

State Charts

sT-Embed Training

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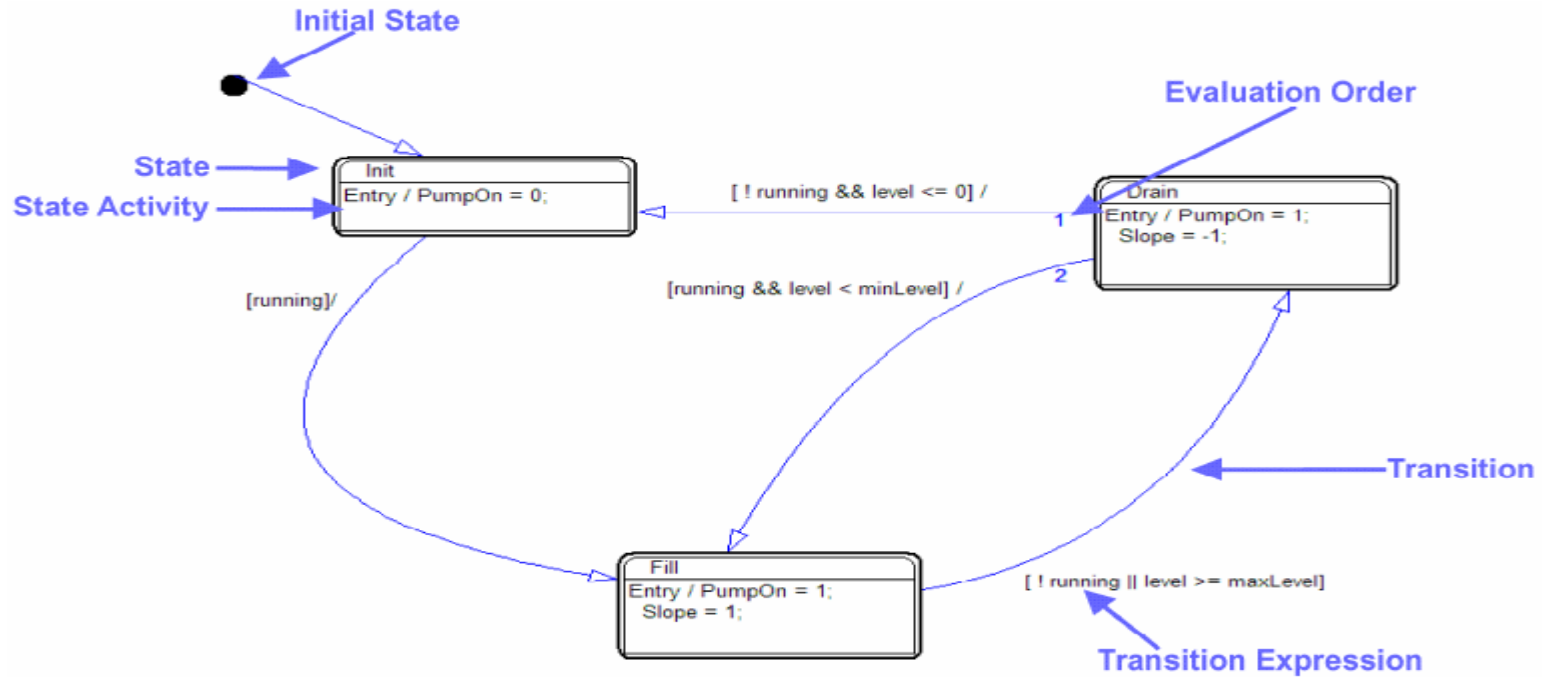
Topics:

- Creating State Charts
- Hierarchy
- Transitions
- Debugging/Logging
- Embedded Considerations

Introduction & Basic Elements of a State Chart

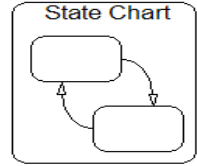
- Introduction
 - A graphical representation of a finite-state machine
 - A system with a fixed number of named states. Transitions between states occur when certain conditions are met.
 - sT-Embed State Charts are OMG UML 2.1 conformant
 - Create state charts anywhere in a sT-Embed diagram
 - Exchange data between the state chart and the continuous portion of a diagram
 - Use sT-Embed variables or Triggers in chart, as well as defined input and output pins
- Basic Elements
 - States – set of named system configurations
 - Transitions - control movement between states
 - Pseudo states – Alter transition operation
 - Behaviors- code associated with transitions and state events
 - Triggers – named events that can cause transitions or code to be executed

Example State Chart



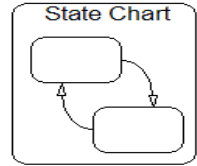
Creating a State Chart

- Step 1: From the “State Chart” menu, select a “state chart” block and place it on the screen.
- Step 2: Define the I/O between the sT-Embed model and the state chart. This can be done either using sT-Embed globally scoped variables or defining inputs and outputs to the state chart using connector names.
- To exchange data between the sT-Embed model and the state chart using Variables.
 - State chart variables are declared in the State Chart Block Properties
 - Activate View > Connector Labels to see the pin names
- To exchange data between the sT-Embed model and the state chart using input and output variables:
 - Add Connector command (or toolbar button)
 - Or ctrl+right click the state chart block and click Data Browser. Data Browser gives you ability to choose name, data type and storage for each variable



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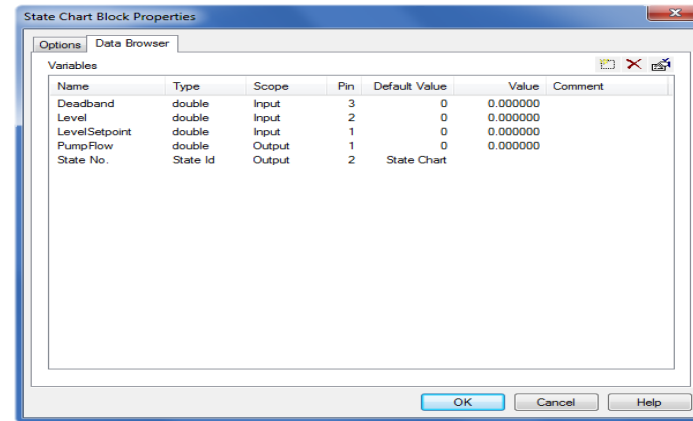
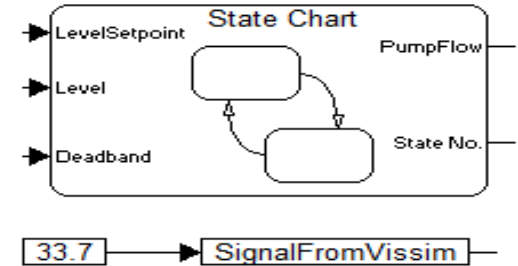
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Step 2: Use the “+” icon to add inputs and outputs to the state chart, Left click on each input and output and define names. The names become internal variables that can be used within the state chart.

Creating a State Chart

- Step 2 (Cont): For our state chart we'll use both connector names and "SignalFromEmbed"

You can see the connector names and their definition by CTRL-right clicking on the state chart block and selecting the "Data Browser" tab.



Creating a State Chart Example Step 1

Creating a State Chart

- Step 3: Right click on the state chart to enter it, from the “State Chart” menu, Insert an “Initial State” and two “state” blocks.
- Step 4: Create Transitions
- Position the cursor over the edge of a source state. The cursor shape changes to a pencil
 - If the cursor is a crosshair with arrow heads, moving the mouse moves the state rather than draws the arc.
- Depress the mouse and drag into the target state body.
 - If the state is a composite state, you may connect to a state within the composite state.
- Release the mouse button.

[Creating a State Chart Example Step 2](#)

Controlling Transitions

- Step 5:
- You can use triggers and C expressions to control if and when transitions are taken
- Double click on Transition to edit
 - Transition syntax: trigger(s) [guard] / C-code
 - Guard is C expression
 - Triggers and guard are optional, but '/' is not
 - All triggers and guard must be true to execute transition and C-code

We will use C expressions for our transitions. The expression is contained in square brackets [...] and may use the named connector variables and the sT-Embed global variables created in Step 2. We'll create the following transition controls

From State1 to State2:

`[(LevelSetpoint - Level) > Deadband + SignalFromEmbed]`

From State2 to State1

`[(LevelSetpoint - Level) < -Deadband]`

[Creating a State Chart Example Step 3](#)

Configuring States

- Step 6:
- Right click in State title bar to open properties
 - Options tab gives name and comment fields and shows some activity code (not editable)
- Activity Manager Tab lets you associate C-code to be called on certain events (actions)
 - Entry – on State entry
 - Exit – on State exit
 - Do – while in State
 - On trigger – when in State and trigger is True
- C Code Expression Rules
- ANSI C expressions, statements and functions are OK.
 - Can put initial C file in Sim Properties> Preferences > startup script file
- Standard library math functions (pow, abs, exp, min, max etc)
- No preprocessor commands supported (#define, #if, #else)

Configuring States

For our model, we'll configure the both State1 and State2 to act on ENTRY. We will use the two states to set the value of the pinned out variable, "PumpFlow"

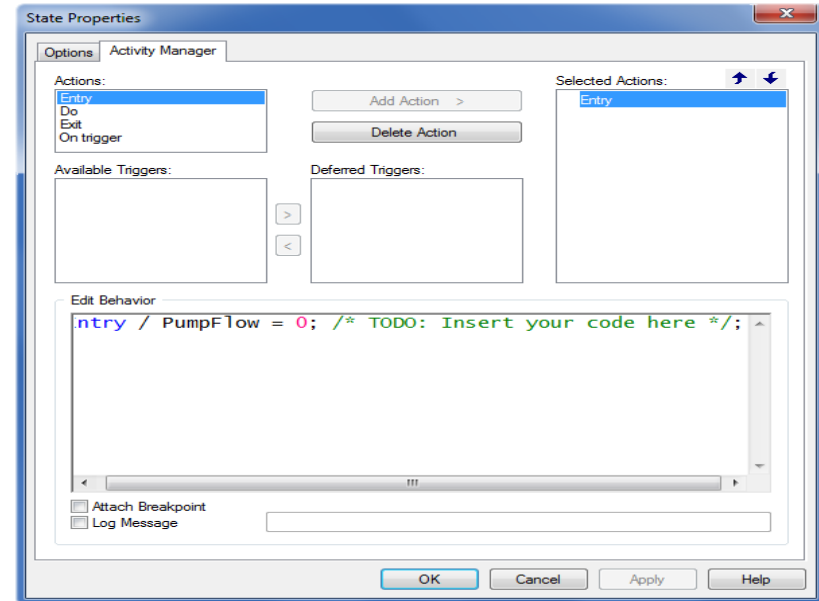
State1 will set PumpFlow = 0

State2 will set PumpFlow = 1

Configuring States

Here is the edit on State1

- A. Right click on the state to view “properties”
- B. Select “Activity Manager” tab
- C. Select the action, we are using “Entry”
- D. Click on “Entry” in “Selected Actions”
- E. In “Edit Behavior” you enter your C expression between the “/...../”, here we have entered “PumpFlow = 0;”



[Creating a State Chart Example Step 4](#)

Test the State Machine

We'll test our state machine to control a pump system that pumps fluid into a container with a drain, so if the pump stops, the container will eventually drain out.

State Chart Pump Control

Transition Evaluation Order

- Multiple output transitions have an evaluation order indicated by number near start of arc
- To change, right click transition, select “Reorder Transitions”
 - Click transitions in order of desired execution
- Transitions with no trigger are always evaluated after transitions with trigger (regardless of order number)
- At most one transition fires per Chart Region during one simulation or codegen timer tick.

End of Section