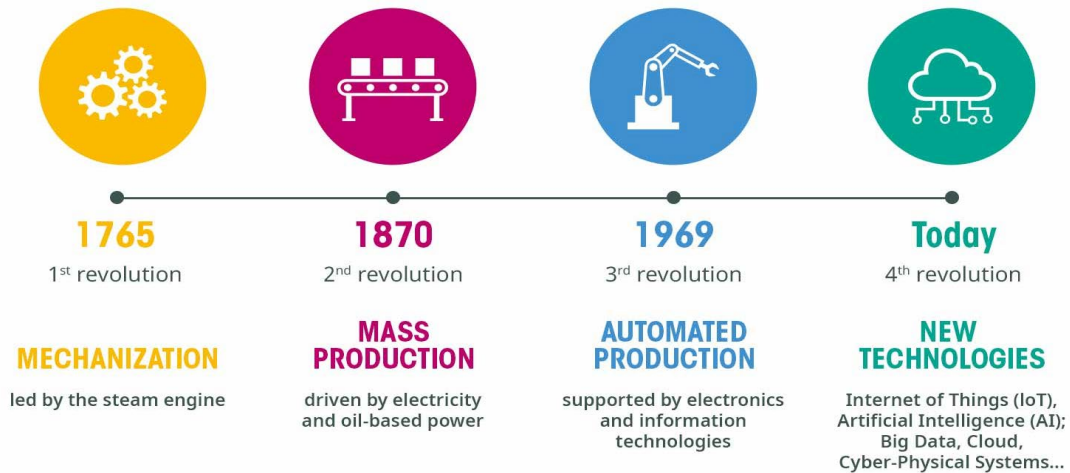


Question (1):

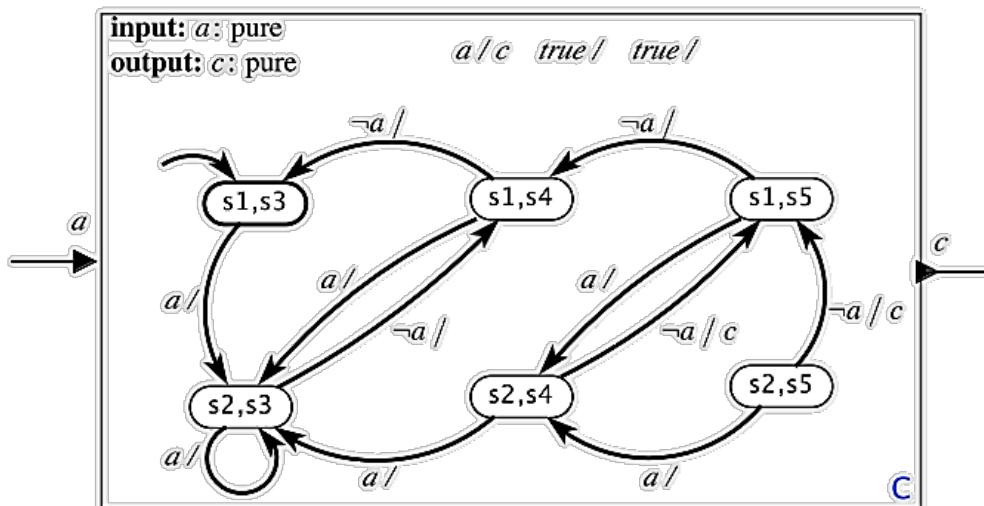
1.



2. This is an open question. Some examples are:

Big Data & Analytics.
Autonomous Robots.
Simulation/Digital Twins.
Horizontal and Vertical Systems.
Industrial IoT (IIoT).

3. a.



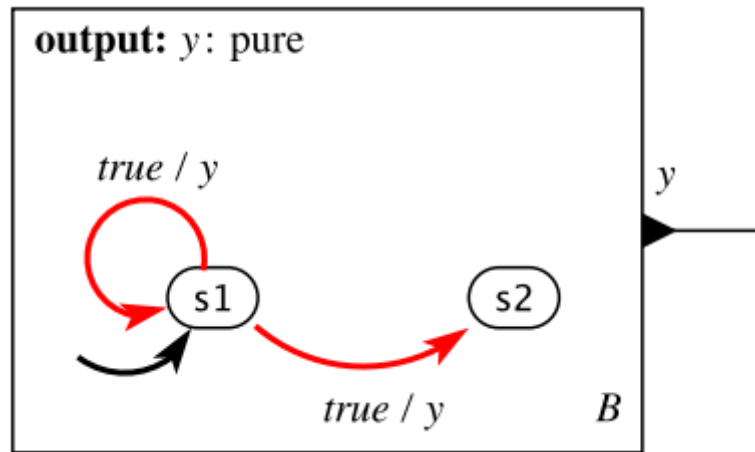
3.b.

The following states are unreachable: $(s1, s5)$, $(s2, s4)$, and $(s2, s5)$

4. a.

Yes to both. In state $s1$, the output is always present, and in state $s2$, the output is always absent. In state $s1$ machine will non-deterministically choose either the self-loop transition or the transition to $s2$. If it transitions to $s2$, thereafter, it will stutter.

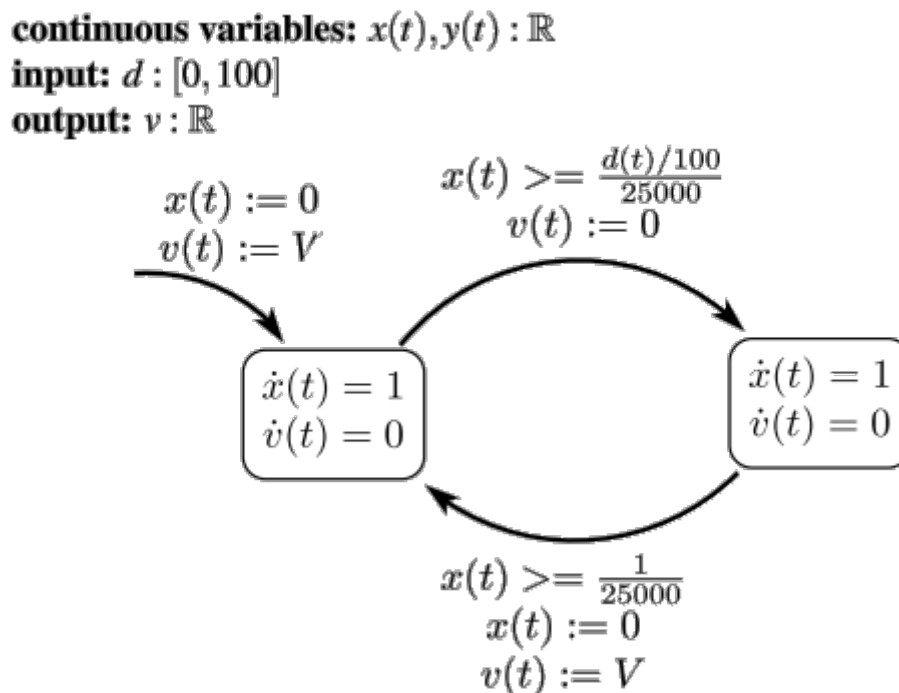
4. b.



Question (2):

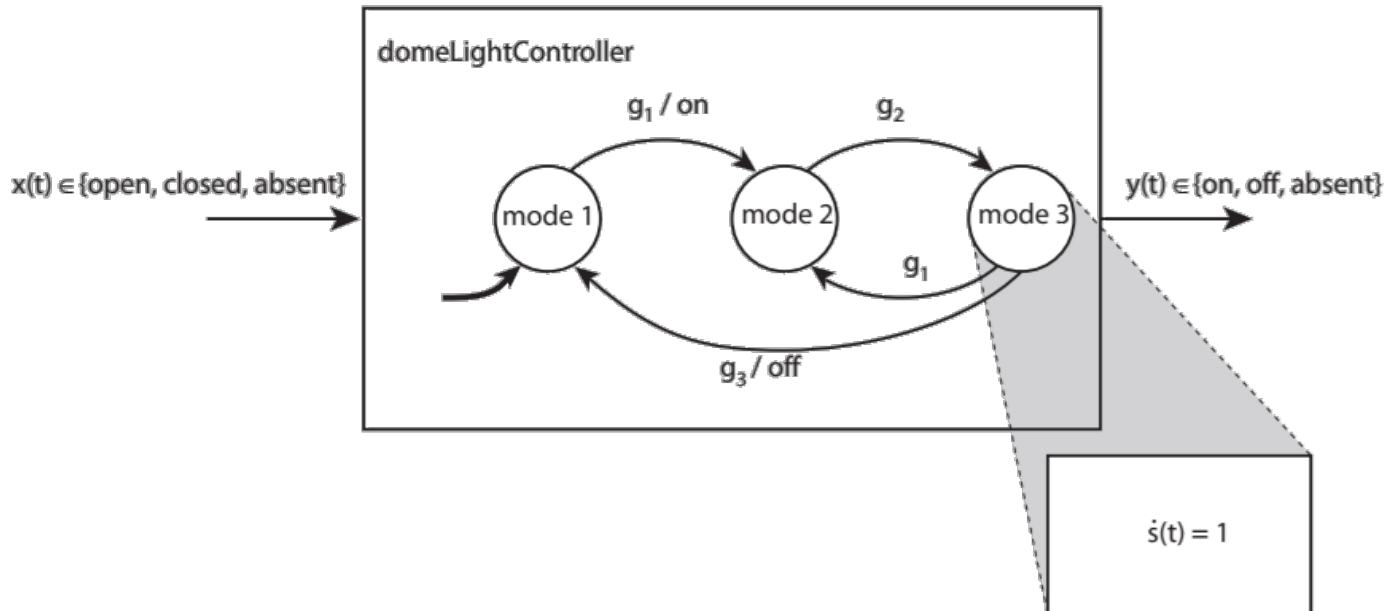
1. Modal models are hybrid systems that combines refinement of time-based system with modes of operation of the system. Cyber physical systems contain both continuous and discrete dynamics which can be described by modal models.

2.



3. a.

Assume that the automobile provides the input open when the first door is opened and closed when the last open door is closed. The following machine provides on to turn on the dome light and off to turn it off:



The guards are given by

$$\begin{aligned}
 g_1 &= \{(x(t), s(t)) \mid x(t) = \text{open}\} \\
 g_2 &= \{(x(t), s(t)) \mid x(t) = \text{closed}\} \\
 g_3 &= \{(x(t), s(t)) \mid s(t) = 30\}.
 \end{aligned}$$

3. b.

Sensors can be easily implemented as a daisy chain, a series connection of switches so that if any door is open, the electrical circuit is open.

Question (3):

1. Model of Computation (MoC):

A collection of three sets of rules that govern the semantics of a concurrent composition of actors:

The first set of rules specifies what constitutes a component.

The second set specifies the concurrency mechanisms

The third specifies the communication mechanisms.

2. a. SDF is a constrained form of dataflow where for each actor, every firing consumes a fixed number of input tokens on each input port and produces a fixed number of output tokens on each output port.

2. b. Unbounded execution: A dataflow model may be able to execute forever or for a very long time. It requires scheduling policies that deliver bounded buffers.

Deadlock: A situation that happens when there are cycles, and a directed loop has insufficient tokens to satisfy any of the firing rules of the actors in the loop.

2. c.

$$q_A = 3q_B$$

$$2q_B = 3q_C$$

2. d.

$$q_A = 9$$

$$q_B = 3$$

$$q_C = 2.$$

2. e.

A, A, A, B, A, A, A, B, C, A, A, A, B, C

2.f.

The buffer between A and B has size 3, and the buffer between B and C has size 4.
