

# MEHRAD HAGHSENAS

## SCICOMP301 TOPICS IN COMPUTER SCIENCE PROJECT 1: PETRI NETS

“THIS IS ALL MY OWN WORK. I HAVE NOT KNOWINGLY ALLOWED OTHERS TO COPY OUR WORK. THIS WORK HAS NOT BEEN SUBMITTED FOR ASSESSMENT IN ANY OTHER CONTEXT.”

## TECHNOLOGY PLATFORM

HARDWARE: MACOS MONTEREY (VERSION 12.2.1)

SOFTWARE: PIPE (PIPE-GUI-5.0.2.JAR) UNDER JAVA 8 (1.8.0\_202.JDK)

SIDE NOTE: THE CPN TOOLS OFFICIAL WEBSITE RECOMMEND NOT INSTALLING CPN FOR MAC INSTEAD INSTALLING THE LATEST WINDOWS VERSION AND USING VIRTUAL MACHINES TO USE THE TOOL.

# BASIC PETRI NETS

**HISTORY:** INTRODUCED BY GERMAN MATHEMATICIAN CARL ADAM PETRI.

**FORMAL DEFINITION:**

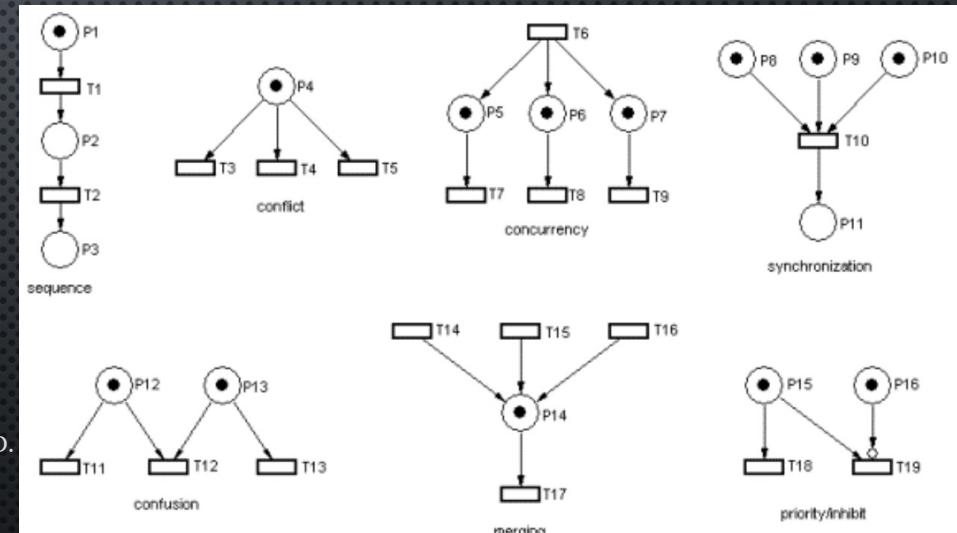
GRAPHICAL AND MATHEMATICAL MODELLING FRAMEWORK

BIPARTITE DIRECTED GRAPH (PLACES AND TRANSITIONS == NODES).

FIVE-TUPLE ( $P, T, I, O, M$ ). ( $I/O == \text{EDGES}$ ).

$M$ : A  $M$ -TUPLE OF THE NUMBER OF TOKENS (DYNAMIC)

**RESTRICTED CONDITION:** NO TWO PLACES OR TWO TRANSITIONS CAN BE CONNECTED.



<https://www.techfak.uni-bielefeld.de/~mchen/BioPNML/Intro/pnfaq.html>

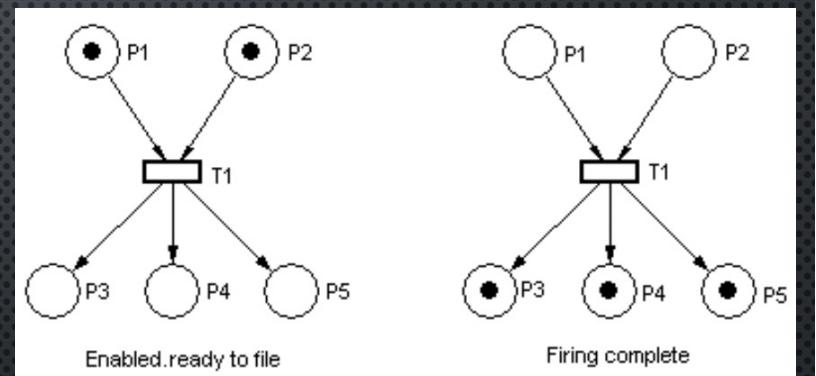
## TERMS DEFINITIONS

**MARKING == STATE:** DISTRIBUTION OF TOKENS IN PLACES.

**STATE SPACE:** THE SET OF ALL MARKINGS

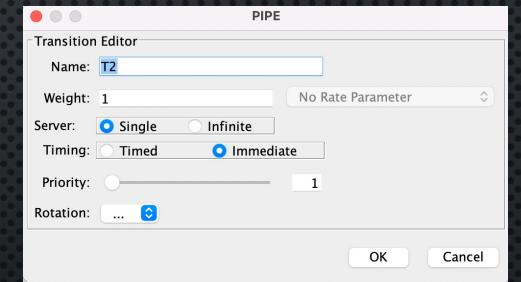
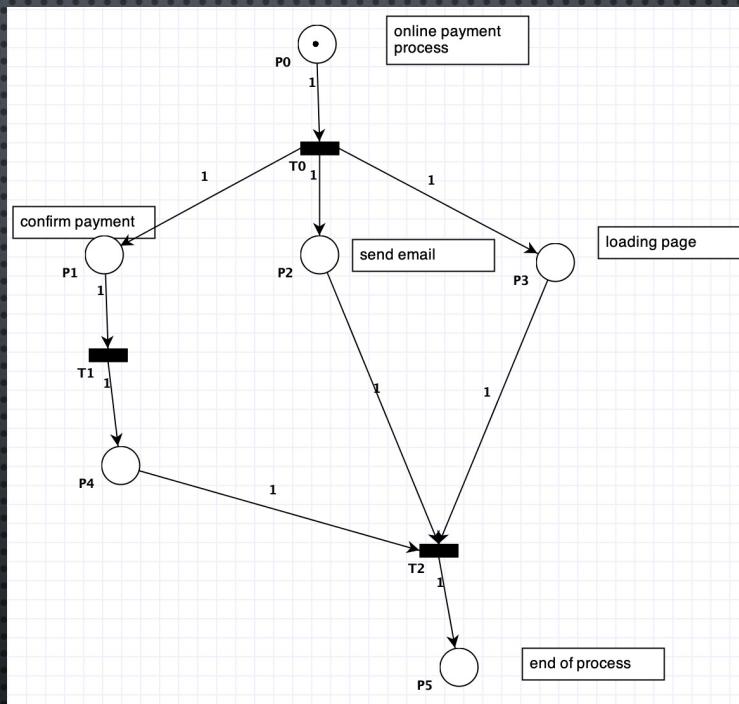
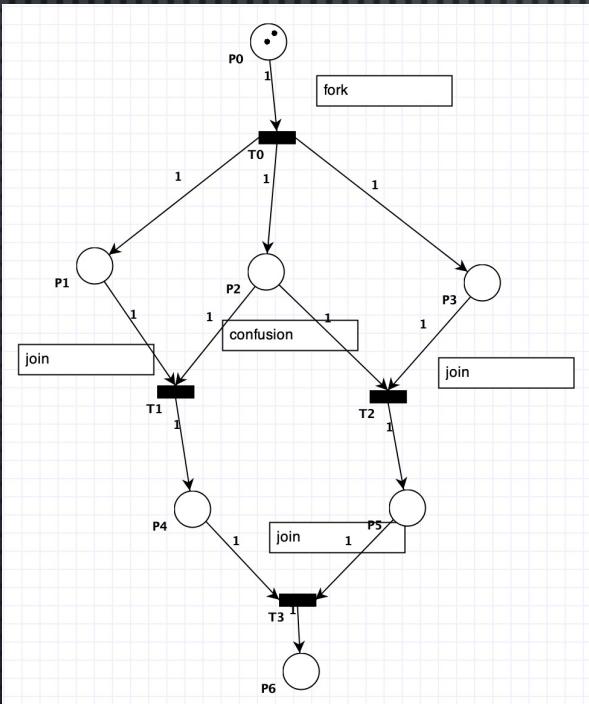
**REACHABILITY SET:** ALL MARKINGS THAT CAN BE OBTAINED FROM SOME INITIAL MARKING

**NON-DETERMINISM:** MULTIPLE TRANSITIONS ARE ENABLED BUT NOT ALL CAN FIRE LIKE  
CONFUSION, CONFLICT ...



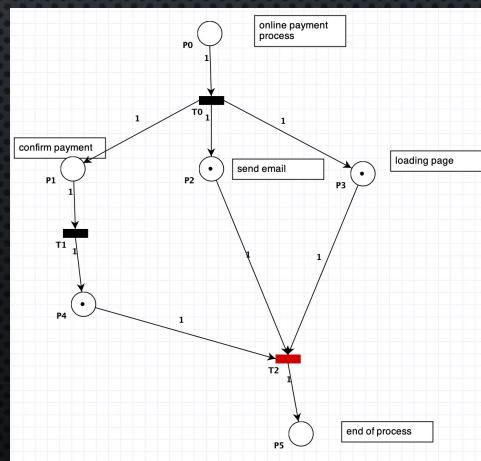
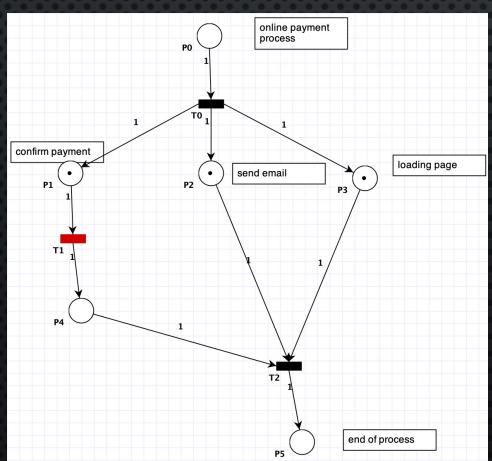
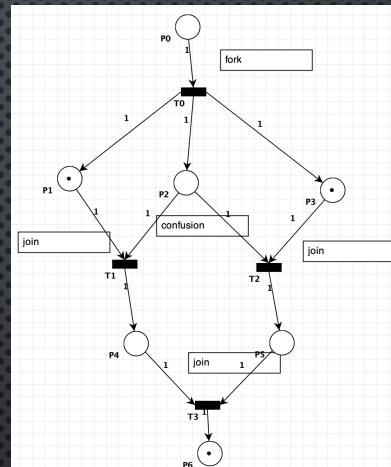
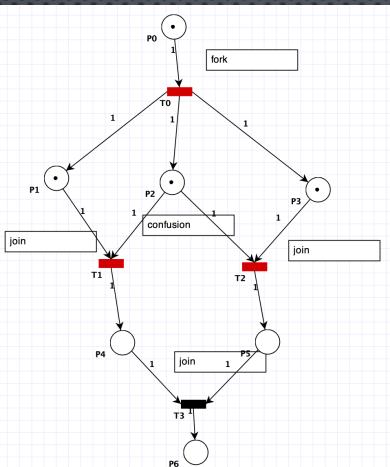
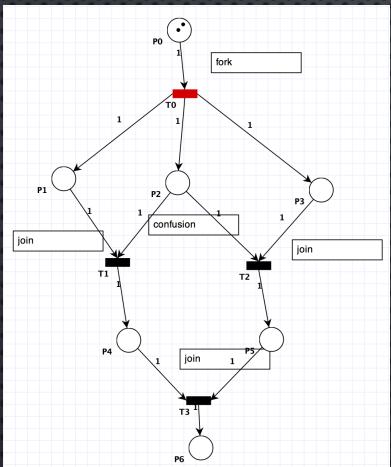
Initial marking:  $M(0) = (1, 1, 0, 0, 0)$ . After firing:  $M(1) = (0, 0, 1, 1, 1)$

## A FORK AND JOIN EXAMPLE BEFORE TRANSITION FIRING.



JOIN IN SYNCHRONIZATION. FORK IS CONCURRENCY.

## A FORK AND JOIN EXAMPLE AFTER TRANSITION FIRING



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## DEADLOCK (CIRCULAR WAITING) PROBLEM

- PROBLEMS IN RESOURCE ALLOCATION --- CPU IS THE RESOURCE IN OS.
- SCARCITY OF RESOURCES COMPARED TO PLACES NEEDS
- “A PETRI NET IS DEADLOCKED IFF NO TRANSITIONS ARE ENABLED.”  
([HTTPS://CITESEERX.IST.PSU.EDU/VIEWDOC/DOWNLOAD?DOI=10.1.1.136.4482&REP=REP1&TYPE=PDE](https://CITESEERX.IST.PSU.EDU/VIEWDOC/DOWNLOAD?DOI=10.1.1.136.4482&REP=REP1&TYPE=PDE))
- A PETRI NET IS DEADLOCKED IF THE STATE OF THE PETRI DOES NOT CHANGE AFTER TRANSITION.  
[HTTPS://WWW.YOUTUBE.COM/WATCH?V=ANNTEELMCW&T=979s](https://WWW.YOUTUBE.COM/WATCH?V=ANNTEELMCW&T=979s)
- **MUTUAL EXCLUSION:** NON SHAREABLE RESOURCES
- **HOLD AND WAIT:** A PROCESS IS HOLDING AT LEAST ONE RESOURCE AND WAITING FOR RESOURCES.
- **No PRE-EMPTION:** A RESOURCE CANNOT BE TAKEN FROM A PROCESS
- **CIRCULAR WAIT:** (WAITING FOR AND ASSIGNED TO)

## A PETRI NET FOR ILLUSTRATING DEADLOCK WITH AN INITIAL MARKING OF TOKENS.

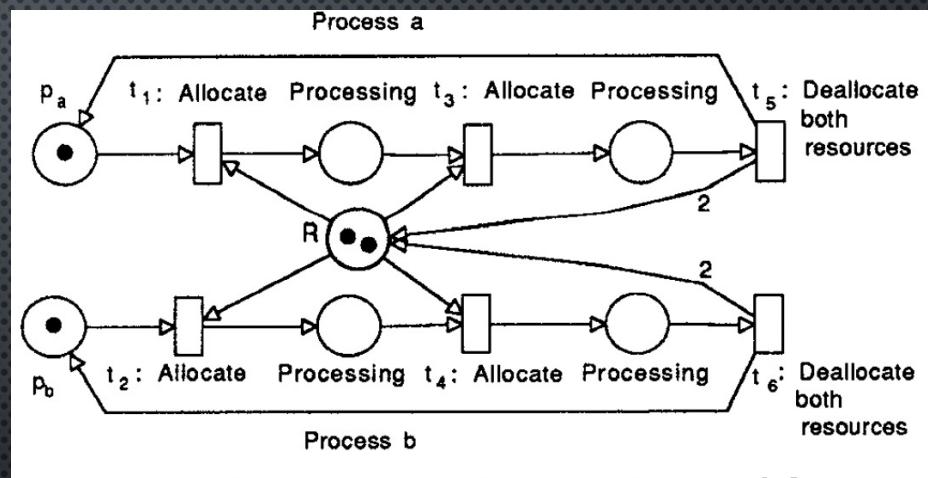
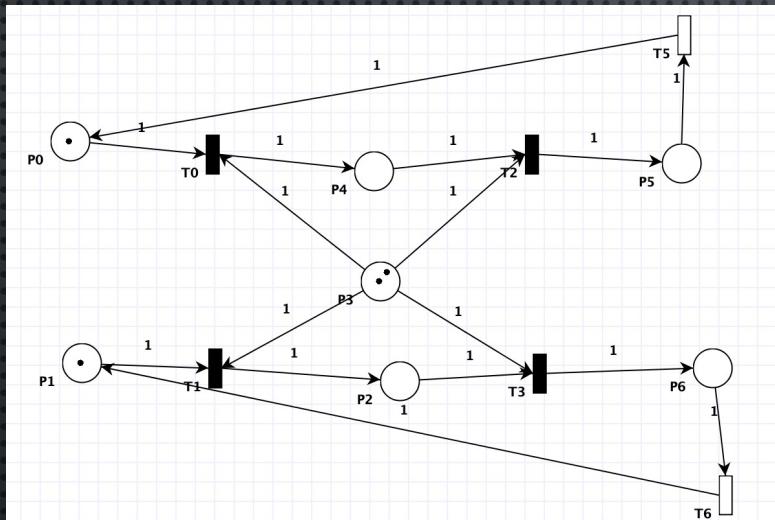
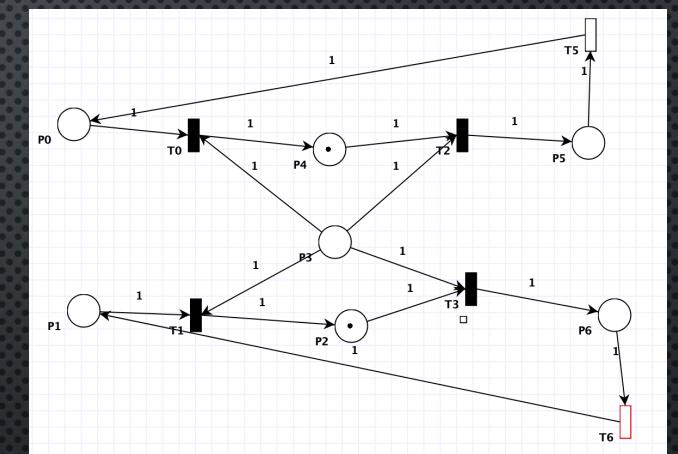
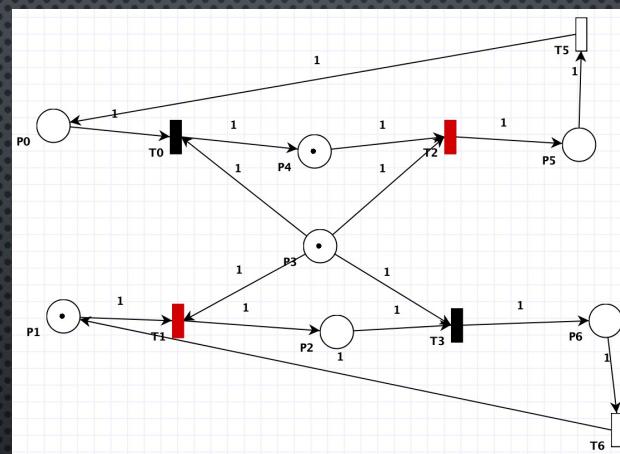
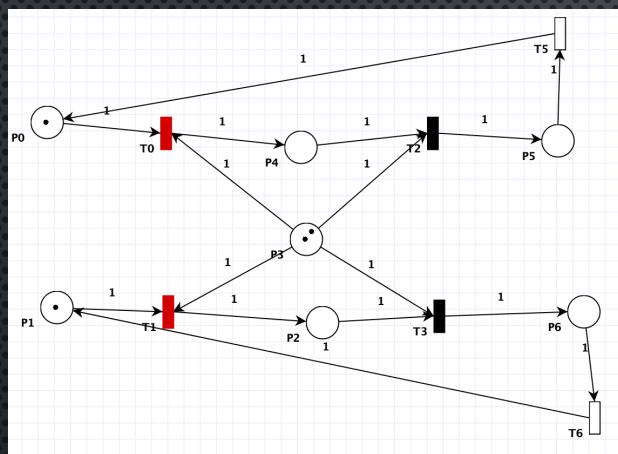


Figure 2: Resource Allocation Net Model 1

Which one is this?

## A PETRI NET FOR ILLUSTRATING DEADLOCK AFTER SEVERAL STEPS HAVE BEEN EXECUTED



## STARVATION (LIVE LOCK)

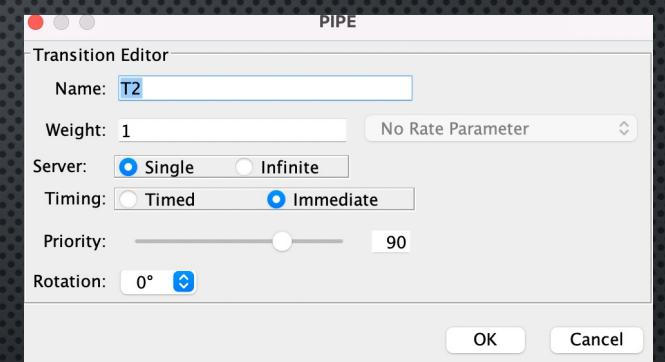
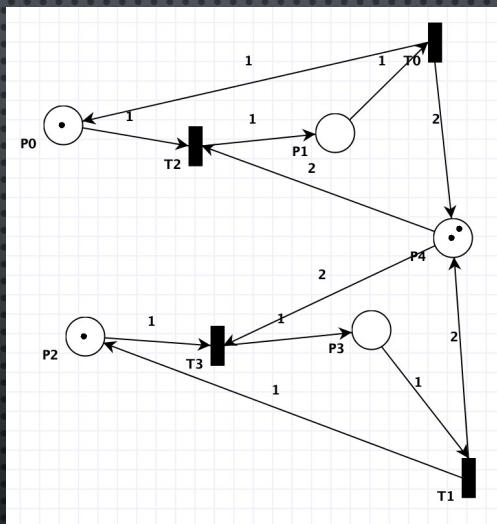
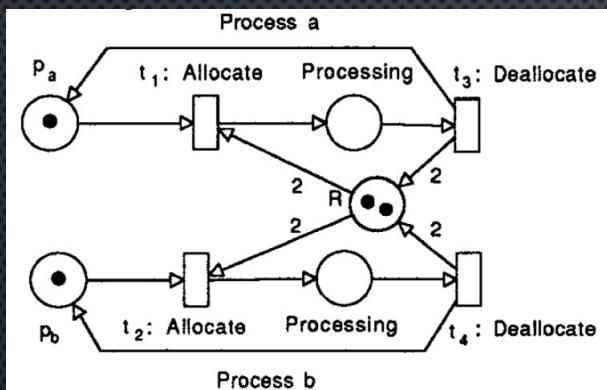
- SCHEDULING ALGORITHMS (FCFS,LCFS,SJF,LJF,RR,SRTF,LRTF,MQS...)
- STARVATION IS RELATED TO PRIORITY SCHEDULING

PRIORITY SCHEDULING: 1- HIGHEST PRIORITY EXECUTED FIRST. 2- SAME PRIORITY EXECUTED ON FCFS

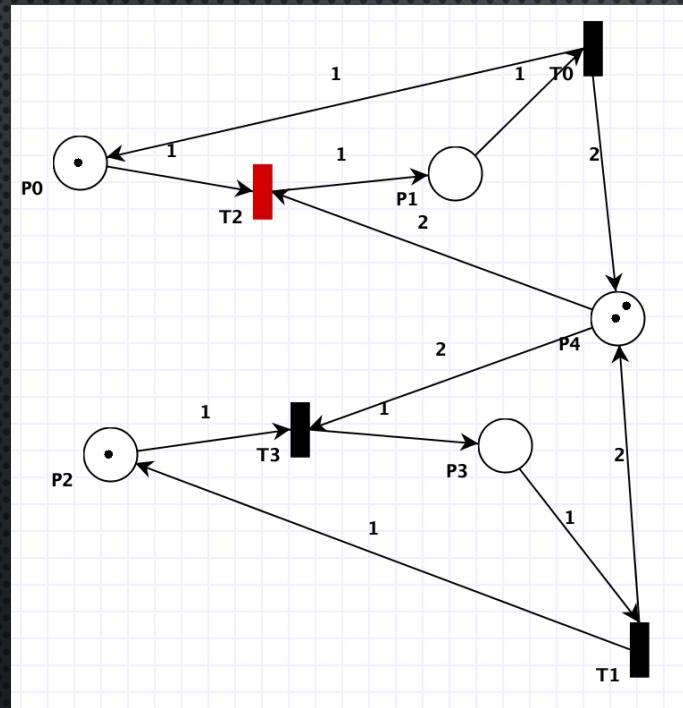
WHAT CAN PRIORITIES BE? TIME, MEMORY, ETC. (FOR EXAMPLE LOWEST BURST TIME)

- STARVATION: A PROCESS READY FOR THE CPU CAN WAIT TO RUN INDEFINITELY BECAUSE OF LOW PRIORITY. (ALWAYS WAITING TO RUN) (EXAMPLE IBM 7094).
- DIFFERENCE BETWEEN STARVATION & DEADLOCK? 1- RESOURCES 2- TRANSITIONS EXCEPT FOR THE VICTIM.
- SOLUTION TO STARVATION: AGING

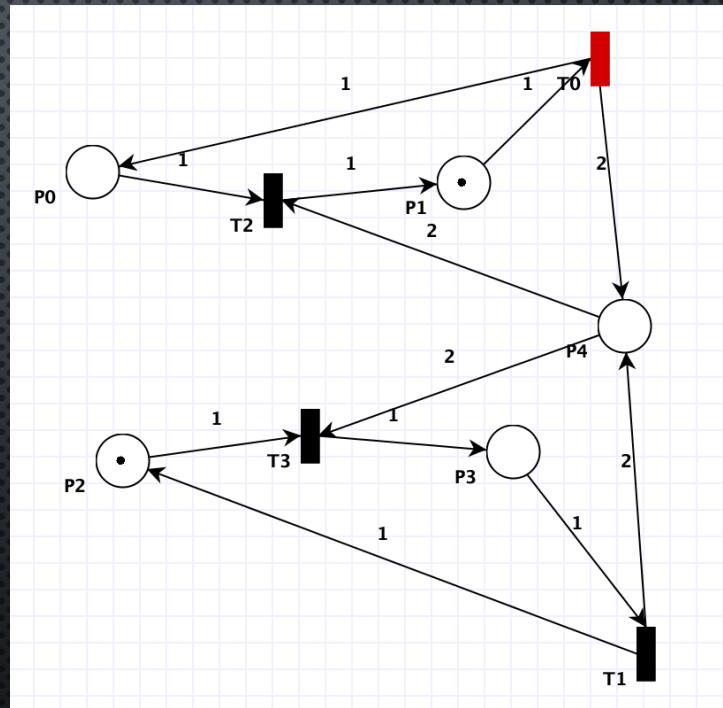
## A PETRI NET ILLUSTRATING STARVATION WITH AN INITIAL MARKING OF TOKENS.



A PETRI NET ILLUSTRATING STARVATION AFTER SEVERAL STEPS HAVE BEEN EXECUTED.



Step 1



Step 2

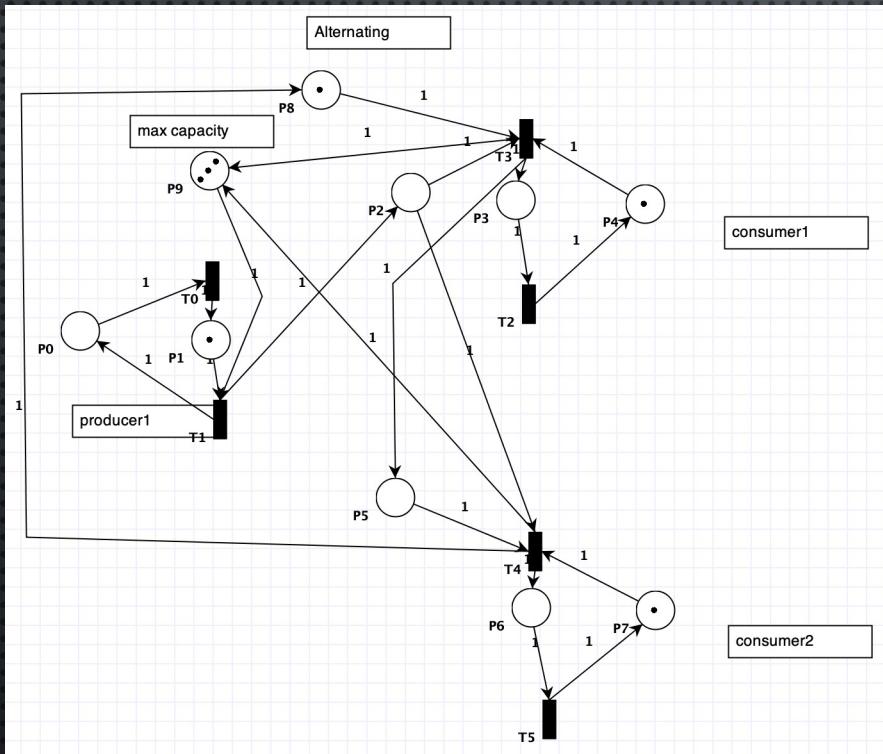
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## PRODUCER-CONSUMER PROBLEM

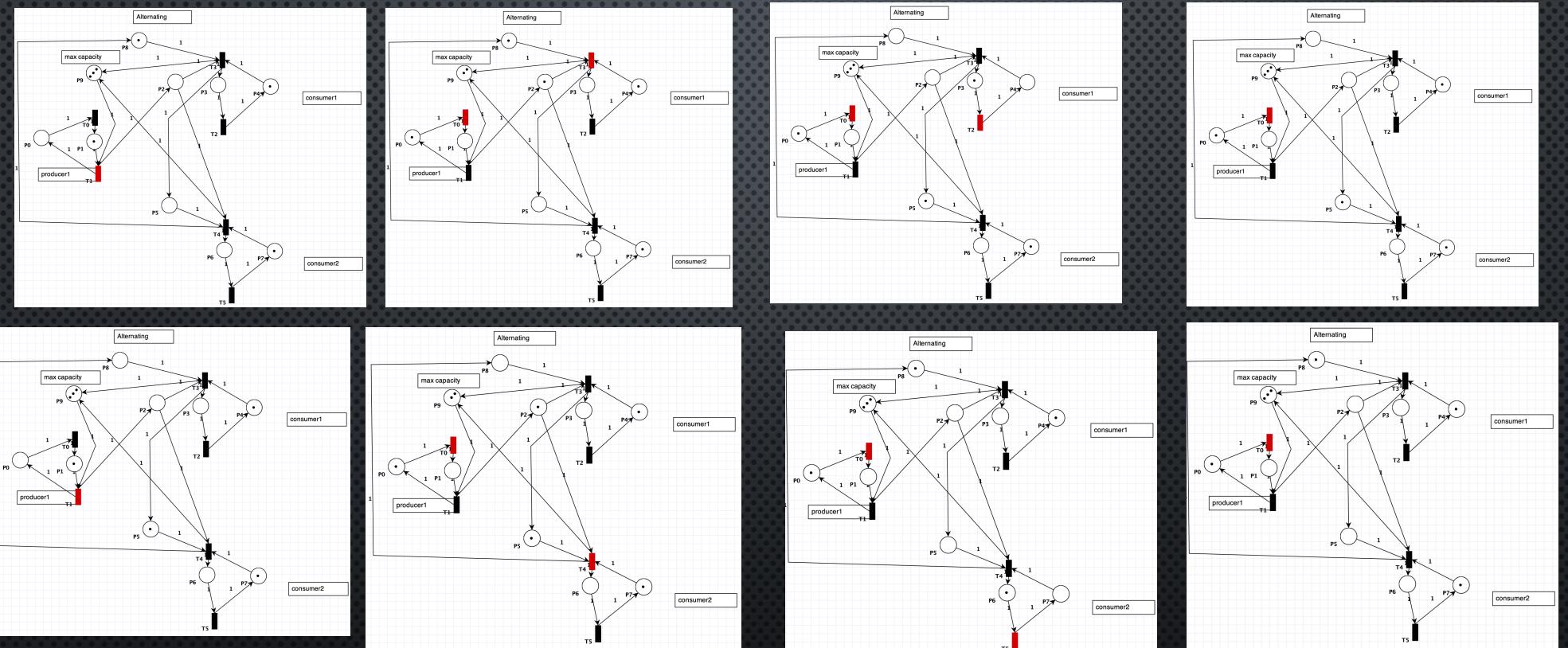
- A **MULTI-PROCESS SYNCHRONIZATION**
- TWO PROCESSES: 1- PRODUCER 2- CONSUMER
- SHARE A **FIXED-SIZE** BUFFER (GENERATING DATA TO THE BUFFER AND USING IT)
- PROBLEM: MAKING SURE THAT:
  - 1- THE PRODUCER CAN'T GENERATE DATA INTO THE BUFFER WHEN FULL
  - 2- THE CONSUMER CAN'T REMOVE DATA FROM AN EMPTY BUFFER.
- SOLUTION  
SLEEPING (IDLE) & NOTIFYING (IF NOTIFYING DOESN'T HAPPEN: DEADLOCK)  
APPROACH TO SOLUTION: BINARY SEMAPHORES, CRITICAL SECTION, CONCURRENCY (PYTHON: IMPORT THREADING)

## A PETRI NET ILLUSTRATING A SOLUTION TO THE PRODUCER-CONSUMER PROBLEM



Consumer and producer insert and generate one at a time  
Maximum capacity is 3  
Alternating consumption.

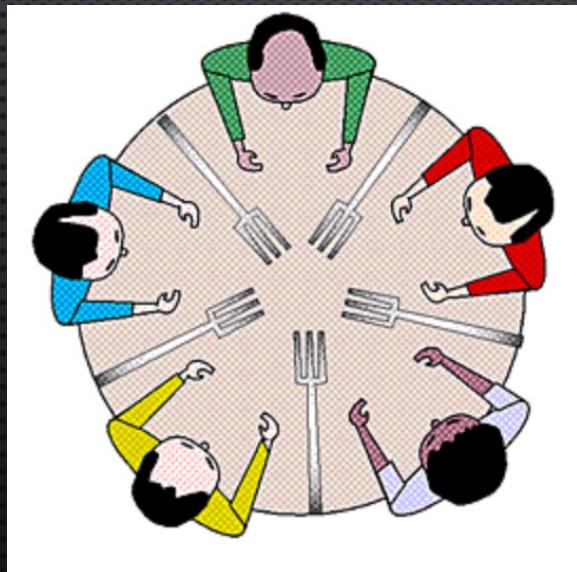
## A PETRI NET ILLUSTRATING PRODUCER-CONSUMER AFTER SEVERAL STEPS



Steps 1 to 8 from left to right and then top to bottom

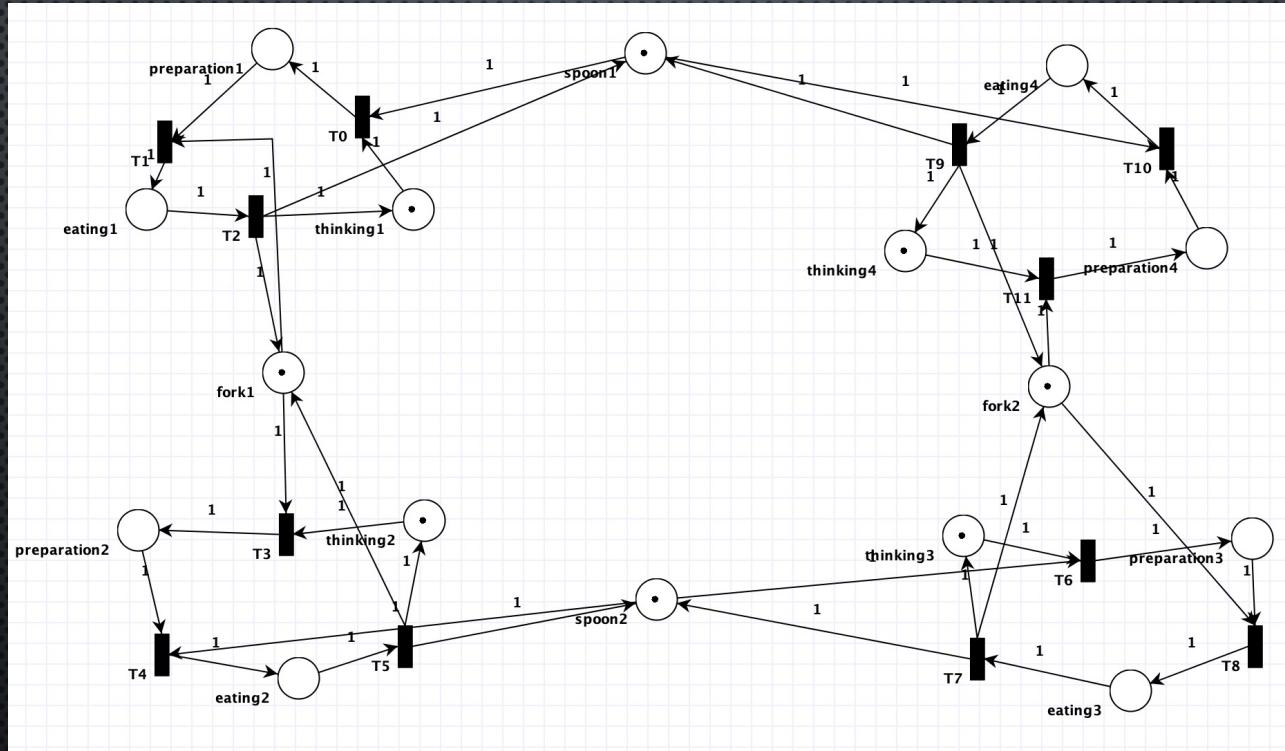
## DINING PHILOSOPHERS PROBLEM

- N PHILOSOPHERS SHARING N CHOPSTICKS AROUND THE TABLE
- CHOPSTICKS ARE LOCATED IN-BETWEEN PHILOSOPHERS
- A PHILOSOPHER IS EITHER IN STATE EATING OR THINKING AND NEEDS TWO CHOPSTICKS TO EAT.



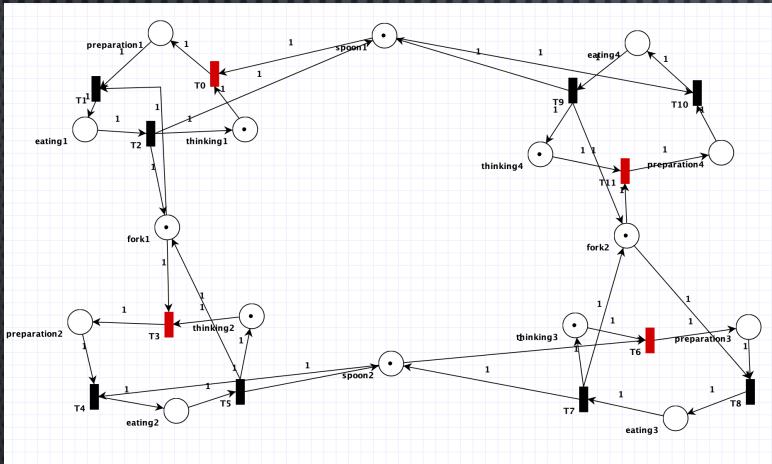
<https://www.javatpoint.com/os-dining-philosophers-problem>

## A PETRI NET ILLUSTRATING A SOLUTION TO THE DINING PHILOSOPHERS PROBLEM

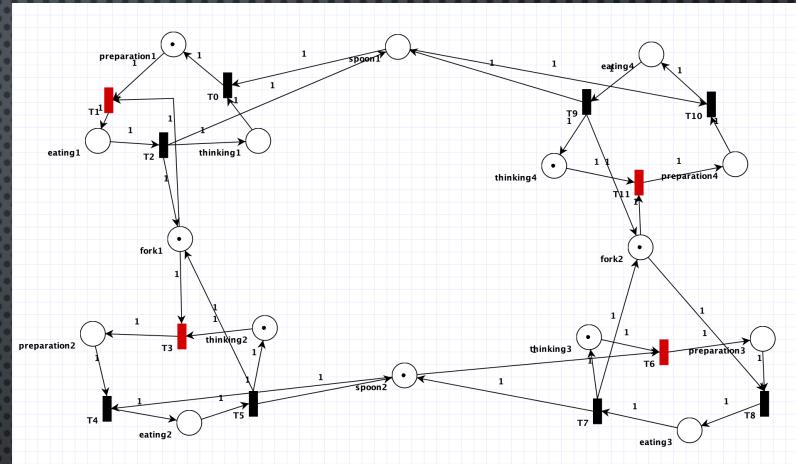


## A PETRI NET ILLUSTRATING DINING PHILOSOPHERS AFTER SEVERAL STEPS

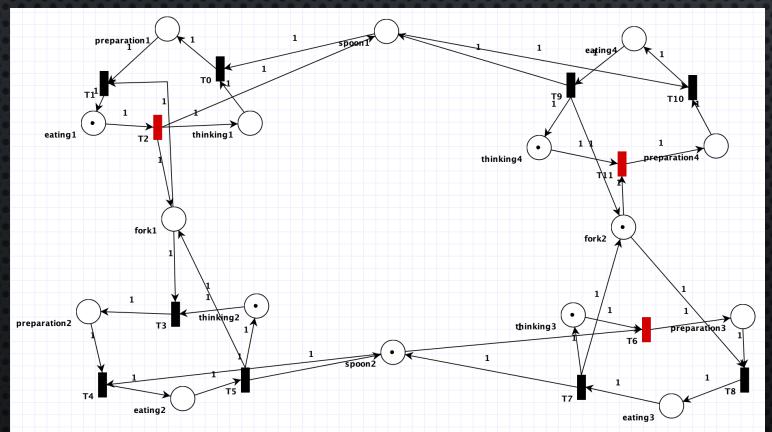
step1



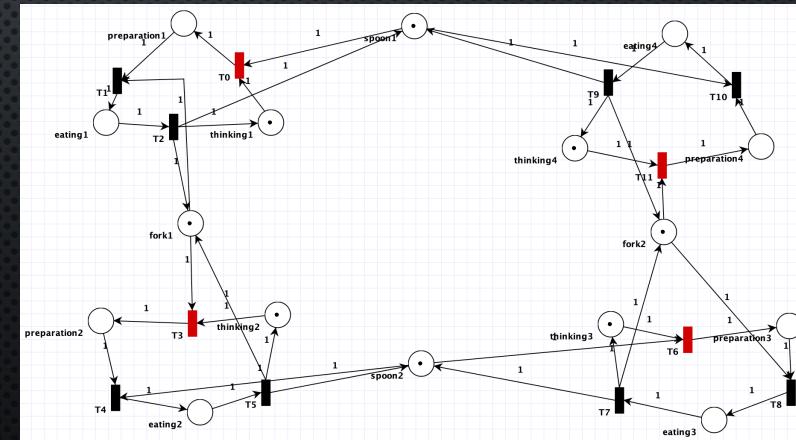
step2



step3



step4



## REFERENCES

- YOUTUBE (DINING PHILOSOPHERS (1/3) - MODELLED USING PETRI NETS) (DINING PHILOSOPHERS (2/3) - MODELLED USING PETRI NETS)
- [HTTPS://WWW.JAVATPOINT.COM/OS-DINING-PHILOSOPHERS-PROBLEM](https://www.javatpoint.com/os-dining-philosophers-problem)
- [HTTPS://WWW.JAVATPOINT.COM/OS-DINING-PHILOSOPHERS-PROBLEM](https://www.javatpoint.com/os-dining-philosophers-problem)
- [HTTPS://WWW.YOUTUBE.COM/WATCH?V=EVh6QCwwAM](https://www.youtube.com/watch?v=EVh6QCwwAM)
- JOHN M. JEFFREY. 1991. USING PETRI NETS TO INTRODUCE OPERATING SYSTEM CONCEPTS. SIGCSE BULL. 23, 1 (MAR. 1991), 324–329.  
[HTTPS://DOI.ORG/10.1145/107005.107074](https://doi.org/10.1145/107005.107074)
- DAVID GARLAN CARNEGIE MELLON UNIVERSITY [HTTPS://MOODLE.UCR.NL/PLUGINFILE.PHP/96632/MOD\\_PAGE/CONTENT/30/24\\_PETRI\\_NETS\\_1-1.PDF](https://moodle.ucr.nl/pluginfile.php/96632/mod_page/content/30/24_Petri_Nets_1-1.pdf)  
[HTTPS://MOODLE.UCR.NL/PLUGINFILE.PHP/96632/MOD\\_PAGE/CONTENT/30/25\\_PETRI\\_NETS\\_2-1.PDF](https://moodle.ucr.nl/pluginfile.php/96632/mod_page/content/30/25_Petri_Nets_2-1.pdf)
- PETRI NETS REFRESHER PROF.DR.IR. WIL VAN DER AALST EINDHOVEN UNIVERSITY OF TECHNOLOGY, FACULTY OF TECHNOLOGY MANAGEMENT, DEPARTMENT OF INFORMATION AND TECHNOLOGY, P.O.Box 513, NL-5600 MB, EINDHOVEN, THE NETHERLANDS.