ASSIGNMENT #1

#1

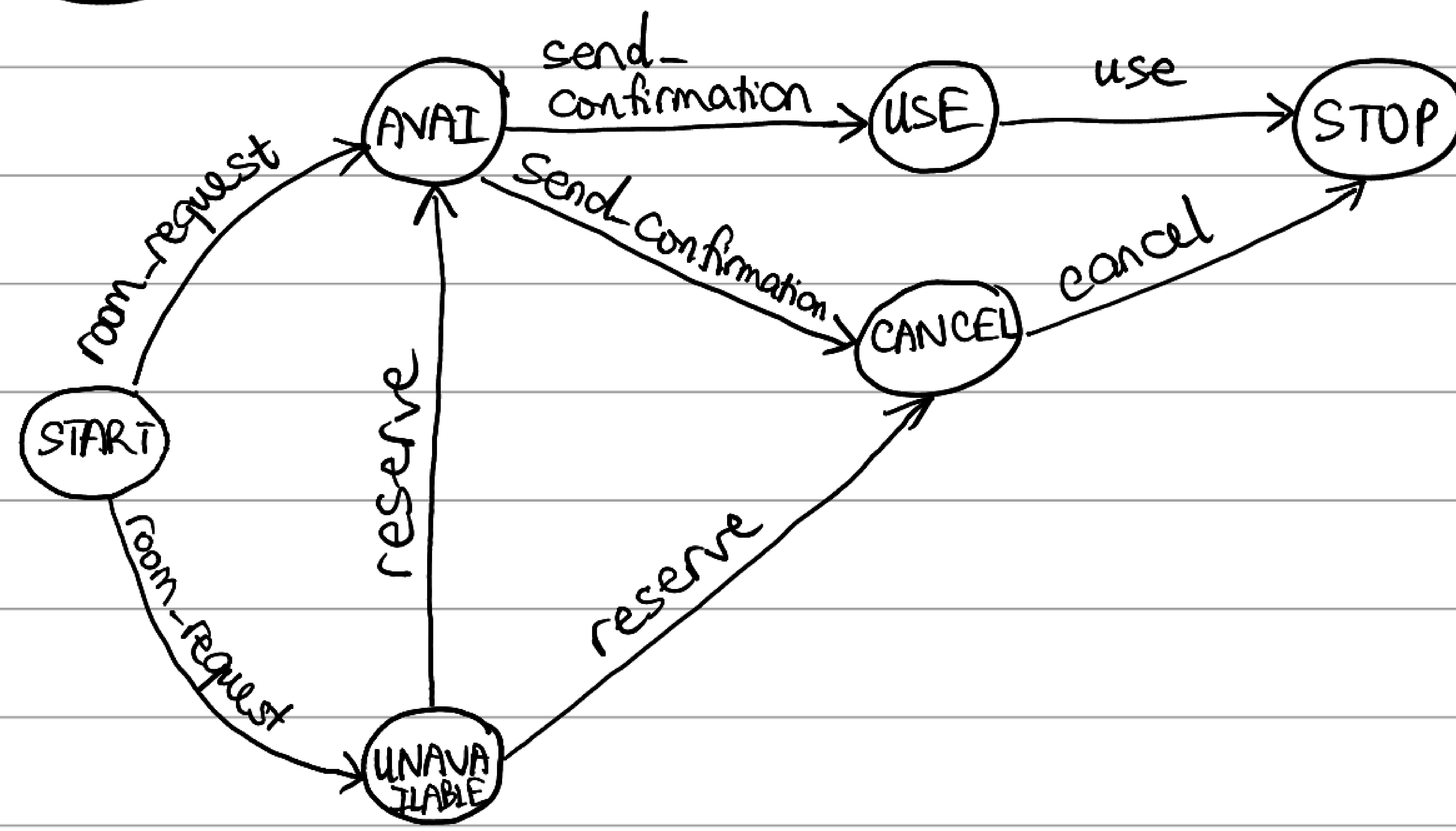
a)

- $P1 = A,$
  $A = (a \to B \mid a \to D),$
  $B = (b \to C \mid c \to D),$
  $C = (a \to D \mid b \to A \mid d \to C),$
  $D = (d \to A).$

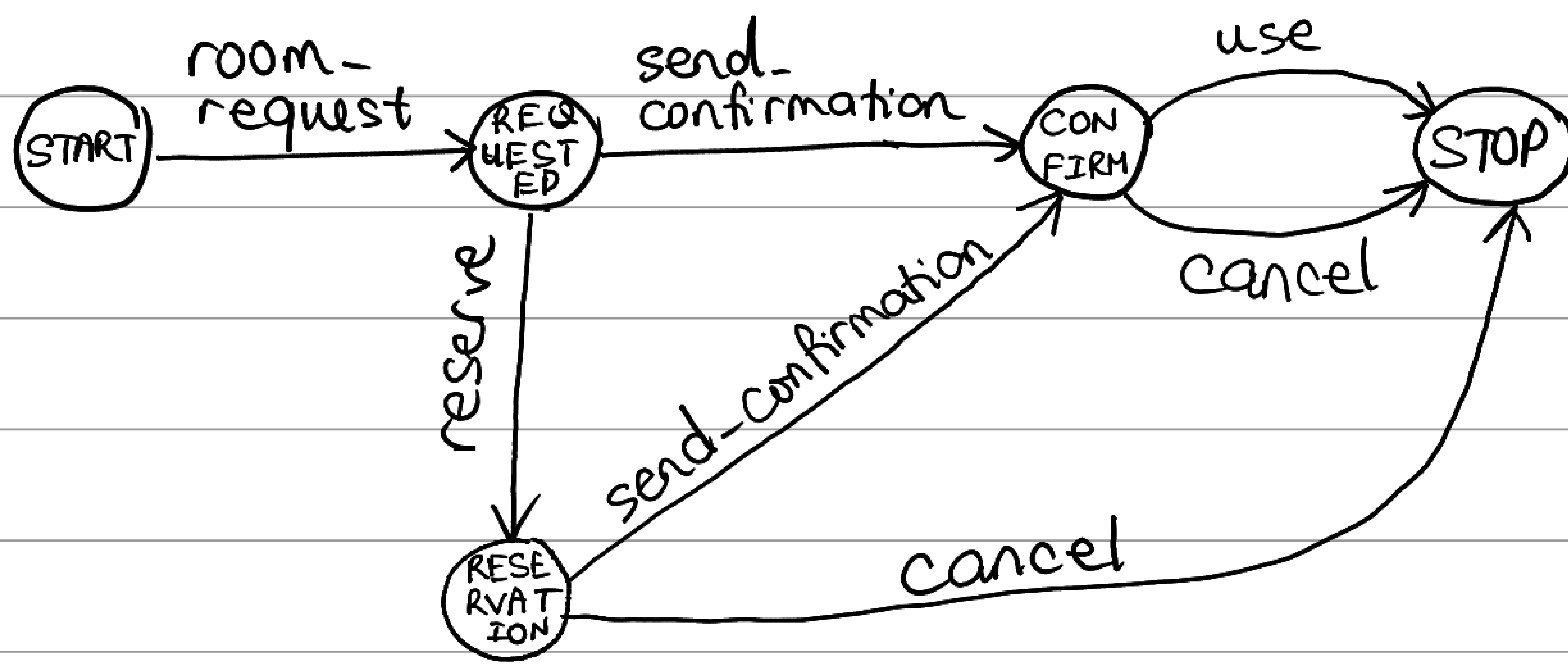
- $P2 = A,$
  $A = (b \to B \mid b \to C),$
  $B = (b \to E \mid d \to D),$
  $C = (c \to B),$
  $D = (a \to A \mid b \to E \mid d \to C),$
  $E = (a \to A \mid c \to C).$

$$
\begin{aligned}
.\ P3 &= A, \\
A &= (a \rightarrow D \mid b \rightarrow B), \\
B &= (a \rightarrow A \mid a \rightarrow C), \\
C &= (b \rightarrow B \mid b \rightarrow D \mid c \rightarrow C), \\
D &= (a \rightarrow C \mid c \rightarrow A).
\end{aligned}
$$

#2



SYSTEM = START,
START = (room_request → AVAILABLE
| room-request → UNAVAILABLE),
AVAILABLE = (send_confirmation → USE
| send_confirmation → CANCEL),
UNAVAILABLE = (resene → AVAILABLE
| reserve → CANCEL),
USE = (use → STOP),
CANCEL = (cancel → STOP).




```
SYSTEM = START,
START = (room_request -> REQUESTED),
REQUESTED = (send_confirmation -> CONFIRM
            |reserve -> RESERVATION),
CONFIRM = (use -> STOP
          | cancel -> STOP),
RESERVATION = (send_confirmation -> CONFIRM
              |cancel -> STOP).
```

#3

```
RADIO     = OFF
OFF       = on → TOP
TOP       = off → OFF
            | reset → TOP
            | scan → SCANNING
SCANNING  = off → OFF
            | reset → TOP
            | lock → STATION
            | end → BOTTOM
STATION   = off → OFF
            | reset → TOP
            | scan → SCANNING
BOTTOM    = off → OFF
            | reset → TOP
```

#3 If OFF and press reset, is it tuned to
to freq?
what does radio do when it reaches bottom?

RADIO =

SWITCH = OFF

OFF = on → TOP FREQ

| reset → TOP FREQ

TOP FREQ = scan → TO BOTTOM SCANNING

TOBOTTOM = lock(s) → STATION

| end → STOP

STATION = scan → TOBOTTOM

| reset → TOPFREQ

#5

DRINKS = CREDIT[0]

CREDIT[0] = in.coin[5] → CREDIT[5]
| in.coin[10] → CREDIT[10]
| in.coin[25] → CREDIT[25]

CREDIT[5] = in.coin[5] → CREDIT[10]
| in.coin[10] → CREDIT[15]
| in.coin[25] → CREDIT[30]

CREDIT[10] = in.coin[5] → CREDIT[15]
| in.coin[10] → CREDIT[20]
| in.coin[25] → CREDIT[35]

CREDIT[15] = in.coin[5] → CREDIT[20]
| in.coin[10] → CREDIT[25]
| in.coin[25] → CREDIT[40]
| sugerola → CREDIT[0]

CREDIT [20] = in.coin [5] → CREDIT [25]
| in.coin [10] → CREDIT [30]
| in.coin [25] → CREDIT [45]
| sugerola → CHANGE [5]
| diet → CREDIT [0]

CREDIT [25] = sugerola → CHANGE [10]
| diet → CHANGE [5]
| superdiet → CREDIT [0]

#6

$A = ((a \to (b \to A)) \mid (c \to (a \to C \mid c \to B))$
$\mid c \to C)$

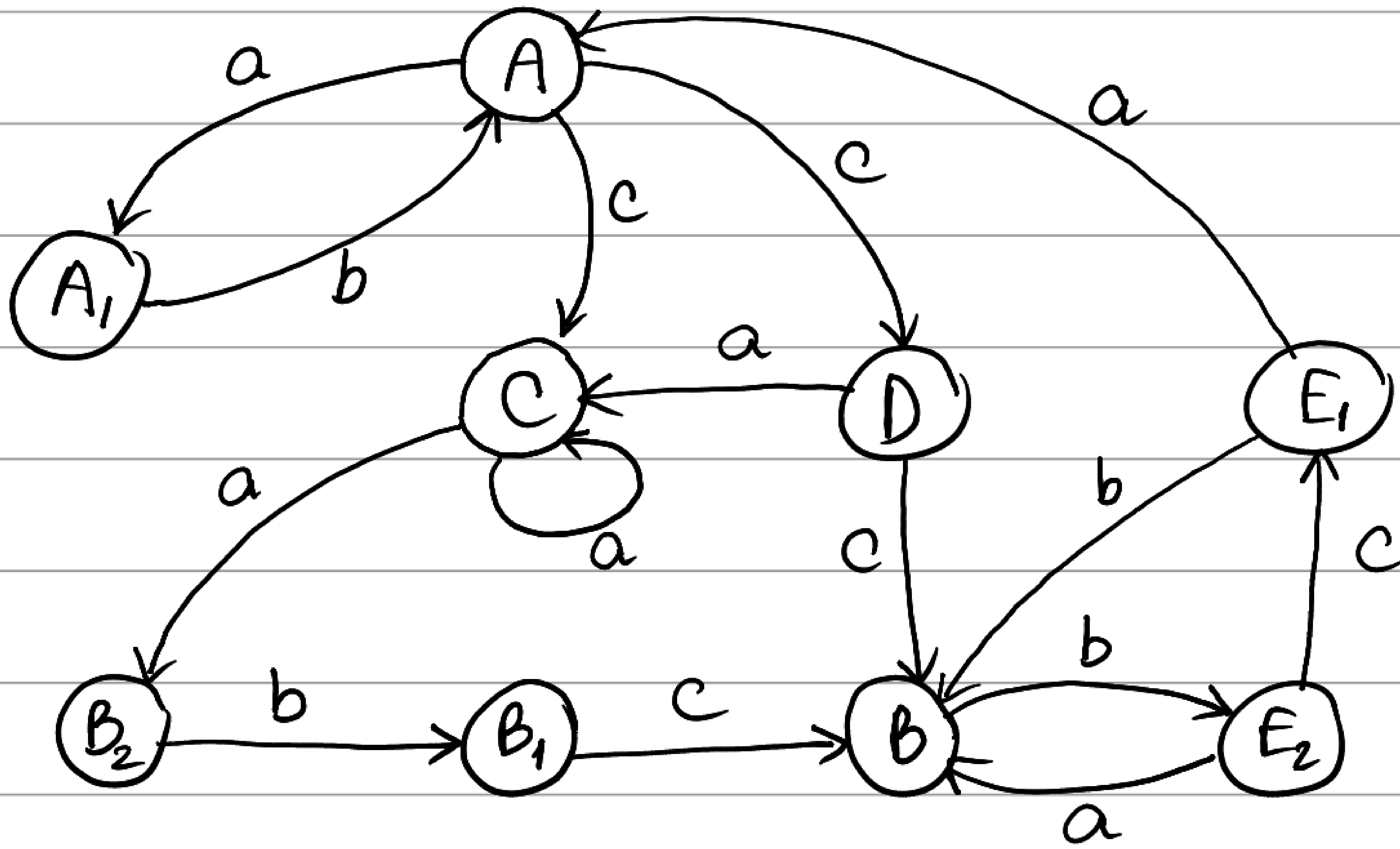
$B = (b \to (a \to B \mid c \to (a \to A \mid b \to B)))$

$C = ((a \to (b \to (c \to B))) \mid (a \to C))$

a)

- $A_1 = b \to A$
- $B_1 = c \to B$
- $D = a \to C \mid c \to B$
- $E_1 = a \to A \mid b \to B$
- $E_2 = a \to B \mid c \to E_1$
- $B_2 = b \to B_1$

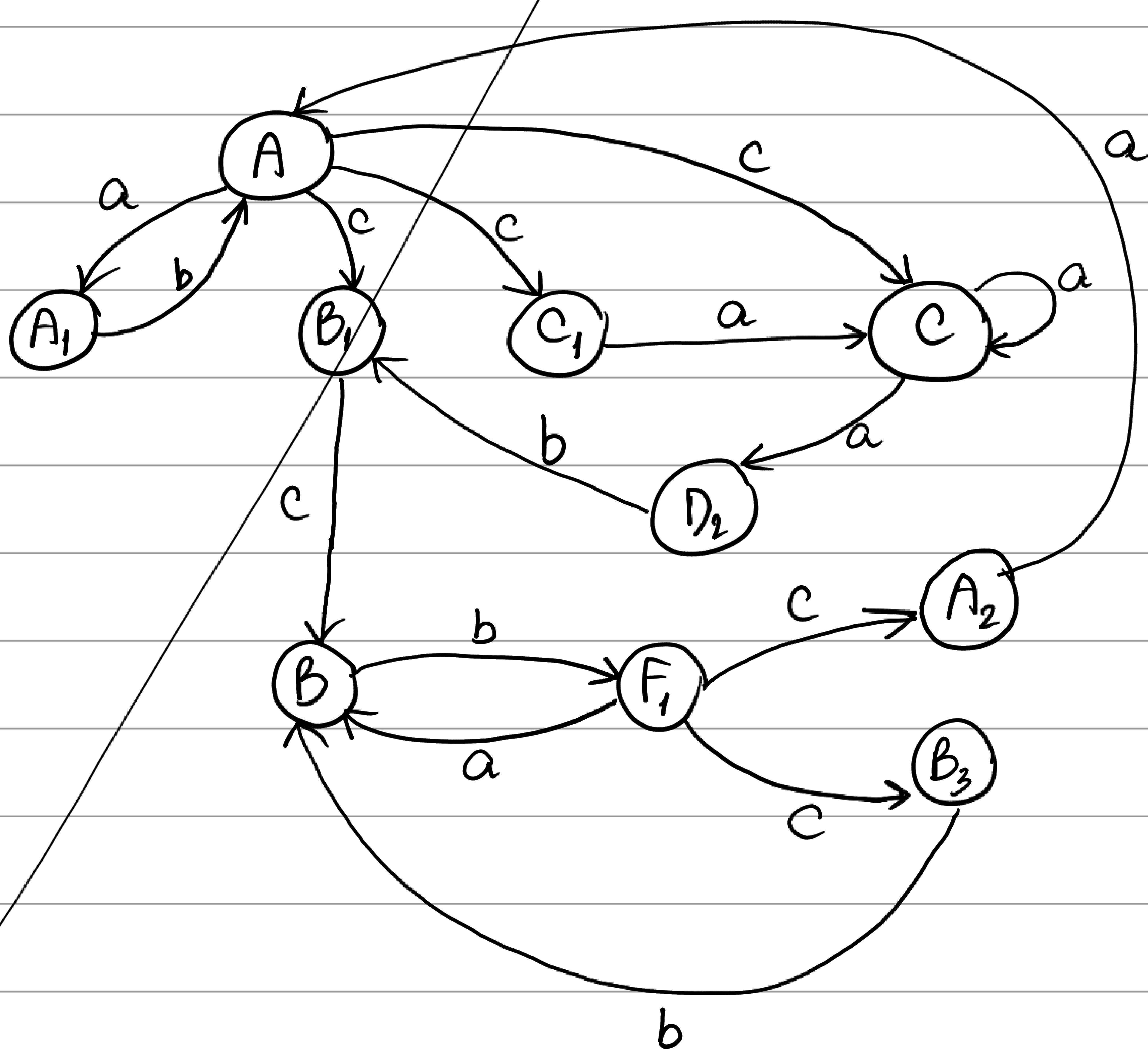
- $A = (a \to A_1 \mid c \to D \mid c \to C)$,
- $B = (b \to E_2)$,
- $C = (a \to B_2 \mid a \to C)$.



A – 0
A1 – 8
C – 1
D – 7
B2 – 2
B1 – 3
B – 4
E2 – 5
E1 – 6

- $D_2 = b \rightarrow B_1 = b \rightarrow (c \rightarrow B)$

- $A = a \rightarrow A_1 \mid c \rightarrow (C_1 \mid B_1) \mid c \rightarrow C$
- $B = b \rightarrow F_1$
- $C = a \rightarrow D_2 \mid a \rightarrow C$

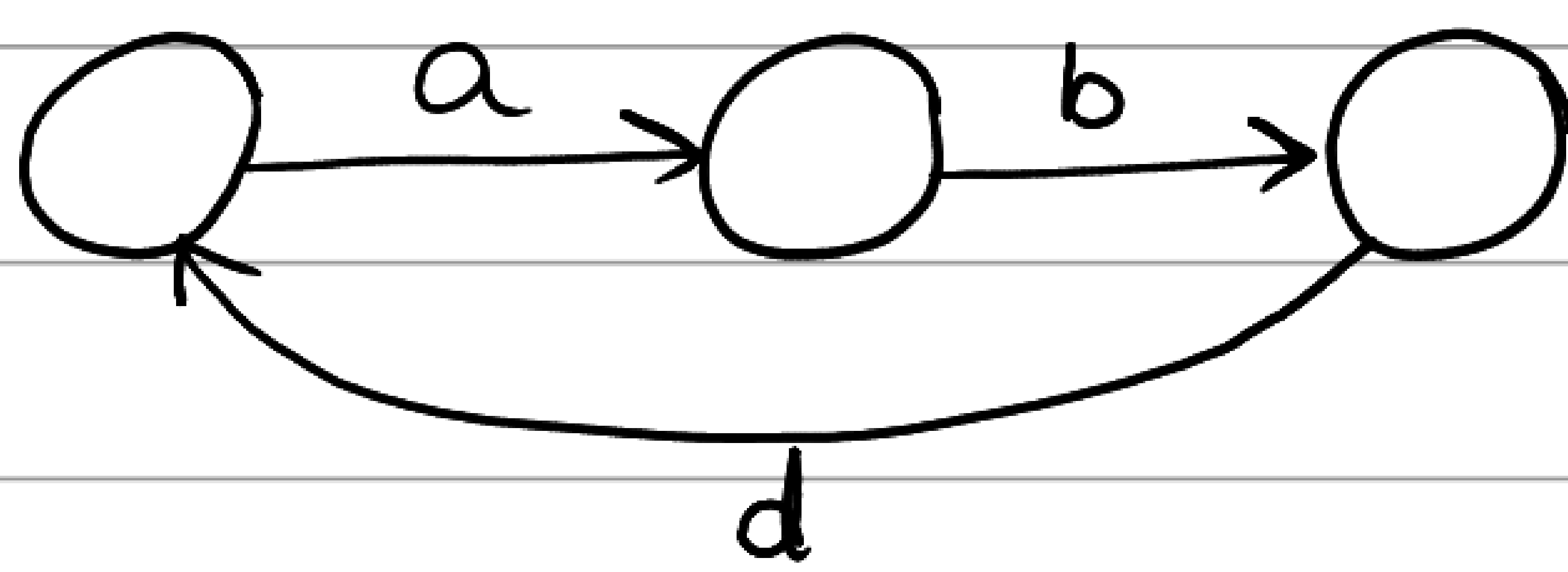


#7

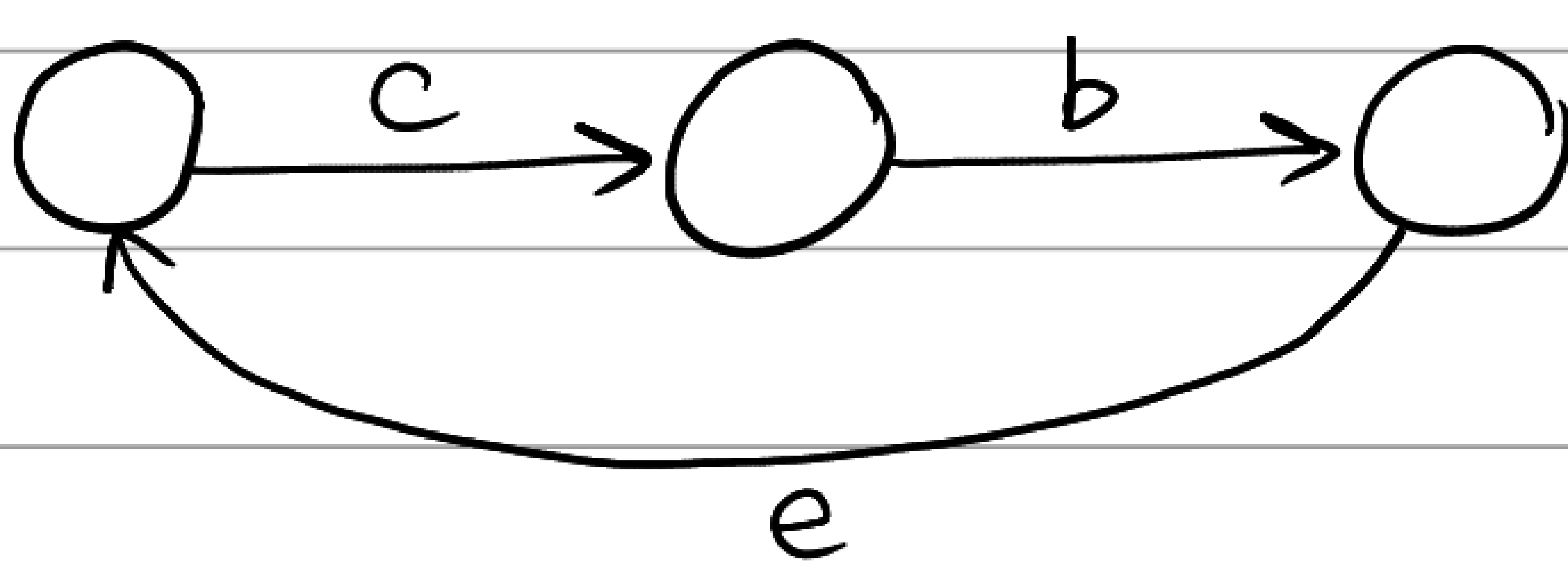
a) $P = (a \rightarrow b \rightarrow d \rightarrow P)$

$Q = (c \rightarrow b \rightarrow e \rightarrow Q)$

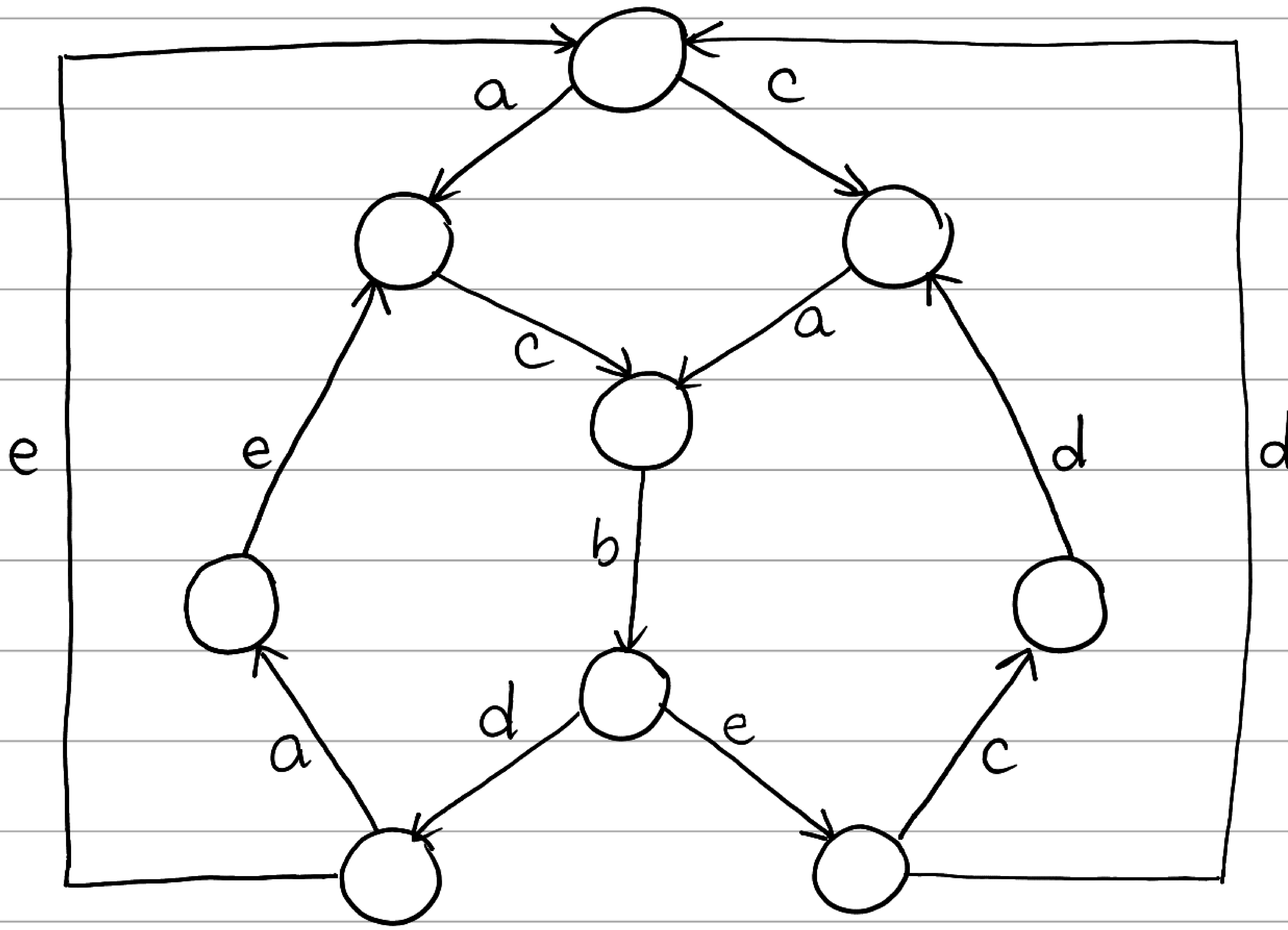
$\| S1 = (P \| Q)$



P



Q



||S1

$S2 = (a \rightarrow S2A \mid c \rightarrow S2B)$

$S2A = (c \rightarrow b \rightarrow d \rightarrow S2C$

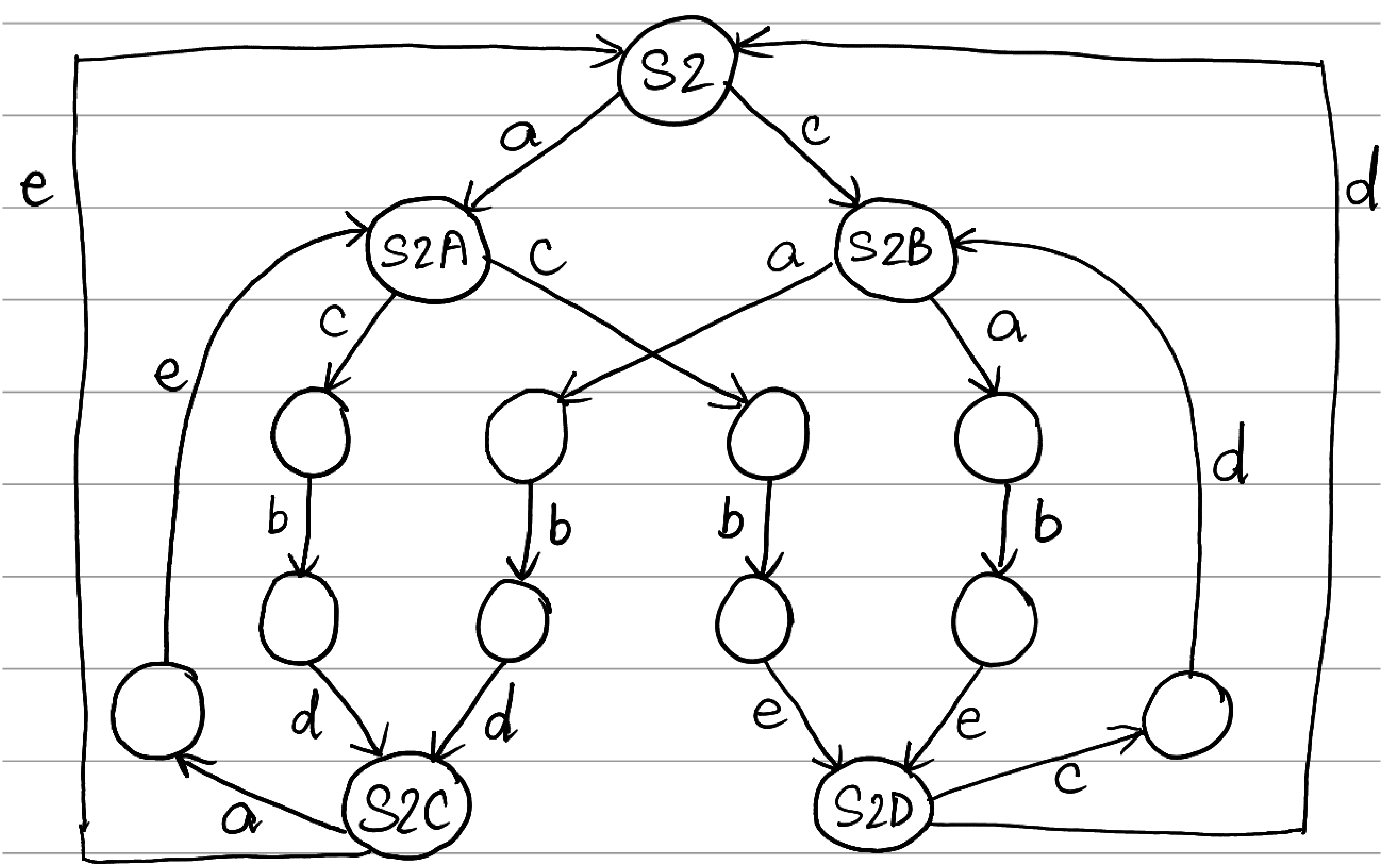
$\mid c \rightarrow b \rightarrow e \rightarrow S2D)$

$S2B = (a \rightarrow b \rightarrow d \rightarrow S2C$

$\mid a \rightarrow b \rightarrow e \rightarrow S2D)$

$S2C = (e \rightarrow S2 \mid a \rightarrow e \rightarrow S2A)$

$S2D = (d \rightarrow S2 \mid c \rightarrow d \rightarrow S2B)$



S2

Notice that the graphs for $\|S1$ and $S2$ are isomorphic. Thus, $LTS(\|S1) = LTS(S2)$

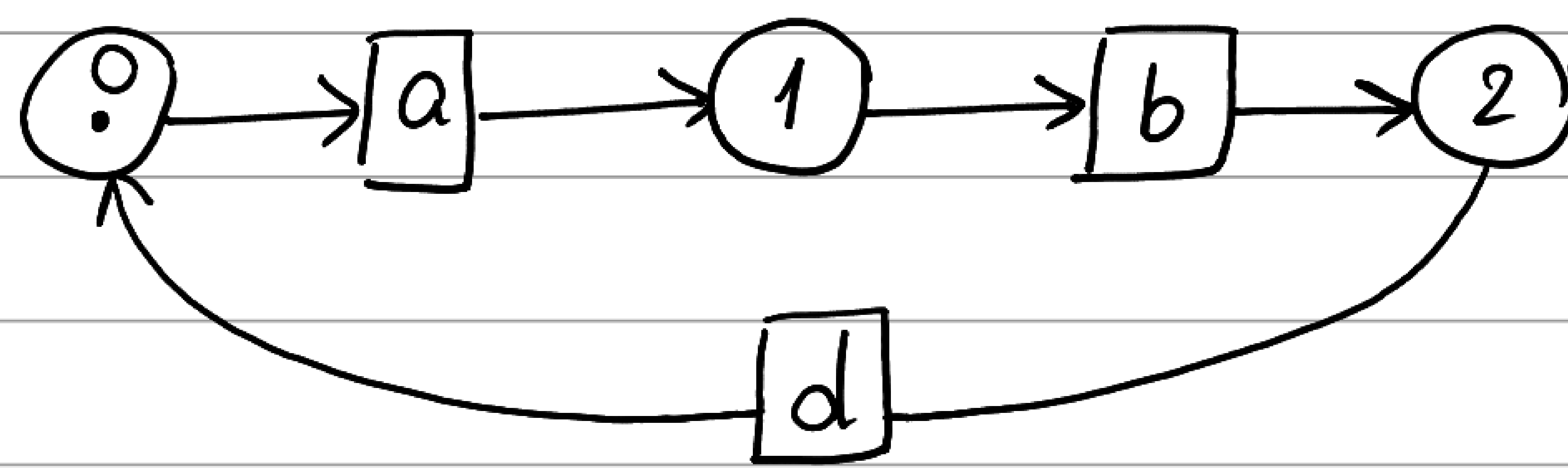
b)

$P = (a \to b \to d \to P)$

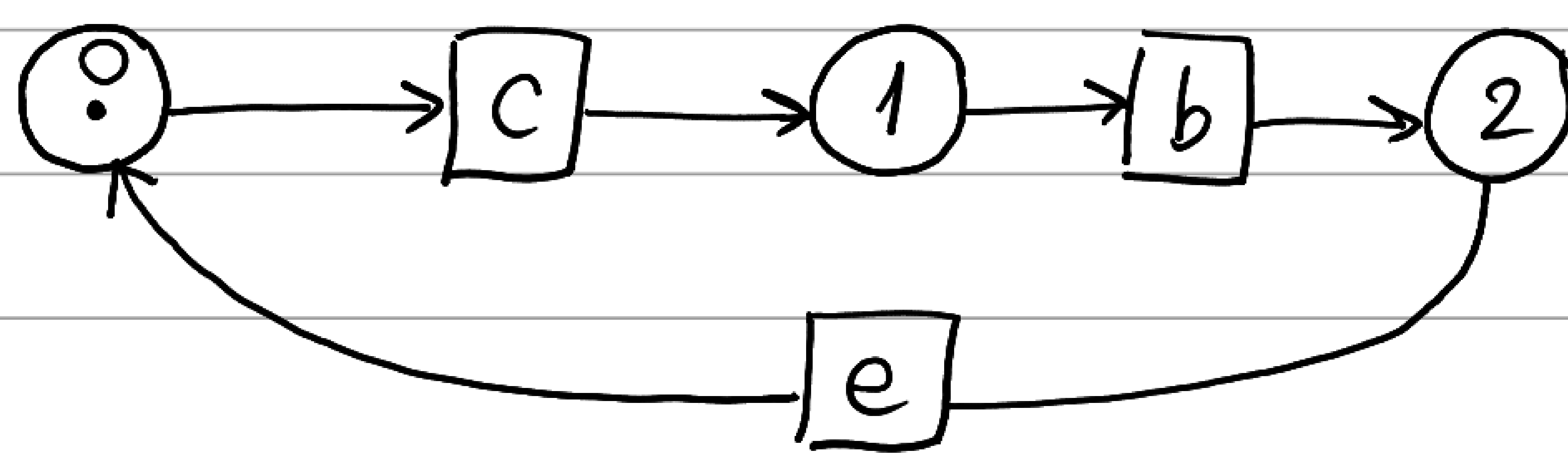
$Q = (c \to b \to e \to Q)$

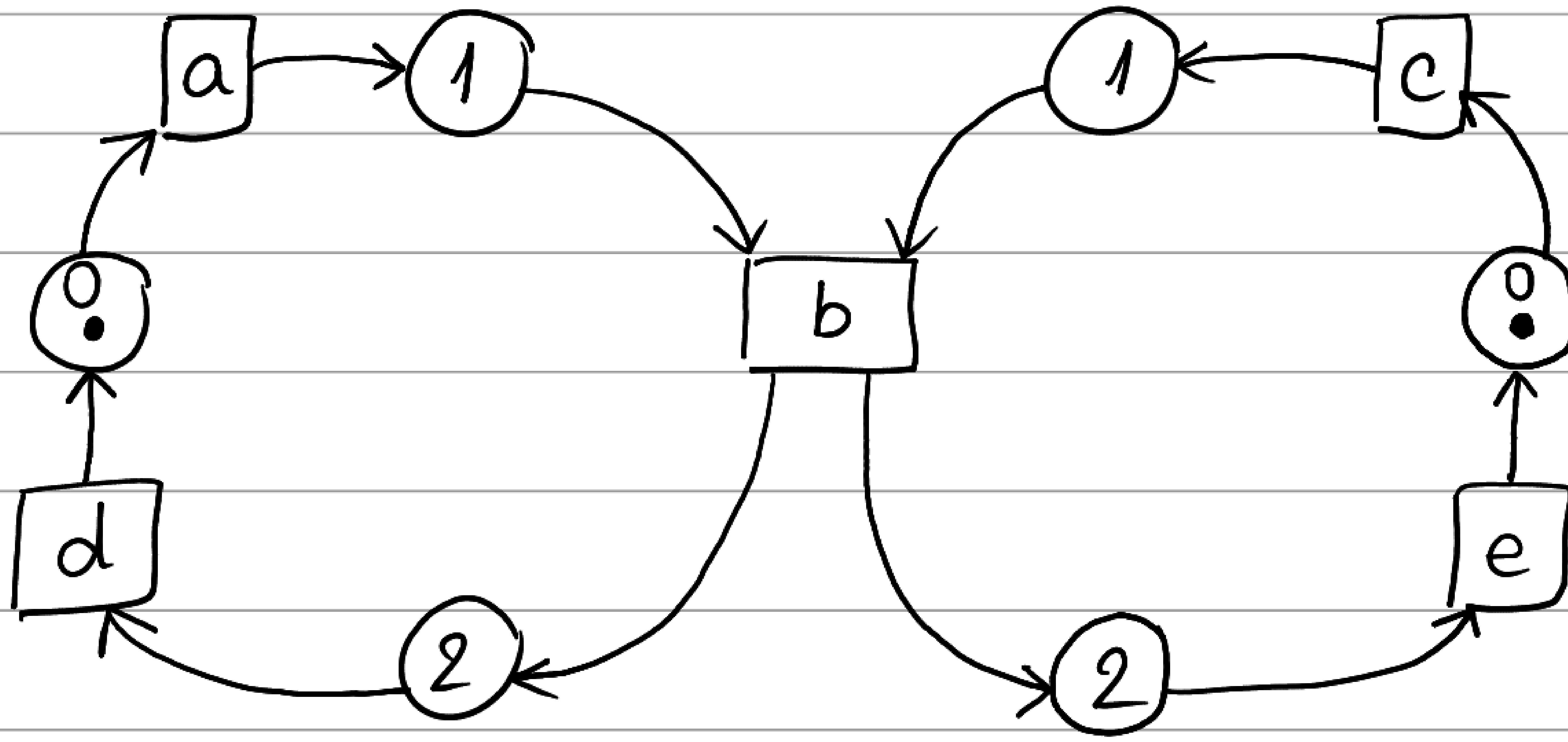
$\| S1 = (P \| Q)$

P



Q





$\| S_1$

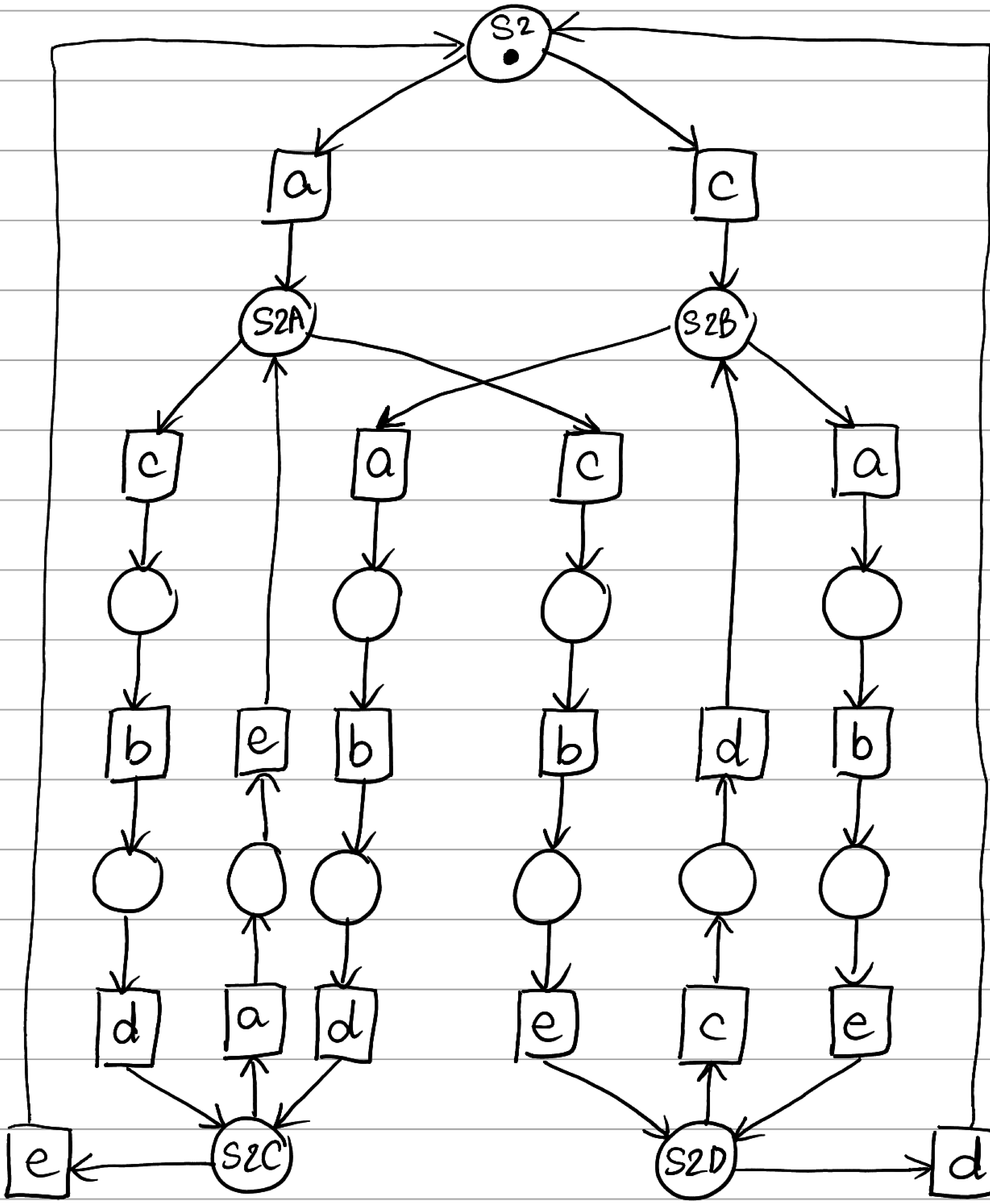
$$S2 = (a \to S2A \mid c \to S2B)$$

$$S2A = (c \to b \to d \to S2C$$
$$\mid c \to b \to e \to S2D)$$

$$S2B = (a \to b \to d \to S2C$$
$$\mid a \to b \to e \to S2D)$$

$$S2C = (e \to S2 \mid a \to e \to S2A)$$

$$S2D = (d \to S2 \mid c \to d \to S2B)$$



S2

. The petri nets for $\| S1$ and $S2$ are different.

. If simultaneity is observed, the net $\| S1$ generates traces like $\{a, c\} \rightarrow b \rightarrow \{d, e\} \rightarrow a \rightarrow c \rightarrow b \rightarrow d \rightarrow a \rightarrow e \rightarrow c \rightarrow b \rightarrow \ldots$, while $S2$ can only generates traces like $a \rightarrow c \rightarrow b \rightarrow d \rightarrow e \rightarrow a \rightarrow \ldots$ or $c \rightarrow a \rightarrow b \rightarrow d \rightarrow e \rightarrow a \rightarrow \ldots$ or $a \rightarrow c \rightarrow b \rightarrow d \rightarrow a \rightarrow e \rightarrow a \rightarrow \ldots$ or $c \rightarrow a \rightarrow b \rightarrow d \rightarrow a \rightarrow e \rightarrow a \rightarrow \ldots$

. Therefore, only $\| S1$ allows simultaneity

#8

$P1 = b \to d \to P1 \mid a \to d \to P1$

$P2 = b \to d \to P2 \mid c \to d \to P2$

$\| N1 = P1 \| P2$

$P1 = b \to P3 \mid a \to P3$

$P2 = b \to P4 \mid c \to P4$

$P3 = d \to P1$

$P4 = d \to P2$

$\| P5 = P1 \| P2$

#9

$$
\begin{aligned}
P1 &= idle1 \rightarrow (read1 \rightarrow P1 \\
&\qquad\qquad\quad | write1 \rightarrow P1) \\
P2 &= idle2 \rightarrow (read2 \rightarrow P2 \\
&\qquad\qquad\quad | write2 \rightarrow P2) \\
MUT &= write1 \rightarrow MUT \\
&\quad | write2 \rightarrow MUT \\
\|PRINT &= P1 \;\|\; P2 \;\|\; MUT
\end{aligned}
$$

#10

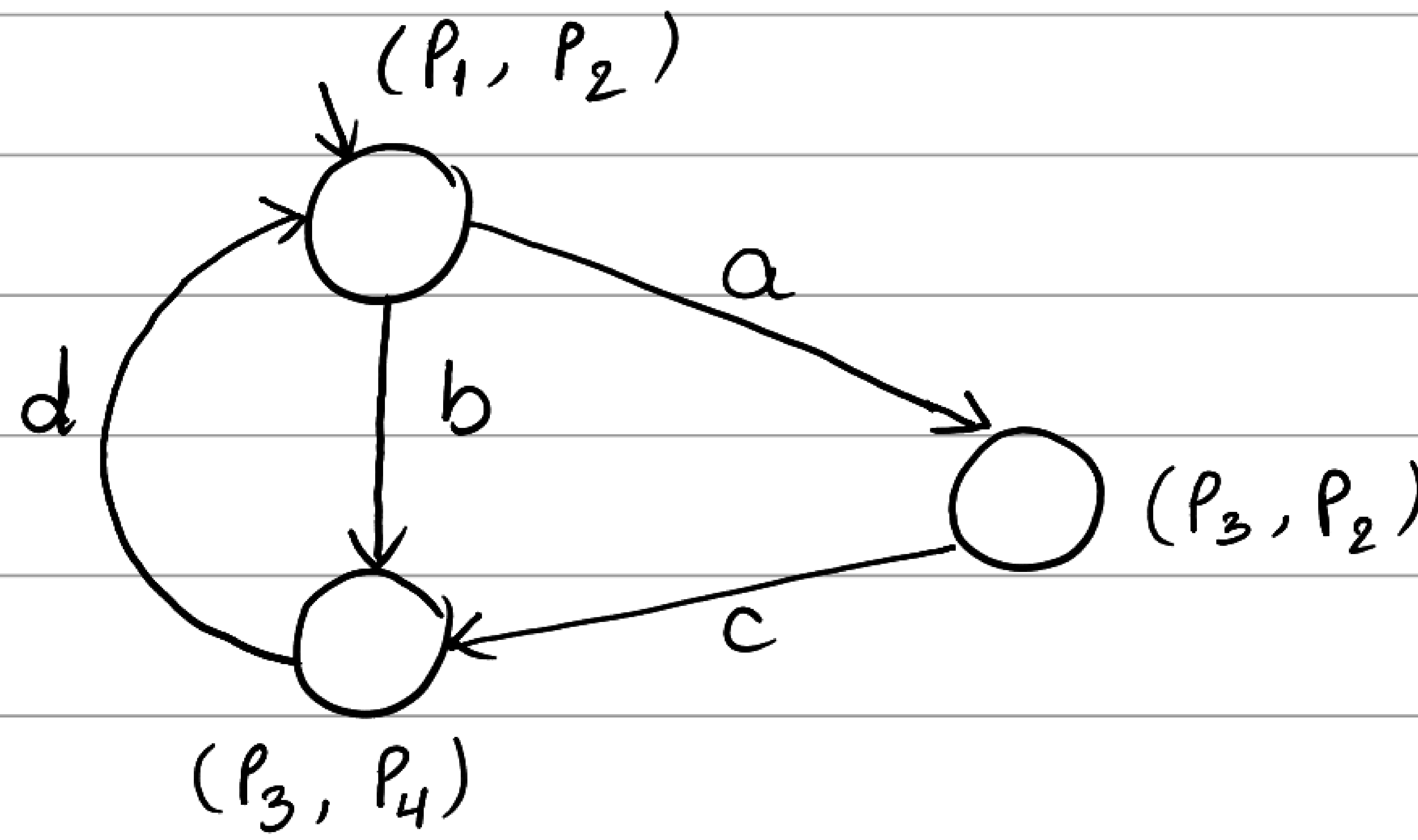
```
TURNSTILE = (passenger -> TURNSTILE).

CONTROL(N=M) = CONTROL[0],
CONTROL[i:0..N] =
    (when (i<N) passenger -> CONTROL[i+1]
    |when (i==N) depart -> CONTROL[0]).

CAR = (depart -> CAR).

||ROLLERCOASTER = (TURNSTILE
                  || CONTROL
                  || CAR).
```

11



(#12)

a) Show $P_2 \approx P_3$

Clearly, $p_0 \approx s_0$ as only transition a or b can be executed in both cases. And in both cases, transition a leads to different state from transition b. After trace a, in P2, p_0 goes to state p_1 ; in P3, s_0 goes to state s_1. After trace b, in P2, p_0 goes to state p_4 ; in P3, s_0 goes to s_4. From both p_1 and s_1, only transition a can be executed. From both p_4 and s_4, only a or b can be executed, while trace a moves to different state in both P2 and P3, trace b loop at the current state in both P2 and P3. In P2, executing a from state p_1 will move to state p_2. Similar for P_3, from s_1, executing a moves to state

s_2. $p_2 \approx S_2$ since either a or b or c can be executed. $p_3 \approx S_3$ since either a or c can be executed. $p_4 \approx S_4$ since either a or b can be executed. p_5 is similar to both S_5 and S_6 since only a can be executed

b) Show that $P_1 \not\approx P_2$

$q_0 \approx p_0$ since only transition a can be executed in both P_1 and P_2. $q_1 \approx p_1$ since only transition a can be executed in both cases. After this trace a, in P1, q_1 goes to either q_2 or q_3 while p_1 goes to p_2. However, $p_2 \not\approx q_2$ and $p_2 \not\approx q_3$. At p_2, a and b and c can be executed but at q_2, only a and c can be executed; and at q_3, only a and b are executed. Therefore, $P1 \not\approx P2$

c) Show that $P1 \not\approx P3$

$q_0 \approx s_0$ since only transition a can be executed. After trace a, in P1, q_0 goes to state q_1 while in P3, s_0 goes to state s_1. $q_1 \approx s_1$ since only transition a can be executed in both cases. After this trace a, in P1, q_1 goes to either q_2 or q_3 while in P3, s_1 goes to s_2. However, $s_2 \not\approx q_2$ and $s_2 \not\approx q_3$. At s_2, a and b and c can be executed while at q_2, only a and c can be executed; while at q_3, only a and b can be executed. Hence $P1 \not\approx P3$

d)

Traces (P1) = Traces (P2) = Traces (P3)

= Pref (give a proper regul expression)

= Pref($(aa(c^*a \cup b^*a)c)^*$)

$$(aa(c^*a \cup b^*a)c)^*$$

or

$$(aa(a \cup cc^*a \cup bb^*a)c)^*$$