Hardware Modeling [VU] (191.011)
– WS25 –
Finite-State Machine Modeling

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WS 2025/26

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Motivation

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  - Draw FSMs as graphs (nodes for states, edges for transitions)
  - Implementation derived by tools

Common FSM Model

Behavior Description

The `simple_timer` module keeps an internal `N`-bit counter that is (synchronously) incremented as long as `en` is asserted. When the counter reaches its maximum value ($2^N - 1$) it overflows back to zero. If the counter hits its maximum and `en` is asserted the `tick` output is asserted.

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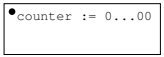

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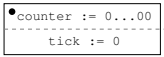

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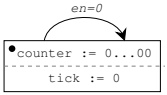

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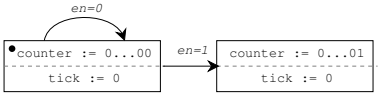

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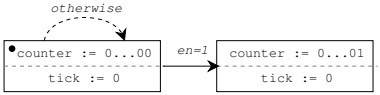

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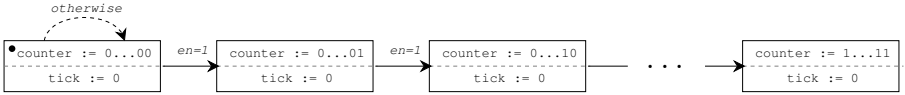

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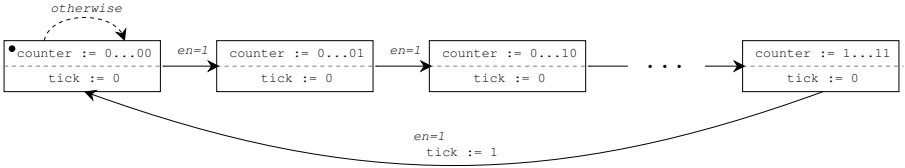

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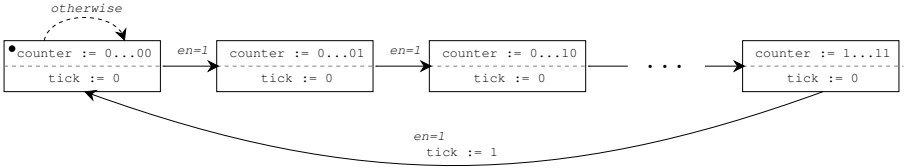

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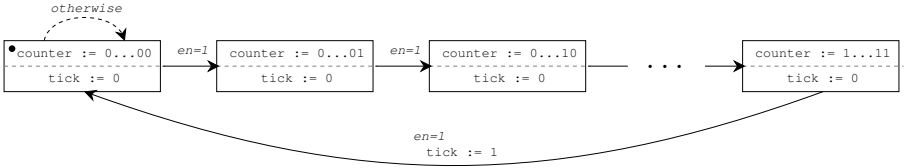
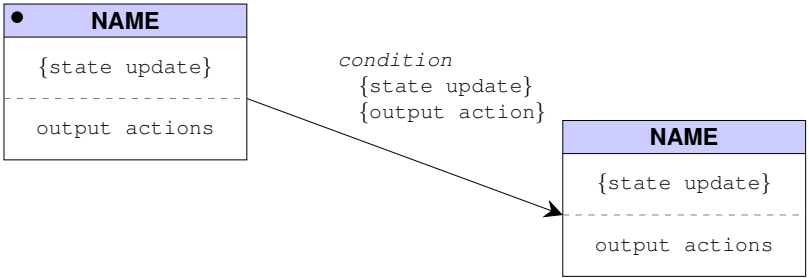


2^N states$\Rightarrow$ Scaling poorly! (“state explosion”)

HWMod FSM Model

- Need more abstract FSM model



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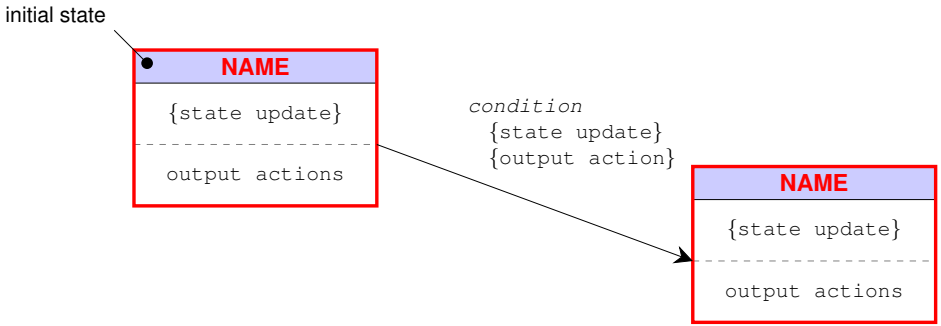
- Need more abstract FSM model
  - “Abstract states” gather multiple states with similar behavior



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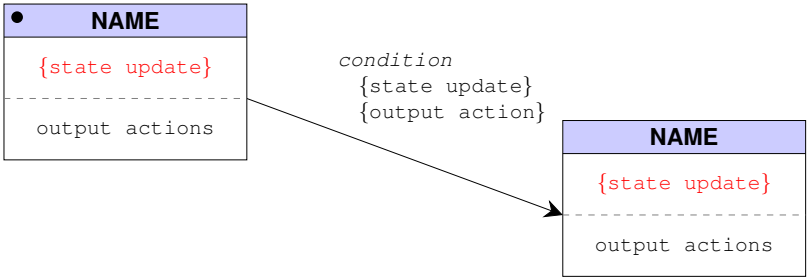
- Need more abstract FSM model
  - Optional assignment to state register; per default value unchanged



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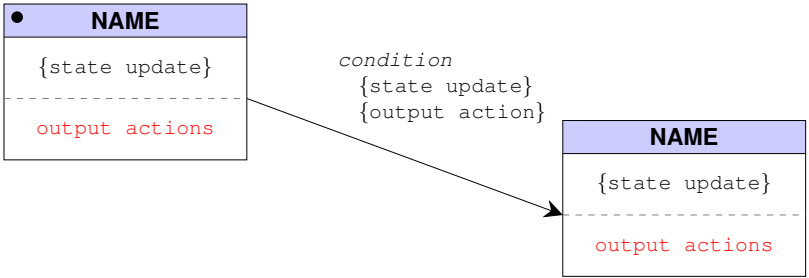
- Need more abstract FSM model
  - Mapping of each state to an output



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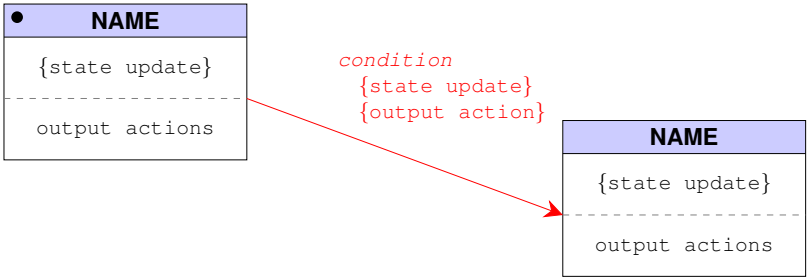
  - Optional assignments to state register and outputs; overriding node's actions



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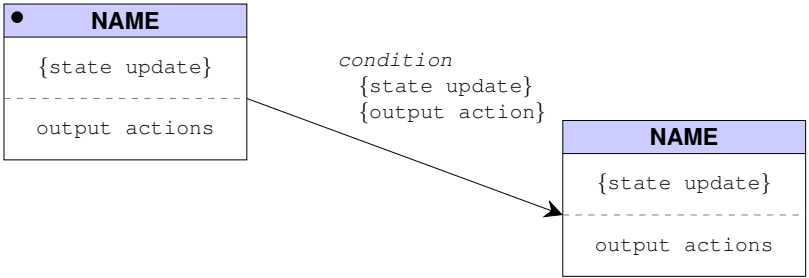
  - Optional assignments to state register and outputs; overriding node's actions
- Mealy when transition output action depends on input



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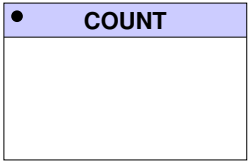

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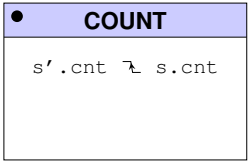

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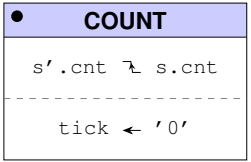

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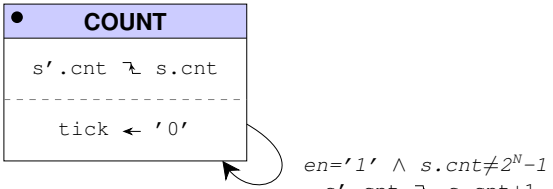

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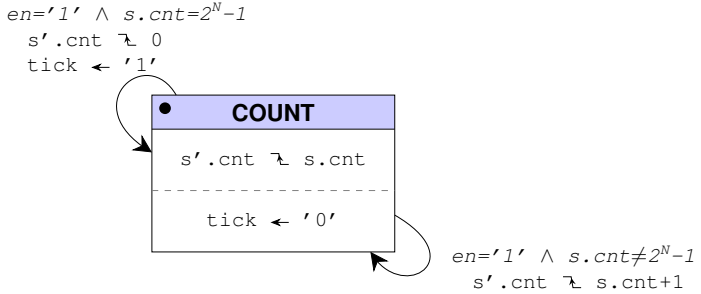
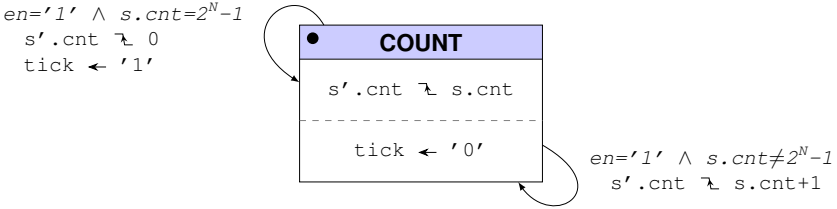
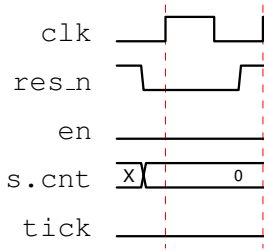


Synchronous FSM Behavior





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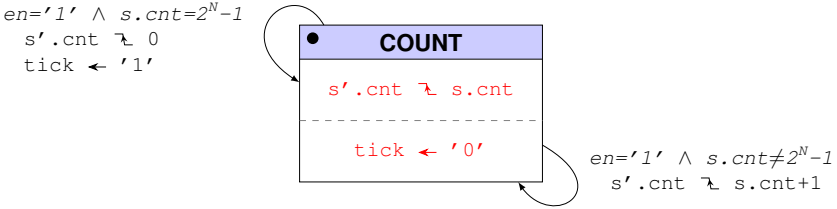

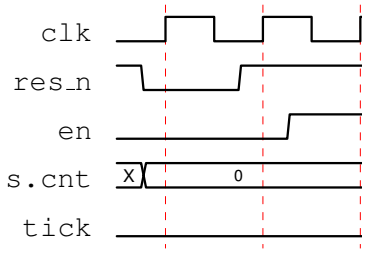

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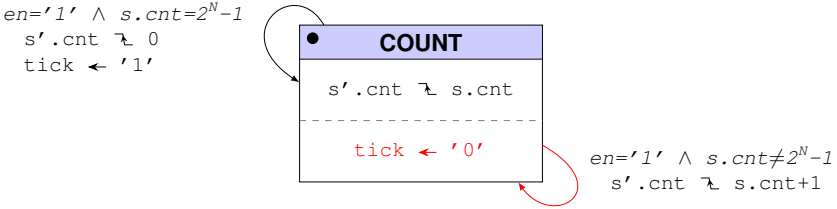

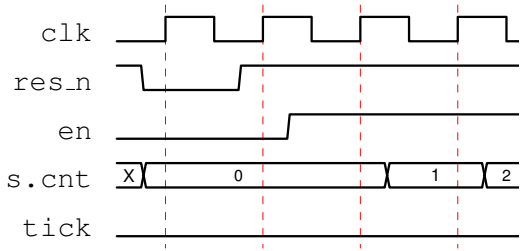

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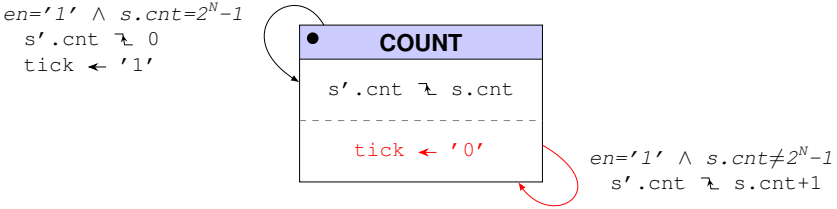

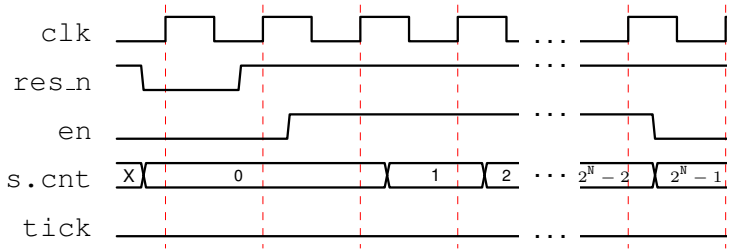

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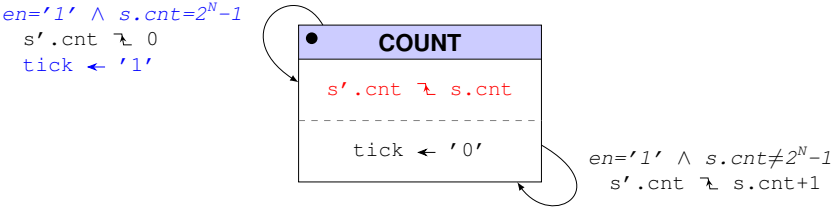

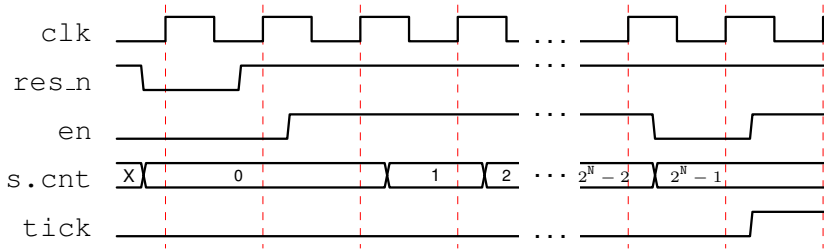

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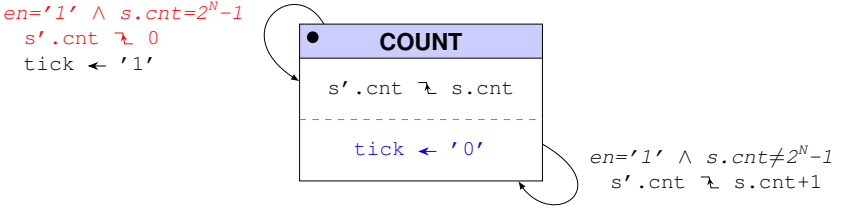

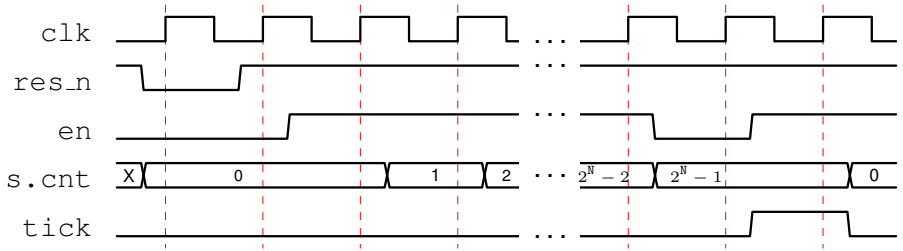

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After a press of button `btn_n` the synchronous `advanced_timer` module starts counting from zero to 15 seconds (inclusive). It shall display the current second as hex value on the seven-segment display `hex`. Before the button press and after it finished counting, the seven-segment display shall be turned off.

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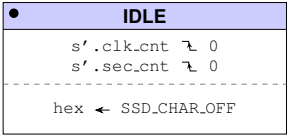

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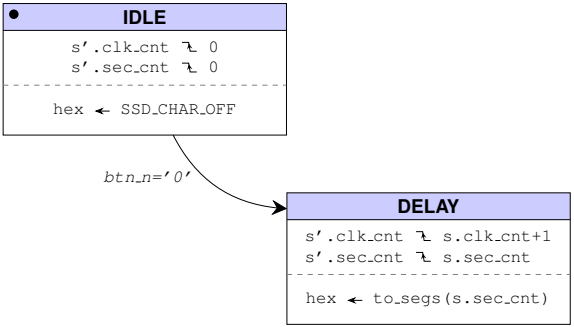

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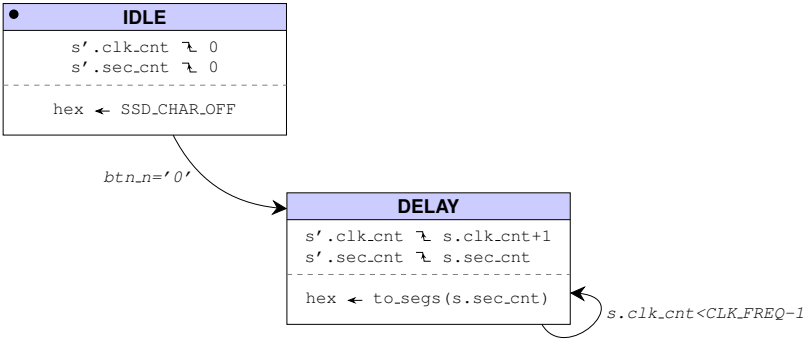

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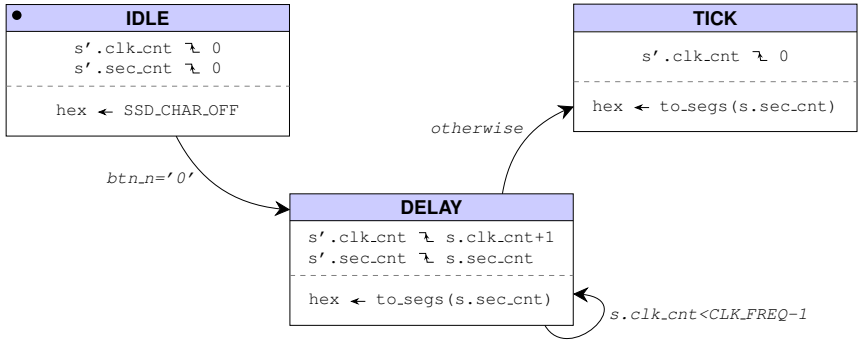

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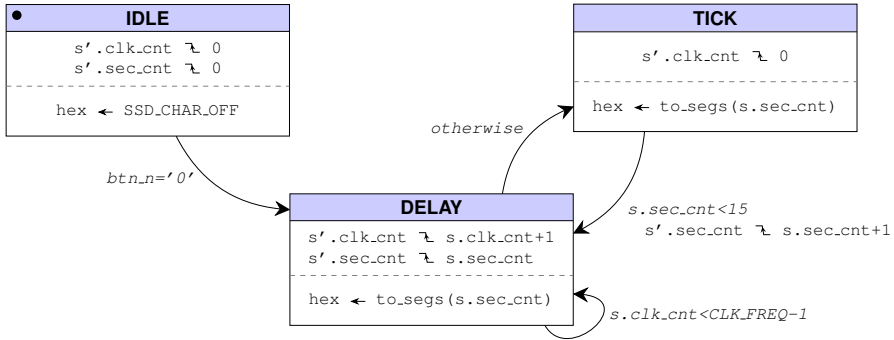

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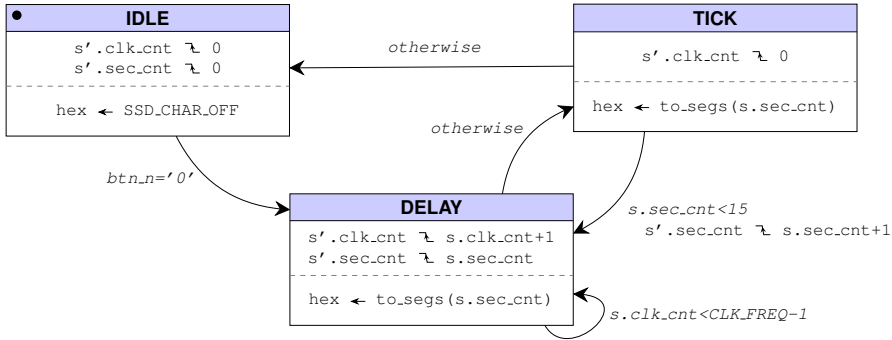

Lecture Complete!