AGPSS

aGPSS – *Simulation made simple*

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GPSS

- General Purpose Simulation System.
- Developed by Geoffrey Gordon during 60's of XX century.
- Discrete systems modeling.

GPSS world

- Entities (transactions) traveling through the system.
- Through the blocs.
  - The number of blocs is different depending on the GPSS version used.
  - Minuteman
  - aGPSS
  - JGPSS
  - GPSS/H
  - …

Architecture

- Based in blocs diagrams.
- Blocs joined using lines representing a transactions sets, that makes its movement through the blocs.
- Entities making its path through the system elements. Transactions.
- Its movement is from bloc to bloc → representing actions or events that affects the entities.

Transactions

- Temporal or permanent.
  - Temporal: created and destroyed.
  - Permanents: dynamic.
- Have attributes.
- Individual and unique identifier.

GPSS code example

```
    SIMULATE
*
*   ONE-LINE, SINGLE-SERVER QUEUEING MODEL
*
    GENERATE        18,6        ARRIVALS EVERY 18 +- 6 MINUTES
    ADVANCE         0.5         HANG UP COAT
    SEIZE           JOE         CAPTURE THE BARBER
    ADVANCE         15,3        HAIRCUT TAKES 15 +- 3 MINUTES
    RELEASE         JOE         FREE THE BARBER
    TERMINATE       1           EXIT THE SHOP
*
    START           100 ( = TC , transaction counter)
    END
```

Blocs

Program logic instructions

Generate

- Creation of model transactions.
- Time between arrivals: random variable.
- A: Average interval time.
- B: ½ range (A ± B).
- C: Time for the first transaction.
- D: Maximum number of created transactions.
- E: Priority level

Terminate

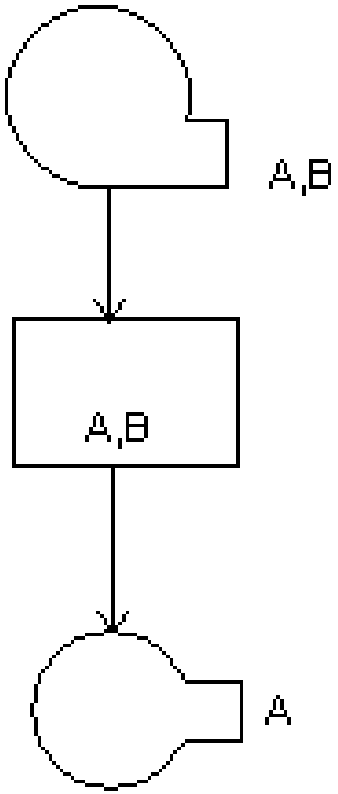
- To destroy the transactions.
- A: Number to decrement the TC.

Advance

- Stops the transaction movement some time.
- A: Average waiting time
- B: ½ range

Example

- Museum

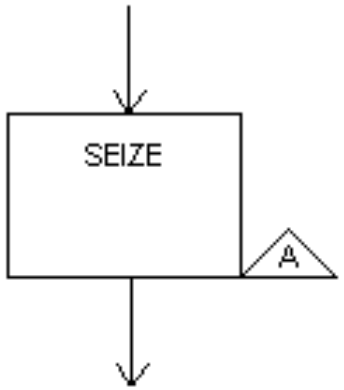


Modeling simple servers

- People or objects that performs a service.
- Limited resource-
- Kind:
  - Simple → 1 server by time unit.
  - Complex → more than one server by time unit.

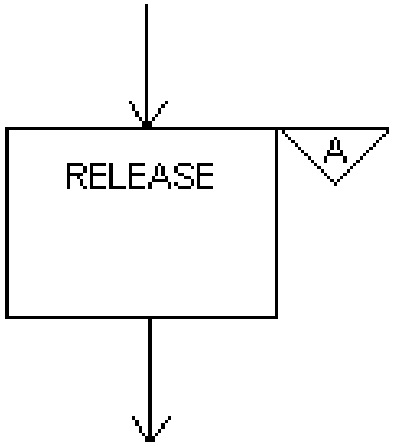
Seize

- The entity request the server.
- A: Identifier of the requested server.



Release

- To release a server.
- A: Identifier of the released server.



Example: Manual lathe

A manual lathe process wooden pieces with a 5 ± 2 minutes (uniform distribution). The arrival of the pieces follows a uniform distribution of parameters 7 ± 3 minutes. Develop a GPSS model to simulate the process of 500 pieces.

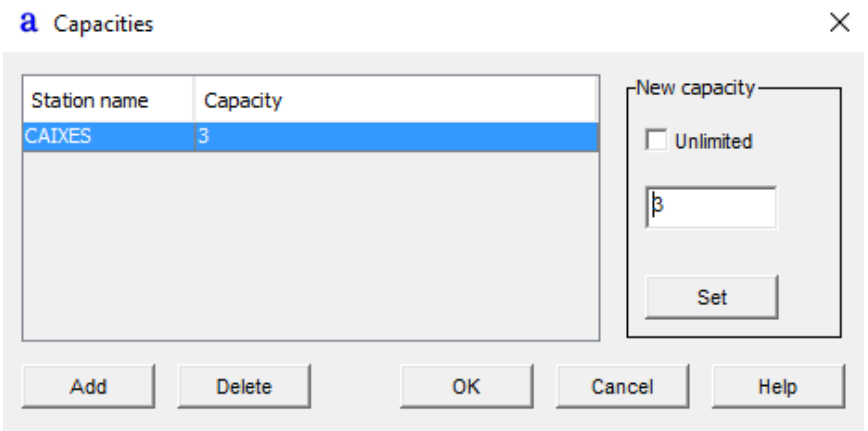
- Pieces arrival: 7 ± 3 (uniform, minutes)
- Time to process a piece: 5 ± 2 (uniform, minutes).

Example: Manual lathe (answer)

- GENERATE 7,3
- SEIZE TORN
- ADVANCE 5,2
- RELEASE TORN
- TERMINATE 1

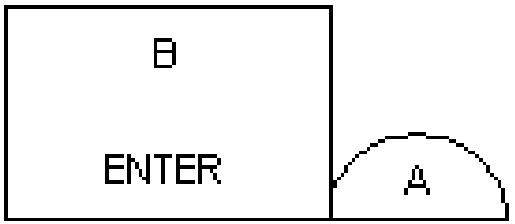
Modeling complex servers

- Is needed to define the server capacity.
- STORAGE S(ELEVATOR),6 (H)
- ELEVATOR STORAGE 6 (w)
- Is needed to show when the server is requested and when the server is released.
- Via Control -> Capacities (g)



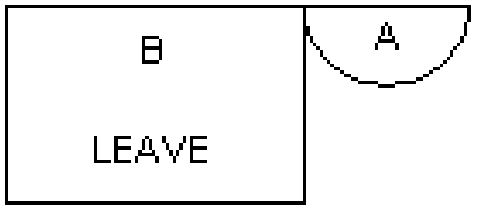
Enter

- Request of one ore more parallel servers.
- Simulates the enter of the entity in the server.
- A: server's name.
- B: number of servers requested.



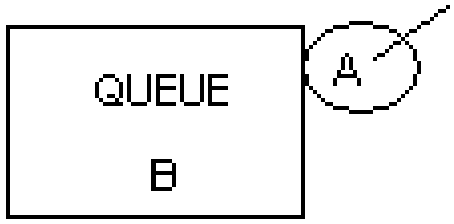
Leave

- To simulate the release of one or more servers.
- A: server's name.
- B: number of servers to release.



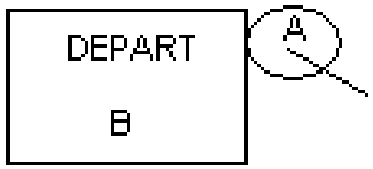
Arrive (QUEUE on [W])

- To model the queues in front of a server. It measures the time it takes for a transaction to go from the ARRIVE block to the corresponding DEPART block.
  - A: queue identifier.
  - B: Number of entities [W].



Depart

- To show that an entity is leaving a queue.
  - A: queue identifier.



Example: Banc Fortuna v1.0

- In a banc the clients arrives following a uniform distribution of 5 to 9 minutes.
- 1 single cashier.
- Service time of 2 a 6 minutes, following a uniform distribution.
- Simulate 500 clients.

- Remember: we want QUEUE information.

Example: Banc Fortuna v1.0 (answer)

- GENERATE 7,2
- ARRIVE CUA
- SEIZE CAIXER
- DEPART CUA
- ADVANCE 4,2
- RELEASE CAIXER
- TERMINATE 1

Example: Banc Fortuna v1.1 (answer)

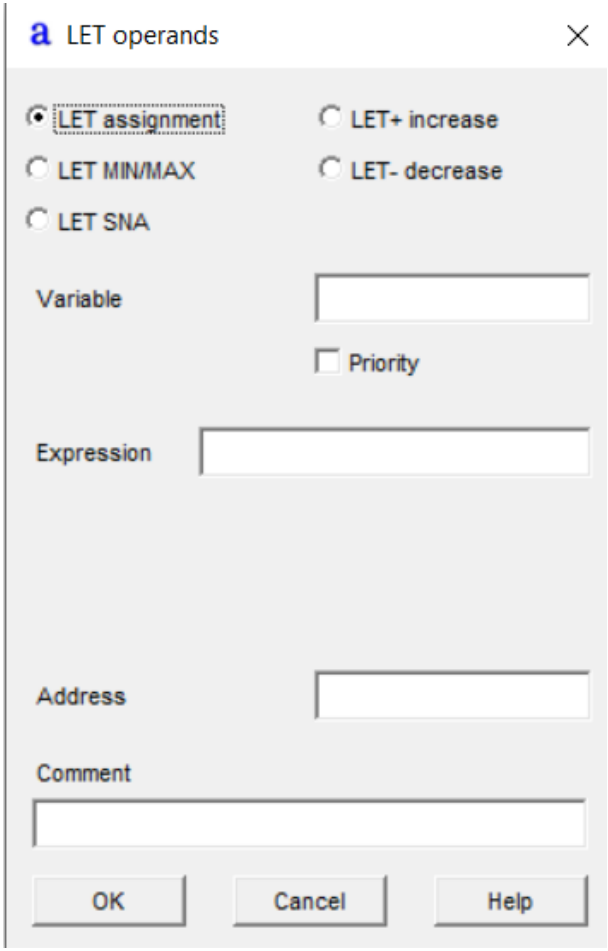
- GENERATE 7,2
- ARRIVE CUA
- SEIZE CAIXER
- ADVANCE 4,2
- RELEASE CAIXER
- DEPART CUA
- TERMINATE 1

Assign or LET

- Allows the modification of the transaction parameters.
- A: parameter's number.
- B: value to assign.

  - ASSIGN COLOR,4
  - ASSIGN TYPE,10
  - ASSIGN TIME,7.5
  - ASSIGN 1+,10

- P$COLOR To access the attribute
- ADVANCE P$COLOR



Labels

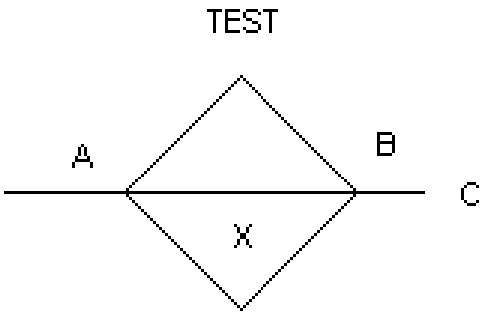
- Is allowed to name the GPSS blocs.
  - To access the SNA's.
  - To break the transaction sequence.

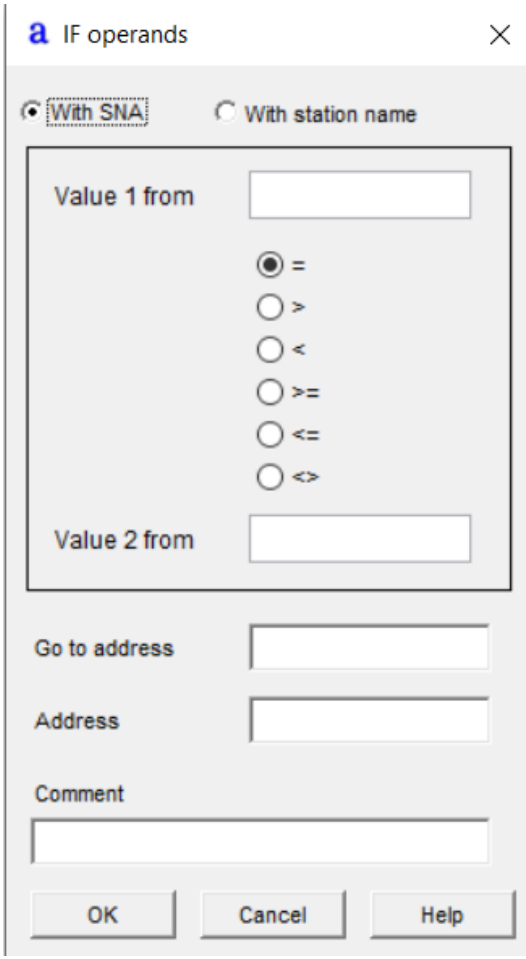
SNA's

- Some information related to the model entities.
- Can be used in simulation time.
- Give information about the simulated model.
- Examples:
  - C1: Clock
  - N$label : #Xacts

IF (Test on [W])

- Allows compare values and control the destination of a transaction.
- X: relation operator.
- A: verification operator.
- B: Reference value.
- C: number of the destination bloc.





Test

- If the operand C is not defined, TEST is working in conditional mode. The transaction enters in the bloc and, when the condition is true, continues its movement.
- If C is specified, when the condition if false the transaction jumps to C.
- Values for X:
  - E: equal
  - G: bigger
  - GE: bigger or equal.
  - L: les
  - LE: les or equal.
  - NE: no equal.

ASSIGN COLOR,4 TEST E P$COLOR,4,END **ADVANCE 10** END TERMINATE 1	ASSIGN COLOR,5 TEST E P$COLOR,4,END ADVANCE 10 **END TERMINATE 1**	ASSIGN COLOR,5 **TEST E P$COLOR,4** ADVANCE 10 END TERMINATE **1**

Example: Banc Fortuna V3.0

- In a banc the clients arrive following an uniform distribution with parameters 5 to 10 (minutes).
- 3 tellers.
- Service time: 2 to 5 minutes (uniform distribution).
- Simulate 1 day of work.
- At the end of the day no client must remain in the banc.

Example: Banc Fortuna V3.0 (answer)

```
CAIXES STORAGE 3

        GENERATE        7.5,2.5
ENT     QUEUE   FILA
        ENTER   CAIXES
        DEPART  FILA
        ADVANCE         3.5,1.5
SORT    LEAVE   CAIXES
FIN     TERMINATE       500
```

But we want to end the simulation by time

Example: Banc Fortuna V3.0 (answer)

```
CAIXES STORAGE 3

            GENERATE 7.5,2.5
ENT         QUEUE    FILA
            ENTER    CAIXES
            DEPART   FILA
            ADVANCE  3.5,1.5
SORT        LEAVE    CAIXES
FIN         TERMINATE

      GENERATE       240
      TERMINATE      1

START               1
END
```

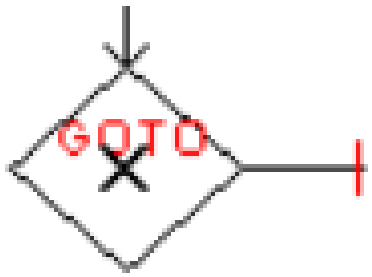
```
                Friday, November 19, 2021 10:55:27

 START TIME          END TIME  BLOCKS  FACILITIES  STORAGES
      0.000           240.000       9           0         1


    NAME                         VALUE
CAIXES                       10000.000
ENT                              2.000
FILA                         10001.000
FIN                              7.000
SORT                             6.000


 LABEL              LOC  BLOCK TYPE      ENTRY COUNT CURRENT COUNT RETRY
                    1    GENERATE             32             0       0
ENT                 2    QUEUE                32             0       0
                    3    ENTER                32             0       0
                    4    DEPART               32             0       0
                    5    ADVANCE              32             1       0
SORT                6    LEAVE                31             0       0
FIN                 7    TERMINATE            31             0       0
                    8    GENERATE              1             0       0
                    9    TERMINATE             1             0       0
```

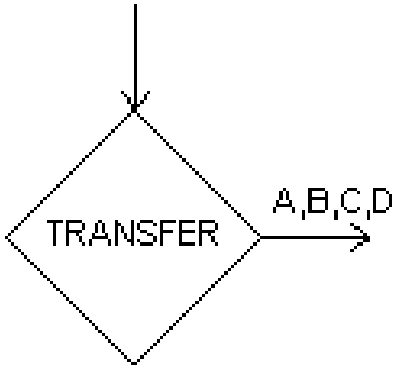
Example: Banc Fortuna V3.0 (answer)

```
CAIXES STORAGE 3

            GENERATE    7.5,2.5
            TEST LE     C1,240,FIN
ENT         QUEUE       FILA
            ENTER       CAIXES
            DEPART      FILA
            ADVANCE     3.5,1.5
SORT                    LEAVE       CAIXES
FIN         TERMINATE

    GENERATE            240
    TEST E              N$ENT,N$SORT
    TERMINATE           1

START                   1
END
```

GOTO (Transfer)

- Allows to break the sequential movement of a transaction.





Example: TalsaV1.0

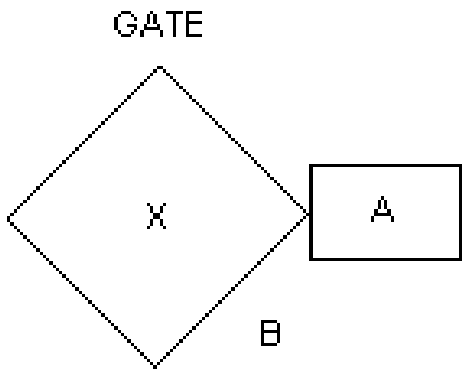
- Two automatic lathes.
- Arrivals (4 ± 1 uniform).
- Lathe A: 1 to 10 minutes (uniform).
- Lathe B: 2 to 15 minutes (uniform).
- Pieces enters in the first free, (we prefer the A).
- Simulate 50 pieces.

Example: TalsaV1.0 (answer)

```
            SIMULATE

            GENERATE    4,1
            QUEUE       MATERIAL
            TRANSFER    BOTH,UNO,DOS
UNO         SEIZE       TALAD1
            DEPART      MATERIAL
            ADVANCE     5.5,4.5
            RELEASE     TALAD1
            TRANSFER    ,PROD
DOS         SEIZE       TALAD2
            DEPART      MATERIAL
            ADVANCE     8.5,6.5
            RELEASE     TALAD2
PROD        TERMINATE   1

            START       50
            END
```

IF with station (Gate on [W])

- Controls the transaction flow.
- A: name or number of the analyzed installation.
- B: name of the label.
- X: Auxiliary operator.
- GATE NU INST,ALT



Gate (2/2)

- Related to SEIZE i RELEASE
  - U Try if the installation is full.
  - NU Try if the installation is free.
- Related to ENTER i LEAVE
  - SF: Try if the server is full.
  - SNF: Try if the server is not full.
  - SE: Try if the server is empty.
  - SNE: Try if the server is not empty.
- Related to LOGIC
  - LS: Set logic
  - LR: Reset logic.

Example: ViatgesV1.0

- The clients call the travel agency following an uniform distribution (3 ± 2 minutes).
- Give the information to the clients follows an uniform distribution of 5 to 8 minutes.
- If the telephone is occupied the client is lost.
- Simulate 8 hours.

Example: ViatgesV1.0 (answer)

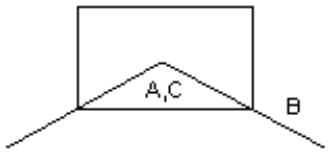
```
        SIMULATE
                GENERATE        3,2
                GATE NU         TELEF,NEXT
                SEIZE           TELEF
                ADVANCE         6.5,1.5
                RELEASE         TELEF
NEXT            TERMINATE
                GENERATE        480
                TERMINATE       1
                START           1
```

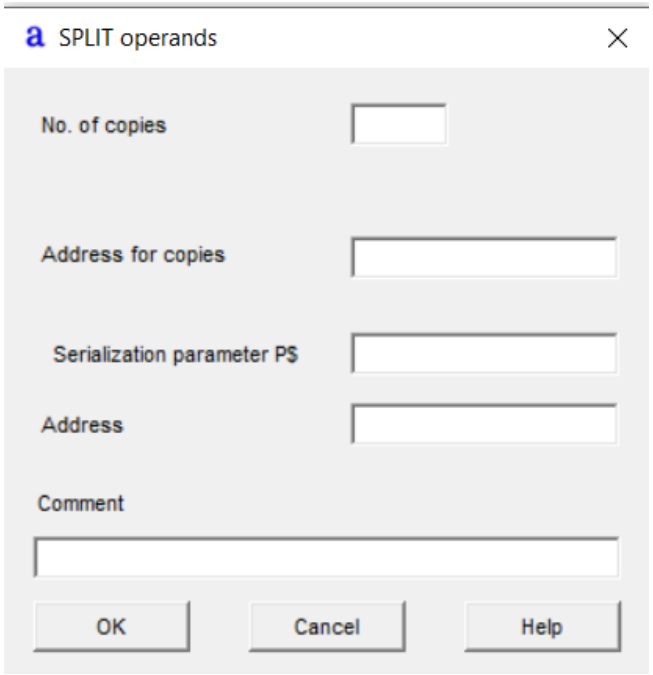
Split

- Allows the creation of new transactions with the same features of active transaction.
- A: N° of new created transactions.
- B: Destination of the new transactions (op).
- C: Parameter that receives the serial number.

- SPLIT 10,COPYs,SERIAL
- ADVANCE 5 ;1 XACTS
- TRANSFER, ENDSIM

- COPYs ADVANCE 10 ;10 XACT





Example: TaladreSplit V1.0

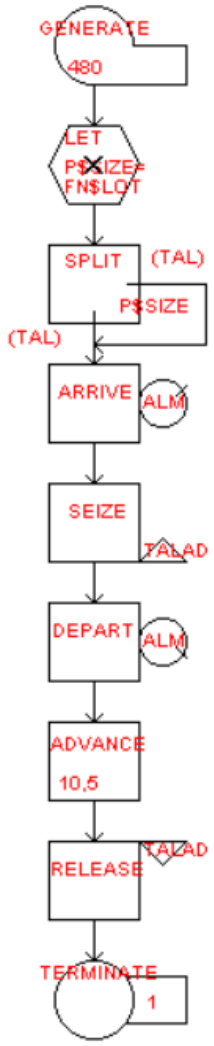
- Entities every 8 hours.
- Size of the lotes:

Lot size	17	18	19	20	21
Probability	0.1	0.4	0.4	0.05	0.05

- Service time 10 ± 5 (in minutes).
- Simulate 3000 pieces

Example: TaladreSplit V1.0 (sample)

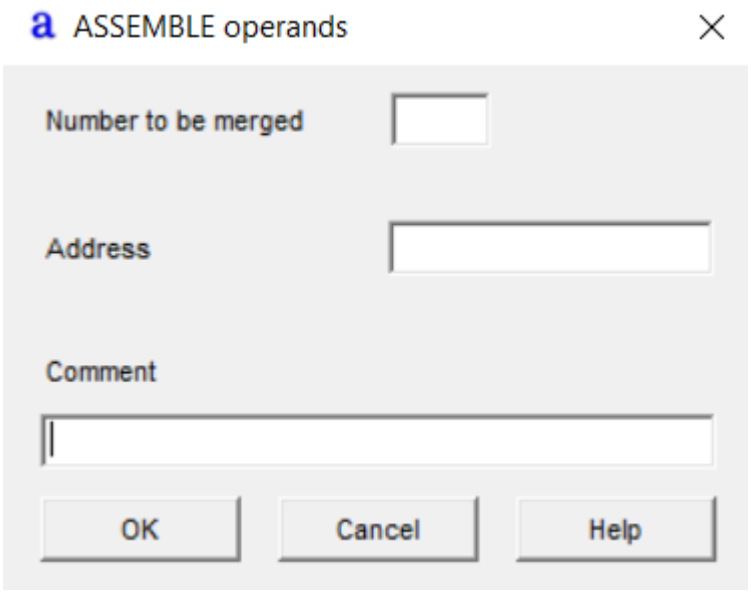
```
LOT FUNCTION            RN1,D5
.1,16/.5,17/.9,18/.95,19/1,20

        SIMULATE
*
*       ONE-LINE, SINGLE-SERVER QUEUEING MODEL
*
        GENERATE        480
        SPLIT           FN$LOT,TAL
TAL     QUEUE           ALM
        SEIZE           TALAD
        DEPART          ALM
        ADVANCE         10,5
        RELEASE         TALAD
        TERMINATE       1
*
        START           3000
        END
```

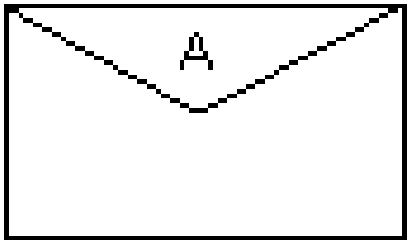


```
LOT  FUNCTION          RN1,D5
.1,17/.5,18/.9,19/.95,20/1,21

     SIMULATE
*
*    ONE-LINE, SINGLE-SERVER QUEUEING MODEL
*
     GENERATE          480
     SPLIT             FN$LOT,TAL
     TERMINATE
TAL  QUEUE             ALM
     SEIZE             TALAD
     DEPART            ALM
     ADVANCE           10,5
     RELEASE           TALAD
     TERMINATE         1
*
     START             3000
     END
```

Assemble

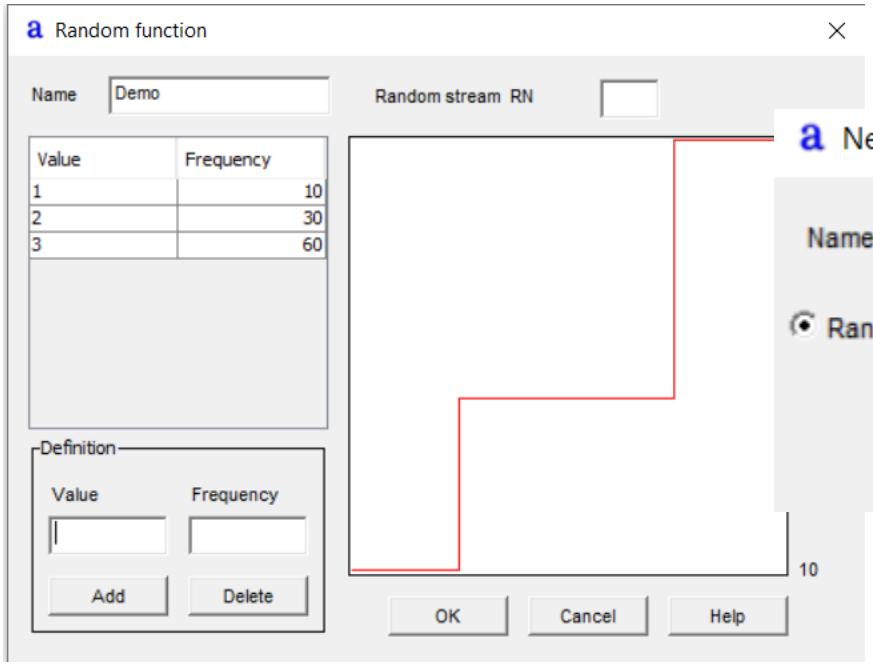
- To synchronize transactions.
- A: Number of transactions we are looking for.

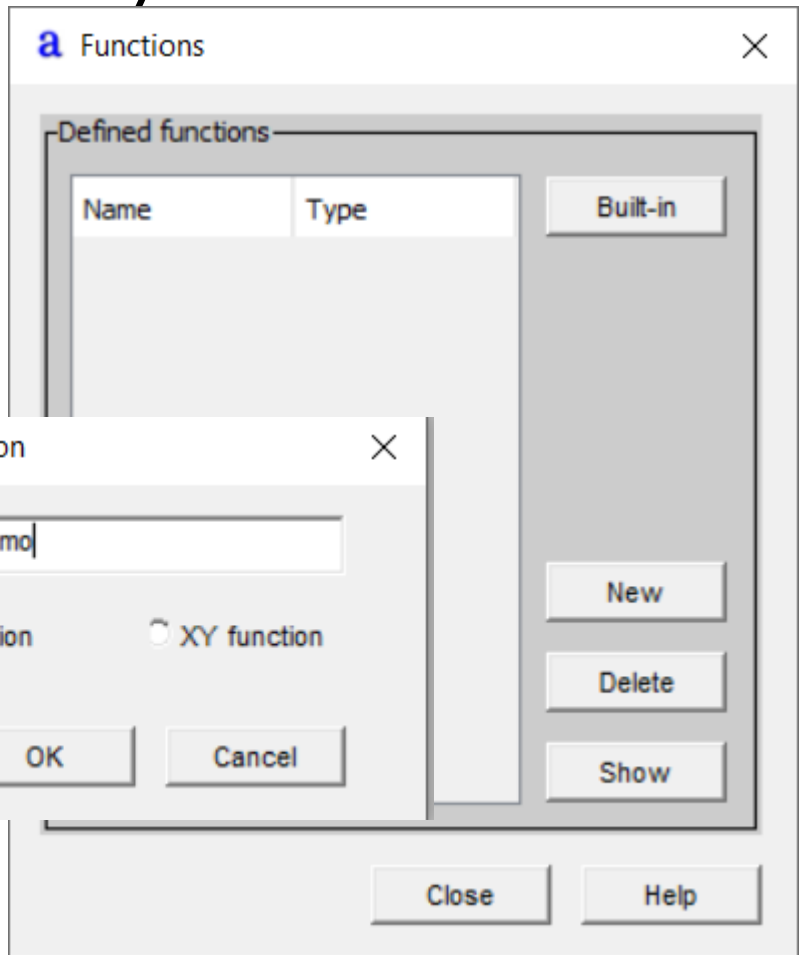




FUNCTION

- Allows to define a new probability distribution.
- Name FUNCTION A,B
  X1,Y1/X2,Y2/../Xn,Yn





FUNCTION

- Nom: Reference name of the function.
- A: Function arguments.
- B: Type of the function.
  - (C,D,E,L,M).
- Xi,Yi: Pair of data to create the distribution function.
  - Xi reference value.
  - Yi is the value that the function returns.

FUNCTION C

- Continuous.
  - Given an X value, interpolates and returns a value for Y.
  - As an example:
    - A=RN1
    - The function must be defined between 0 and 1.

    - MyFuncName FUNCTION RN1,C3
    - 0.1,1/0.8,2/1,3

FUNCTION D

- Discrete.
- Growing values of X.
- If we find a value equals or greater than X we return its related value.
- If we do not find this value, returns the greater value.

FUNCTION E

- Discrete function of attribute value.
  - Returns for an X the attribute value.
  - RESUL FUNCTION X$VALOR,E3
    1,S$ALM1/5,S$ALM2/9,S$ALM3

FUNCTION L

- Value list
- Returns the value of the X position (argument)
- TIPUS FUNCTION P2,L4

  1,3/2,5/3,8/4,12

FUNCTION M

- Attribute value list
- Returns the value of the attribute in the position X (argument)
- LLISTA FUNCTION X$NOM,M3

  1,X$NOM1/2,X$NOM2/3,X$NOM3

Functions main aspects

1. Functions C,D,L do not admit SNA's ans Y's.
2. Functions E, M must have SNA's as Y values.
3. Functions L and M cannot use random arguments.
4. To use a function:
    1. FN(nom).
    2. F$nom(parametres).

Example: Wooden tool v1.0

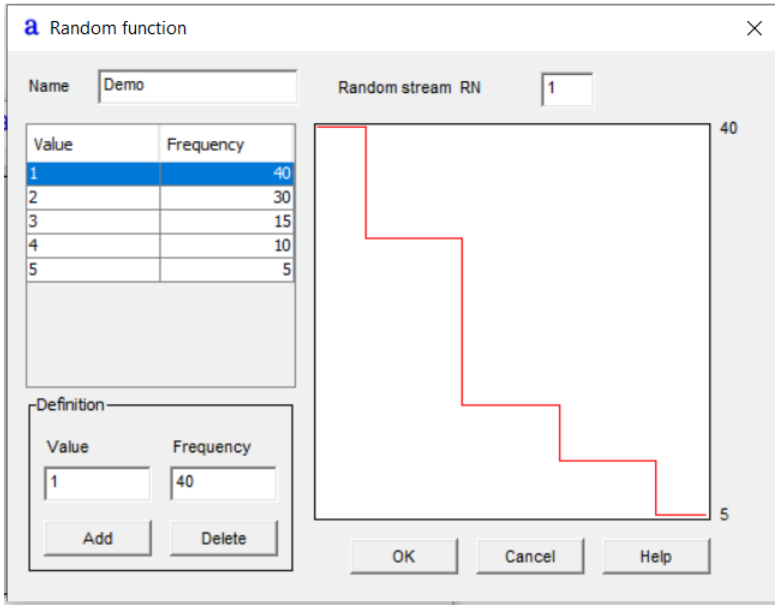
- Arrivals 5 a 9 minutes (Uniform)
- Tool service time (minutes)

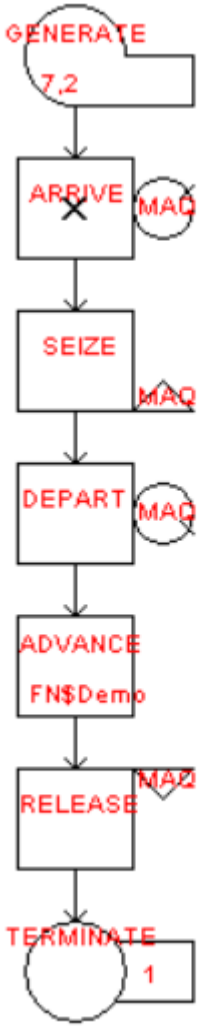
Temps de procés	1	2	3	4	5
Freqüència relativa	.4	.3	.15	.10	.05

- Model this system during 8 hours.

Resposta Serreria V1.0

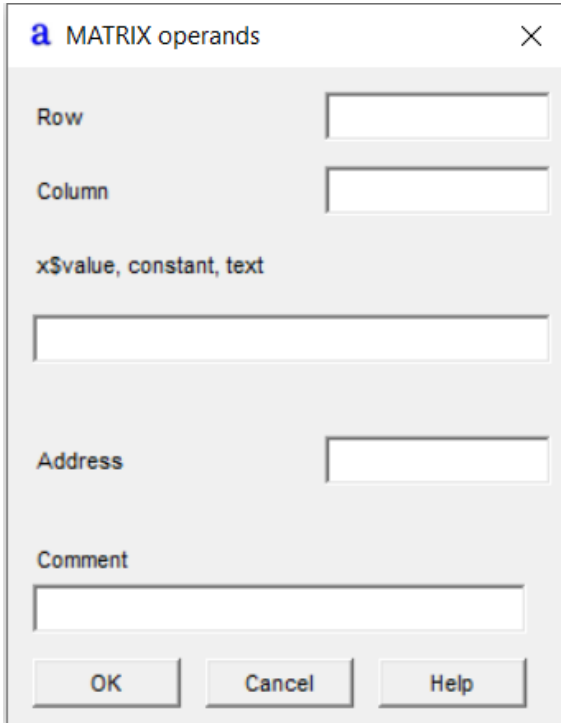
```
        SIMULATE
TRAB        FUNCTION   RN1,D5
.4,1/.7,2/.85,3/.95,4/1,5
        GENERATE        7,2
        QUEUE           UNO
        SEIZE           MAQ
        DEPART          UNO
        ADVANCE         FN$TRAB
        RELEASE         MAQ
        TERMINATE
*
*Termination control blocks
*
        GENERATE        480
        TERMINATE       1
        START           1
```





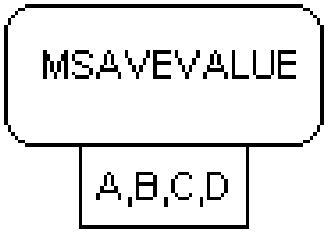
Matrix

- Name MATRIX A,B,C
- A: Matrix type.
- B: Rows.
- C: Columns.
  - MAGATZEM MATRIX MH,200,4
  - Defines a 200 x 4 matrix.



Msavevalue

- To give or modify the value of a matrix.
- A: name.
- B: row number.
- C: column number.
- D: information to be stored.



Internal vision of the transaction's movement

Understanding the process interaction paradigm

Example (Blocs)

1. Entering 3 ± 1 minutes
2. Start Storage
3. Entering Resource
4. Exit Storage
5. Using the resource 3
6. Release resource
7. Exit system

Example (Programming blocs)

1. New entities arrivals
   - 3 ± 1 minutes
2. Verification and *capture* of the free resource
3. Using the resource
   - 3 minutes
4. Release the resource
5. The entity leaves the system

Example(+ statistical adquisition)

1. New entity arrival
   - 3 ± 1 minutes
2. Start of the acquisition of data to represent the accumulation
3. Verification and capture of the free lathe
4. End of the data acquisition to represent the accumulation
5. Turning the raw material
   - 3 minutes
6. Release the lathe
7. Exit the system

Example (Event chains)

1. Enters a new transaction on the system
   - On t enters the new entity i+1 to the future event chain, remaining here until t+u(2,4).
2. Verification of the lathe entrance
   1. If the entity enter the lathe continues its movement to the next block
   2. If the lathe is not free, the entity is send to the end of the current event chain, remaining here until the lathe be free
3. Entering in the future event chain, remaining here 3 minutes
4. Leaving the future event chain, the lathe is free
5. The entity leaves the system

Points of view of a GPSS model

- External vision of the transactions. From the point of view of the block programming
  - The set of blocks that defines the movement of the transactions
- Internal vision of the transactions. From the point of view of the event chains
  - The places where the transactions are send during its movement through the model.

Event chains

- Transactions list
- In any moment
  - Transaction $\in$ bloc
  - Transaction$\in$ chain
- The transaction makes it movement from:
  - One block to another: no blocking situation, no delay.
  - From a chain to a chain: blocking situation, usually form FEC to CEC
  - From a block to a chain: A blocking situation or a delay in the system (ADVANCE)
  - From a chain to a block: An unblocking situation (or the end of a delay)

Blocking in the event list

- Blocking due to a delay
  - The transaction enters in the block in t1 and leaves the block in t2 (typically an advance)
  - In GPSS only due to ADVANCE and GENERATE.
- Blocking due to a model condition
  - The resource is “full”, typically a SEIZE used by any other entity

Type of chains

1. Current esdeveniment chain
2. Future esdeveniments chain

Current event Chain (CEC)

- Contains the transaction that want move now
  - Some problems prevents this movement
    - Blocking situations
    - Server busy
  - Sorted by decreasing priority (no time)

CEC

- Move time: Current simulation time

xact id	curBlk	nxtBlk	moveTime	priorityLevel
5	7	8	...	20
3	12	13	...	16
8	9	10	...	12

Future event Chain (FEC)

- The transactions are waiting for the correct time to finish its actions
- Can be caused by
  - A new transaction enters in the model, GENERATE
  - The transaction is in a process delay, ADVANCE
- Sorted by time and priority

FEC

- 7,2,11 : blocks ADVANCE
- 9 : block GENERATE

xact id	curBlk	nxtBlk	moveTime	priorityLevel
7	3	4	42.6	3
9	Neix	19	47.6	15
2	7	8	51.9	12
11	32	33	51.9	16

Example GPSS

GPSS World Simulation Report - TaladreSplit V1.0.3.1

Tuesday, March 08, 2005 10:40:14

START TIME	END TIME	BLOCKS	FACILITIES	STORAGES
0.000	493.810	8	1	0

LABEL	LOC	BLOCK TYPE	ENTRY COUNT	CURRENT COUNT	RETRY
	1	GENERATE	1	0	0
	2	SPLIT	1	0	0
TAL	3	QUEUE	18	16	0
	4	SEIZE	2	1	0
	5	DEPART	1	0	0
	6	ADVANCE	1	0	0
	7	RELEASE	1	0	0
	8	TERMINATE	1	0	0

Example GPSS

FACILITY	ENTRIES	UTIL.	AVE. TIME	AVAIL.	OWNER	PEND	INTER	RETRY	DELAY
TALAD	2	0.028	6.905	1	3	0	0	0	16

QUEUE	MAX	CONT.	ENTRY	ENTRY(0)	AVE.CONT.	AVE.TIME	AVE.(-0)	RETRY
ALM	17	17	18	1	0.475	13.043	13.810	0

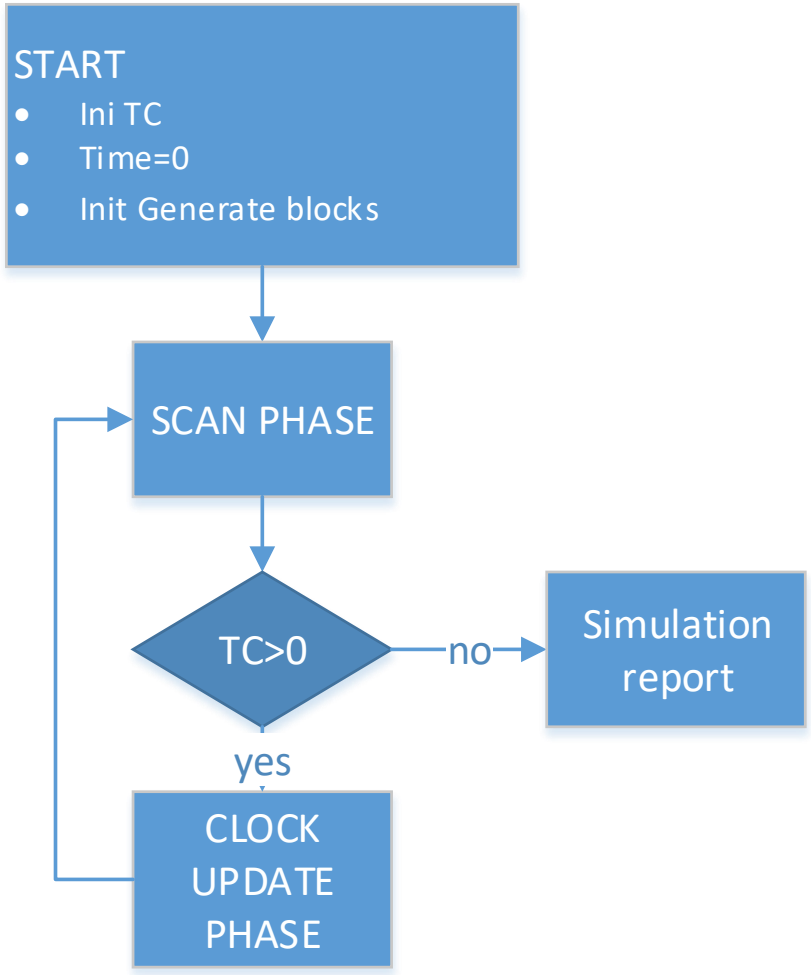
CEC XN	PRI	M1	ASSEM	CURRENT	NEXT	PARAMETER	VALUE
3	0	480.000	1	4	5		

FEC XN	PRI	BDT	ASSEM	CURRENT	NEXT	PARAMETER	VALUE
2	0	960.000	2	0	1		

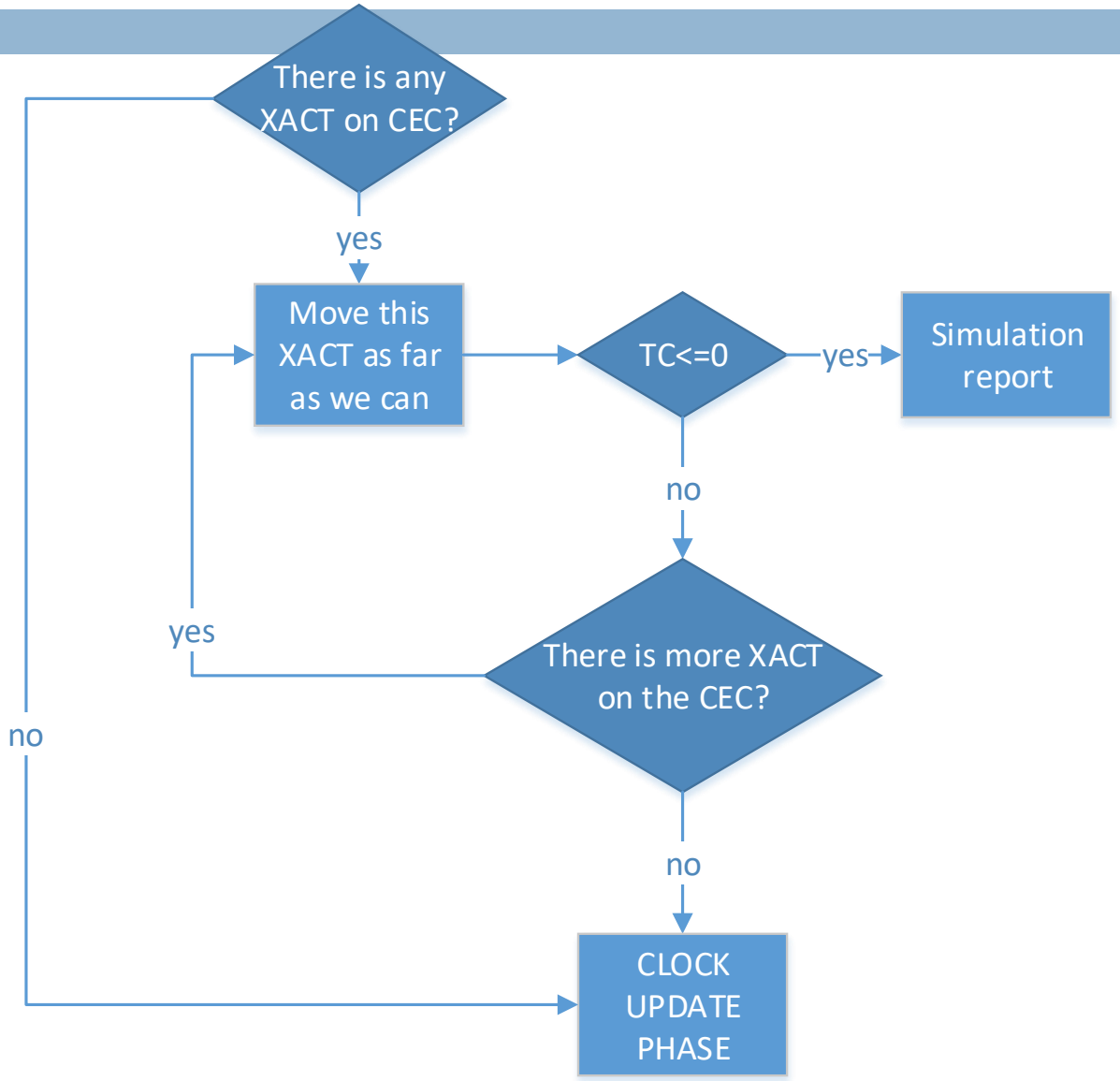
GENERATE blocs initialization

- On time 0.
- In Top-Down order (GPSS/H)
- For each bloc one transaction are created.
- Identifiers are assigned consecutively.
- Assigning the moveTime for each transaction.
- If the moveTime is equals to 0, this transaction I queued in the CEC, otherwise in the FEC.

Transactions movement

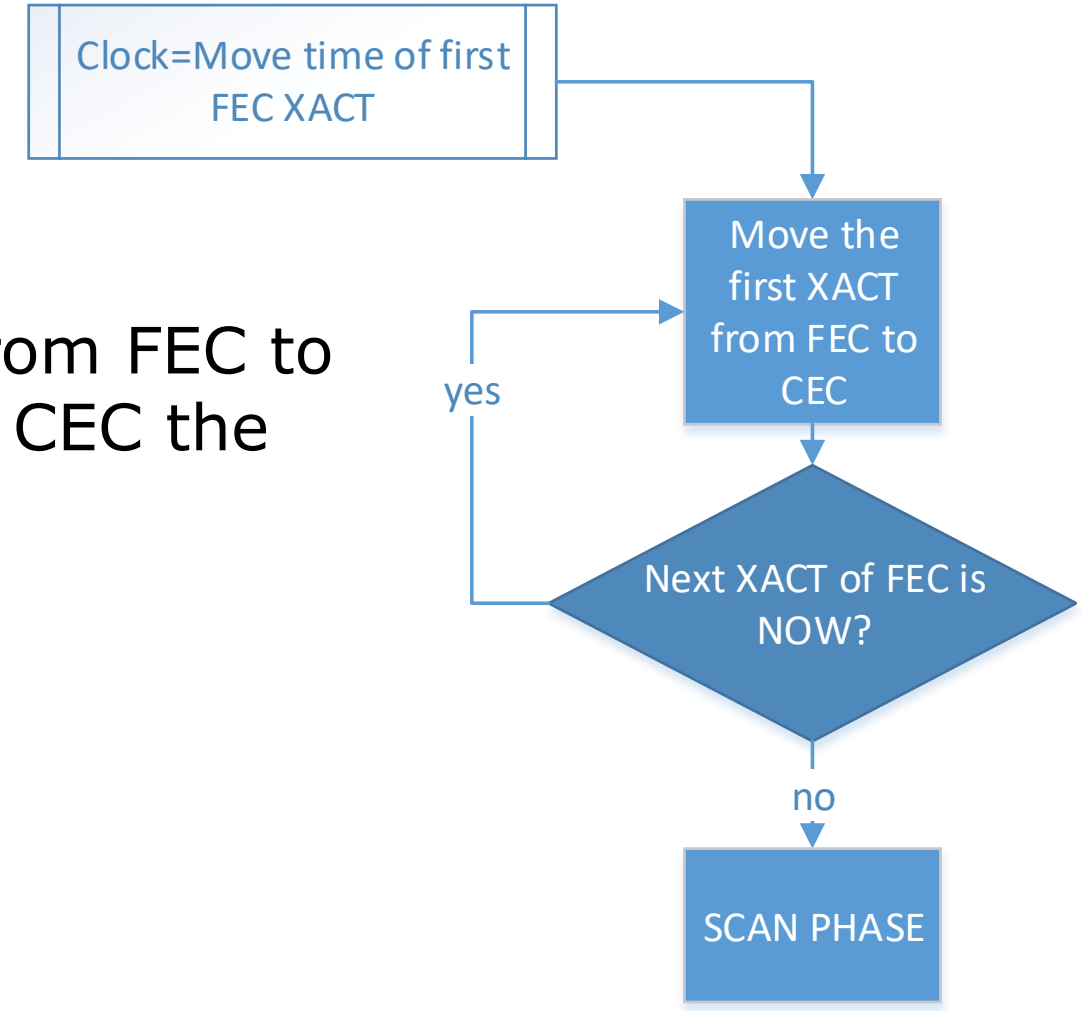


SCAN PHASE


There is any XACT on CEC?
yes
Move this XACT as far as we can
TC<=0
yes
Simulation report
no
There is more XACT on the CEC?
yes
no
no
CLOCK UPDATE PHASE

UPDATE PHASE

Moving the XACT from FEC to CEC keeping in the CEC the priority order.



Example (Blocks)

1. Enter 3 ± 1 minutes
2. Start Store
3. Entering Lathe
4. Leaving Store
5. Turning 3
6. Exit Lathe
7. Exit System

Example (data)

- Interval between generations:
  - (2,2,4,4)
- We only generate 4 entities.

1. Enter 3 ± 1 minutes
2. Start Store
3. Entering Lathe
4. Leaving Store
5. Turning 3
6. Exit Lathe
7. Exit System

Steep	Time	CEC	FEC
1	Start	-	-
2	0	-	(1,Out,1,2)

Example (event chains)

Step	Time	CEC	FEC	Comments
1	Inici	-	-	
2	0	-	(1,Out,1,2)	First Xact.
3	2	(1,Out,1,Now)	-	Xact from FEC to CEC.
4	2	-	(2,Out,1,4) (1,5,6,5)	Moving the Xact 1 all that we can, entering in 5 (*advance)*. Generatio of the second Xact.
5	4	(2,Out,1,Now)	(1,5,6,5)	Xact from FEC to CEC.
6	4	(2,2,3,Now)	(1,5,6,5) (3,Out,1,8)	Moving the Xact 2 all that we can, entering the 2 (*seize). Generation of the third* Xact.

Example (event chains)

Step	Time	CEC	FEC	Comments
7	5	(2,2,3, now) (1,5,6, now)	(3,Out,1,8)	Xact from FEC to CEC.
8	5	-	(3,Out,1,8) (2,5,6,8)	Moving the Xact 1 all that we can, leaving the system. Moving the Xact 2 all that we can, entering the 5 (*advance*).
9	8	(3, Out,1,now) (2,5,6, now)	-	Xact from FEC to CEC.
10	8	-	(3,5,6,11) (4,Out,1,12)	Moving the Xact 2 all that we can, leaving the system. Moving the Xact 3 all that we can, entering the *5(advance*). Programming the next arrival.

Example (event chains)

Step	Time	CEC	FEC	Coments
11	11	(3,5,6,Now)	(4,Out,1,12)	Xact from FEC a CEC.
12	11	-	(4,Out,1,12)	Moving the Xact 3 all than we can, leaves the system.
13	12	(4,Out,1,Now)	-	Xact from FEC a CEC.
14	12	-	(4,5,6,15)	Moving the Xact 4 all that we can, entering the 5 bloc (*advance*).
15	15	(4,5,6,Now)	-	Xact from FEC to CEC.
16	15	-	-	Moving the Xact 4 all that we can, leave the system.