# Petri nets: Process modeling

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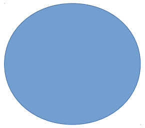
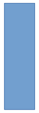
# Basic Petri-net Elements

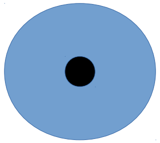
- Places
  - Represent states



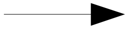
- Transitions
  - Represent actions



- Token
  - Current State



- Arrows
  - Flow elements

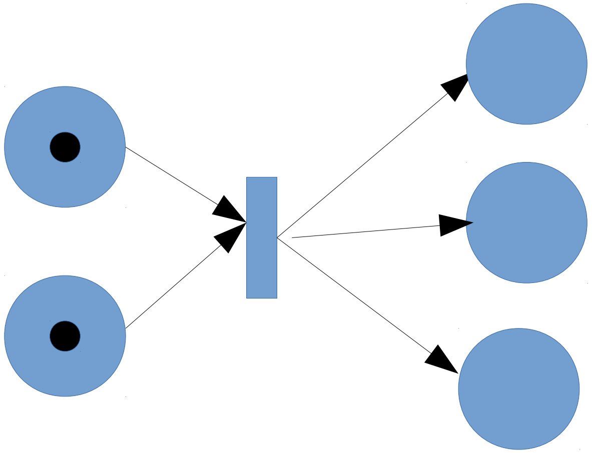


# Elementary Petri-Nets

- at most one token per place

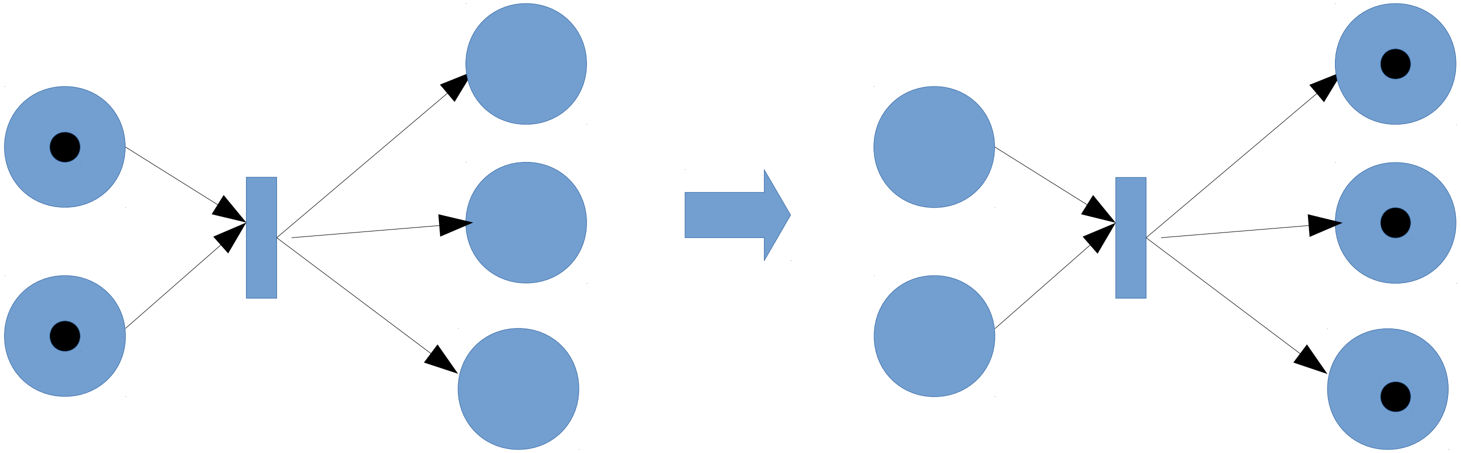
# Transitions

- **Enabled** if all its preplaces has a token
- All post places are empty
  - No token in them



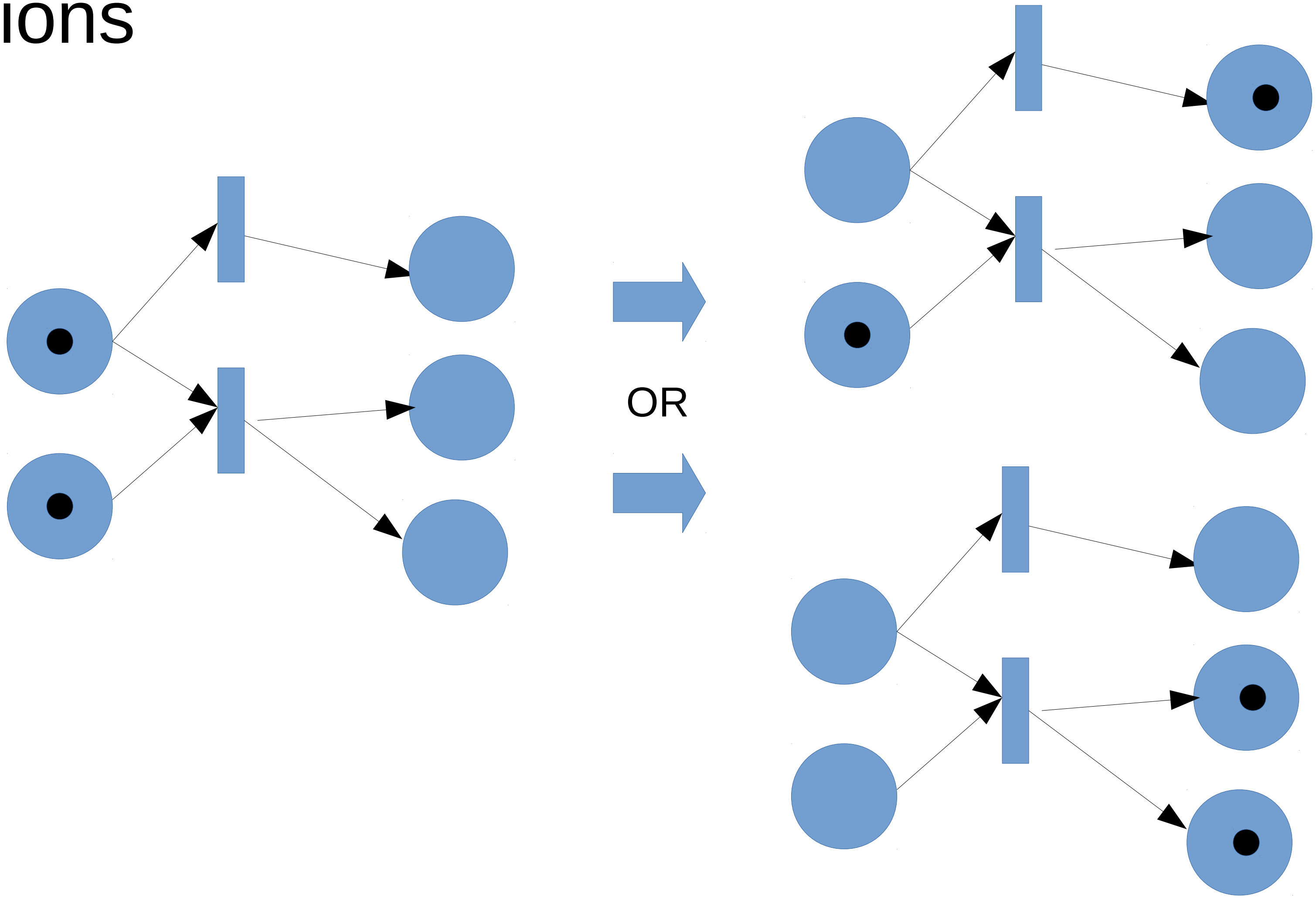
# Transitions

- Enabled transition **fires**, and it moves the token(s) downstream
- Into all post places

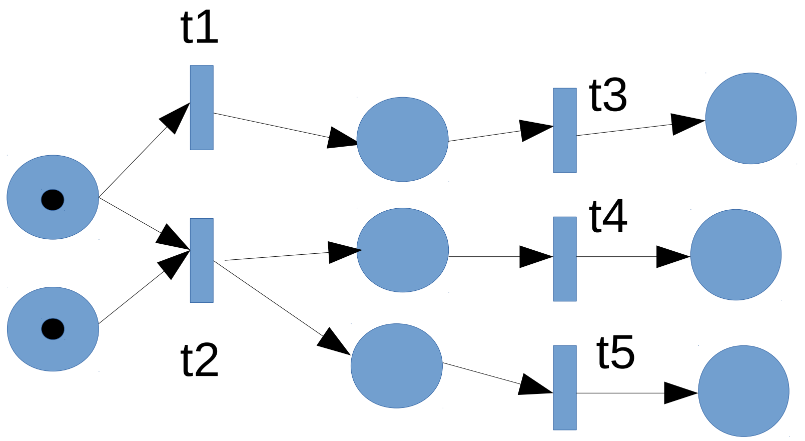


# Places

- A token may enable one or more transitions
- It gets consumed by firing one of the enabled transitions

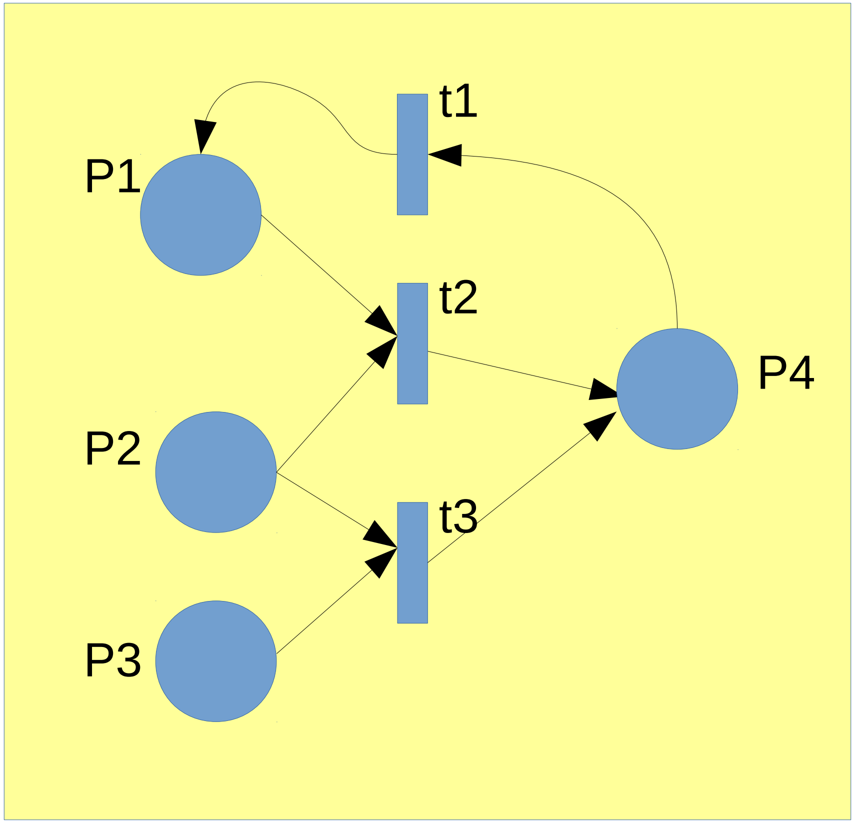


# Firing Sequence = sequence of transition firings (not markings)

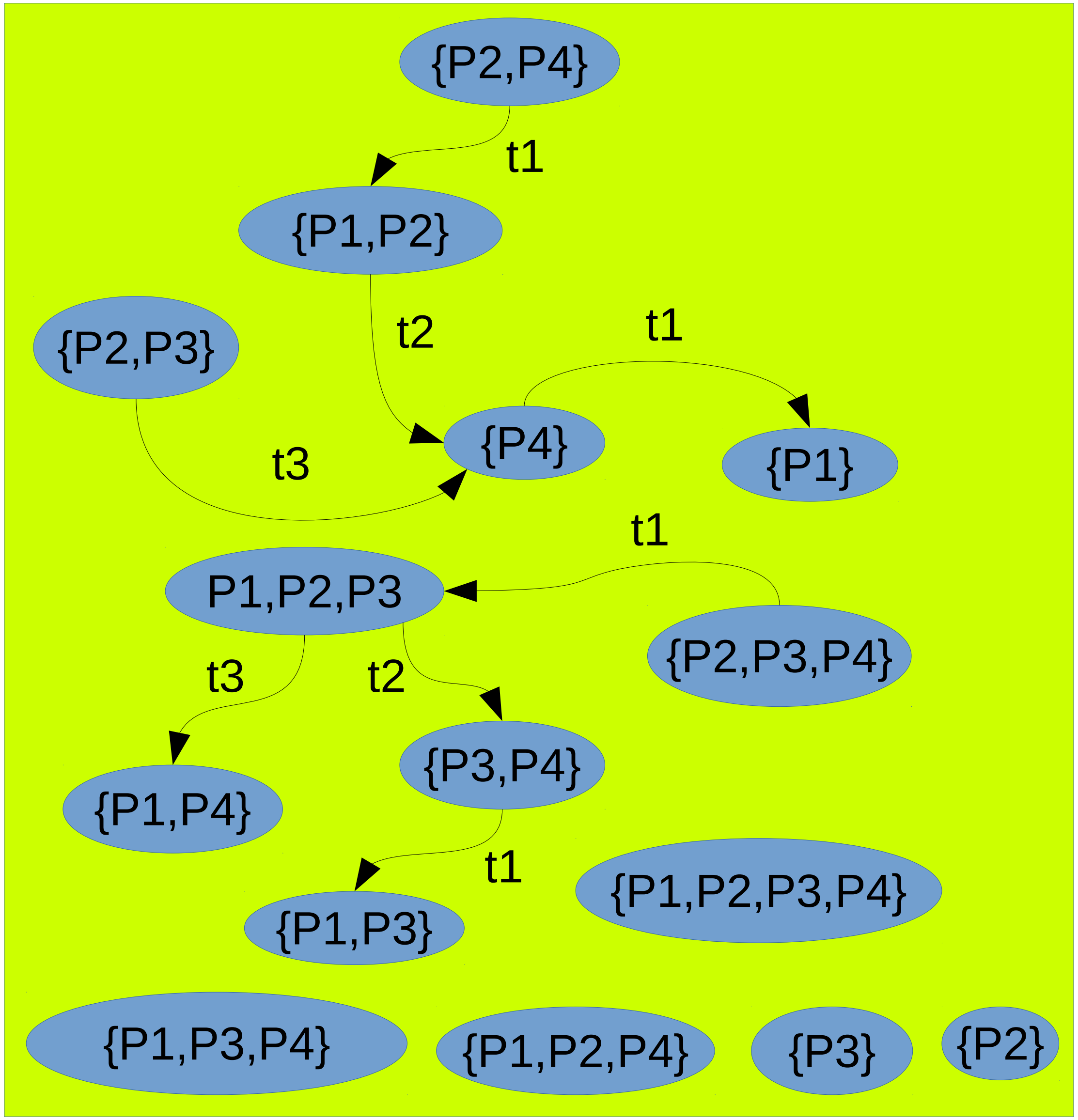


- Following firing sequences are possible (considering one transition firing at a time)
  - t1 --> t3
  - t2 --> t4 -->t5
  - t2 --> t5 -->t4

# State Space
# = set of all possible markings and the transitions through them

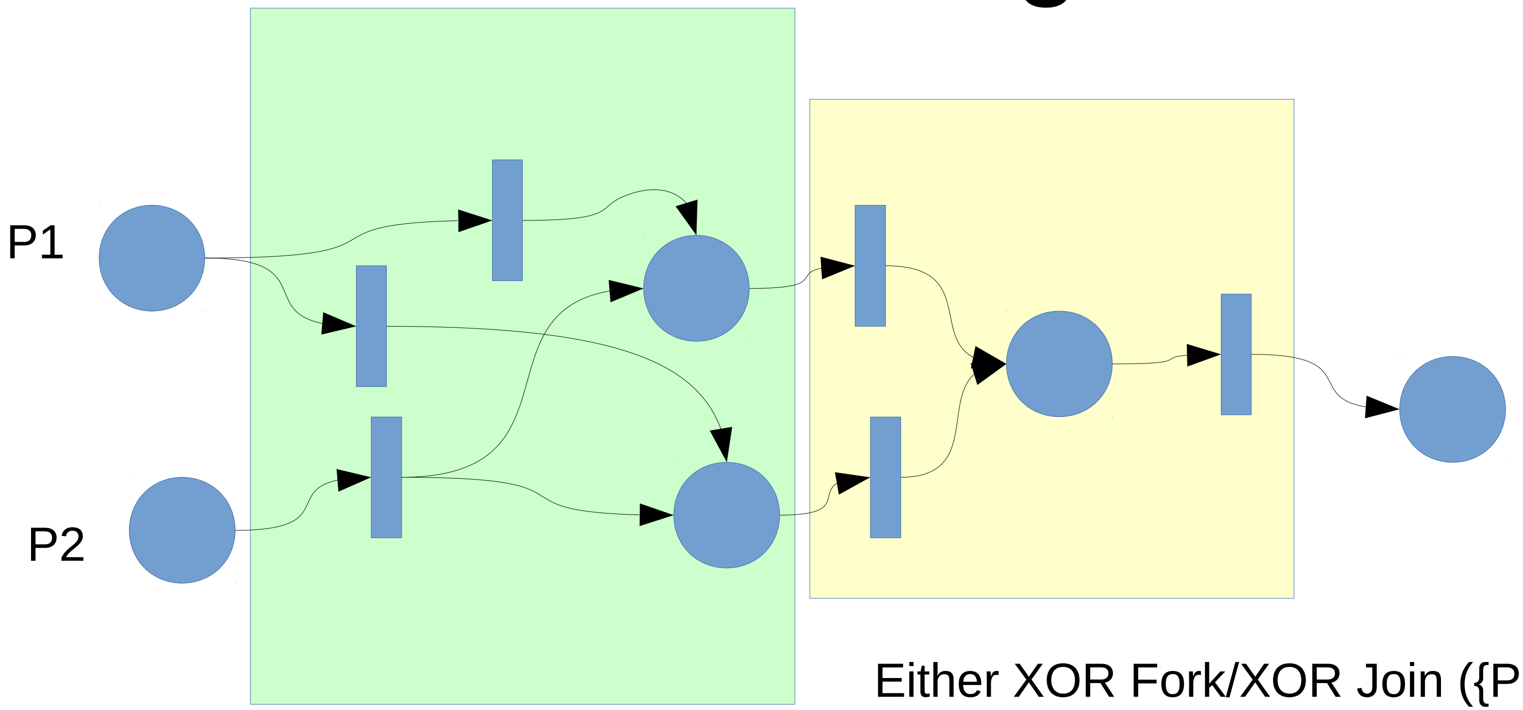


The Net



The State Space

# The same Petri-net for different purposes with different initial markings

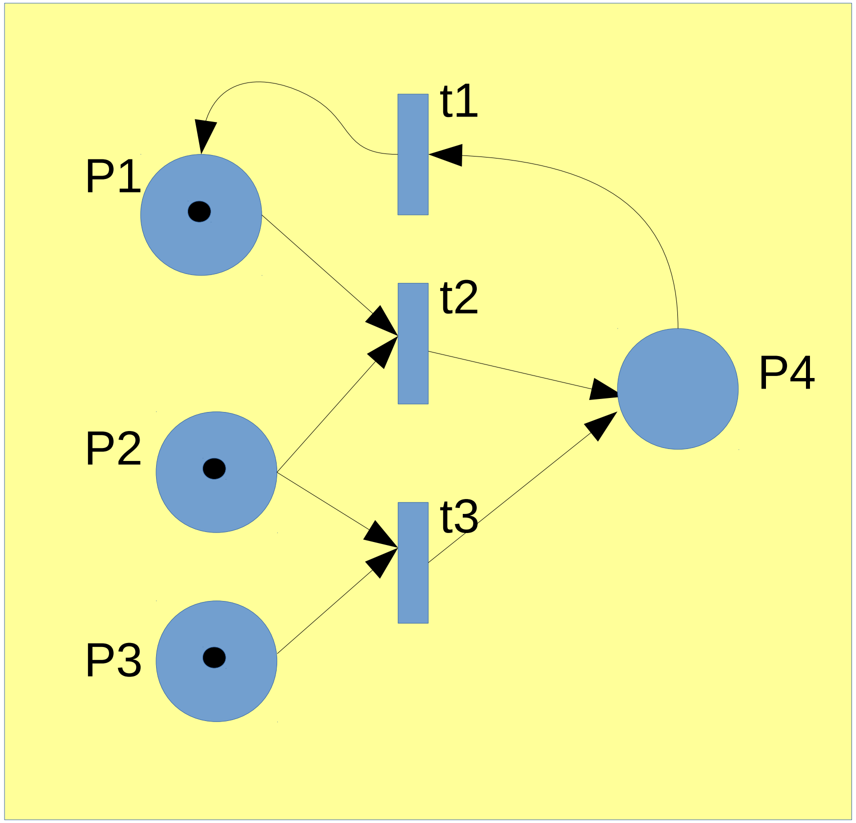


The helper part of the net

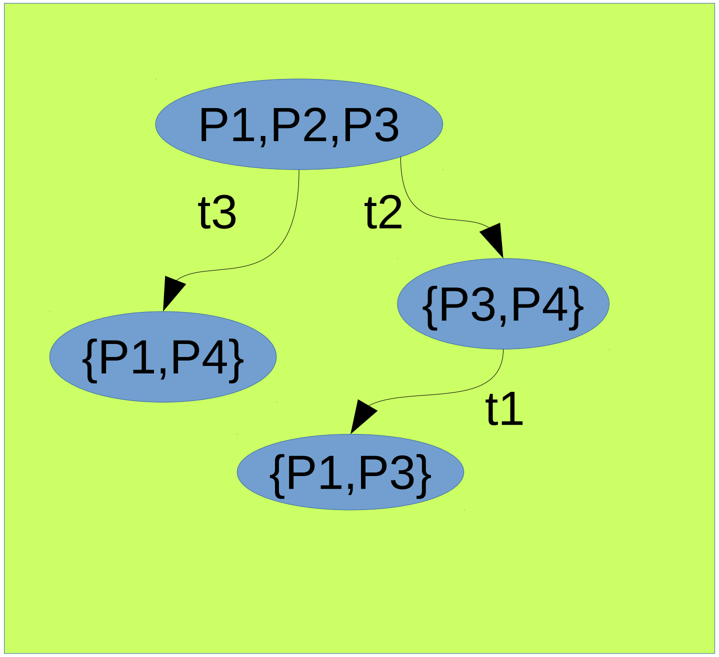
Either XOR Fork/XOR Join ({P1} as initial)
Or AND Fork/Multi-join

In Multi-join, multiple tokens get collected one after  the other ({P2} as initial)

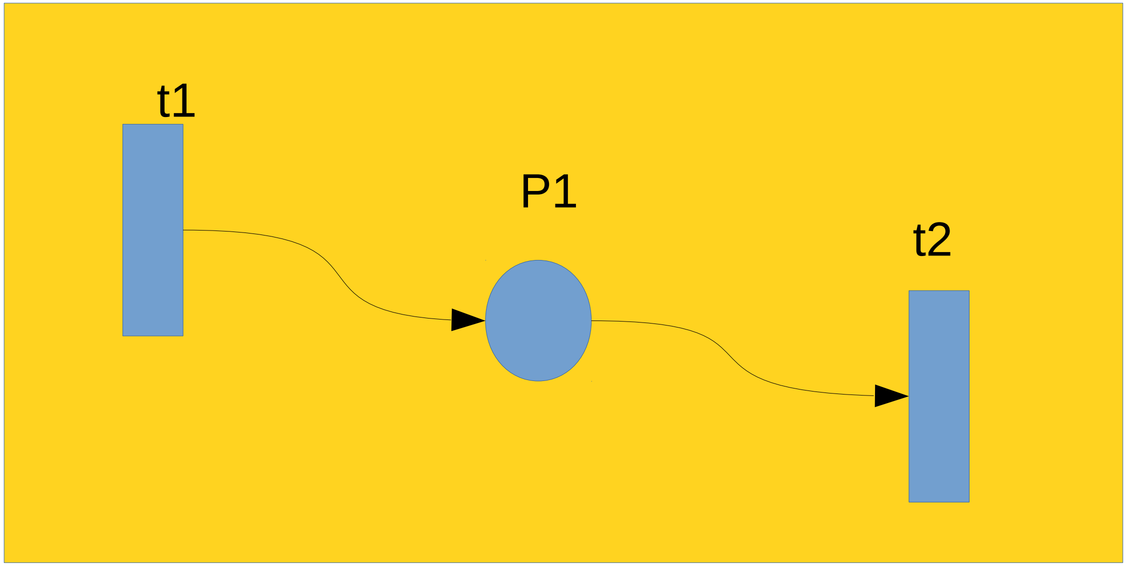
# Reachability Graph
# = state space given initial marking



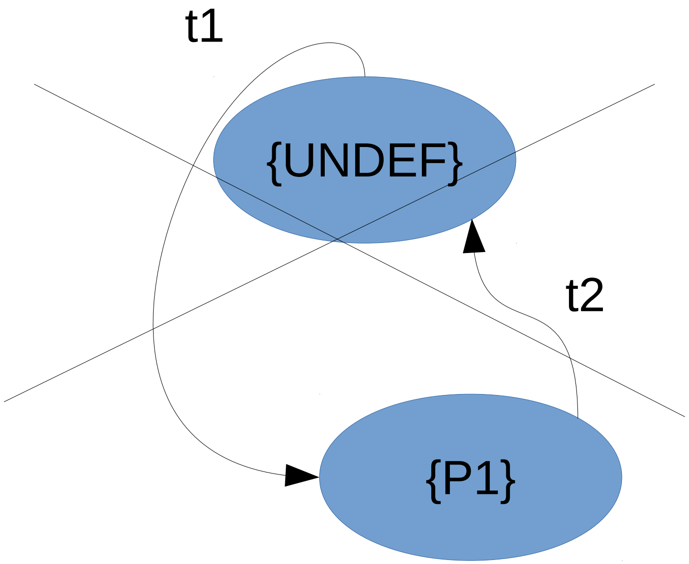
Reachability Graph
for
initial marking as {P1,P2,P3}

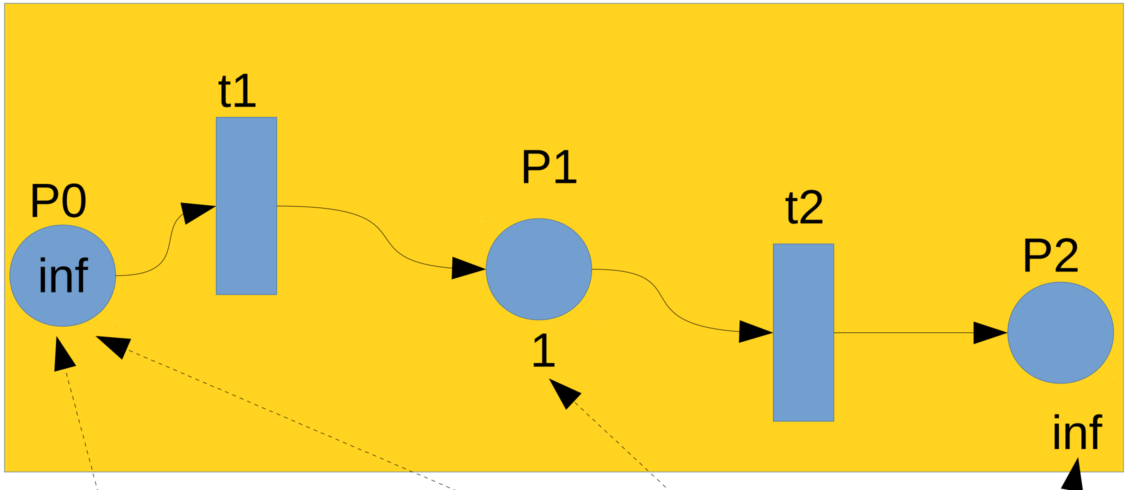


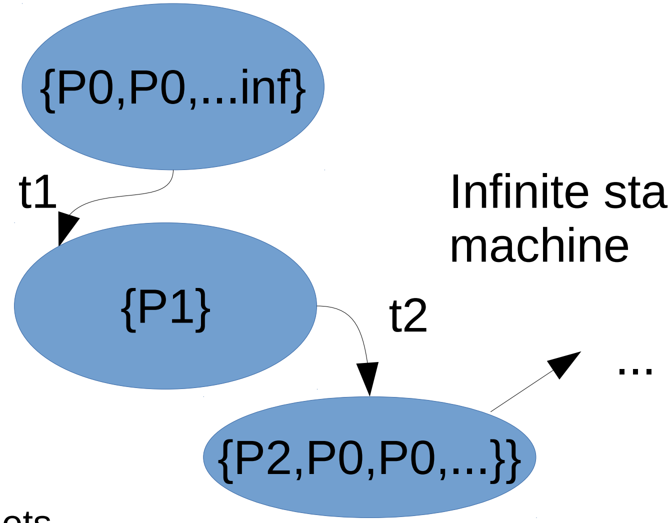
# Infinitely enabled net



Reachability graph
With initial marking=UNDEF







Infinite state
machine

P0 has inf tokens

The number written inside
represents those many (initial) tokens
in the given state of the machine.

Capacity of P1 is 1,
capacity of P0,
Capacity of P2 is inf
Inf is default capacity in classical nets

# A Problem: Rules of one masters program

- It's 2 semester program
- At most 10 courses
- Minimum 8 courses
- Per semester max 5 courses
- One R&D project can be taken as one course
- One masters project can be taken in place of 3 courses.
- MTP 1 in sem 1: counted as 3 courses, MTP 2 in sem 2: counted as 2 courses
- 1 seminar in 1st sem is must
- Backlogs of sem1 can be  taken in sem2
- If any backlogs remain, one more semester is granted

# Simplified Version of the Problem

- 5 courses
- 2 semester
- 2 courses per semester: total exactly 4 courses
- A course cannot be taken twice

- Make  your net to represent this system
- Try to reduce the no. of transitions
- Model with: One transition representing one course

# Vending machine Problem

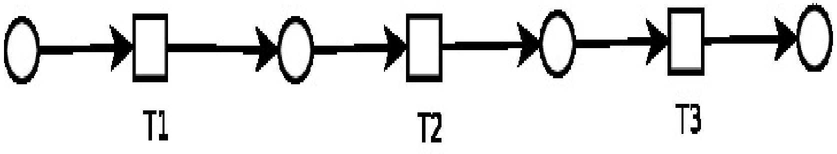
- Insert Rs. 25: currency Rs. 5, Rs. 10 coins accepted e.g. 5+5+5+5+5, 10+5+10 etc. (design as small a machine as possible)
- Choose the drink
- Pick it up
- The machine is ready for the next task
- Time out of 1 minute, the machine returns all the coins inserted and resets to initial state
- Invalid coin is rejected, and all the coins are returned, the machine resets with a spoken message of invalid coin.

# Workflow Nets

# Workflow Nets

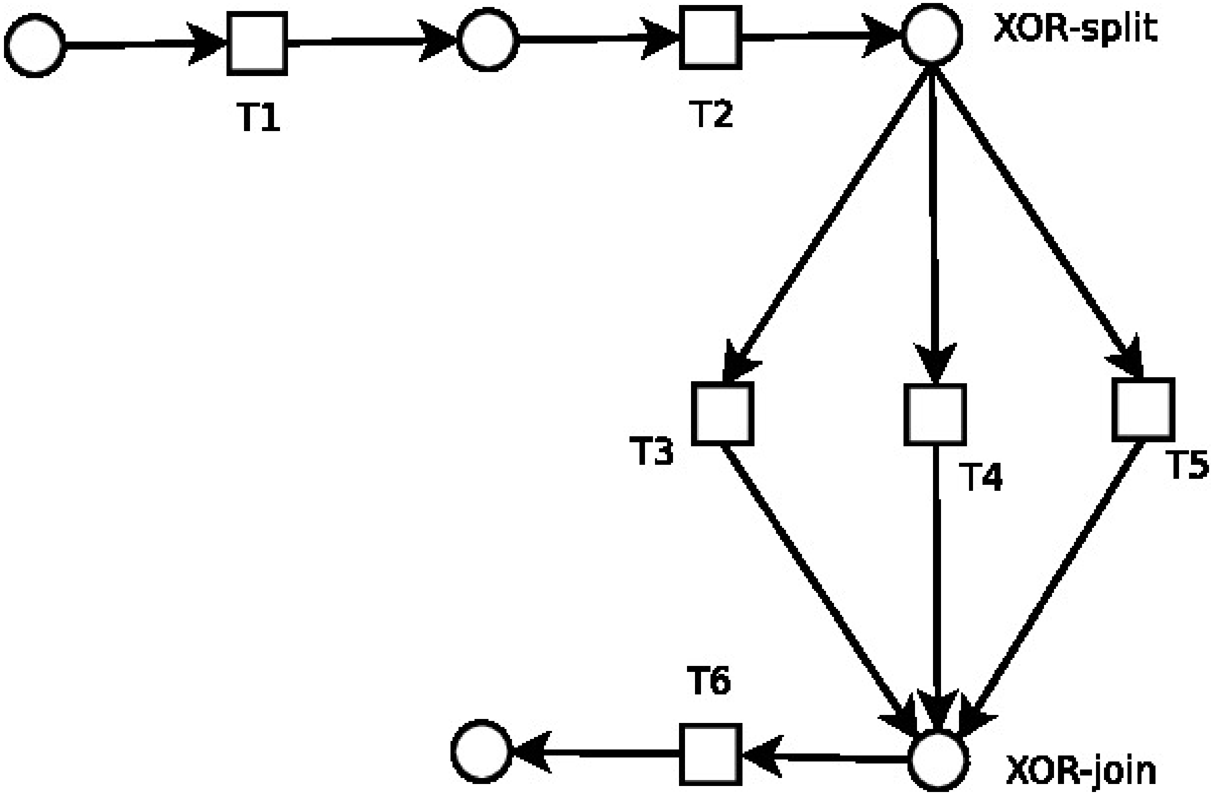
- Unique source place
- Unique sink place
- Connected
- Unique initial marking, unique terminal marking
- Well-formed – every transition is reachable, every marking is reachable, every marking terminates

# Workflow Patterns: SEQUENCE

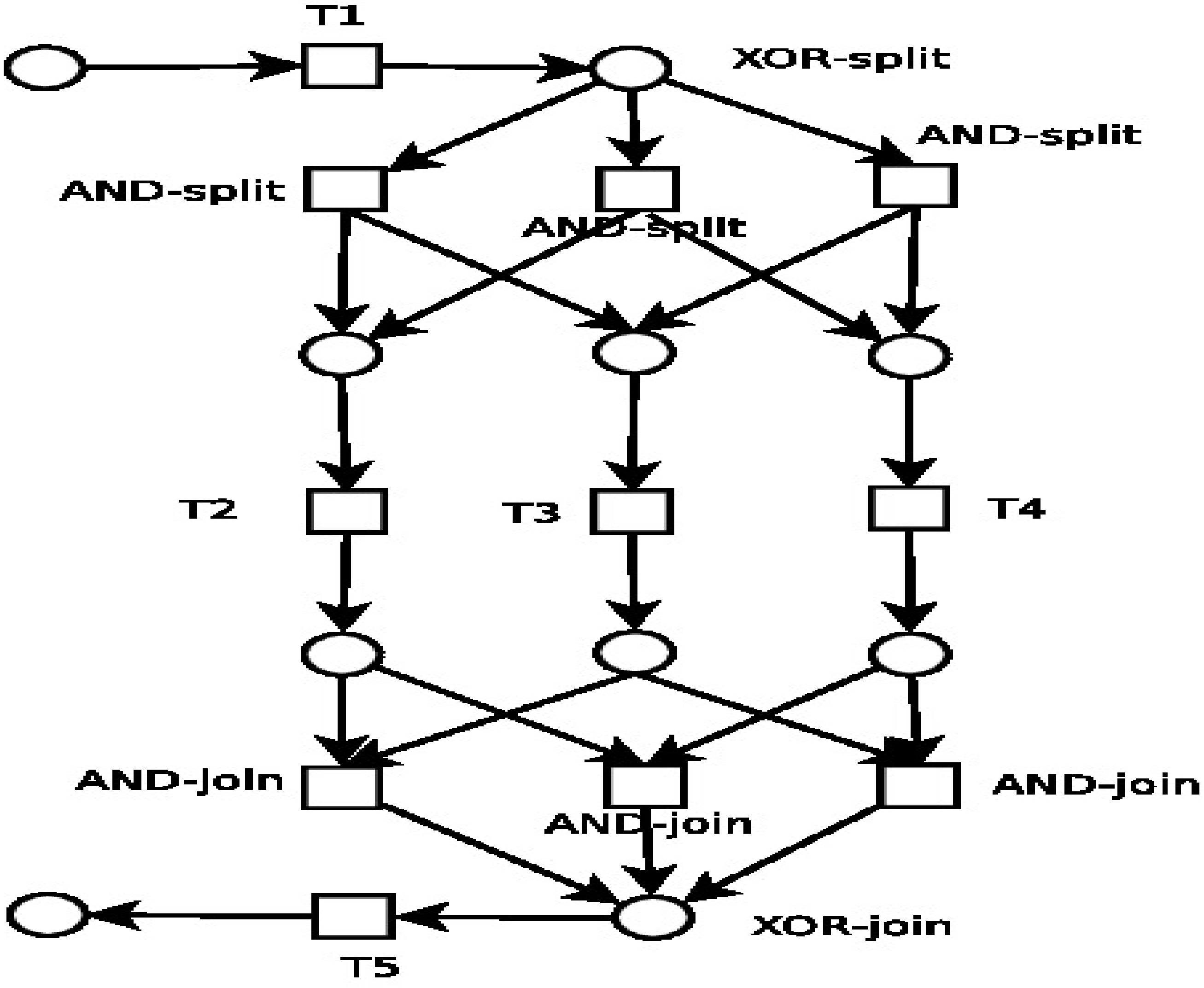


Sequence

# Workflow Patterns: XOR

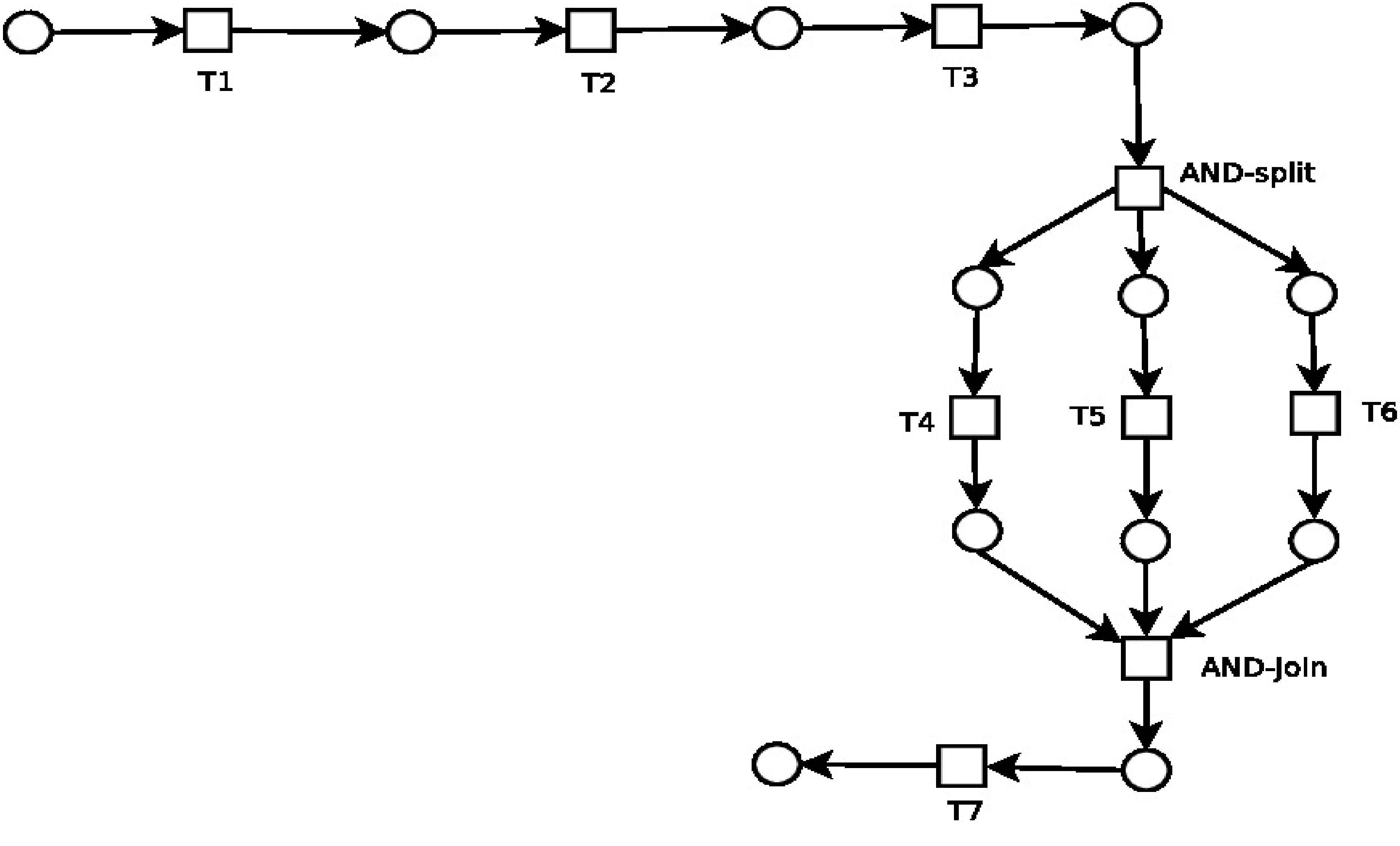


# Workflow Patterns: 2/3 Choice



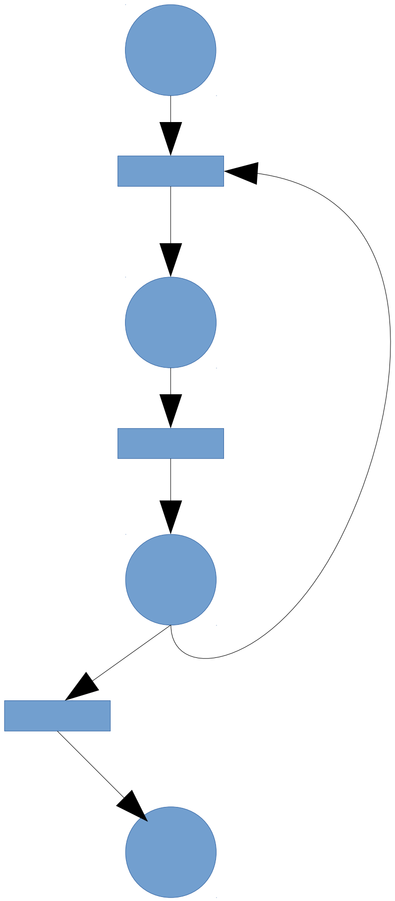
2/3 split-join

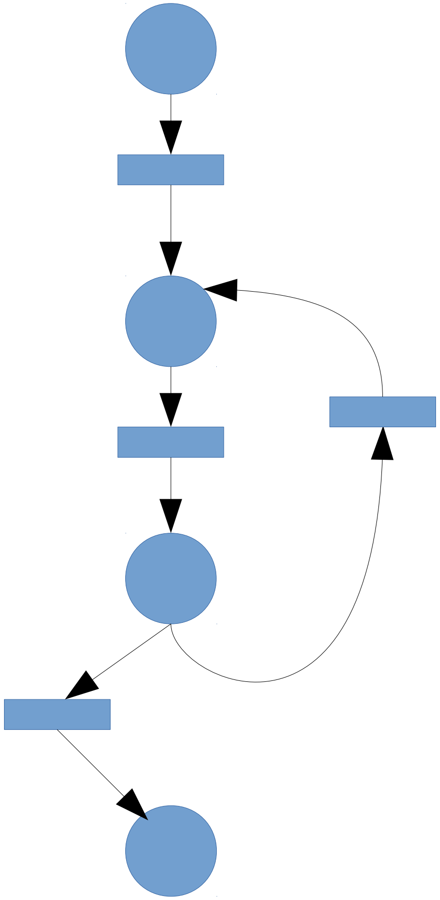
# Workflow Patterns: AND



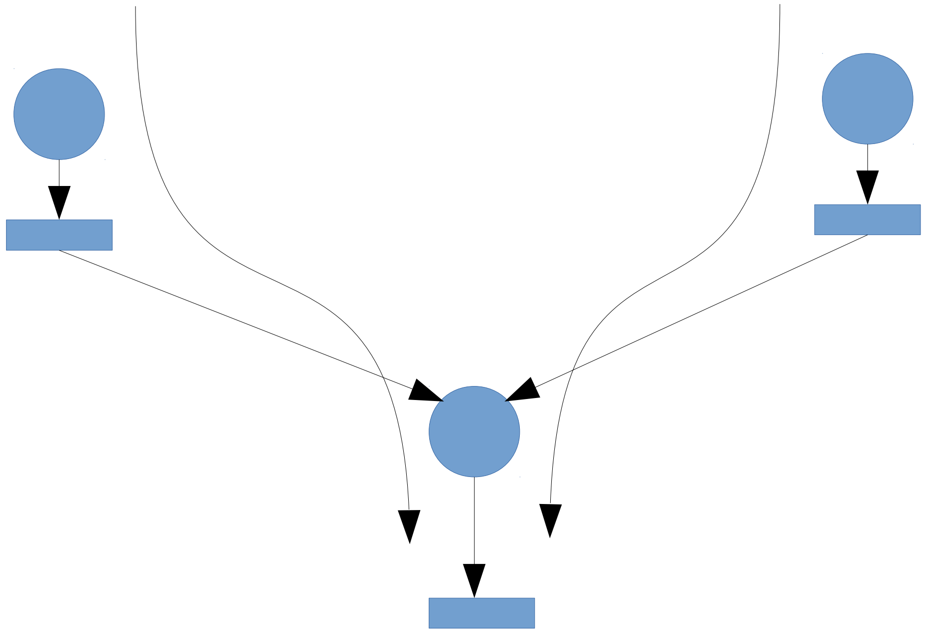
# Workflow Patterns: Iteration

which one is correct? Which one is incorrect? Why?





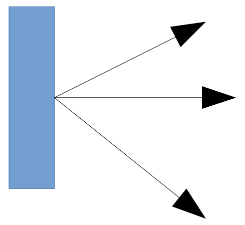
# Workflow Patterns: Multi-merge



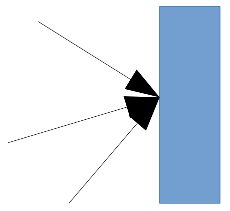
Tokens can arrive both ways, and they are all sent down

# Split/Join

- Parallel split

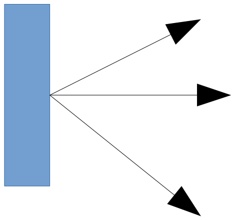


- Synchronization (parallel merge/AND join)

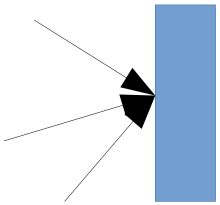


# Split/Join

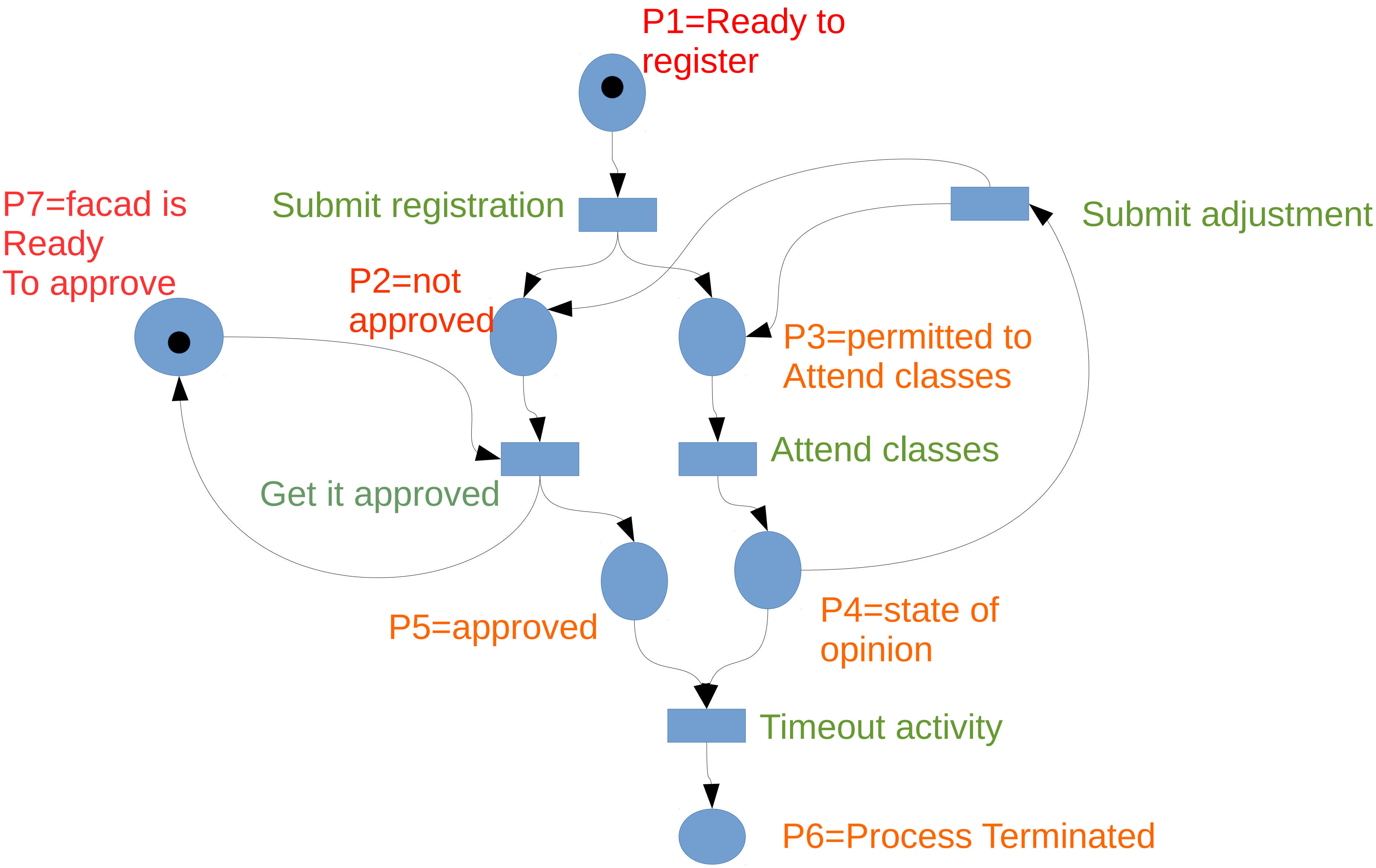
- Parallel split



- Synchronization (parallel merge/AND join)



# Roles as tokens in places



P1=Ready to register

Submit registration

Submit adjustment

P7=facad is Ready To approve

P2=not approved

P3=permitted to Attend classes

Attend classes

Get it approved

P5=approved

P4=state of opinion

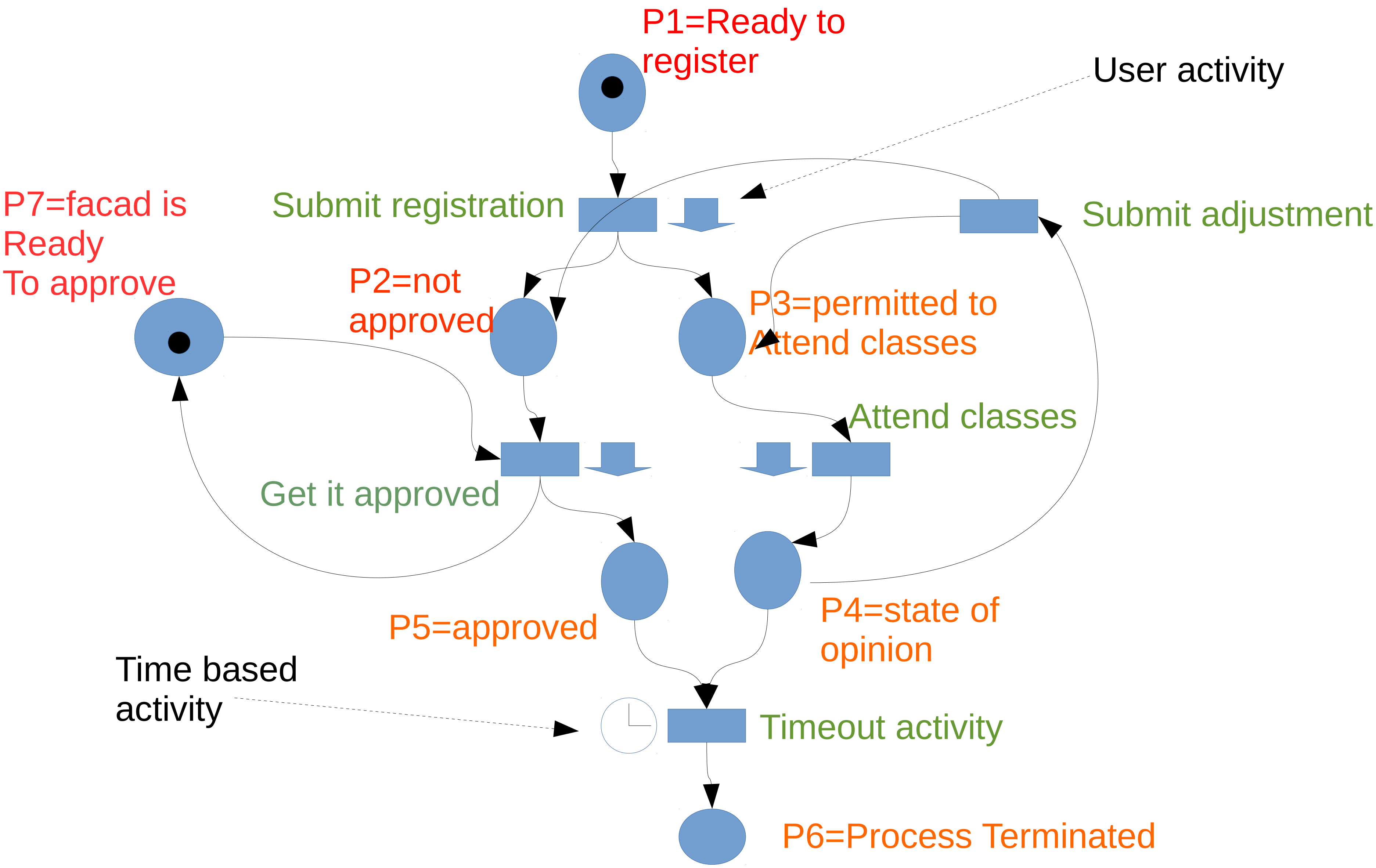
Timeout activity

P6=Process Terminated

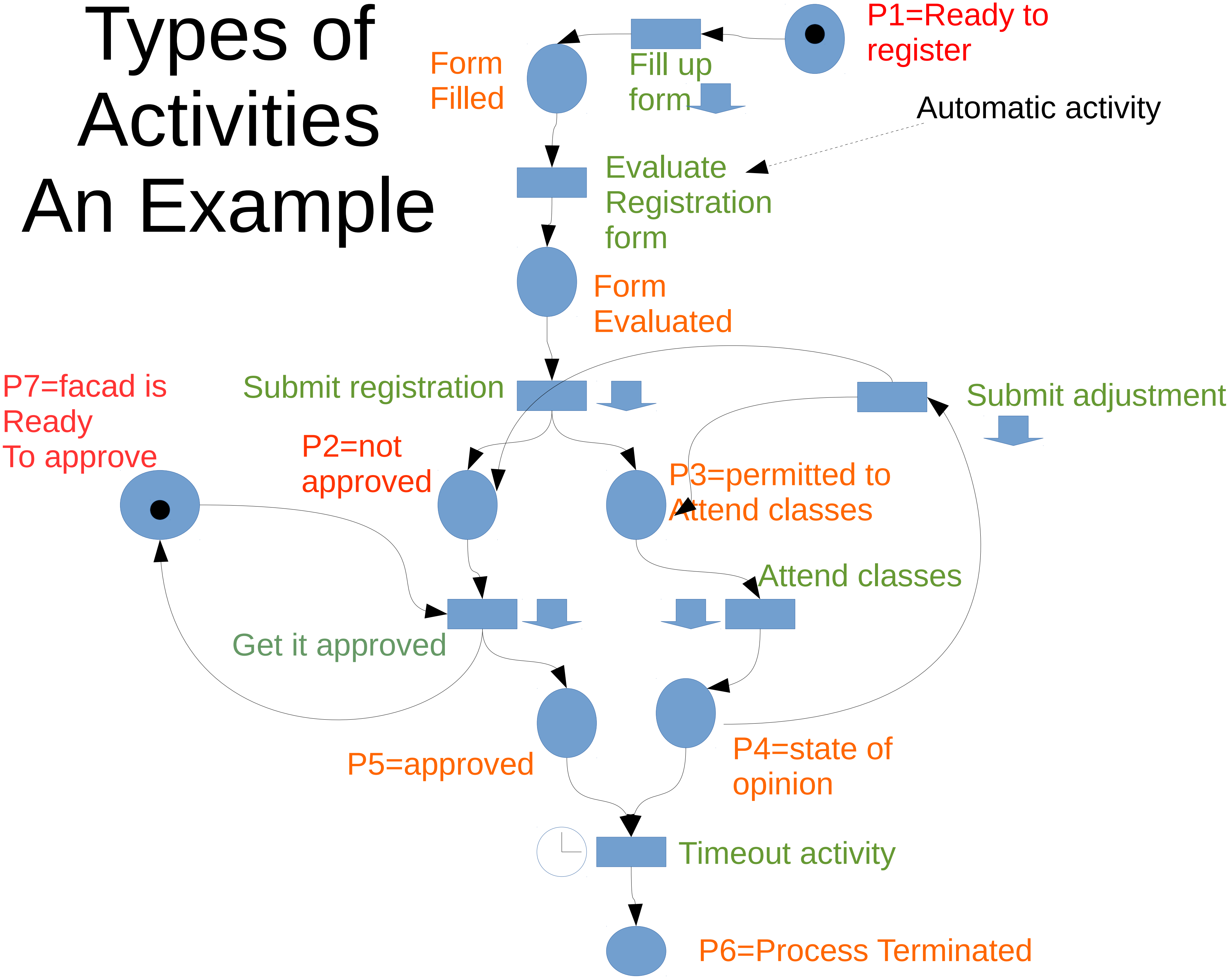
# Types of activities

- Automatic Activity
  - Computer can execute it fully
    - (when enabled, it is executed automatically such as by an algorithm, script task etc.)
- User Activity
  - A human being executes it
    - (though enable, it is done manually)
- Message Activity
  - An external message triggers the task instance
    - (though enabled, it requires a message to trigger it)
- Time Triggered Activity
  - Task needs to be trigged at a particular time, or after a certain period of timeout
    - (though enabled, time has to trigger it)

# Types of Activities
# An Example



# Types of Activities An Example



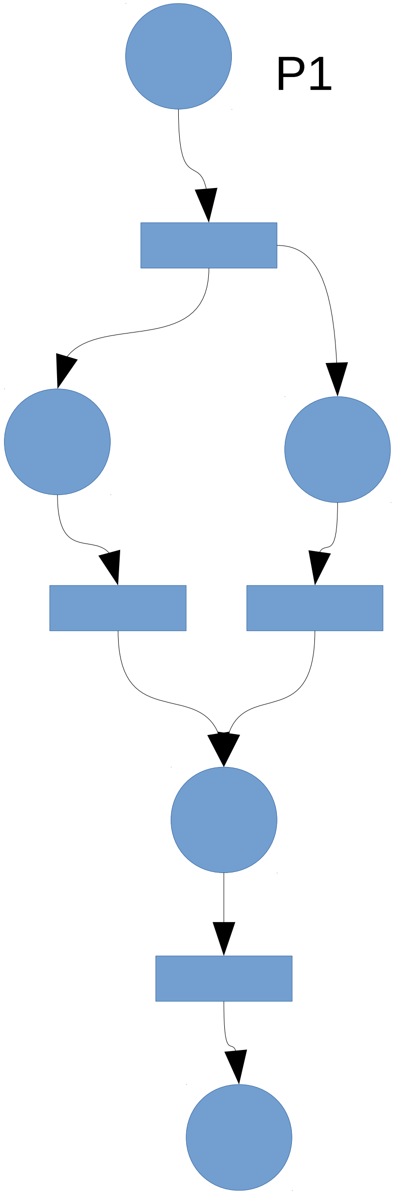
# Problem

- Re-engineer the above net to reflect the process that we are actually following
- Make sure all traces that we actually take are in
- Also make sure the traces that we donot take are not in
- i.e. the aim is to get the exact model that is necessary and sufficient to represent the present process.

# Classical Petri Nets

- A place can contain 0 or more tokens (more than 1)
  - The state then needs to mention the count of tokens held in places
    - e.g. {1 p1, 2 p3, 4 p4}
    - This state is different from {2 P1, 2 P3, 4 p4}

# Places with multiple tokens



Build a state space

Initial marking: {P1}