SIMULATION DISCRETE PARADIGMS

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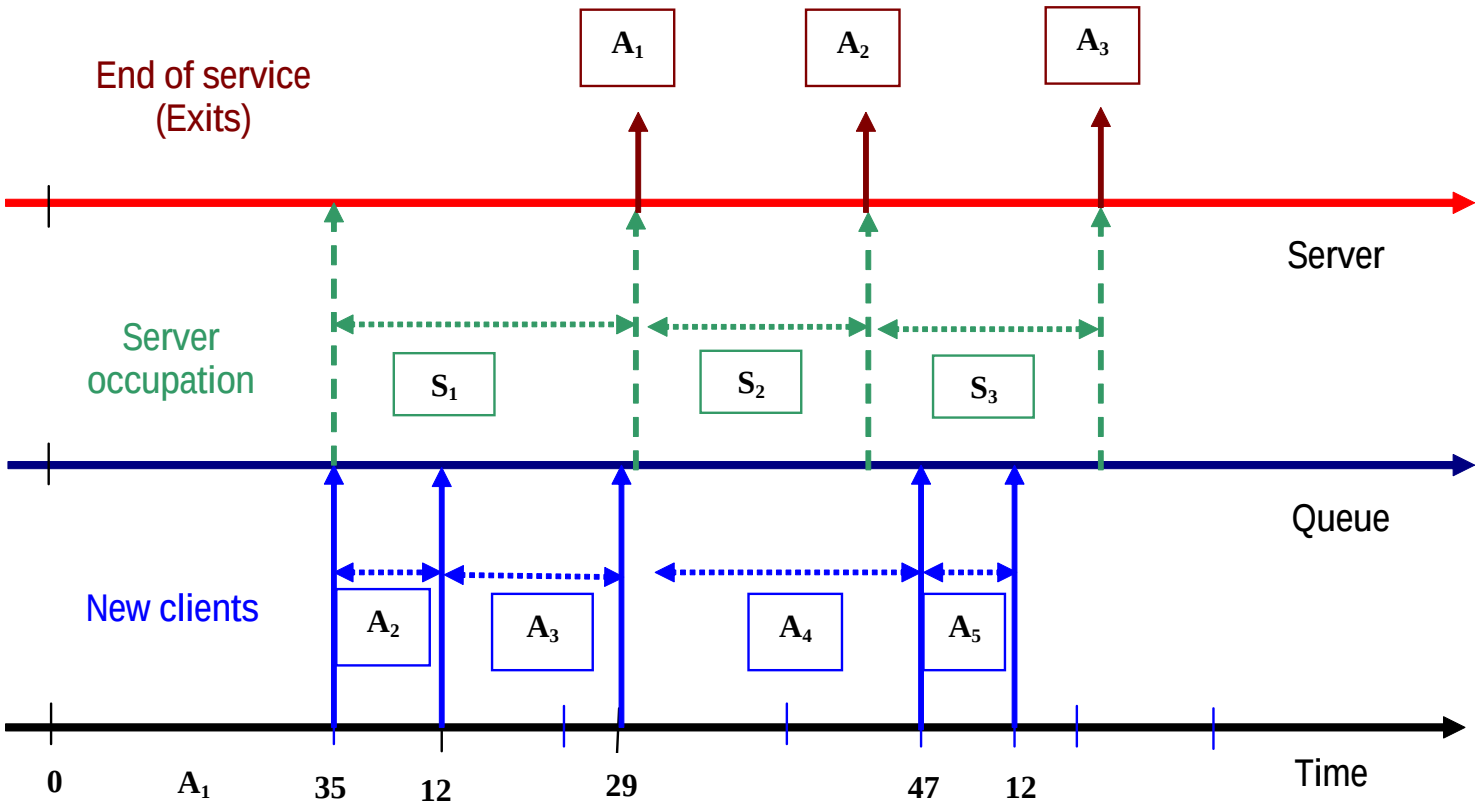
Discrete simulation paradigms

- Event Scheduling
  - Programació d'esdeveniments (PE)
  - Programación de eventos.
- Process interaction
  - Interacció de processos (IP)
  - Interacción de procesos.
- Activity scanning
  - Exploració d'activitats (EA)
  - Exploración de actividades.

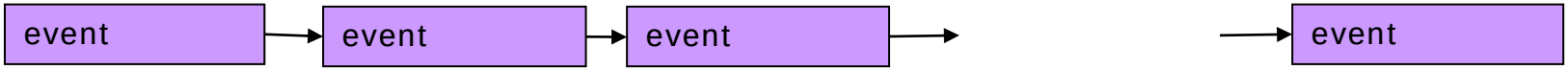
ES: example

Time between arrivals		Service time	
a_1	35	b_1	40
a_2	12	b_2	30
a_3	29	b_3	30
a_4	47	b_4	20
a_5	12	b_5	30

ES: chronogram



ES: Event list



event
struct
{
    Execution time: real
    Priority: enter
    Kind: enter
}
End struct

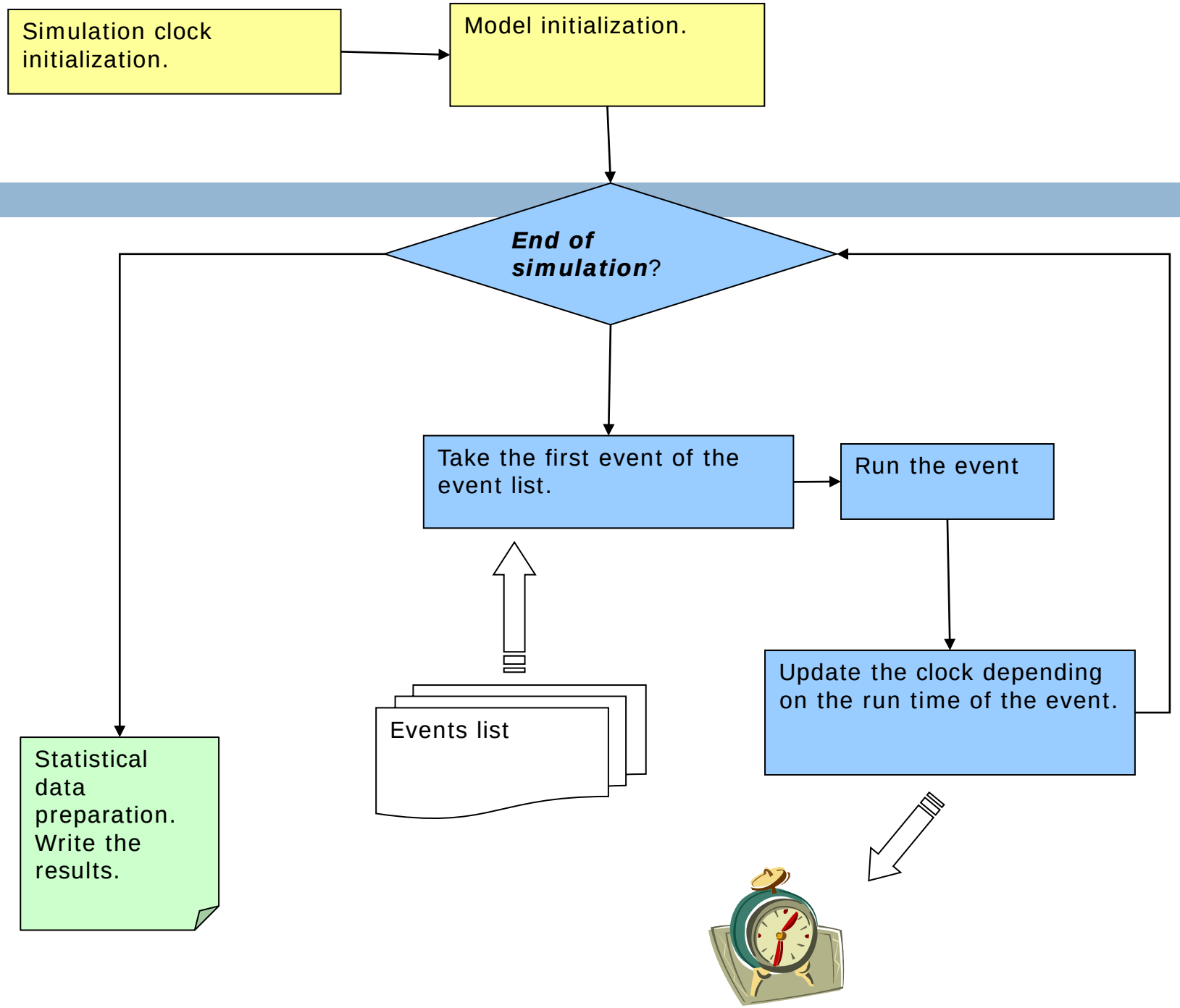
ES: event

- Kind of event
  - Depends on the model definition.
  - Exit event, enter event for a MM1 queue.
- Creation time
  - Shows the time when the event enters in the simulation system.
- Running time
  - Shows when the simulation engine must run the event.
- Priority

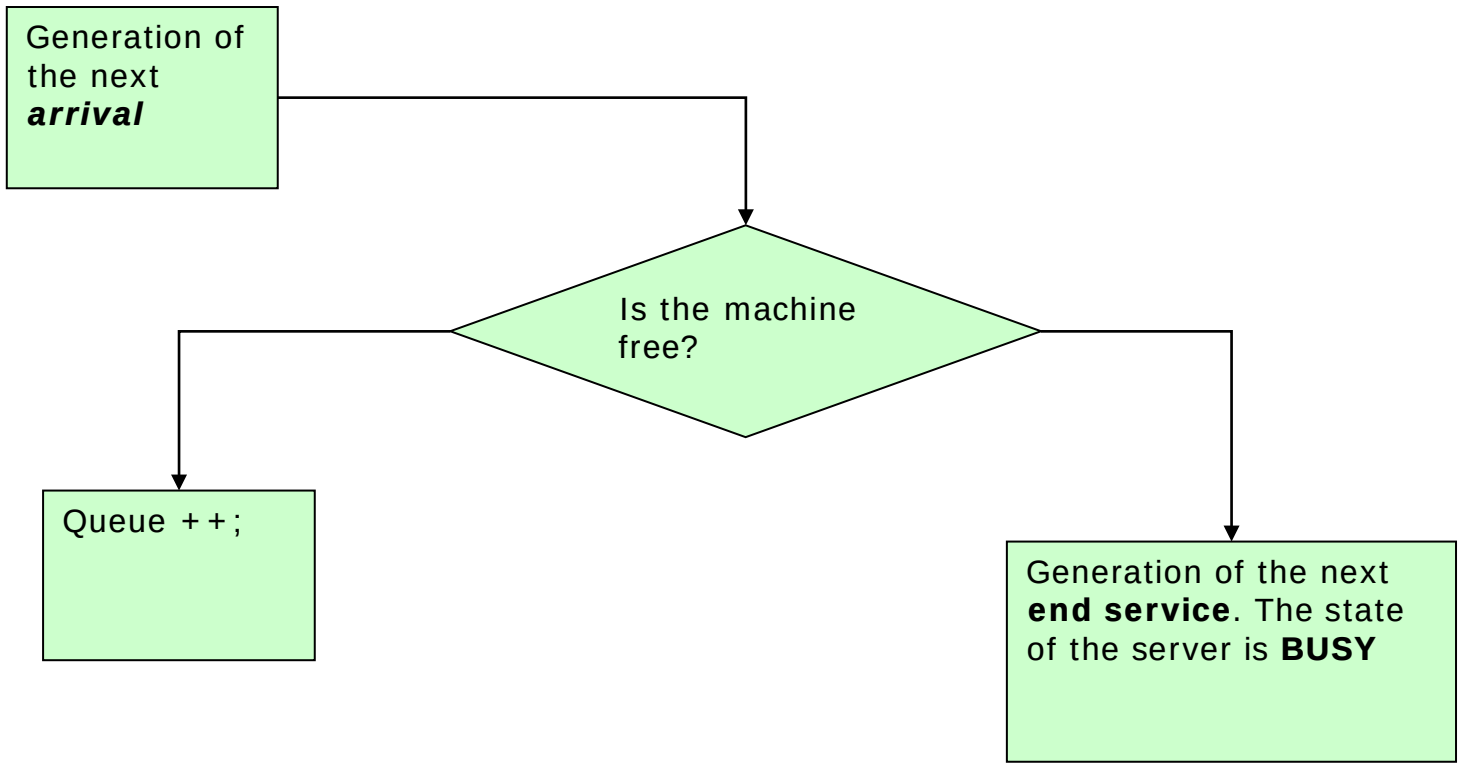
ES: event

- The time when the simulation engine runs the event.
- Priority must be taken in consideration only if two ore more) events have the same *run time*.
- The Kind of event allows to define the procedure that the simulation engine must run when the event is exe

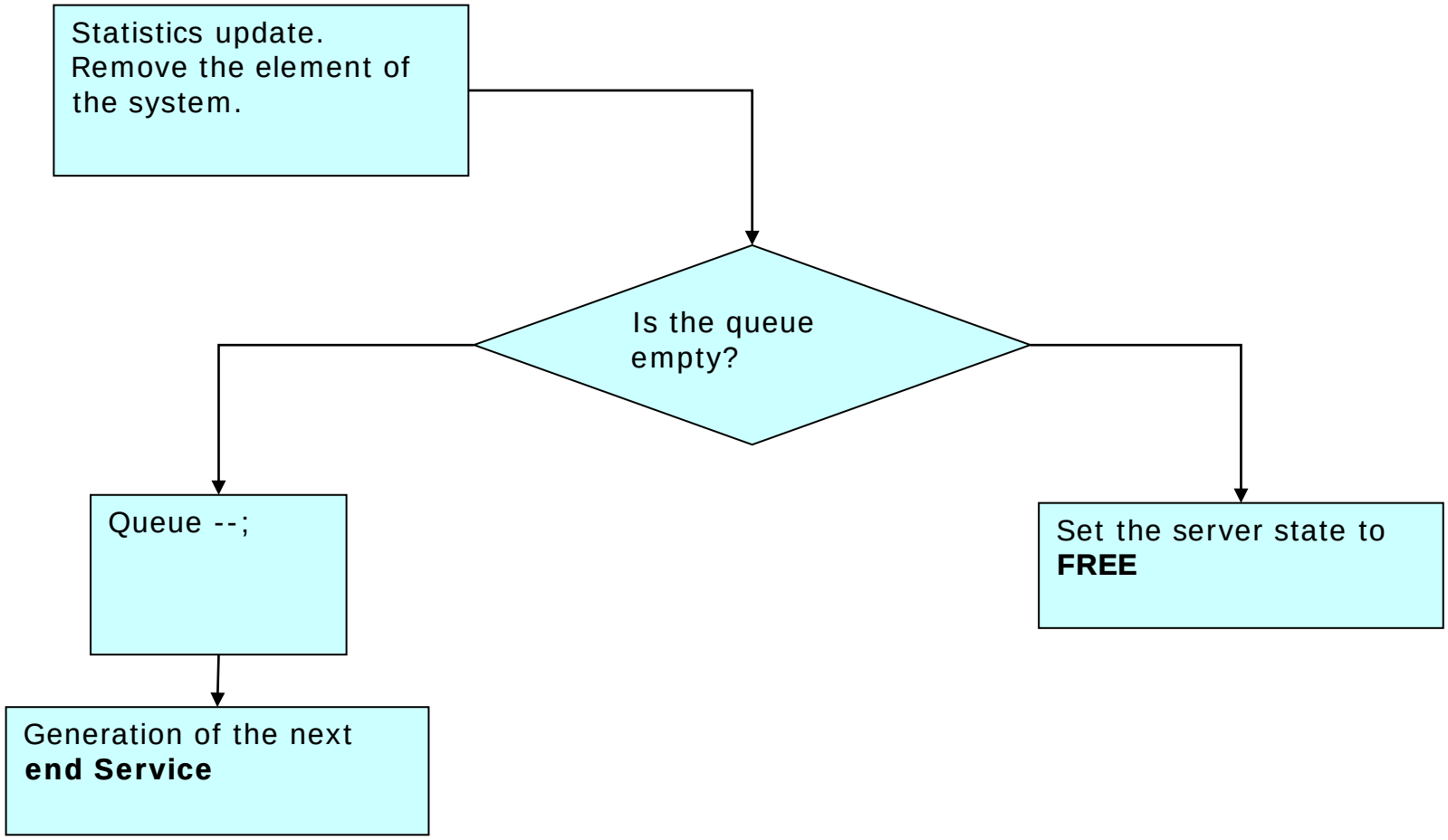
ES


Simulation clock initialization.
Model initialization.
End of simulation?
Take the first event of the event list.
Run the event
Events list
Update the clock depending on the run time of the event.
Statistical data preparation. Write the results.

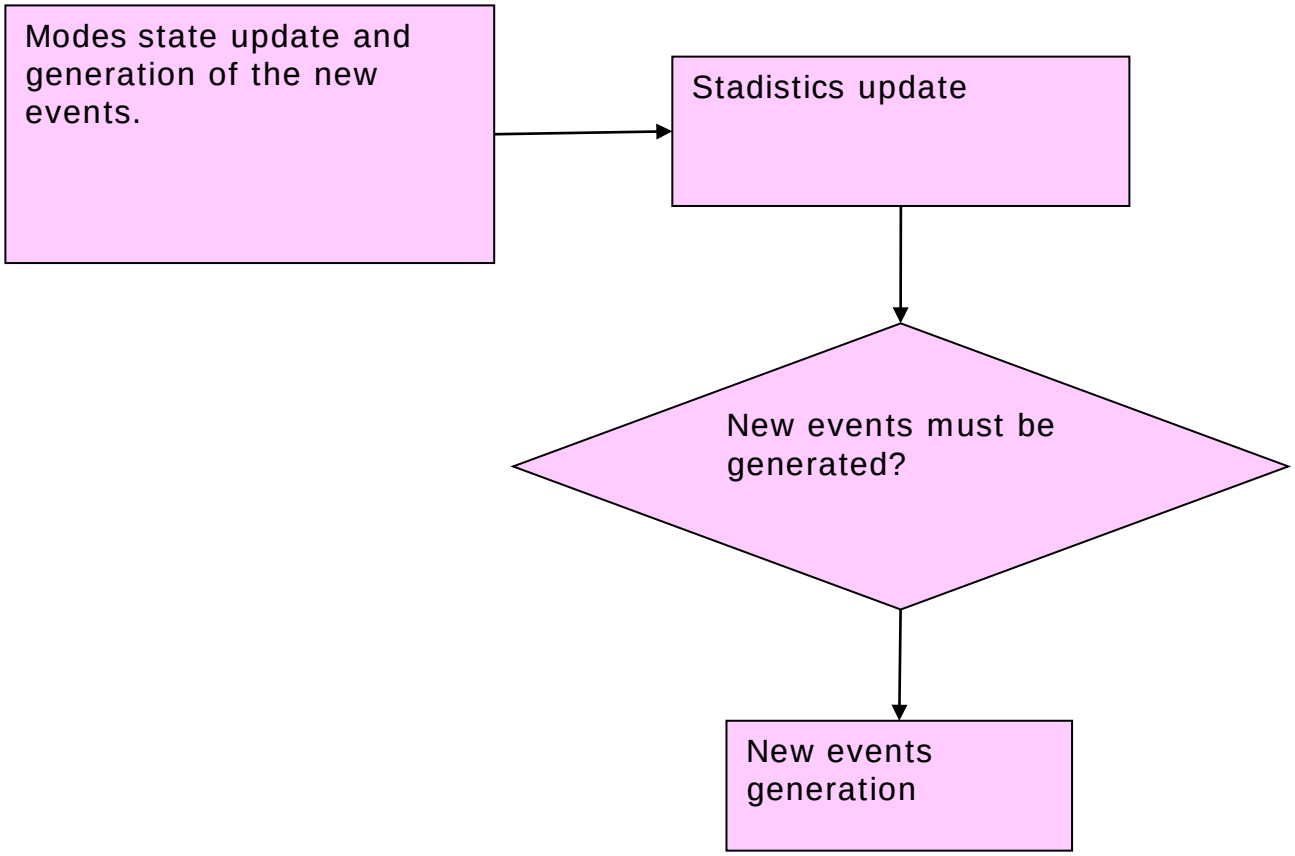
ES: Arrive event procedure



ES: Exit event procedure



ES: General event procedure



ES: Events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
0	0	0	0	0	0	0	0

ES: Events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
0	0	0	0	0	0	0	0
	0	0,1509	1E+12	0	0	0	0

ES: Events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
0	0	0	0	0	0	0	0
	0	0,1509	1E+12	0	0	0	0
1	0,1509	0,5778	0,93940	1	0	1	0

ES: Events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
0	0	0	0	0	0	0	0
	0	0,1509	1E+12	0	0	0	0
1	0,1509	0,5778	0,93940	1	0	1	0
2	0,5778	1,4772	0,93940	1	1	1	0

ES: Events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
0	0	0	0	0	0	0	0
	0	0,1509	1E+12	0	0	0	0
1	0,15099	0,5778	0,9394	1	0	1	0
2	0,57788	1,4772	0,9394	1	1	1	0
3	0,93940	1,4772	3,5225	1	0	0	1

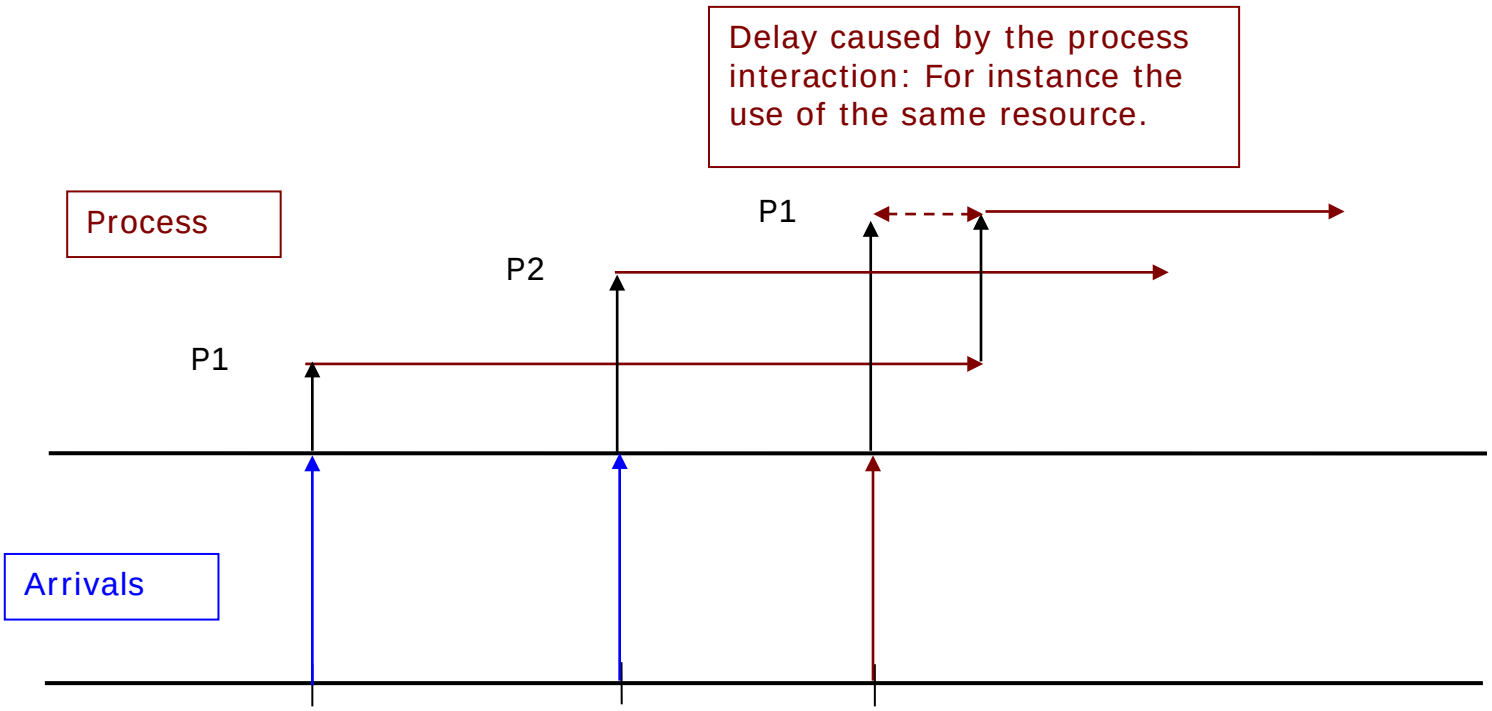
ES: Events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
0	0	0	0	0	0	0	0
	0	0,1509	1E+12	0	0	0	0
1	0,1509	0,5778	0,9394	1	0	1	0
2	0,5778	1,4772	0,9394	1	1	1	0
3	0,9394	1,4772	3,5225	1	0	0	1
4	1,4772	1,5657	3,5225	1	1	1	0

Process interaction

- Two different process typologies, P1 and P2:
  - P1 in the usual process of a G|G|1 system. The entity that arrives to the system needs the services of the server.
  - The second process, P2, represents the process where the entities do no require the services of a server, however the entities suffers a delays.

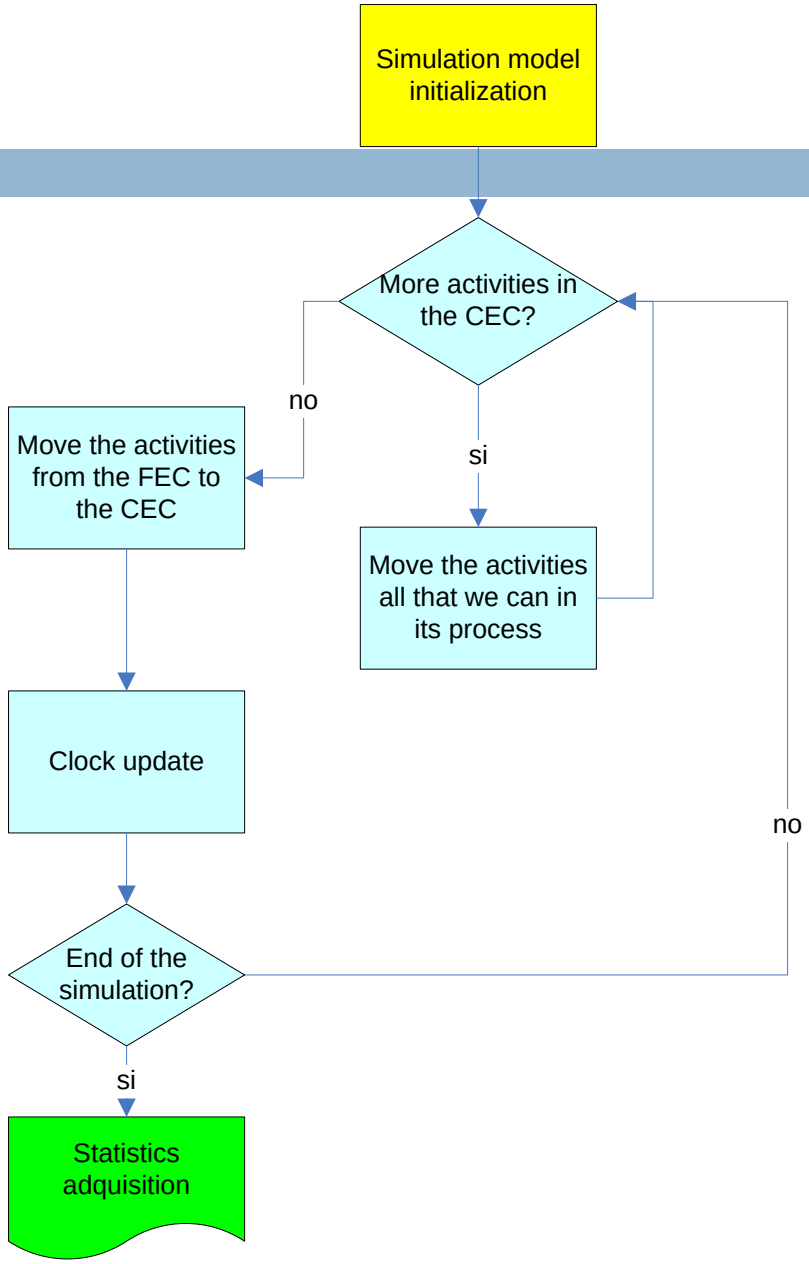
PI: chronogram



PI: Event list

- To simplify usually two list of activities are used. The activities that must be processed in the actual time, and the activities that must be processed in the future.
- The structure, however is quite similar to the structure shown in the Event Scheduling paradigm. Is important to remark the strong relation between the entity and the process linked to each entity.

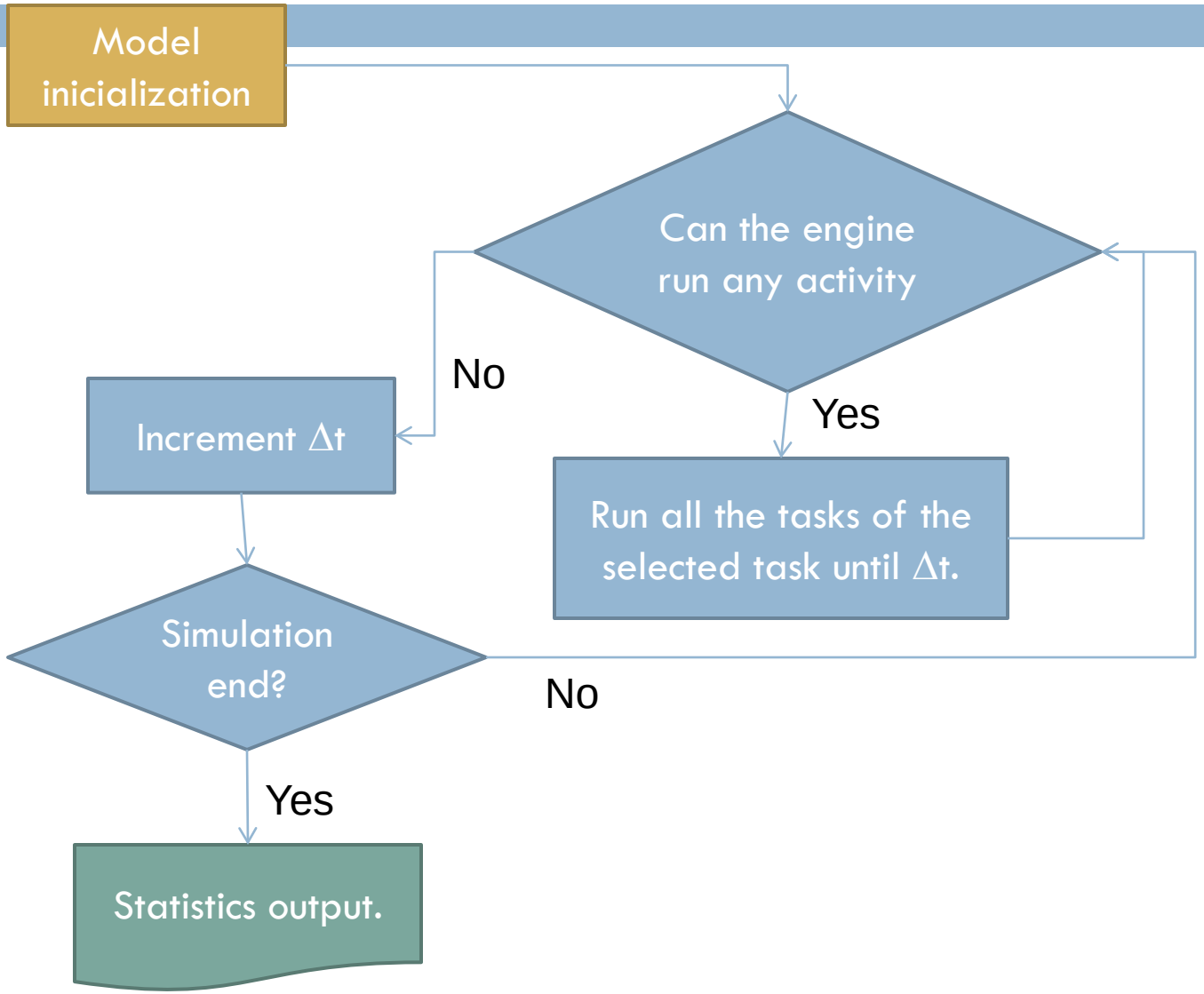
PI:


Simulation model initialization
More activities in the CEC?
no
si
Move the activities from the FEC to the CEC
Move the activities all that we can in its process
Clock update
End of the simulation?
no
si
Statistics adquisition

Activity scanning

1. Analyze if the simulation engine can run some activity, this depends on the conditions of each activity, and run it until Δt.
2. When the simulation engine cannot run more activities increment the clock with Δt.

AS: simulation engine



Events evolution Examples

ES(Event scheduling)

AS(Activity scanning)

Event scheduling events evolution

Using this data

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
0	0	0	0	0	0	0	0

Arrive:

1,6933
4,0012
5,2509
5,5315
5,6327
6,0014
7,3736

Exit:

1,8840
4,3038
5,6282
6,5012
7,0477

Event scheduling events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
		1,6933	1E+12				

Event scheduling events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
		1,6933	1E+12				
1	1,6933	4,0012	1,8840	1	0	1	0

Event scheduling events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
		1,6933	1E+12				
1	1,6933	4,0012	1,8840	1	0	1	0
2	1,8840	4,0012	1E+12	0	0	0	1

Event scheduling events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
		1,693356	1E+12				
1	1,693356	4,001288	1,884081404	1	0	1	0
2	1,884081	4,001288	1E+12	0	0	0	1
3	4,001288	5,250927	4,303805741	1	0	1	0

Event scheduling events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
		1,6933	1E+12				
1	1,6933	4,0012	1,8840	1	0	1	0
2	1,8840	4,0012	1E+12	0	0	0	1
3	4,0012	5,2509	4,3038	1	0	1	0
4	4,3038	5,2509	1E+12	0	0	0	1

Event scheduling events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
		1,6933	1E+12				
1	1,6933	4,0012	1,8840	1	0	1	0
2	1,8840	4,0012	1E+12	0	0	0	1
3	4,0012	5,2509	4,3038	1	0	1	0
4	4,3038	5,2509	1E+12	0	0	0	1
5	5,2509	5,5315	5,6282	1	0	1	0

Event scheduling events evolution

Id	Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
		1,6933	1E+12				
1	1,6933	4,0012	1,8840	1	0	1	0
2	1,8840	4,0012	1E+12	0	0	0	1
3	4,0012	5,2509	4,3038	1	0	1	0
4	4,3038	5,2509	1E+12	0	0	0	1
5	5,2509	5,5315	5,6282	1	0	1	0
6	5,5315	5,6327	5,6282	1	1	1	0
7	5,6282	5,6327	6,5012	1	0	0	1
8	5,6327	6,0014	6,5012	1	1	1	0
9	6,0014	7,3736	6,5012	1	2	1	0
10	6,5012	7,3736	7,0477	1	1	0	1
11	7,0477			1	0	0	1

Activity scanning events evolution

- Using $\Delta t=1$. run the simulation until time = 6.

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0

Next arrival	Next exit
1,6933	1,8840
4,0012	4,3038
5,2509	5,6282
5,5315	6,5012
5,6327	
6,0014	

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0
3	2	1,8840	4,0012	1E+12	0	0	0	1

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0
3	2	1,8840	4,0012	1E+12	0	0	0	1
4	2		4,0012	1E+12	0	0	0	0

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0
3	2	1,8840	4,0012	1E+12	0	0	0	1
4	2		4,0012	1E+12	0	0	0	0
5	3		4,0012	1E+12	0	0	0	0

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0
3	2	1,8840	4,0012	1E+12	0	0	0	1
4	2		4,0012	1E+12	0	0	0	0
5	3		4,0012	1E+12	0	0	0	0
6	4		4,0012	1E+12	0	0	0	0

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,69335	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0
3	2	1,8840	4,0012	1E+12	0	0	0	1
4	2		4,0012	1E+12	0	0	0	0
5	3		4,0012	1E+12	0	0	0	0
6	4		4,0012	1E+12	0	0	0	0
7	5	4,0012	5,2509	4,3038	1	0	1	0

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0
3	2	1,8840	4,0012	1E+12	0	0	0	1
4	2		4,0012	1E+12	0	0	0	0
5	3		4,0012	1E+12	0	0	0	0
6	4		4,0012	1E+12	0	0	0	0
7	5	4,0012	5,2509	4,3038	1	0	1	0
8	5	4,3038	5,2509	1E+12	0	0	0	1

Activity scanning events evolution

Id	Time	Event Time	Next arrival	Next exit	Server state	Queue	Arrive	Exit
1	1		1,6933	1E+12	0	0	0	0
2	2	1,6933	4,0012	1,8840	1	0	1	0
3	2	1,8840	4,0012	1E+12	0	0	0	1
4	2		4,0012	1E+12	0	0	0	0
5	3		4,0012	1E+12	0	0	0	0
6	4		4,0012	1E+12	0	0	0	0
7	5	4,0012	5,2509	4,3038	1	0	1	0
8	5	4,3038	5,2509	1E+12	0	0	0	1
9	6	5,2509	5,5315	5,6282	1	0	1	0
10	6	5,5315	5,6327	5,6282	1	1	1	0
11	6	5,6282	5,6327	6,5012	1	0	0	1
12	6	5,6327	6,0014	6,5012	1	1	1	0