Embedded Systems

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Model of Computation

Introduction

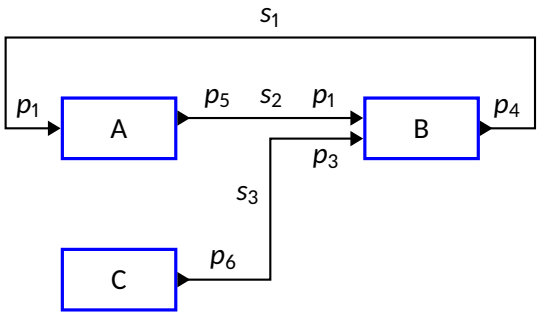
- Big systems are developed by composing elements
- Need to handle concurrent composition
- Actor composition
  - Actor can be FSM, hardware, code, etc.
- Three things need to be defined while composing elements
  - List of components
  - Concurrency mechanism
  - Communication mechanism

Components

- An actor with input, output ports and a set of execution actions
  - Port will be interconnected to provide communication between actors
  - Execution action will be invoked by environment

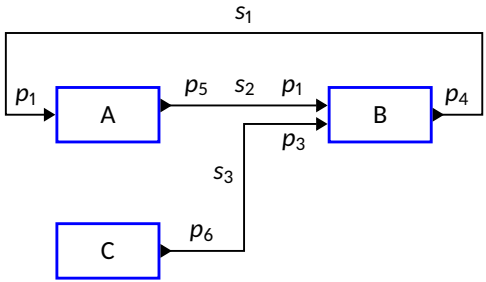
Structure of model

- Fixed interconnection
- Communication takes place through signals
  - Discrete signal
  - Continuous signal



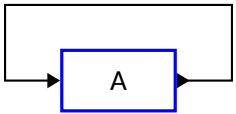
System of equations for actor network

- **If actor is determinate, then actor is a function that maps input to output**
- **For example**
  - $s_2 = A(s_1)$
  - $s_1 = B(s_2, s_3)$
  - $s_3 = C(\emptyset)$
  - **For a system,** $s' = F(s)$
- **Fixed point**
  - **Given any function** $F : X \to X$ **for any set** X**, if there is an** $x \in X$ **such that** $x = F(x)$ **then** x **is called fixed point**
    - **Existence of fixed point**
    - **Uniqueness of fixed point**
    - **Procedure for finding fixed point**



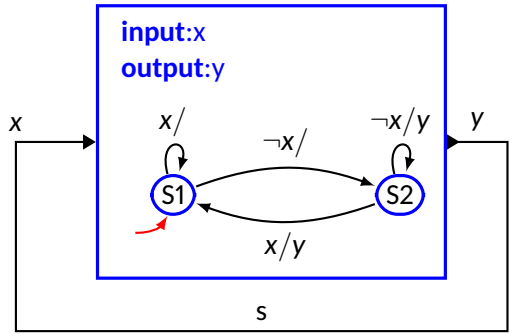
Synchronous reactive model

- Need to know inputs at the time of reaction
- But it is the same as output
  - Circular dependency
- Synchronous reactive (SR) model of computation is proposed
  - Signals are absent at all time except at ticks of a global clock
  - Execution of a model is a sequence of global reactions that occur at discrete time
  - Reaction of all actors is simultaneous and instantaneous

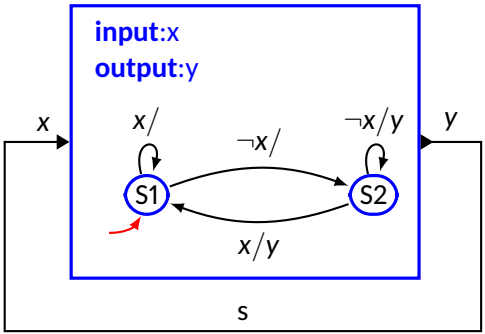


Feedback model

- Given the current state determine the value of $s(n)$, value at the nth reaction
- If machine is in s_1 then $a_{s_1} = absent$
  - a_{s_1} is the firing function in state s_1
- We are looking for $s(n) = a_i(s(n))$;



Semantics



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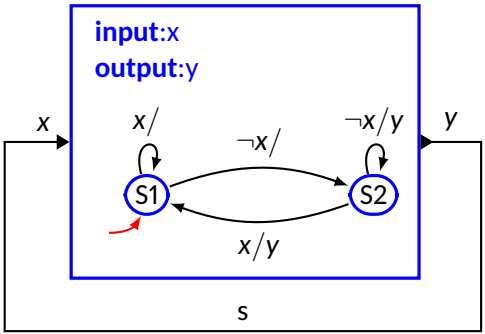

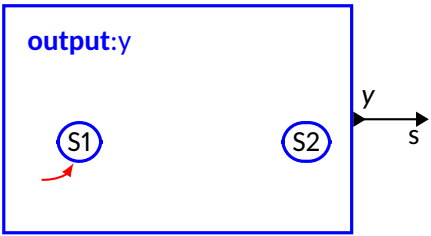

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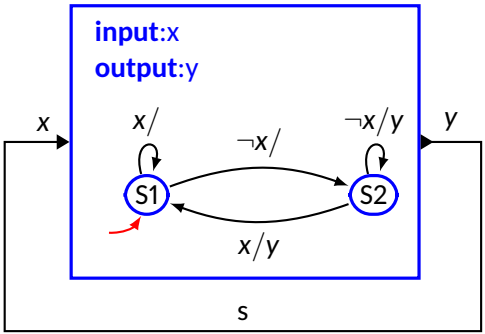
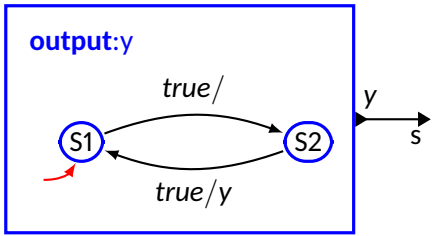
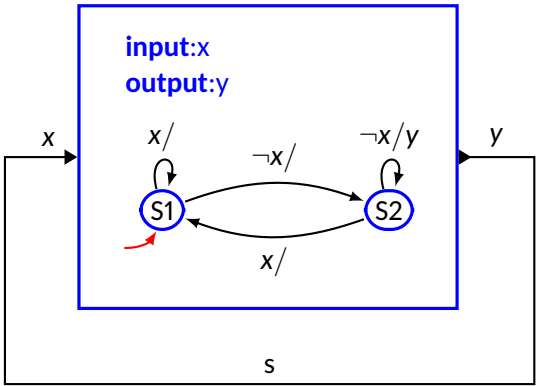




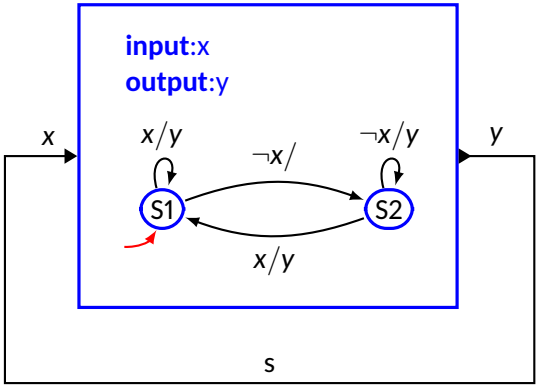
Well formed vs Ill formed

- While finiding out the fixed point we may come across the following
  - All states are reachable but no fixed point
  - All states are reachable but more than one fixed point
- In the above scenarios, we call the system to be ill formed
- Otherwise, well formed

Ill formed



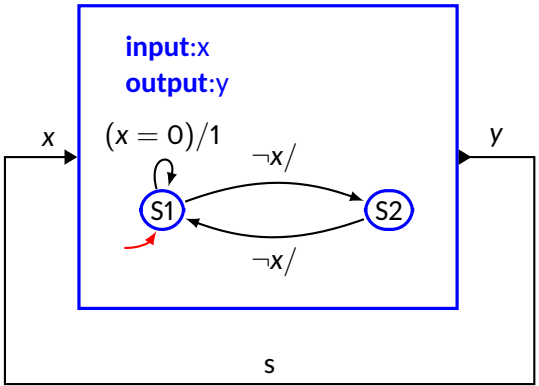
Non-unique fixed point



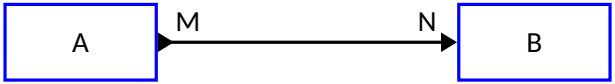
Constructing a fixed point

- **Start with $s(n)$ unknown**
- **Determine as much as possible about $f_i(s(n))$ using only firing function**
- **Repeat above step untill all values in $s(n)$ become known**
- **If unknown remains, then reject the model**

Not constructive



Synchronous dataflow model



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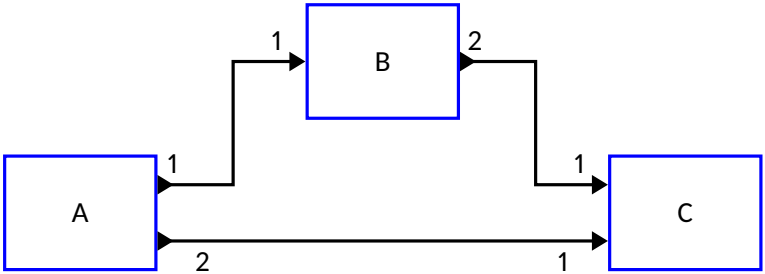

Summary

- There exists many other modeling schemes with varied semantics
- One needs to choose appropriate scheme for the problem at hand