

State Machine Generator User Manual

System Documentation

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Contents

1 Overview

This tool generates a safety-critical Hierarchical State Machine (HSM) in Rust from a YAML definition. It supports advanced features like orthogonal regions (parallelism), history patterns, and complex decision trees.

2 Generating the Code

The generator is a Python script (`sm-builder.py`) that validates your model and produces Rust code.

```
# Basic Usage
python3 sm-builder.py model.yaml

# Specify Output Language (Default is Rust)
python3 sm-builder.py model.yaml --lang rust
```

Listing 1: Command Line Usage

2.1 Outputs

- `statemachine.rs`: The complete Rust implementation.
- `statemachine.dot`: A Graphviz visualization of your logic.

3 Integration & API

3.1 The Main Loop

The generated code provides a `StateMachine` struct. You must initialize it and call `tick()` cyclically.

```
mod statemachine;
use statemachine::StateMachine;

fn main() {
    let mut sm = StateMachine::new();

    // Initialize inputs (accessing public context)
    sm.ctx.counter = 0;

    // Execution Loop
    while sm.is_running() {
        // 1. Advance logical time (if using timers)
        sm.ctx.now += 0.1;

        // 2. Run logic
        sm.tick();

        // 3. Debug Output
        println!("Current State: {}", sm.get_state_str());

        std::thread::sleep(std::time::Duration::from_millis(100));
    }
}
```

Listing 2: Example main.rs

3.2 Public API Methods

These methods are available on the `StateMachine` instance (`sm`) or its context (`ctx`).

Function	Location	Description
<code>tick()</code>	<code>sm</code>	Executes one cycle of logic (Do-activities & Transitions).
<code>is_running()</code>	<code>sm</code>	Returns <code>false</code> if the machine has terminated.
<code>get_state_str()</code>	<code>sm</code>	Returns a string representation (e.g., <code>/run/active</code>).
<code>in_state_X()</code>	<code>ctx</code>	Returns <code>true</code> if state <code>X</code> is currently active.

Example Usage of `in_state`: Inside a guard or action, you can check peer states:

```
guard: ctx.in_state_heater_on() && ctx.temperature > 50.0
```

4 Writing Code in Hooks & Actions

All logic hooks (`entry`, `do`, `exit`, `action`) allow you to write Rust code directly.

4.1 Available Variables

The following variables are injected into the scope of your Rust snippets:

Variable	Type	Availability	Description
<code>ctx</code>	<code>&mut Context</code>	All	The shared context struct holding your data.
<code>time</code>	<code>f64</code>	All	Time elapsed (seconds) since entering the current state.
<code>t_src</code>	<code>&str</code>	Action / Hook	The full path of the state being left.
<code>t_dst</code>	<code>&str</code>	Action / Hook	The full path of the target state.

Note: `t_dst` is not available if the transition targets a Decision Tree, as the final destination is not yet known.

5 Transitions

A transition determines how the machine moves.

5.1 Transition Flow

When a transition fires:

1. **Guard Check:** Is the condition true?
2. **Action Execution:** Run the `action` code.
3. **Exit Chain:** Run `exit` hooks for source state and parents.
4. **Entry Chain:** Run `entry` hooks for target hierarchy.
5. **Initialization:** Run `initial` transitions for composite targets.

5.2 Using Actions (The Mealy Aspect)

The `action` keyword allows you to execute code *during* the transition, before the old state is exited. This is ideal for logging, sending messages, or arithmetic that depends on the transition event itself.

```
states:
  reading:
    transitions:
      - guard: ctx.value > 100
        action: |
          println!("Alert: Moving from {} to {}", t_src, t_dst);
          ctx.log_alert("Threshold Exceeded");
        to: alert_mode
```

Listing 3: Example using Action variables

5.3 Path Syntax

The `to:` keyword supports several addressing modes:

- `/absolute/path`: Starts from the root. Use for long jumps.
- `sibling`: Looks for a state in the same parent.
- `./child`: Looks for a direct child of the current state.
- `../uncle`: Moves up one level, then finds a sibling.
- `..`: **Self-Transition**. The state exits and immediately re-enters.

5.4 Transition Scenarios

Lateral (Sibling to Sibling)

- **Exits:** A
- **Enters:** B

Drill Down (Parent to Child)

- **Exits:** None (P remains active).
- **Enters:** C

Move Up (Child to Parent/Uncle)

- **Exits:** C
- **Exits:** Parent P.
- **Enters:** U

6 Orthogonal States (Parallelism)

An orthogonal state runs multiple child regions simultaneously. **Keyword:** `orthogonal: true`

6.1 Fork Transitions (Drilling Down)

You can enter an orthogonal state by targeting its children directly.

1. **Implicit Fork:** `to: /run/g/a/sub_state`
The generator forces region `a` to `sub_state`. Other regions start normally.
2. **Explicit Fork:** `to: /run/g/[a/sub_state, b/other]`
Explicitly sets the target for multiple regions at once.

6.2 Joining (Synchronization)

To "join" parallel states, transition from the **Parent** based on the status of the **Children**.

```
# Parent State
main_task:
  orthogonal: true
  states:
    A:
      states:
        working:
          transitions:
            - guard: done
              to: finished
          finished: {} # Idle wait state
    B:
      # ... similar logic ...

# Transition on the Parent Container
transitions:
  - guard: ctx.in_state_A_finished() && ctx.in_state_B_finished()
    to: next_step
```

7 Decisions (Logic Trees)

Decisions allow you to externalize branching logic. A decision node can point to states, or **chain to other decisions**.

Restriction: You cannot use `action` or `hooks` inside a decision block. Actions must be placed on the transition *leading to* the decision, or on the state transitions following it.

1. **Define the Decision (Root Level):**

```
decisions:
  validate_input:
    - guard: ctx.input < 0
      to: /error/negative
    - guard: ctx.input > 100
      to: check_permissions # Chaining to another decision
    - to: /process/calc      # Default

  check_permissions:
    - guard: ctx.is_admin
      to: /admin/override
    - to: /error/denied
```

2. **Use the Decision:**

```
transitions:  
  - guard: ctx.data_ready  
    to: validate_input
```