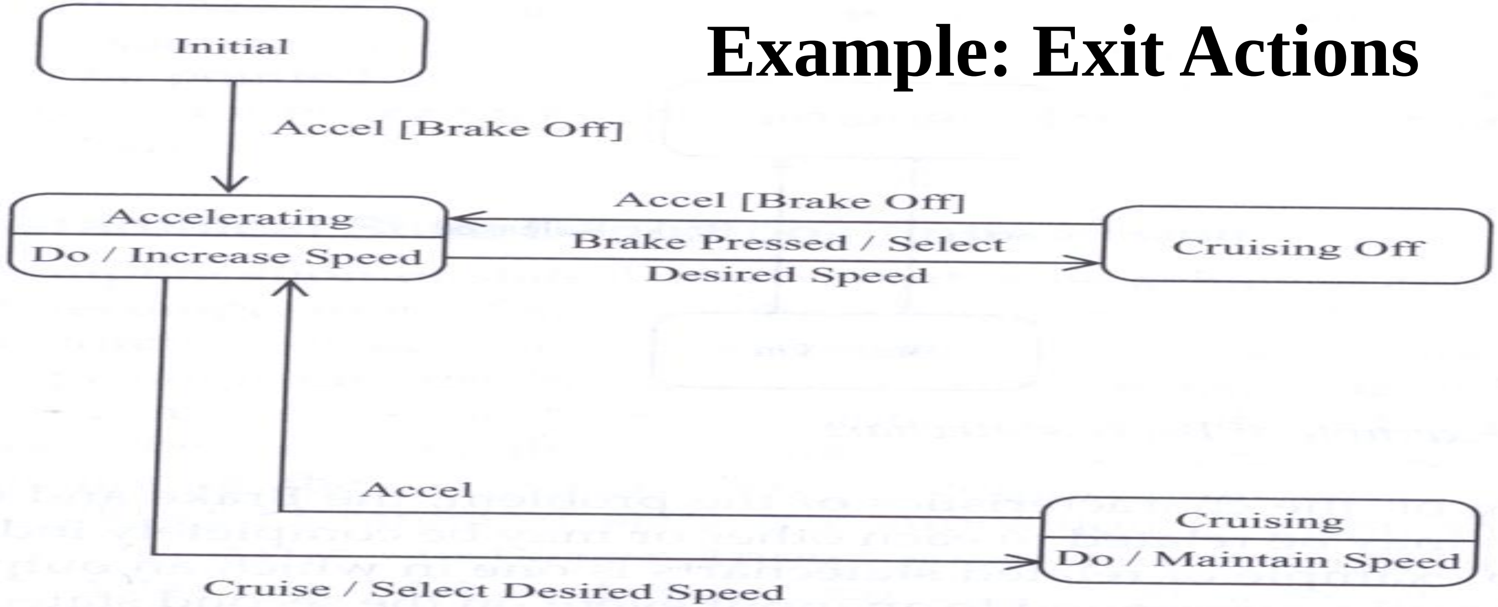


Figure 10.12a *Actions on state transitions*

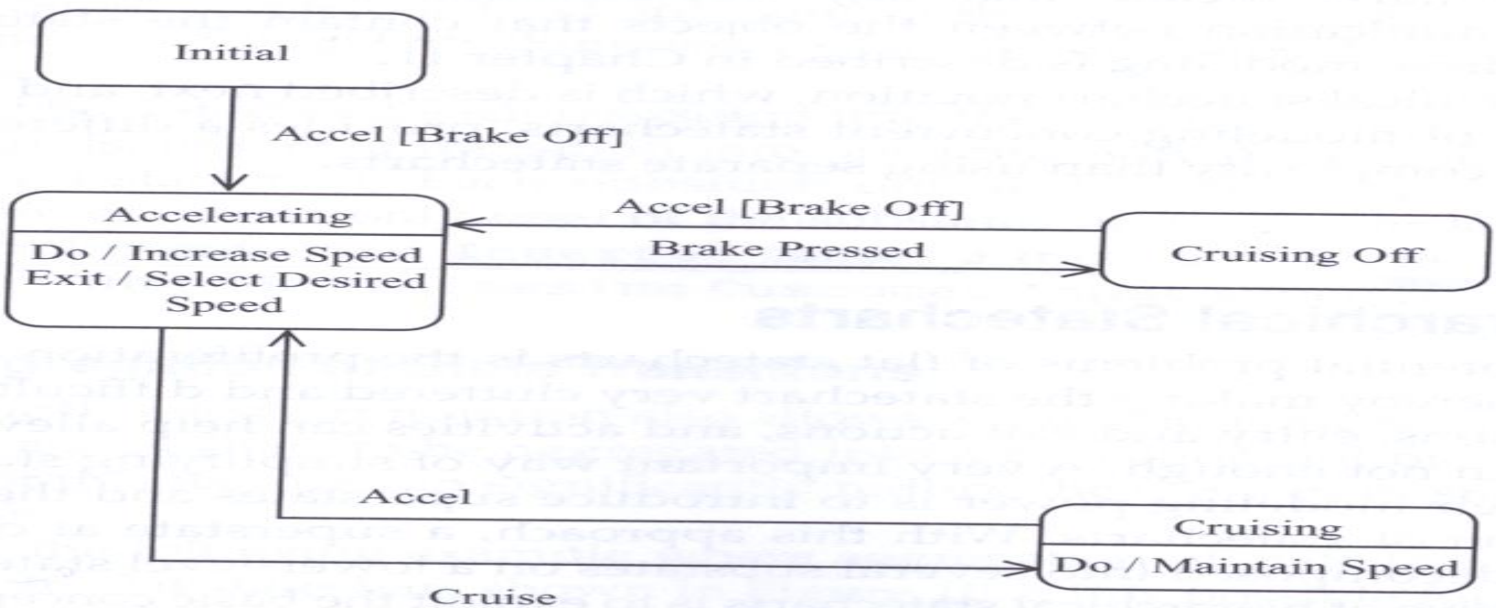


Figure 10.12b *Exit action*

ure 10.12 *Example of exit action*

Activities

- Activity
  - –Executes for duration of state
    - •Enable Activity on entry to state
    - •Disable Activity on exit from state
- Examples of activities
  - –Increase Speed
    - •Executes for duration of Accelerating state
  - –Maintain Speed
    - •Executes for duration of Cruising state
  - –Resume Cruising
    - •Executes for duration of Resuming state

Example: StateChart with Activities, Auto Cruise Controller

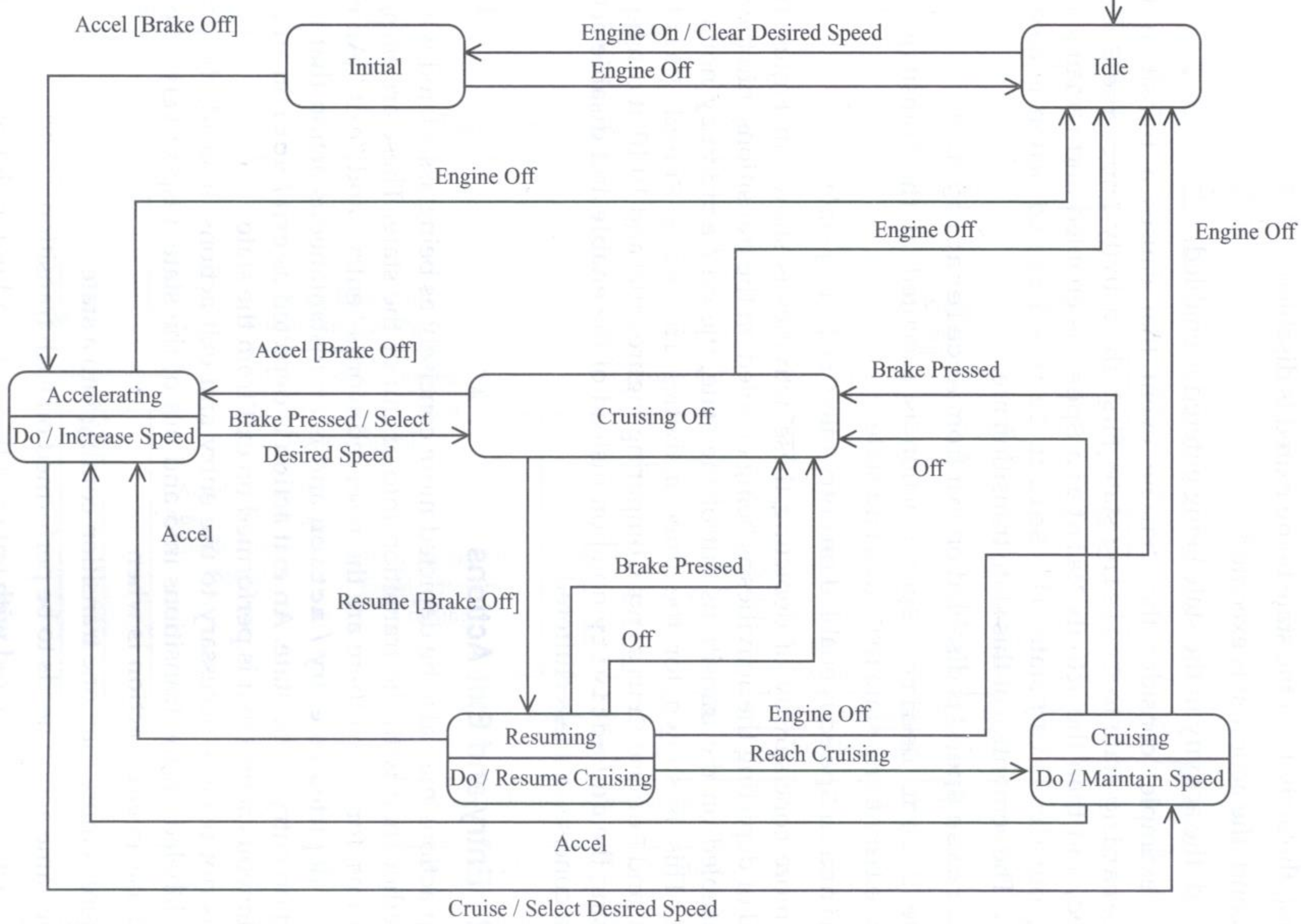


Figure 10.10 *Cruise Control statechart with activities*

outline

- UML Development - Overview
- The Requirements Model and the Analysis model
- The Analysis Model and the importance Statecharts
- Finite State Machines and Statecharts
- StateChart Elements
- Examples

The Sound Recorder Analysis Level Class Diagram

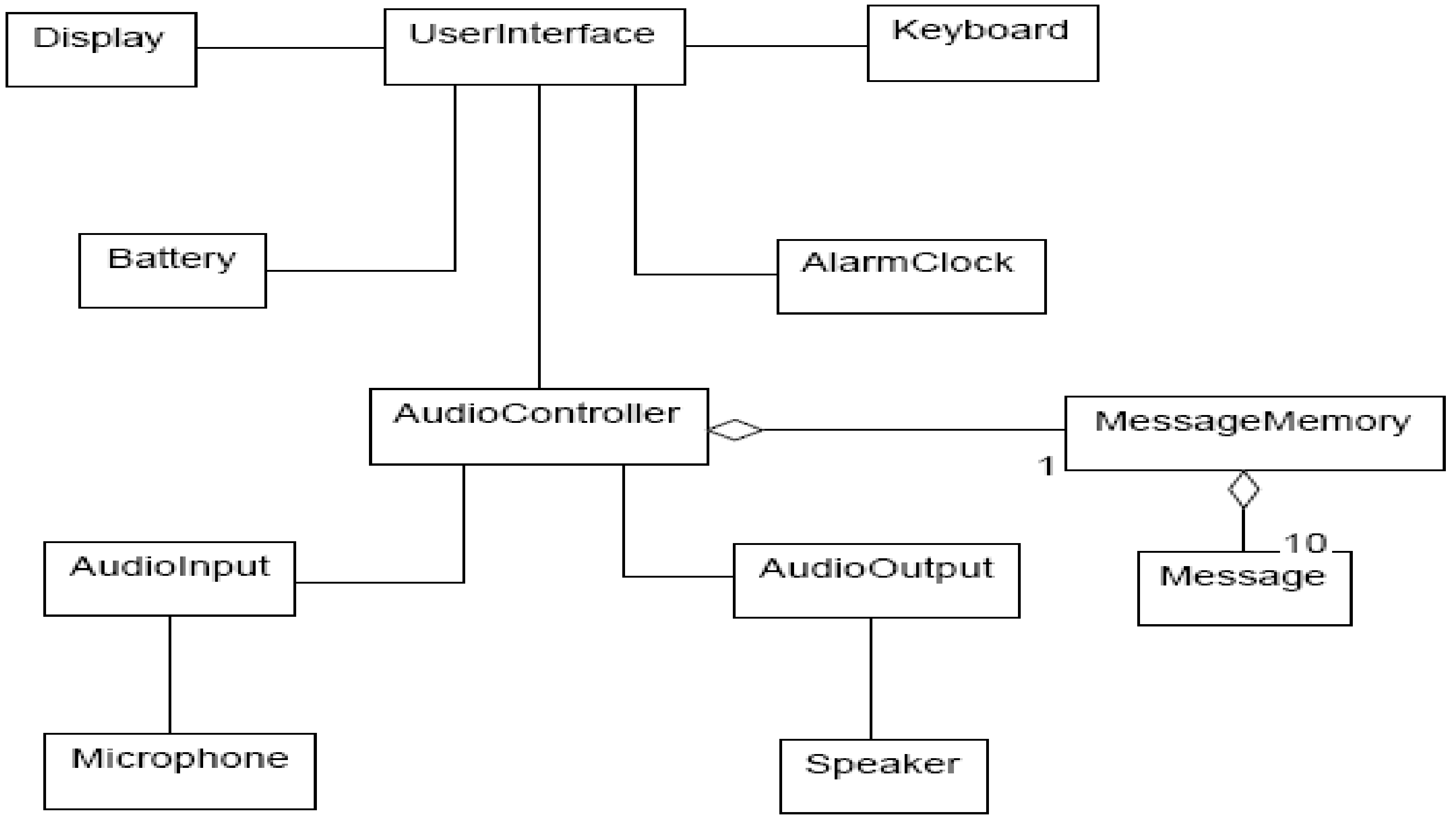


Figure 3.2: Sound Recorder class diagram

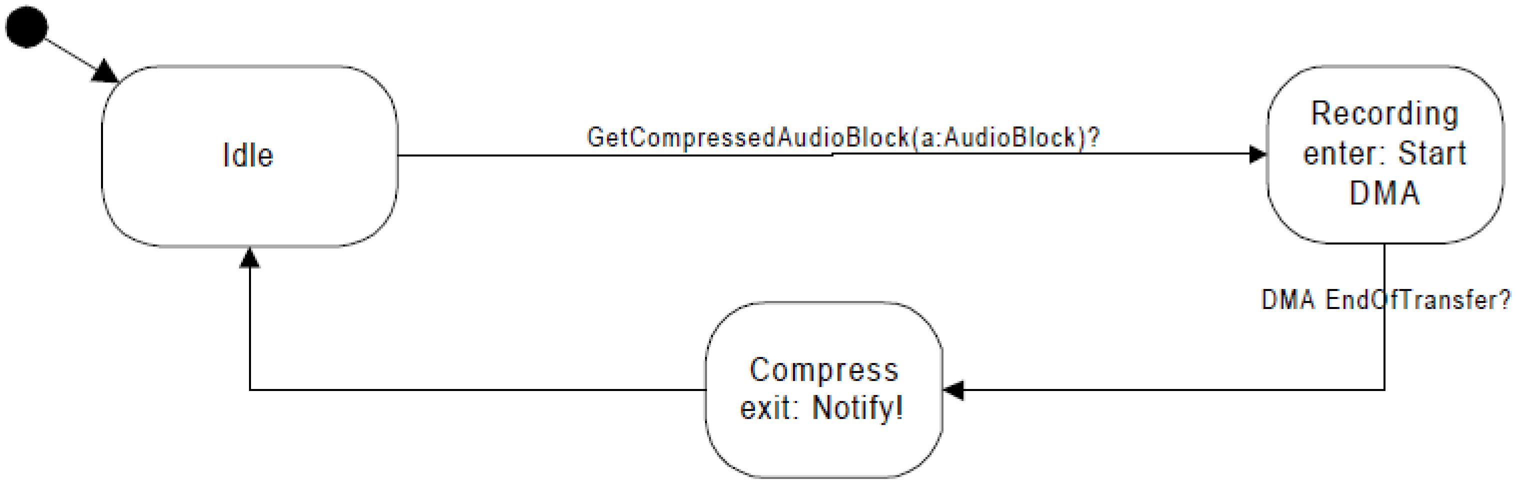


Figure 4.2: AudioInput statechart

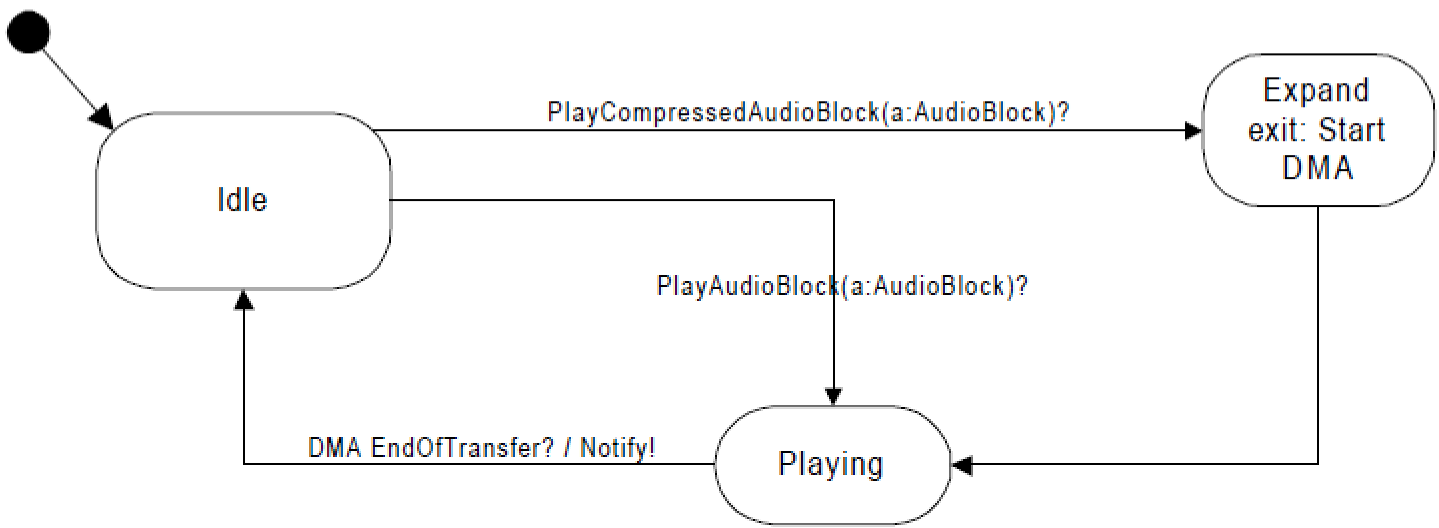


Figure 4.3: AudioOutput statechart

Incomplete Statechart and incorrect state label

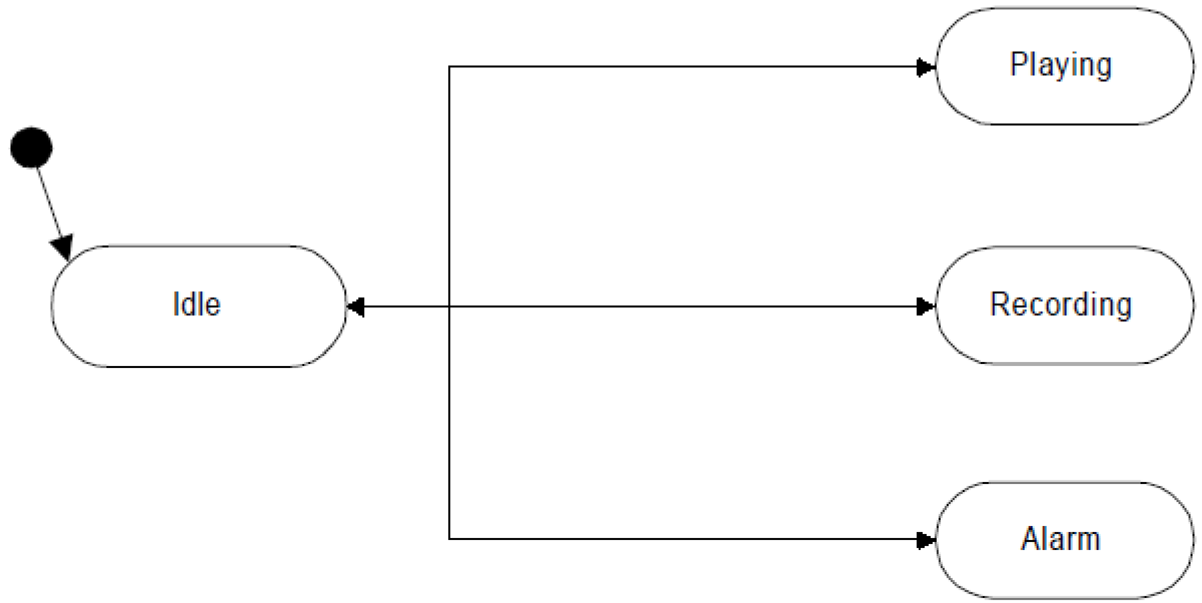


Figure 4.1: Behaviour of an AudioController

Why?

Example: Digital Sound Recorder User Interface subsystem Design Class diagram

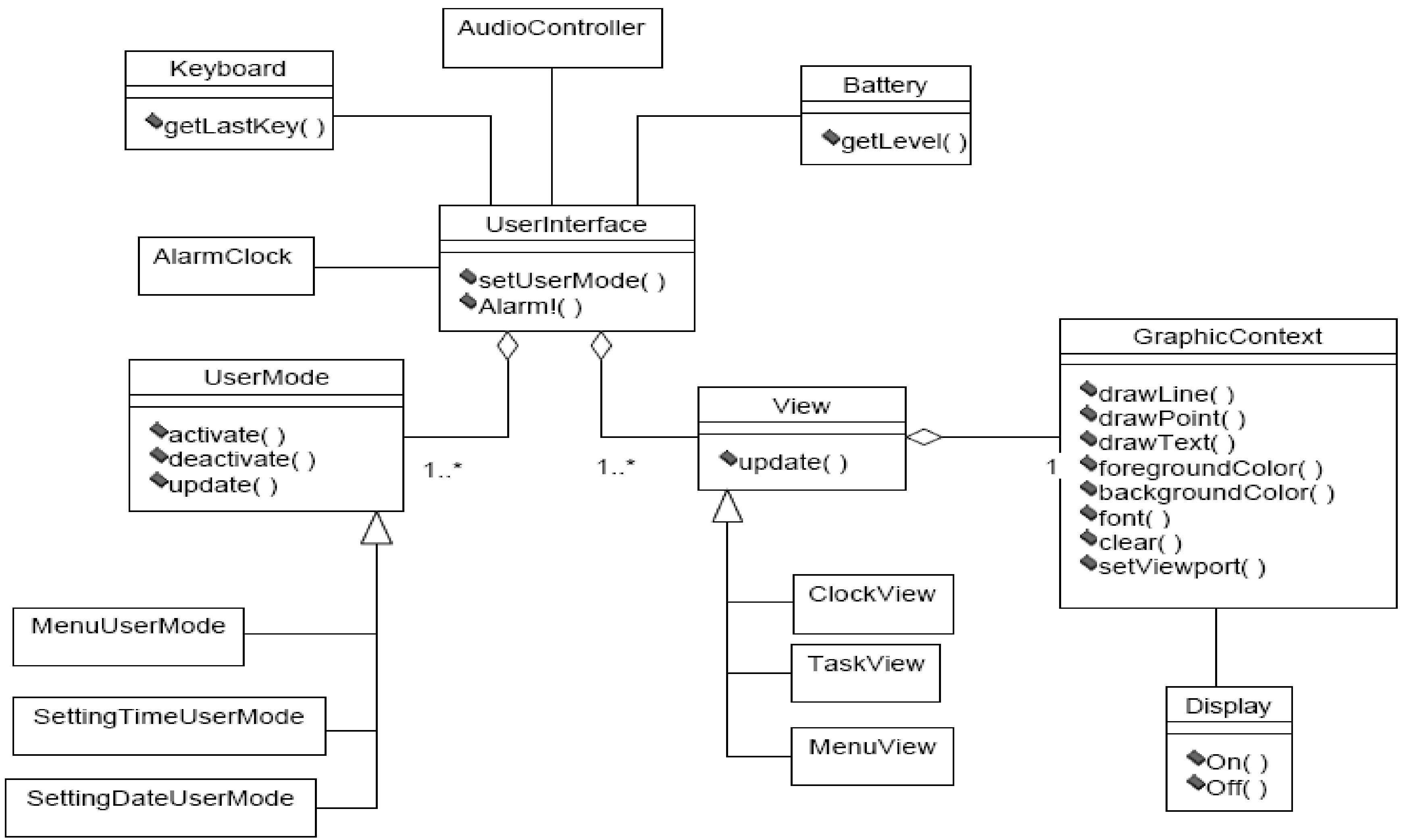


Figure 3.11: User interface subsystem class diagram

Example: Digital Sound Recorder StateChart of MenuUserMode class

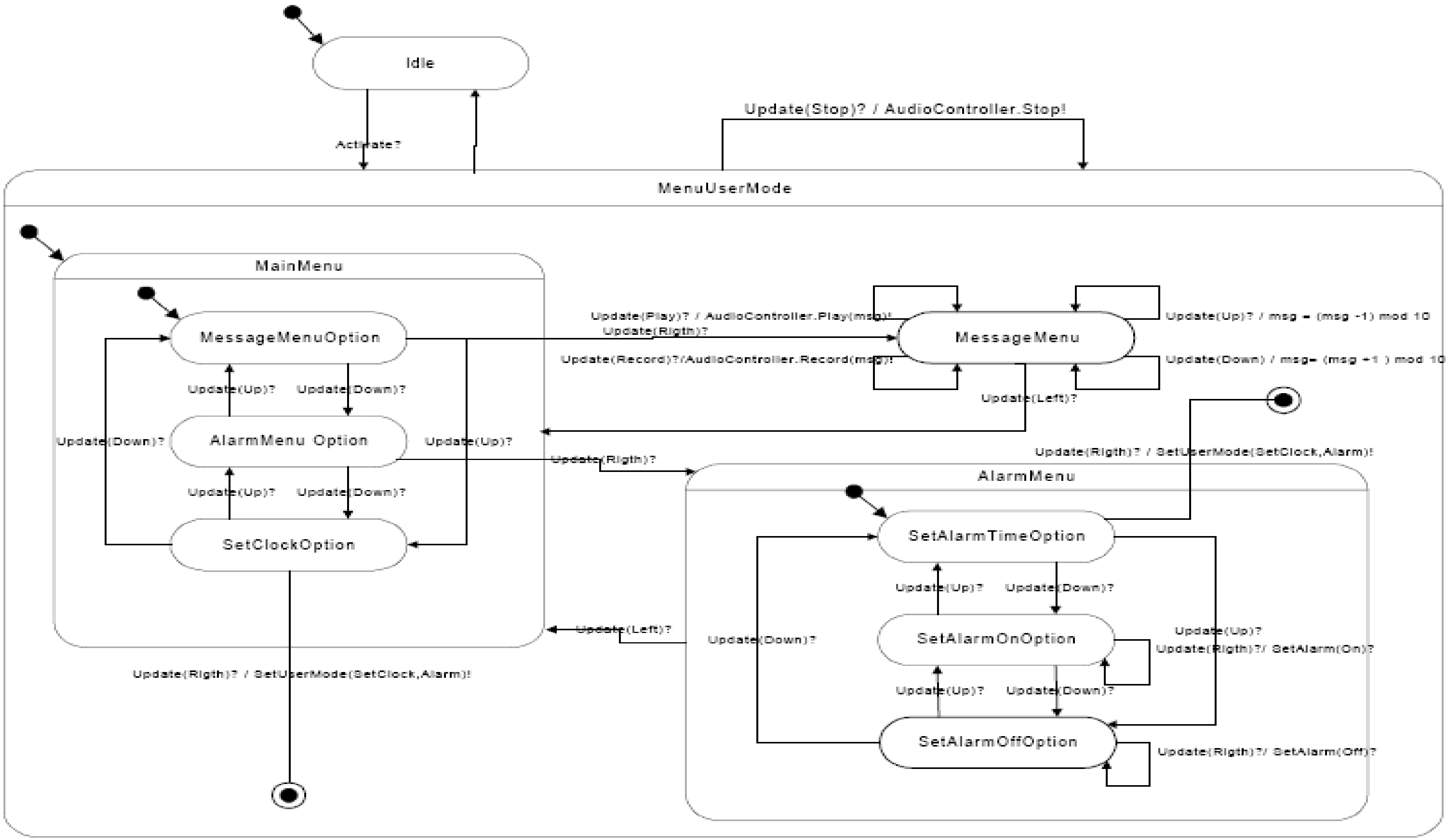


Figure 4.7: MenuUserMode statechart

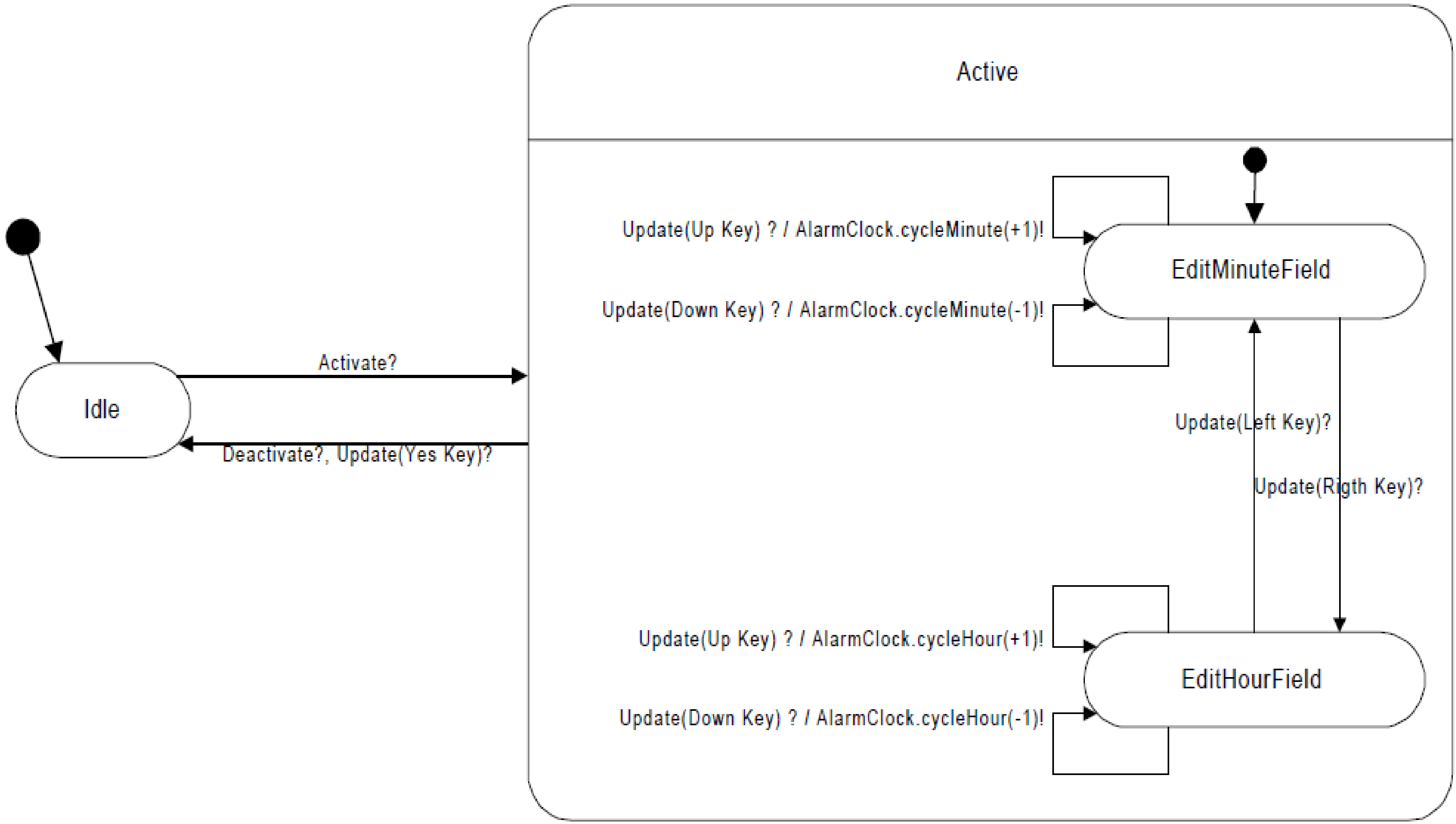


Figure 4.8: SettingClockUserMode statechart

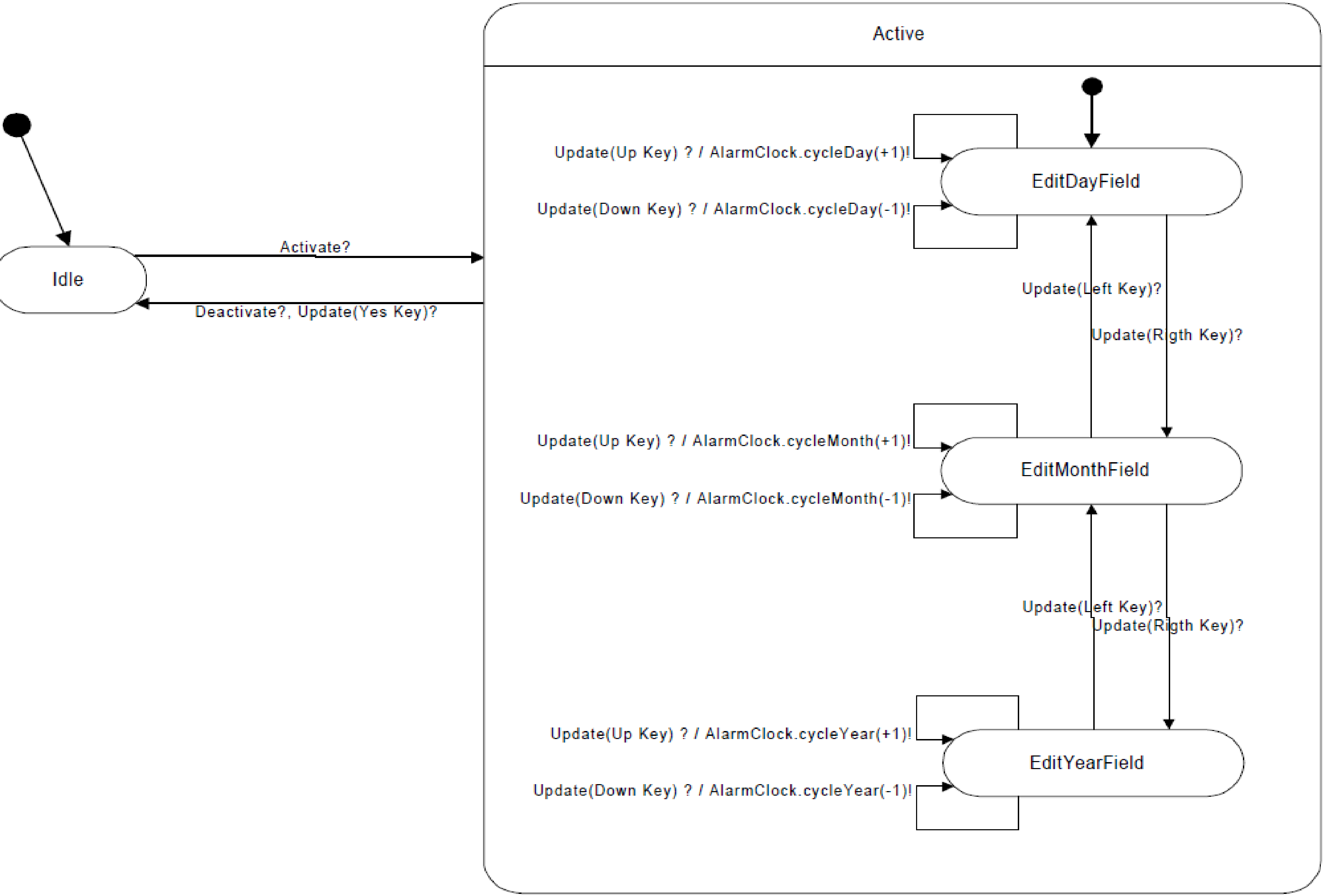
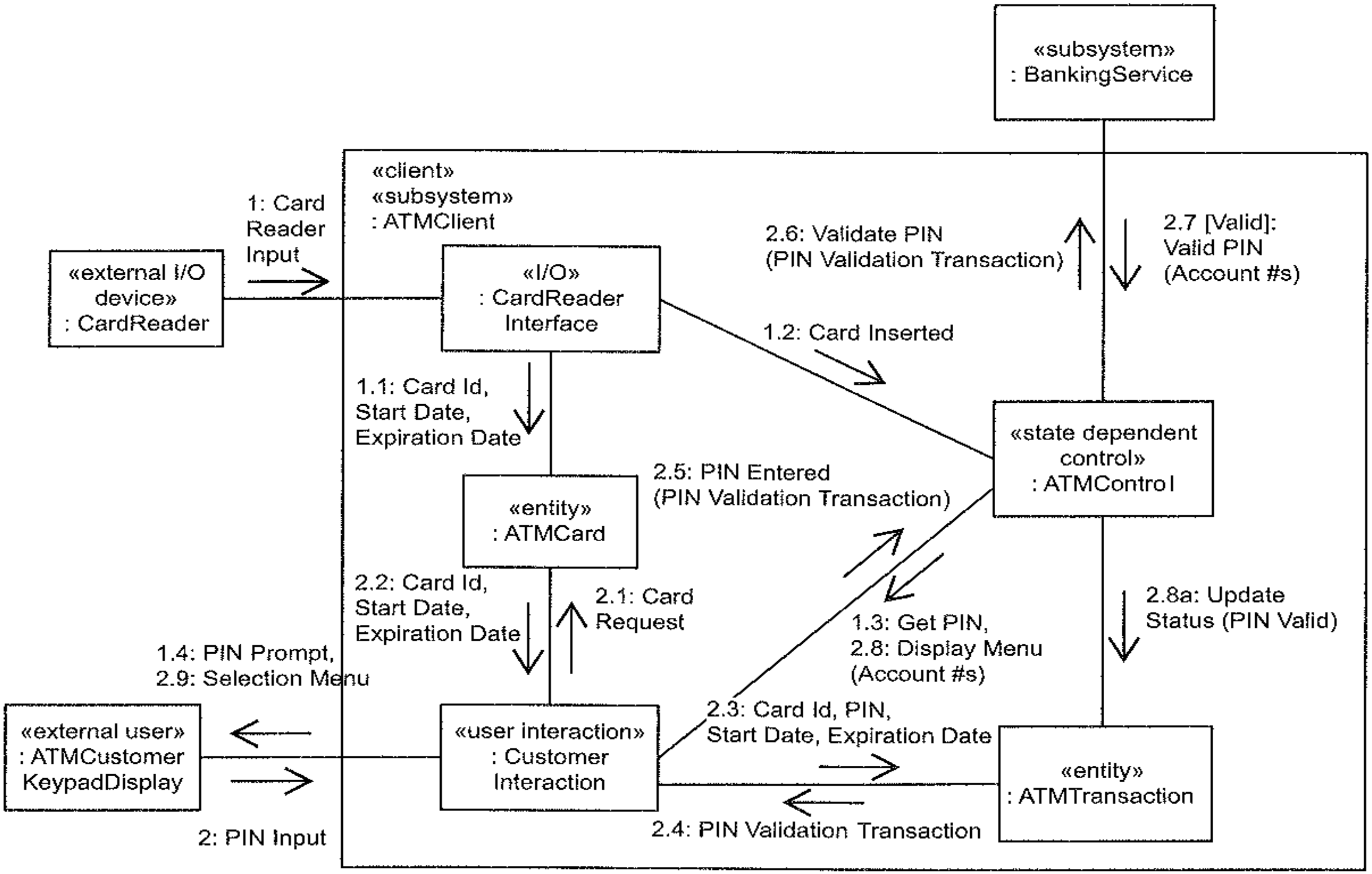


Figure 4.9: SettingDateUserMode statechart

Recall the ATMControl class



PIN Validation Transaction = {transactionId, transactionType, cardId, PIN, starDate, expirationDate}

Figure 21.11. Communication diagram: ATM client Validate PIN use case

Example: StateChart for the ATMControl class

What are the limitations of this Diagram?

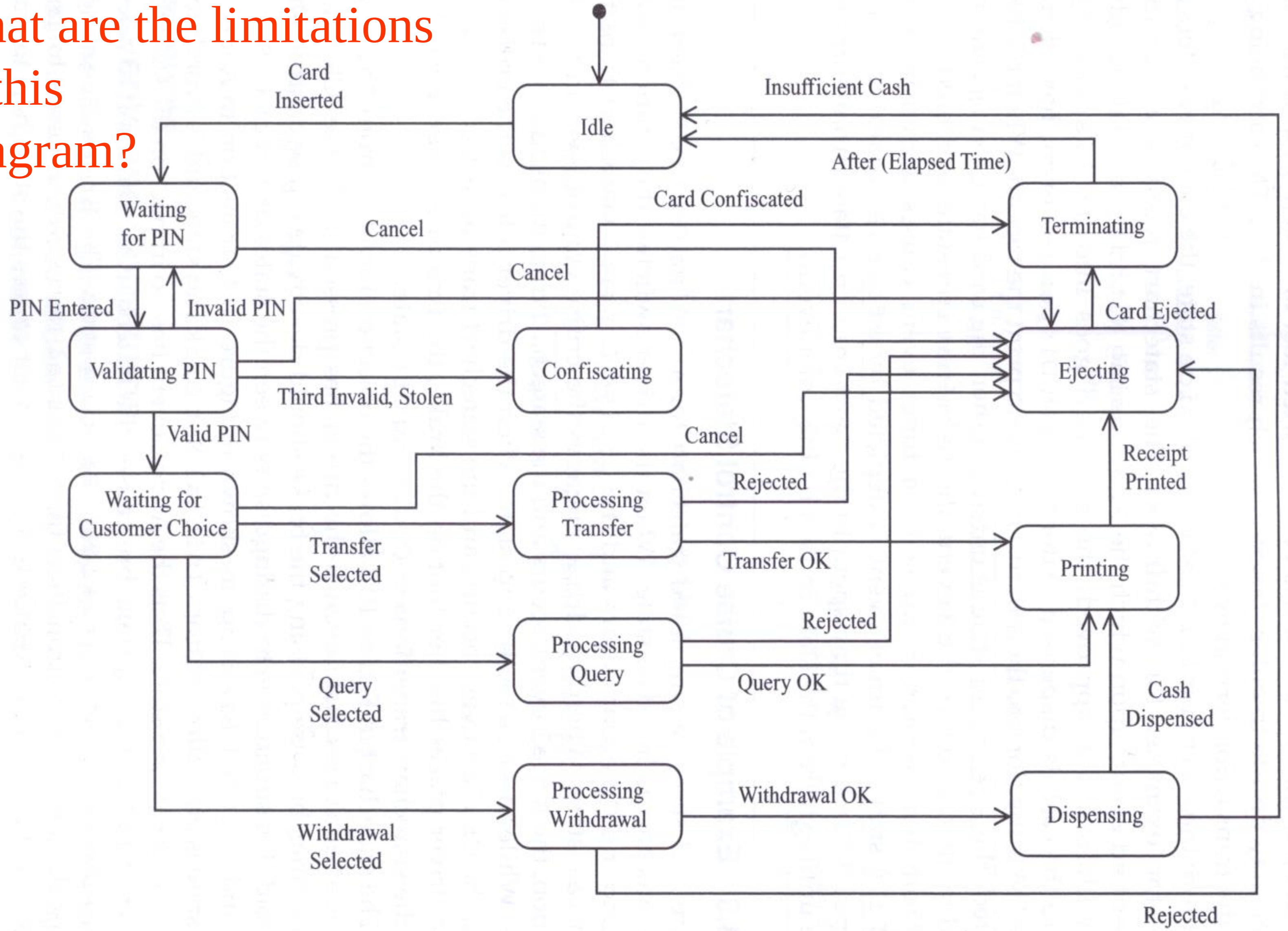


Figure 10.2 *Example of flat ATM statechart*

Example: Macro States, Hierarchical StateCharts ATM system

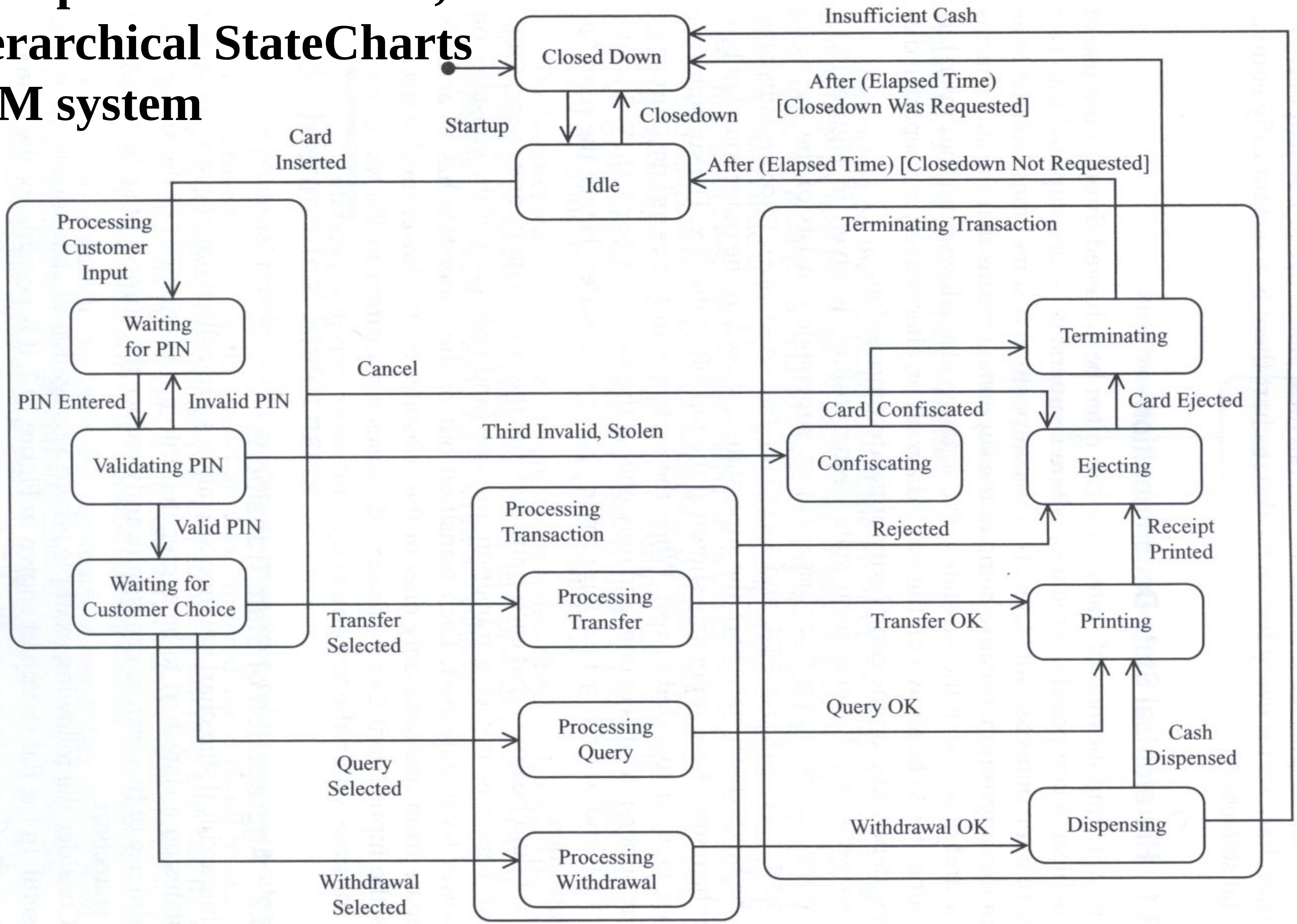


Figure 10.14 *Example of hierarchical statechart*

Example: Auto Cruise Control and Monitoring (The Cruise Cont. Subsys)

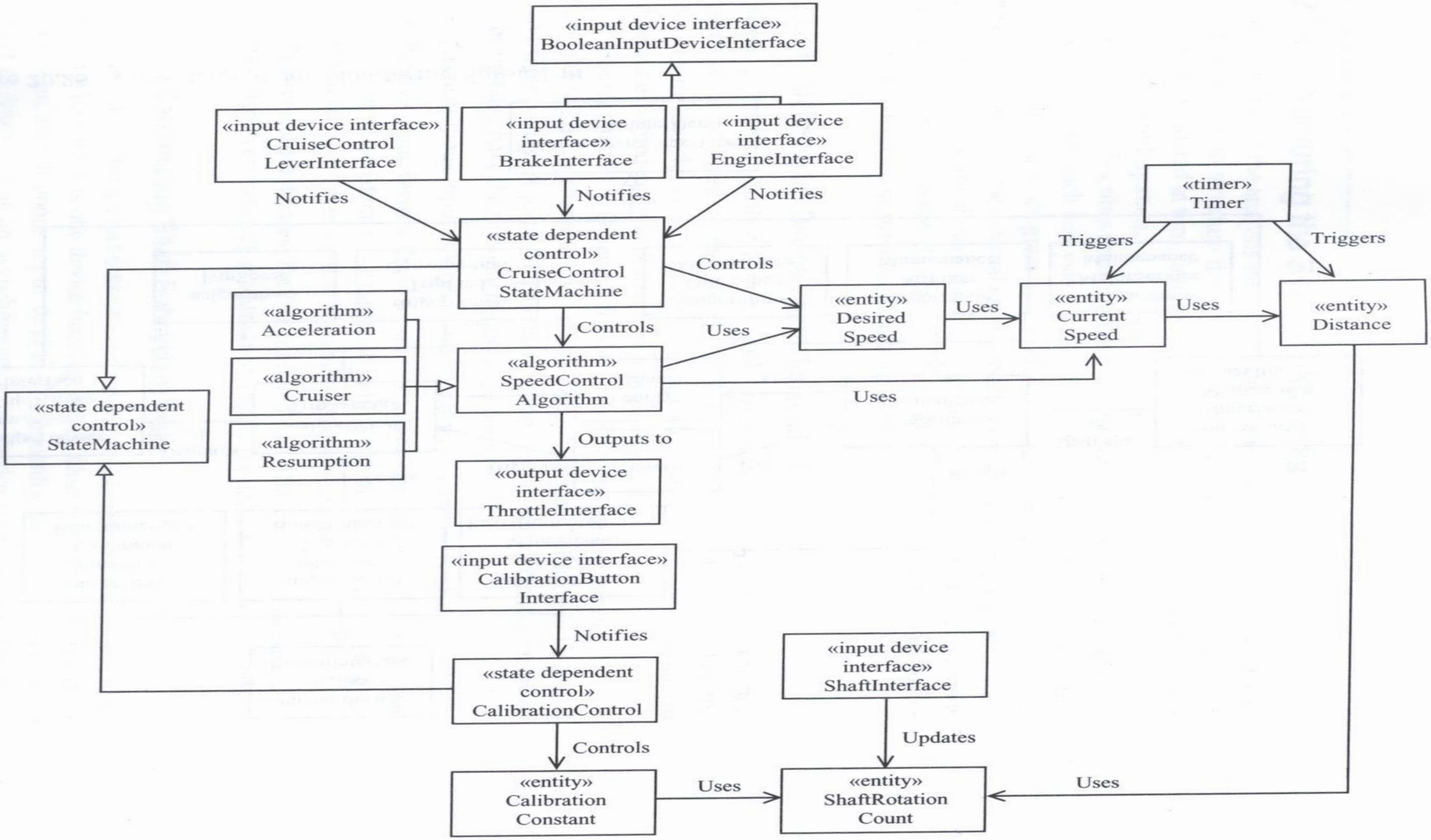


Figure 20.25 *Class diagram for Cruise Control Subsystem*

Example: Auto Cruise Controller initial statechart

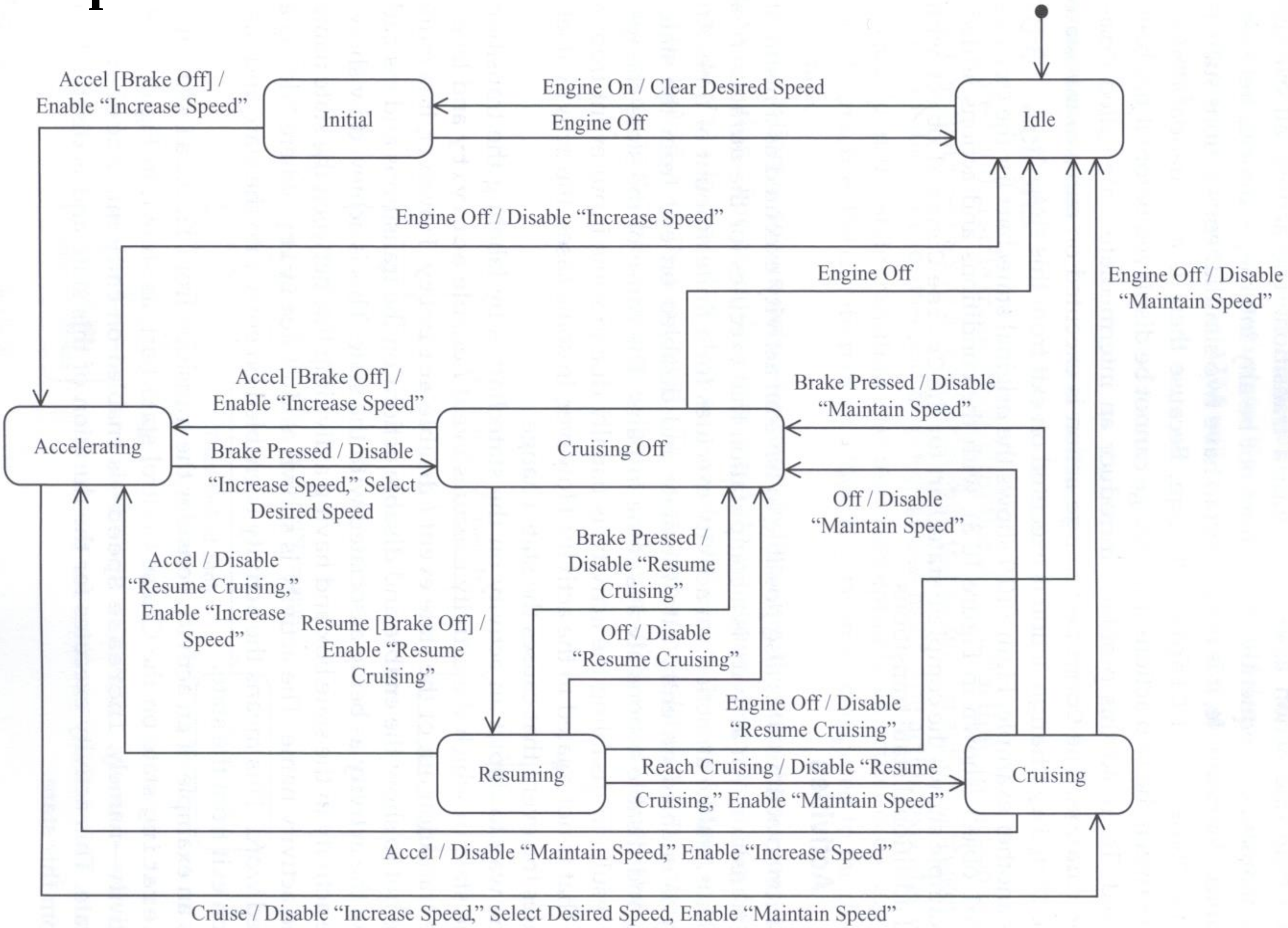


Figure 10.9 *Detailed Cruise Control statechart with actions and conditions*

Example: Auto Cruise Controller Refined statechart

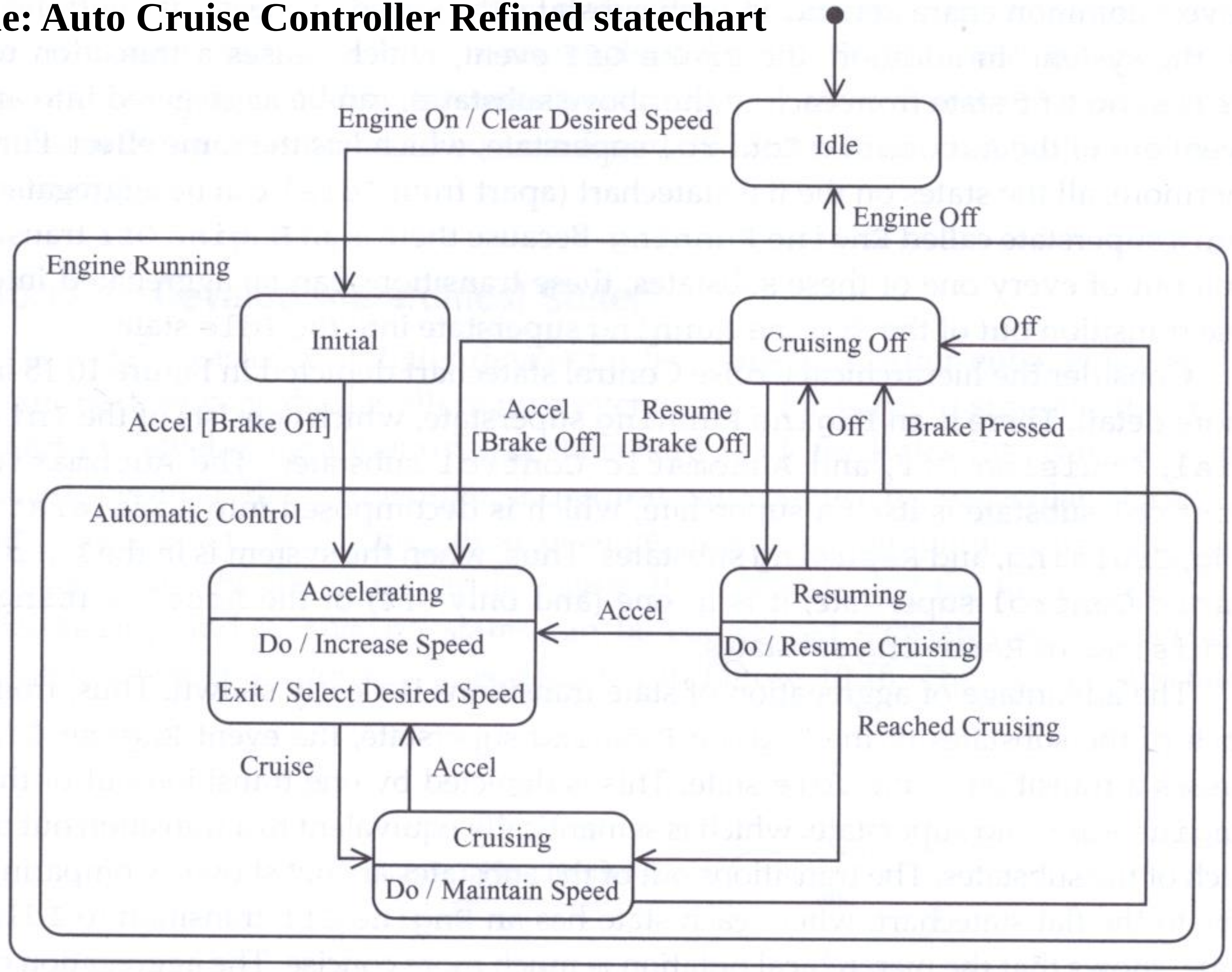
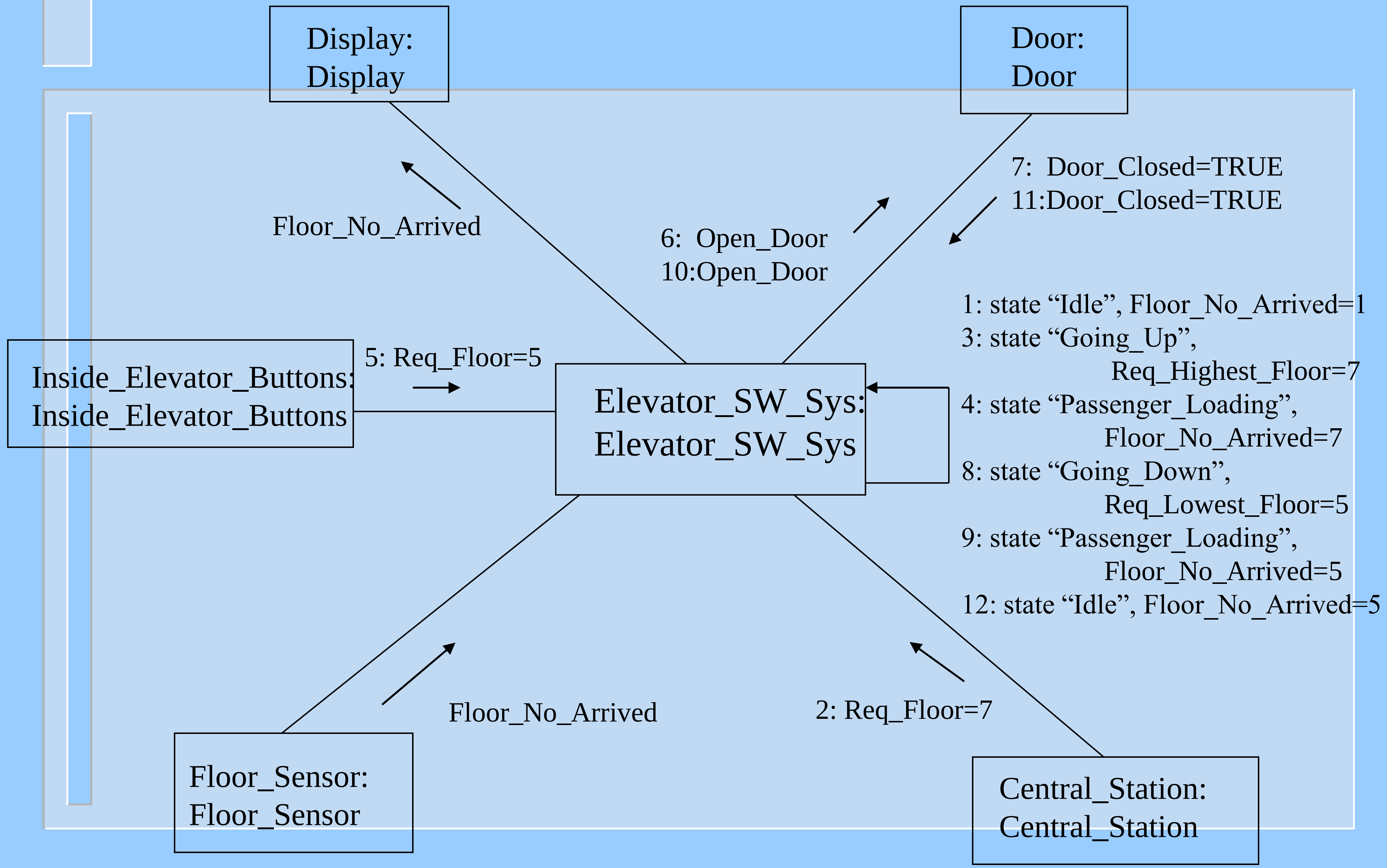


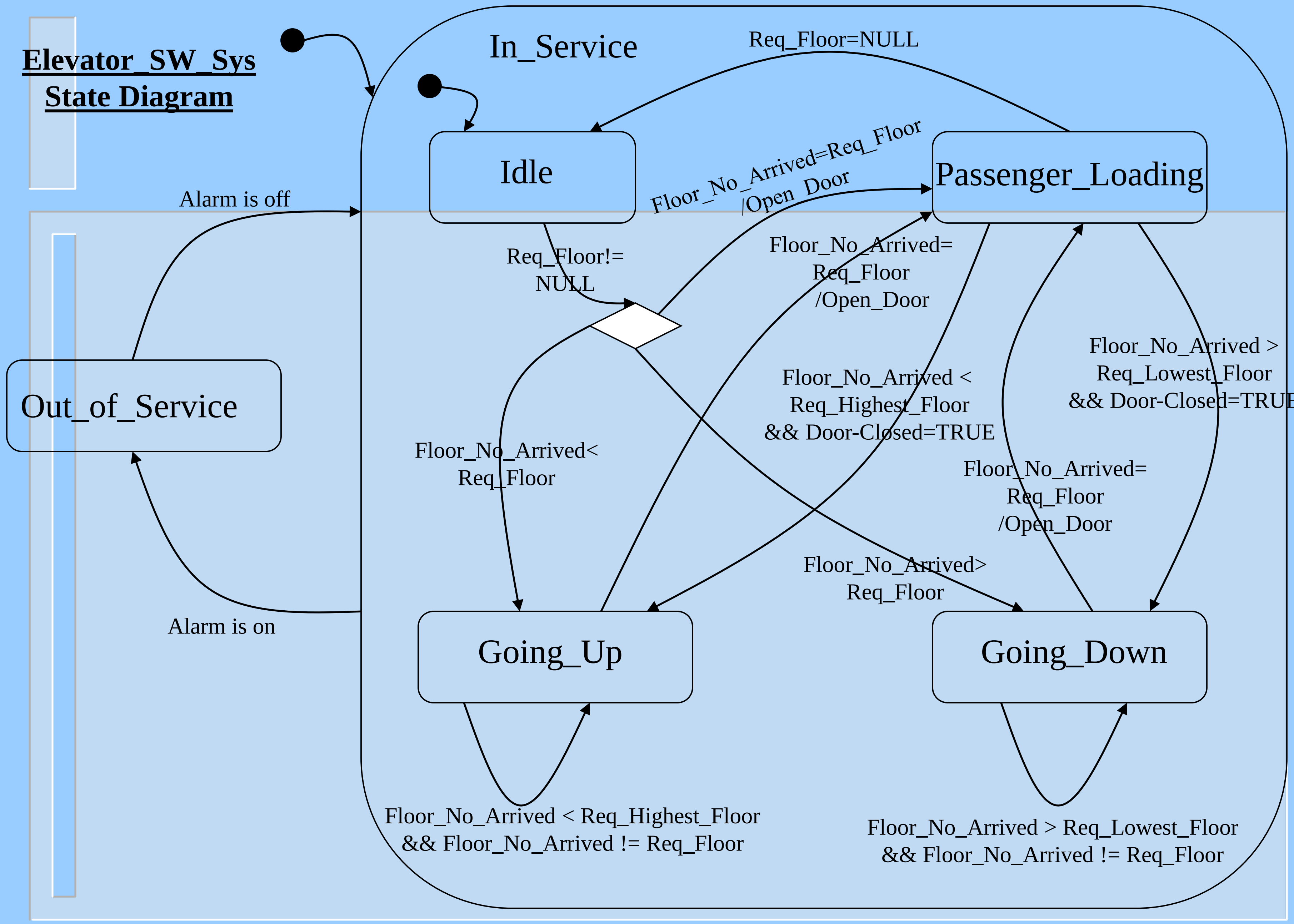
Figure 10.19 *Hierarchical Cruise Control statechart with activities and exit action*

Example: Elevator Control Collaboration Diagram



Scenario of the Collaboration Diagram

- Idle on Floor 1
- Gets request from Floor 7
- Going Up to Floor 7
- Gets request from inside passenger to Floor 5
- Loading on Floor 7
- Going Down to Floor 5
- Loading on Floor 5
- Idle on Floor 5


Elevator_SW_Sys
State Diagram
In_Service
Req_Floor=NULL
Idle
Passenger_Loading
Floor_No_Arrived=Req_Floor
/Open_Door
Alarm is off
Req_Floor!=
NULL
Floor_No_Arrived=
Req_Floor
/Open_Door
Floor_No_Arrived >
Req_Lowest_Floor
&& Door-Closed=TRUE
Floor_No_Arrived <
Req_Highest_Floor
&& Door-Closed=TRUE
Out_of_Service
Floor_No_Arrived<
Req_Floor
Floor_No_Arrived=
Req_Floor
/Open_Door
Floor_No_Arrived>
Req_Floor
Alarm is on
Going_Up
Going_Down
Floor_No_Arrived < Req_Highest_Floor
&& Floor_No_Arrived != Req_Floor
Floor_No_Arrived > Req_Lowest_Floor
&& Floor_No_Arrived != Req_Floor

Example: Elevator Control, a better example

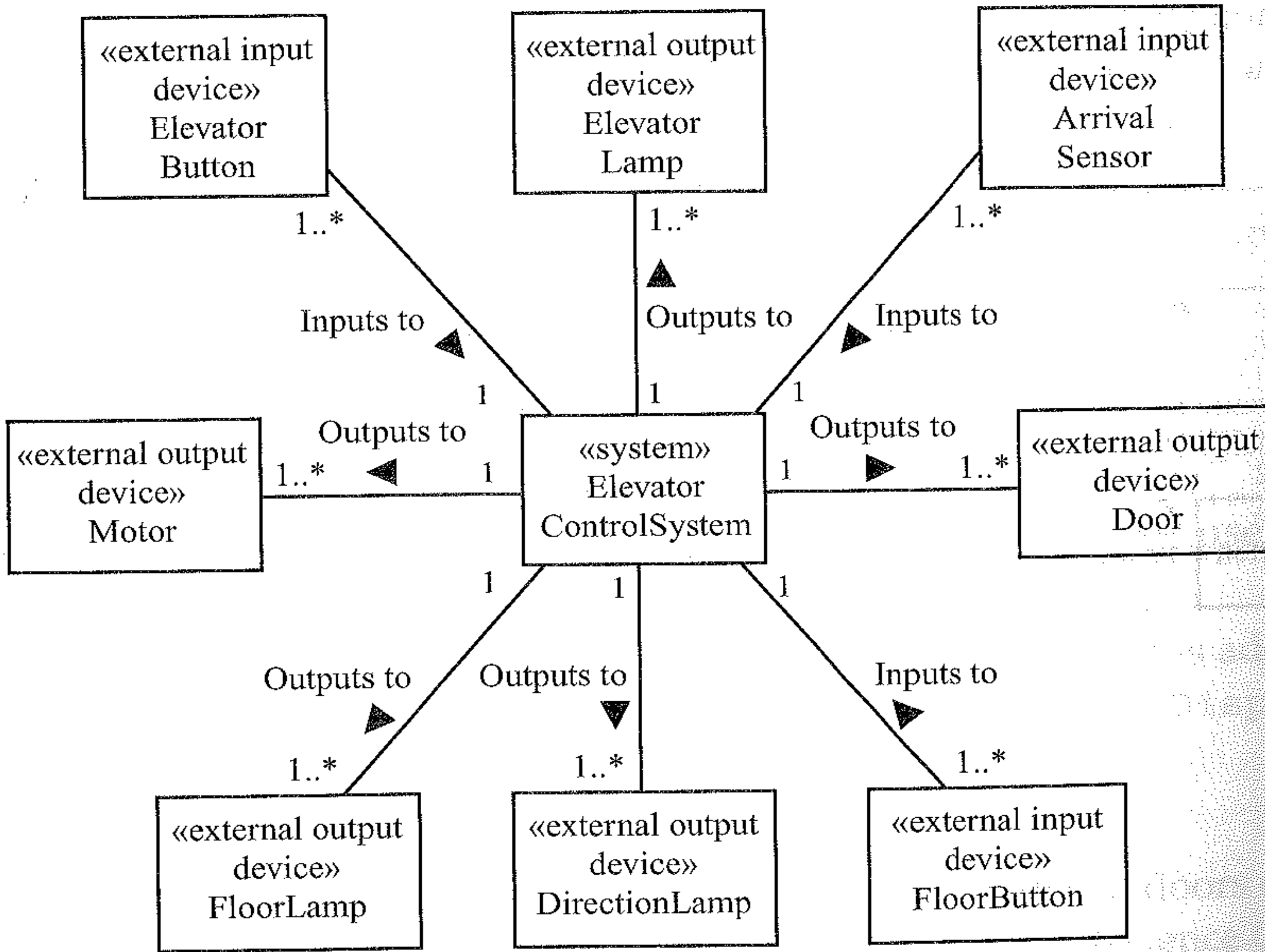


Figure 12.4 *Elevator Control System context class diagram*

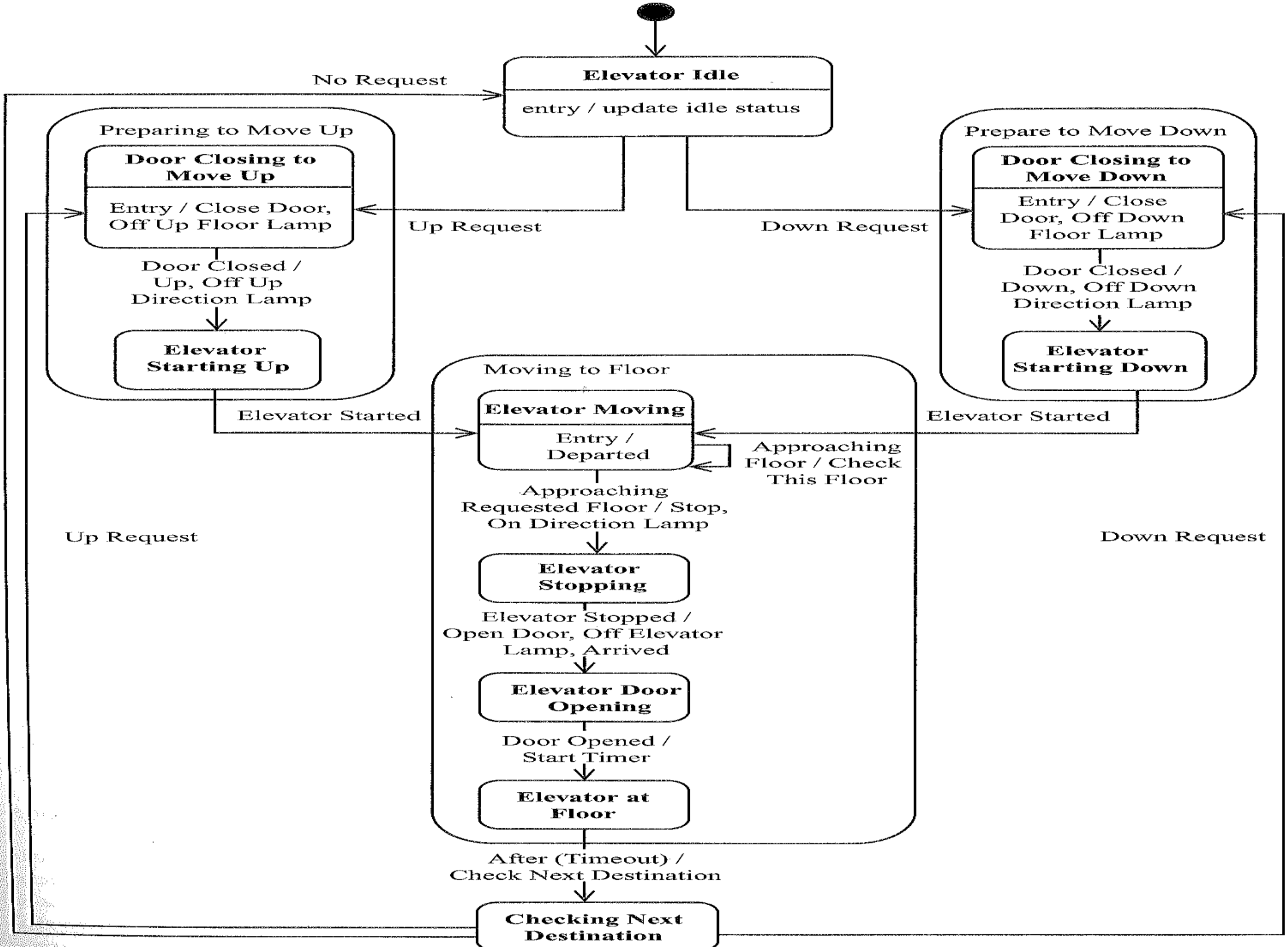


Figure 18.13 *Hierarchical statechart for Elevator Control*

Example: The Pacemaker

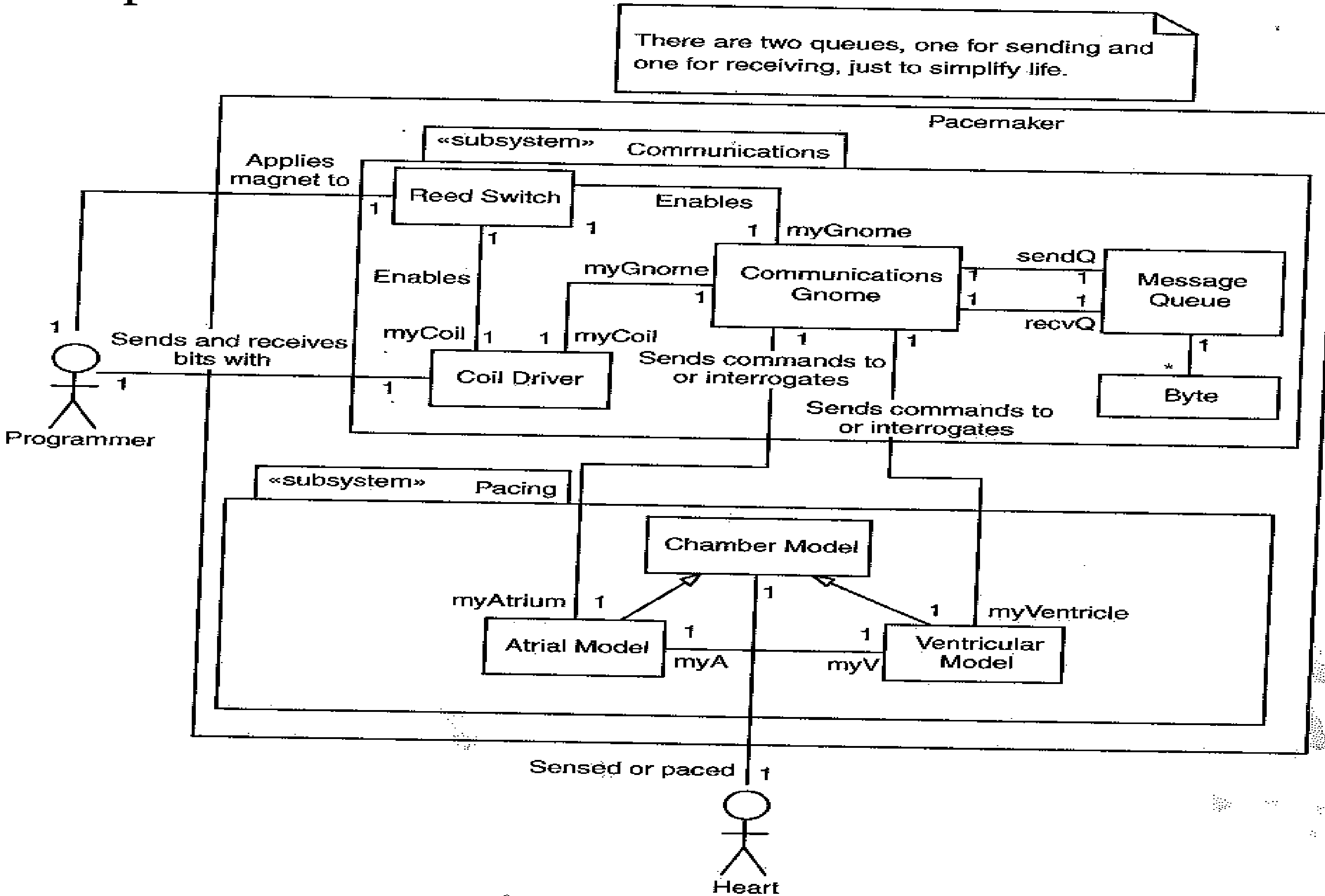


Figure 4-15: *Pacemaker Class Diagram*

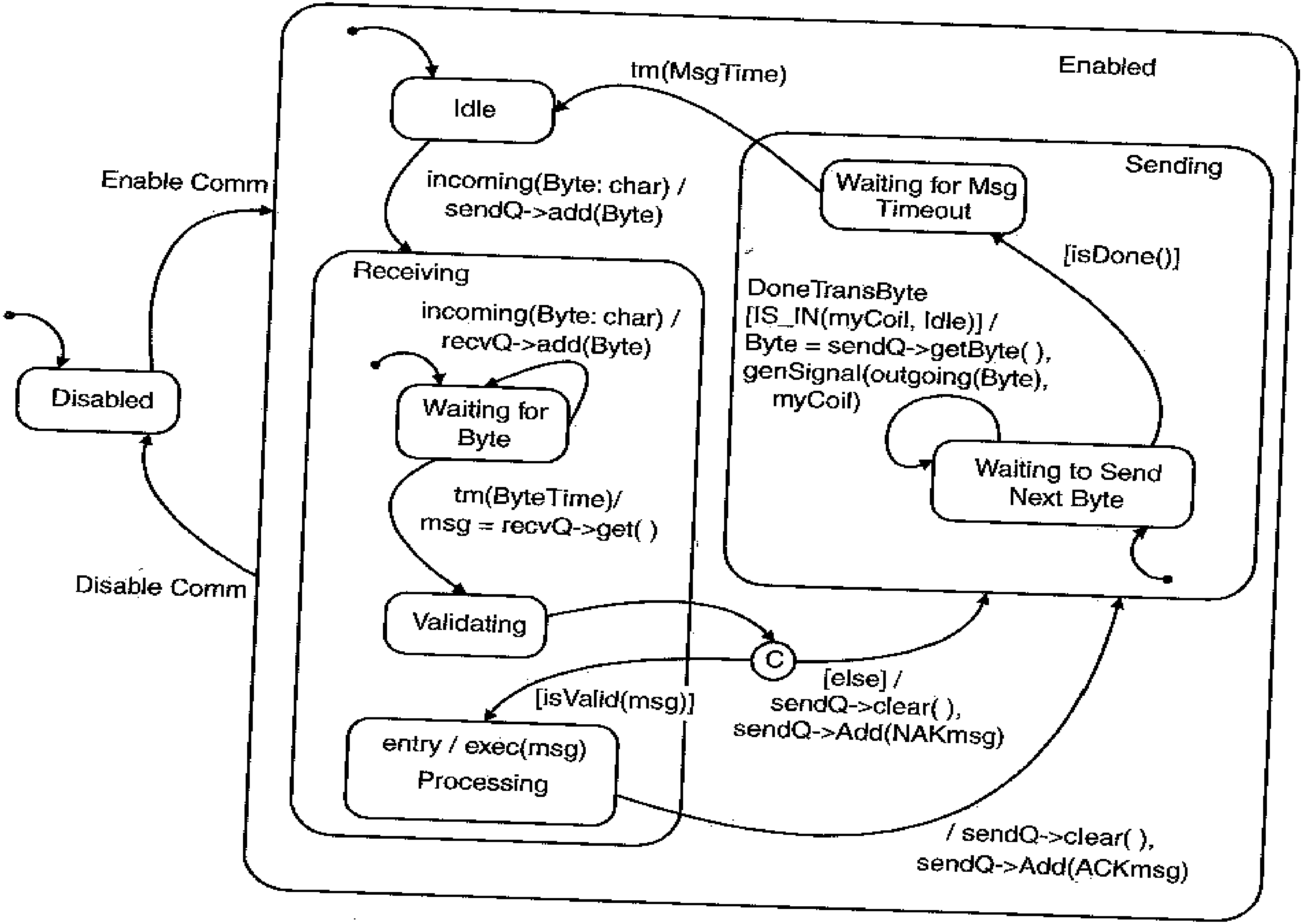


Figure 4-18: *Communication Gnome State Model*

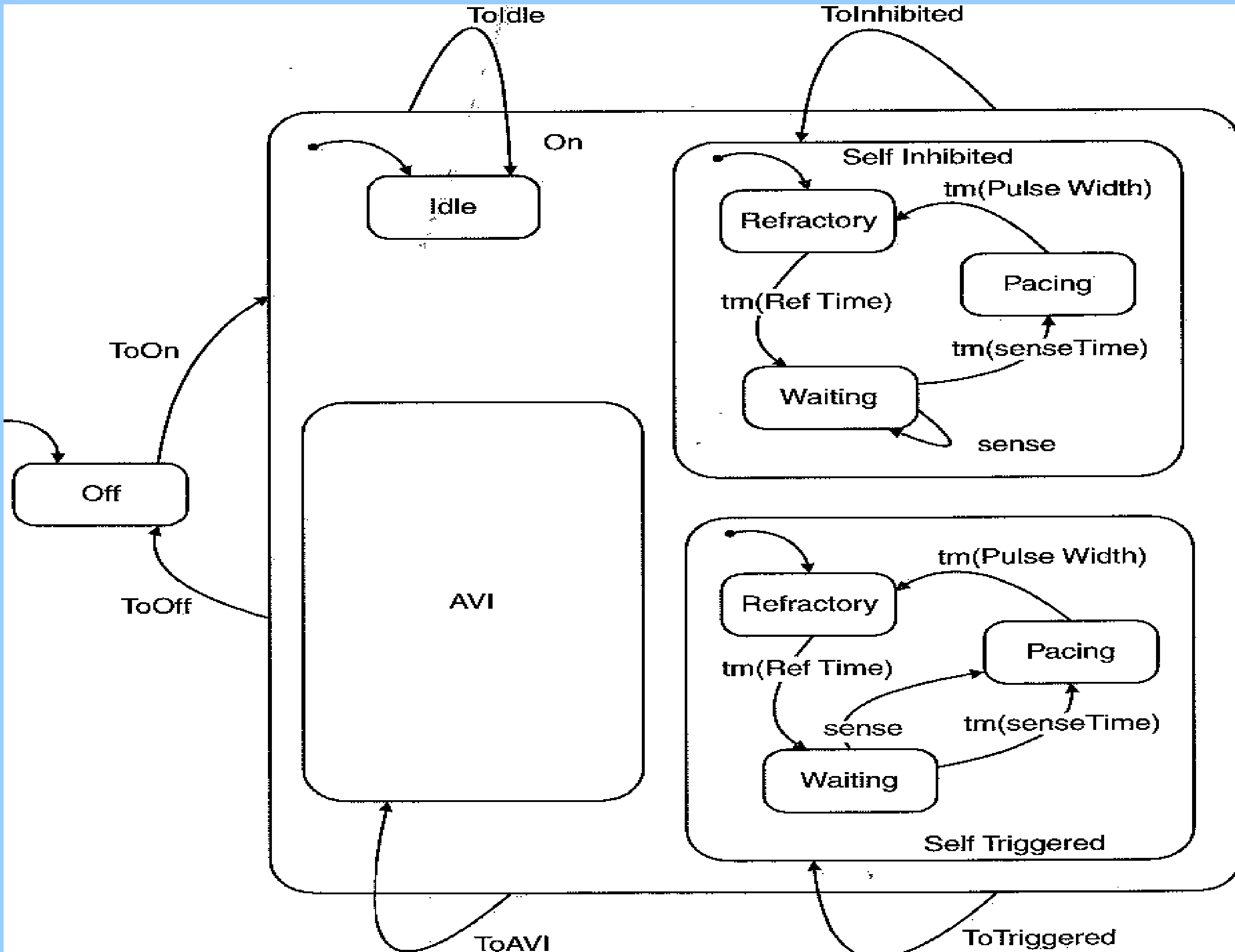


Figure 4-19: *Chamber Model State Model*

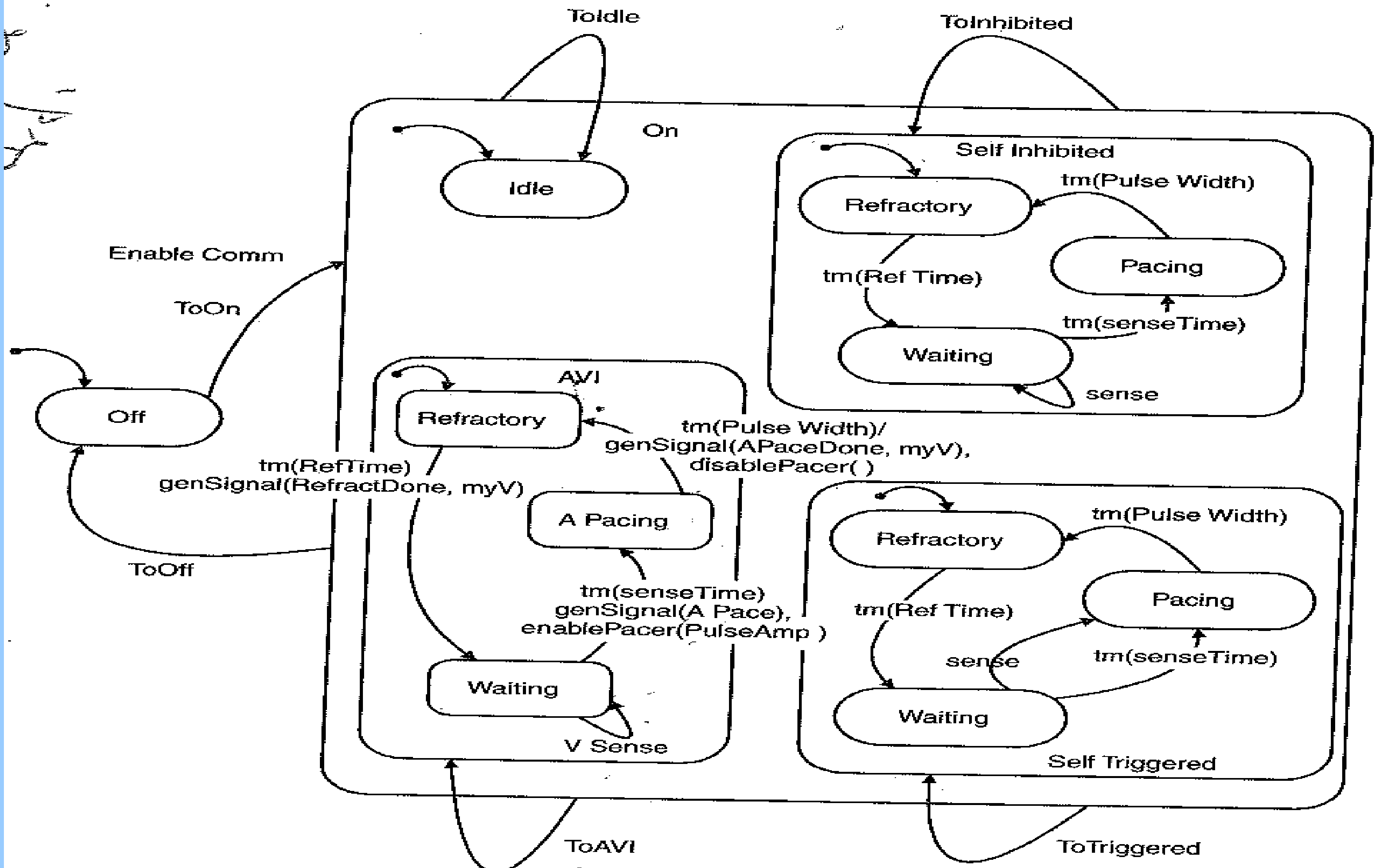


Figure 4-20: *Atrial Model State Model*

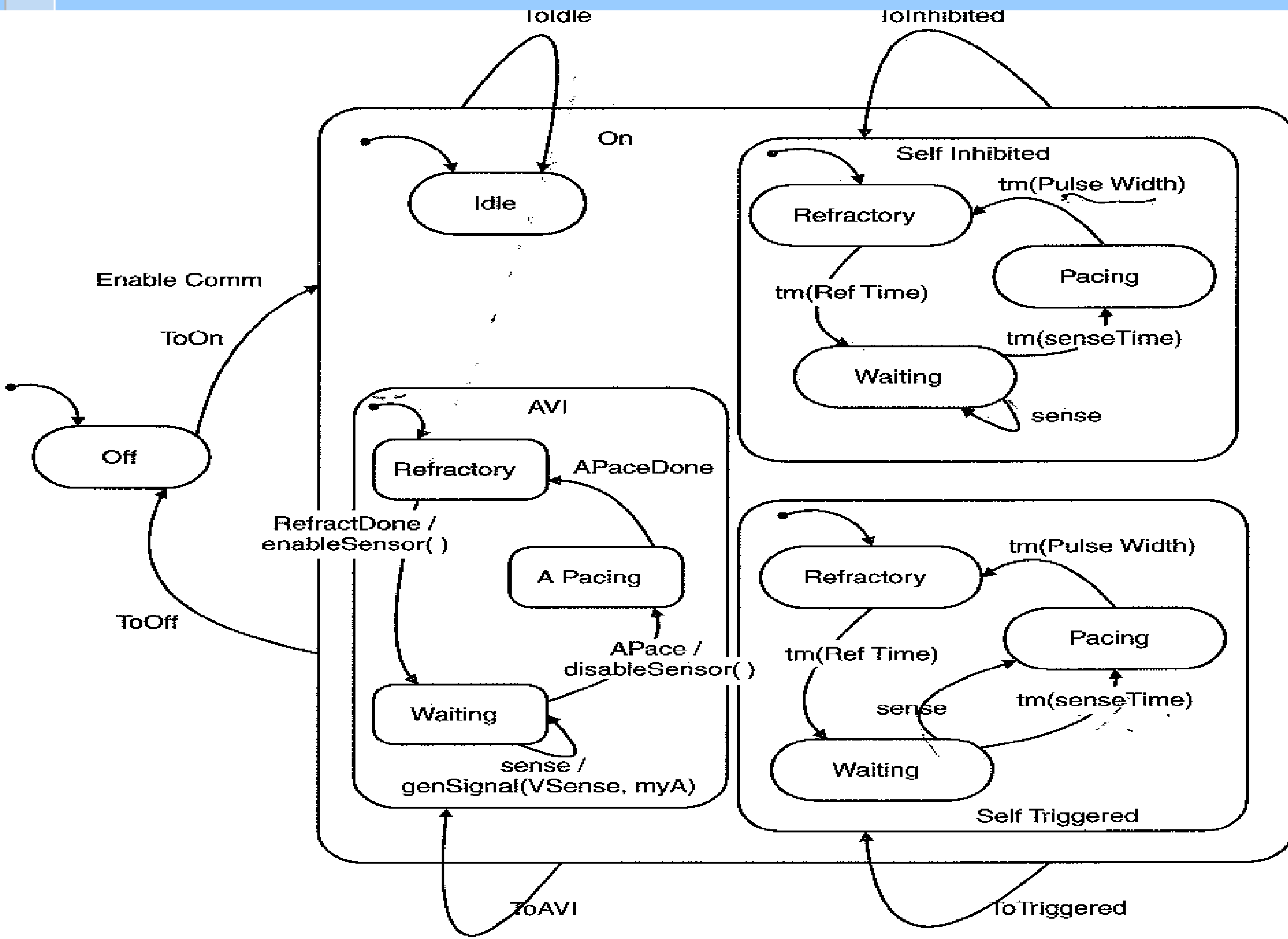


Figure 4-21: *Ventricular Model State Model*