STATEMATE Semantics of Statecharts

EE 249 Journal Paper Presentation

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Basic Step Algorithm

- Algorithm for executing single step of Statecharts
- Inputs
  - –Status of system
  - –Current time (time unit defined by clock rate)
  - –External changes (events, changes in values of conditions and data-items)
- Output:
  - –New system status
- Representation of system status
  - –Active states
  - –System activities
  - –Current values of conditions and data-items
  - –Internal events generated in previous step
  - –Scheduled actions
  - –Timeout events
  - –History of States

Basic Step Algorithm
Stage 1: Step Preparation

- Add external events to event list
- Modify values of conditions, data-items, activities according to external changes
- Evaluate scheduled events
  - Action sc(a,d) adds (a, next-a) to scheduled event list
  - Execute scheduled action 'a' if next-a <= current time
- Evaluate timeout events
  - (E, next-E) in event list
  - E = tm(e, d)
  - If trigger 'e' generated, set next-E
  - Generate timeout event E when next-E <= current time

Basic Step Algorithm
Stage 2: Compute Contents of the Step

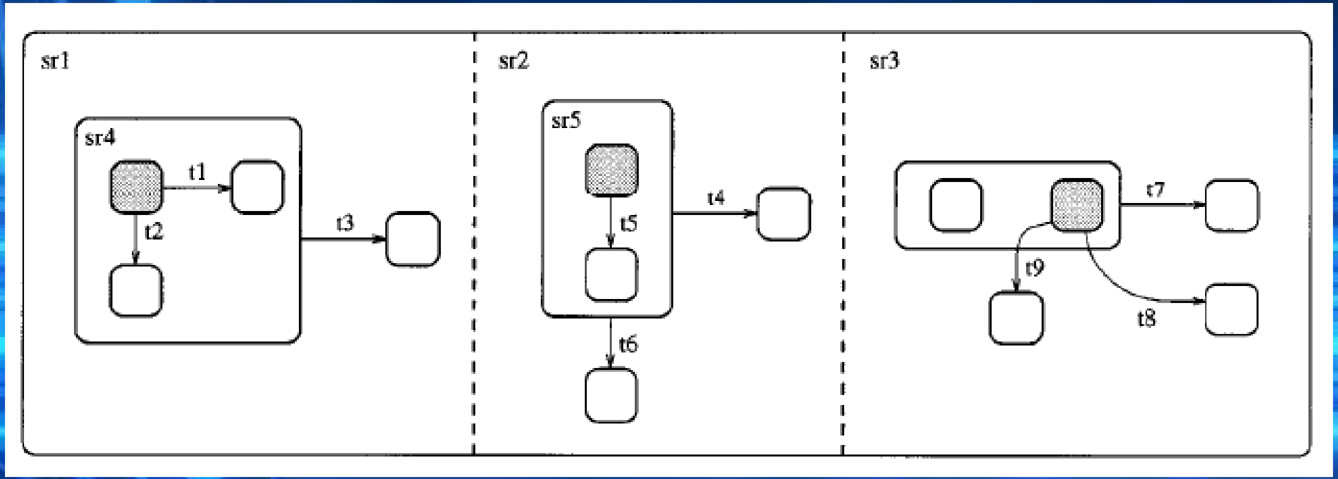
- •Find set of enabled compound transitions (CTs)
- •Eliminate conflicting CTs with lower priorities
- •Construct non-conflicting transition sets from remaining CTs
- •For each non-conflicting set, determine enabled static reactions (SRs)
- •Possible Scenarios
  - –No enabled CTs or SRs – empty step
  - –Single set of CTs and SRs
  - –Multiple sets of CTs and SRs - nondeterminism

Basic Step Algorithm
Stage 3: Execute the CTs and SRs

- For each enabled SR, execute associated action
- For each enabled CT
  - –Update history for parents of exited states
  - –Delete exited states from list of active states
  - –Execute actions associated with
    - States exited by CT
    - CT itself
    - States entered by CT
  - –Add entered states to list of active states

Basic Step Algorithm

Example for Computing Nonconflicting Sets



- Enabled non-conflicting sets
  - {t3,t4,t7,sr1,sr2,sr3}
  - {t3,t4,t8,sr1,sr2,sr3}
  - {t3,t4,t9,sr1,sr2,sr3}
  - {t3,t6,t7,sr1,sr2,sr3}
  - {t3,t6,t8,sr1,sr2,sr3}
  - {t3,t6,t9,sr1,sr2,sr3}

Basic Step Algorithm
Implementation Issues

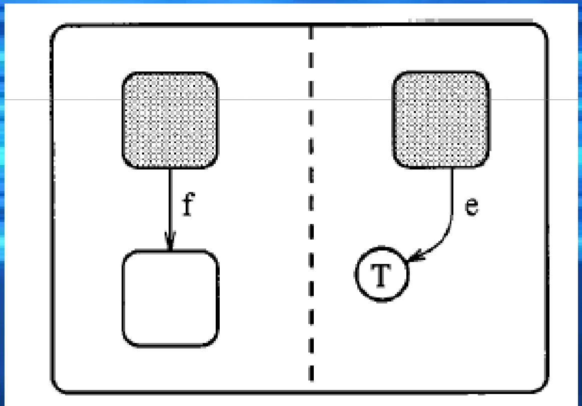
- Assignment of values in two stages:
  - Create list {element, new-value}
  - Assign all values at end of step
  - Insensitive to order of execution
- Conflicting assignments
  - Element assigned value twice in single step
  - Write-write racing
  - Last assignment counts
- Chain reactions
  - Default: activity and subactivities executed in same step
  - Activity with controls: subactivities activated on following step

Basic Step Algorithm
Implementation Issues

- Events generated in a step collected in list as input to next step

- Scheduled events
  - Action sc(a,d)
  - Added to scheduled events list as (a, current-time + d)

- Termination Connector
  - Considered basic state
  - When entered, no more steps executed



Models of Time in Statecharts

- STATEMATE supports two timing models:
  - Synchronous
  - Asynchronous
- Synchronous time model
  - Assume single step executed every time unit
  - Reacts to external changes occurred since end of previous step
- Asynchronous time model
  - Reacts when external changes occur
  - Allows several changes to occur simultaneously
  - Allows several steps at once – superstep
- In both models, execution of step takes zero time

Synchronous Time Model

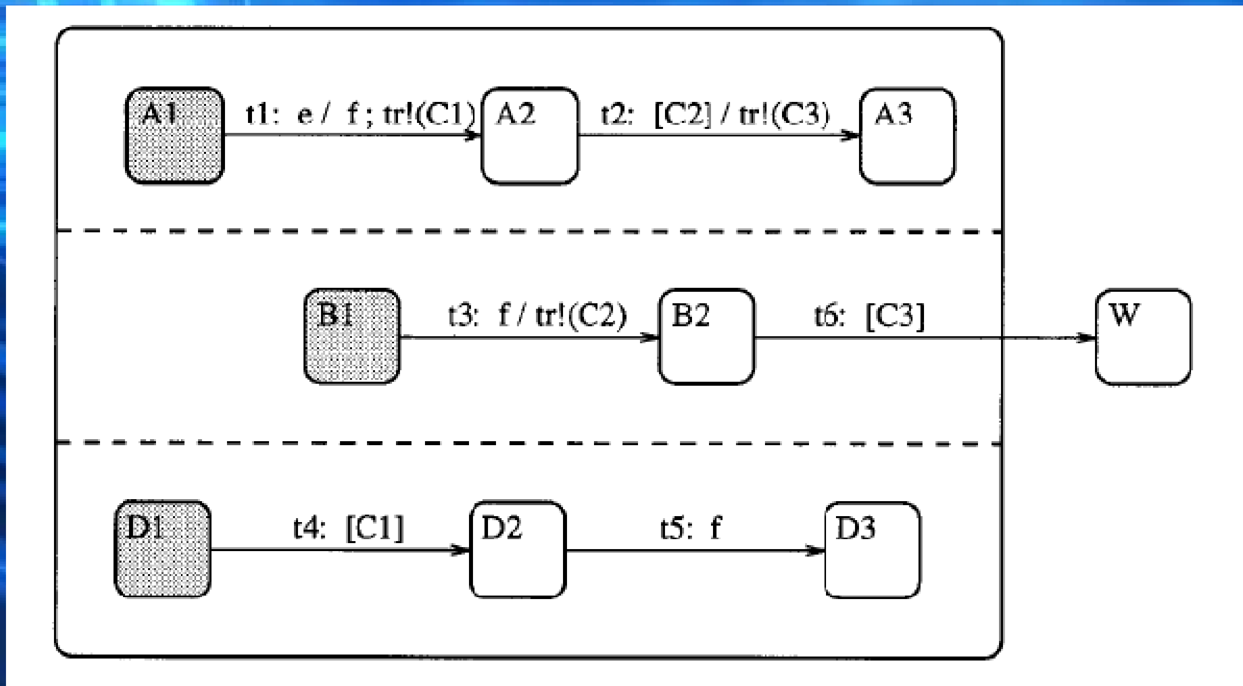
- Suited for systems synchronized on system clock
- In STATEMATE, single step executed using ‘GO’ command
- Semantics for GO (assume previous step at t)
  - Execute external changes since end of last step
  - Increment system clock
  - Execute timeout and scheduled actions with due time in interval (t, t+1]
  - Execute basic step algorithm

Asynchronous Time Model

- Suited for reactive systems
- Execution of step does not advance time
- In STATEMATE, GO-REPEAT command executes superstep
- Semantics for GO-REPEAT
  - Execute external changes since end of last step
  - Execute timeout and scheduled actions that are due
  - Execute basic step algorithm until system in stable state (no generated events, no enabled CTs, SRs)
- GO-REPEAT may result in infinite loop

Asynchronous Time Model

- Example of GO-REPEAT execution
  - –Assume C1, C2, C3 false, and event e generated



Asynchronous Time Model

- To advance time, need to execute GO-ADVANCE
- Assume current time = t, want to advance to time t + n
- Semantics for GO-ADVANCE
  - Execute external changes since end of last step
  - Repeat until time = t + n
    - Execute due timeout and scheduled events
    - Execute GO-REPEAT
    - Increment time to nearest timeout or scheduled event

Asynchronous Time Model

- Other commands supported by STATEMATE:
  - GO-STEP
  - GO-NEXT
  - GO-EXTENDED
- GO-STEP: perform single step without advancing time
- GO-NEXT: advance clock to nearest timeout or scheduled event
- GO-EXTENDED: combination of GO-NEXT and GO-REPEAT
  - Advance clock to nearest timeout or scheduled event
  - Execute timeout and scheduled events
  - Execute superstep

STATEMATE Generated Code

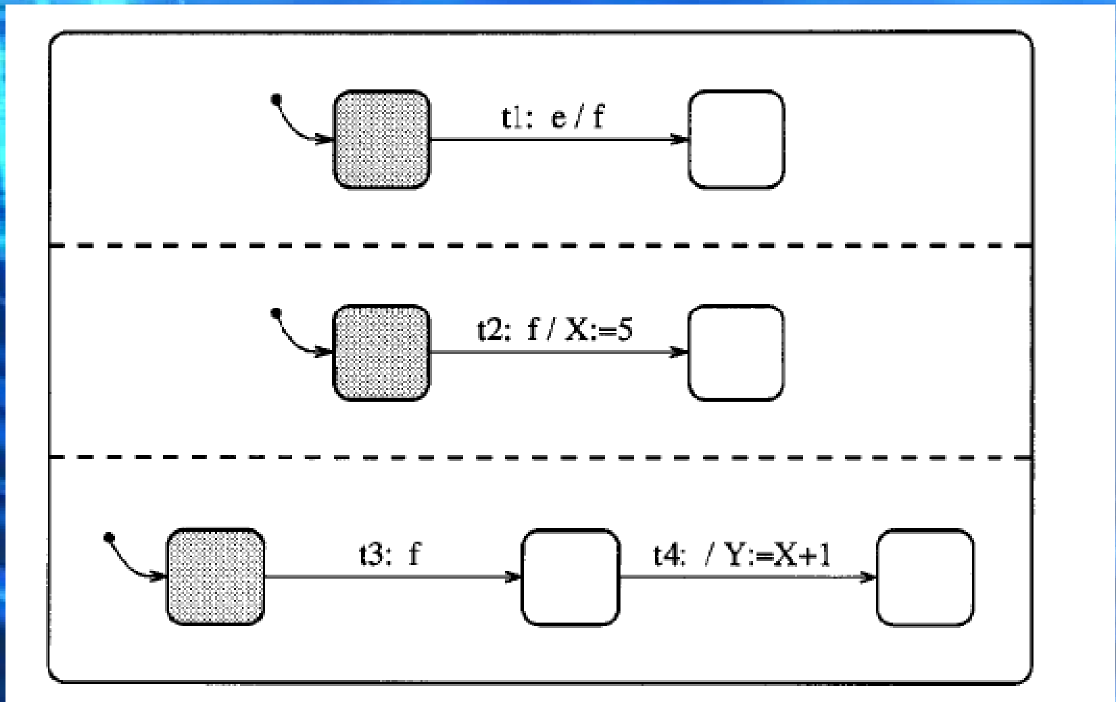
- RTL code style
  - VHDL or Verilog code
  - Steps sensitive to rising or falling edge of clock
  - Similar to synchronous mode
- Behavioral code style
  - Reacts to input changes when they occur
  - Similar to asynchronous mode
- Two schedulers
  - CPU clock time – steps take more than zero time
  - Simulated clock – advances time only when system reaches stable state

Racing Conditions

- Two cases:
  - –Value of element modified more than once at single point in time
  - –Value of element modified and used in single point in time
- Transitions or actions in one step can be in conflict with another step
- Racing conditions in superstep
  - –Enabling order: each transition must be executed after the transition that enabled it
  - –If two executions obeys enabling order but produce different results, then racing detected

Racing Conditions

- Example of racing



Multiple Statecharts

- Can be interpreted as orthogonal components in a superstate
- Used to represent concurrency
- Termination of one statechart does not affect others
- Statecharts can be reactivated in default configuration
- Asynchronous model – All statecharts executes superstep at same time
- Synchronous model – Each statechart may have different time units for evaluating time expressions

Multiple Statecharts

- Example of multiple statecharts