Chapter 4:
How Transactions Are Managed by GPSS/H
Chapter 4
Transaction Management in GPSS/H
(Fundamental Treatment)

- Transaction Chains
- The Current Events Chain (CEC)
- The Future Events Chain (FEC)
- A Broad View of Transaction Movement
- GENERATE-Block Initialization
- The display Test-Mode Command
- The trap scan and run Test-Mode Commands
- Scrolling and Zooming in Test-Mode Windows
- The Scan Phase (Fundamental)
- The Clock Update Phase (Complete)
- Zero Interarrival Times at a GENERATE Block
Data Structures in GPSS/H

- GPSS/H manages Transactions internally by arranging them in lists known as chains.

- There are 5 types of chains:
  1. Current Events Chain (CEC)
  2. Future Events Chain (FEC)
  3. User Chains
  4. Interrupt Chains
  5. MAG Chains (Matching; Assemble; Gather)

- An informal representation of an Xact chain is shown on the next frame.

- An Xact is resident on only one chain at a time.

- An Xact is capable of moving from chain to chain (as well as moving from Block to Block) during a simulation.
An Informal Representation of a Transaction Chain
(each ● is an Xact on the chain)

Front of the chain

●

●

●

●

●

●

Back of the chain
An Alternative Representation of Transactions: Xacts Shown as Stickpersons
(Figure 2.3)
Another Representation of a Transaction Chain
(Figure 4.1)
Views of a Simple Conveyor
(flow schematic for the simple conveyor model of Figure 3.10)

Side View

Objects Are Placed onto the Conveyor from Source 1 at Times 15, 45, 75, 105, 135, ...

Travel Time: 250 Time Units

Objects Are Placed onto the Conveyor from Source 2 at Times 30, 60, 90, 120, 150, ...

Top View

Instantaneous Removal of the Objects
Block Diagram for the Conveyor Model

(not given in ISU; the START Statement and the Model's Termination Counter are also pictured here)
The Conveyor Model File and its Block-Diagram Equivalent

(Figure 3.10)

SIMULATE
*
GENERATE 30,15 objects arrive from source 1
TRANSFER ,CONVEYOR go onto a conveyor
*
GENERATE 30 objects arrive from source 2
CONVEYOR ADVANCE 250 conveying time
TERMINATE 1 conveyed objects leave system
*
START 25 initialize the model's TC
* and the GENERATE Blocks;
* start the Xact-Movement Phase
* end of Model-File execution
*
END

![Block-diagram](image-url)
The Current Events Chain (CEC)

- The CEC consists of Xacts that will move forward along their path in the model at the current simulated time

  as we will see in Chapters 6 and 7, also resident on the CEC in general are Xacts that will try to move forward at the current simulated time, but that can't do so because they are blocked and so must wait for the cause of their blockage to be eliminated

- Xacts are ordered on the CEC, from front to back, in order of decreasing (or, in case of ties, nonincreasing) Xact Priority Level (PR)

- Priority Level (PR) is a signed integer

  (PR values range from $-2^{31} + 15$ to $+2^{31} - 15$, that is, from about $-2,000,000,000$ to about $+2,000,000,000$)

- The GENERATE Block's E Operand specifies Xact Priority Level at the time of Xact creation

  (the default value is 0)

- The PRIORITY Block (a Chapter 12 Block) can be used to change the Priority Level of Xacts that move through the Block
A Representation of the CEC in a Specific Example

(Figure 4.2)

<table>
<thead>
<tr>
<th>Xact Id</th>
<th>Priority Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

Front
Current Events Chain
Back
An Expanded View of the Current Events Chain in a Specific Example

(Figure 4.3)
The Future Events Chain (FEC)

- The FEC is composed of Xacts that will not move forward along their path in the model until some known future simulated time has been reached

  (it is true of all Xacts on the FEC that their Move Time exceeds the current simulated time)

- Xacts are ordered on the FEC, from front to back, in order of increasing (or, in case of ties, nondecreasing) Xact Move Time
A Representation of the Future Events Chain in a Specific Example

(Figure 4.4)

<table>
<thead>
<tr>
<th>Xact Id</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>Move Time</th>
<th>Priority Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>3</td>
<td>4</td>
<td>42.6</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>Birth</td>
<td>19</td>
<td>47.6</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>8</td>
<td>51.9</td>
<td>12</td>
</tr>
<tr>
<td>11</td>
<td>32</td>
<td>33</td>
<td>51.9</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Birth</td>
<td>45</td>
<td>480.0</td>
<td>0</td>
</tr>
</tbody>
</table>

Front

Future Events Chain

Back
Informal Motivation for the Clock Update and Scan Phases

assume the state of the model has been fully updated at simulated time 37.8 and that the CEC is empty as a result.

*The CEC will only be empty after the model has been fully updated at a given simulated time if there are no blocked Xacts on it.
Informal Motivation
for the Clock Update and Scan Phases

assume the state of the model has been fully updated
at simulated time 37.8 and that the CEC nevertheless is not empty
because there are blocked Xacts on it
An Expanded View of Box 3 ("Xact Movement") in Fig. 2.19
(Figure 4.5)

Simulated Time: 0.0
Initialize the model's TC;
Initialize the model's
GENERATE Blocks

(3) ("Transaction Movement")

from
Box 2

START

Scan Phase
(update the model at the
current simulated time)

TC>0

Clock Update Phase
(advance to the next
simulated time)

TC<0

Go on to produce the
Postsimulation Report

to
Box 4
The Steps in Executing a Model File
(Figure 2.19 Modified to Include Comments on START-Statement Execution)

Start

(1) Model Compilation and Compiler Report

- Components of Compiler Report:
  - Source Echo (Enhanced Copy of Model File);
  - Compile-Time Warning and Error Messages;
  - Dictionary;
  - Cross-Reference Listing;
  - Summary of Storage Requirements

- Compile-Time Error(s), or no "SIMULATE"

Stop

(2) Control-Statement Execution

(Execution-Time Warning Messages might be issued)

(3) Transaction Movement (Block-Statement Execution)

(Execution-Time Warning Messages might be issued)

TC ≤ 0

(4) Postsimulation Report

(5) Computer-Usage Report

"END"

Simulated Time: 0.0
- Initialize the Model's GENERATE Blocks
- Initialize the Model's Termination Counter

Stop

Components of Postsimulation Report:
- Clock time; Block Counts;
- Facility Report (see Chapter 6);
- Queue Report (see Chapter 9);
- Storage Report (see Chapter 11);
- Random-Numbers Report (see Chapter 14); etc.
The Steps in Initializing a Model's GENERATE Blocks
(Figure 4.6)

1. For each GENERATE Block... (in the top-down order of their appearance in the Model File)

2. Create a Transaction

3. Has the GENERATE Block's Offset Interval (C Operand) Been Used?
   - Yes: Set this Xact's Move Time Equal to the Value of the Offset Interval
   - No: Set this Xact's Move Time Equal to the Value Sampled from the A/B-Operand Distribution

4. Transactions are serially numbered 1, 2, 3, ... in the model in the order of their creation

5. Does this Transaction's Move Time Equal Zero?
   - Yes: Merge this Transaction into the CEC (Current Events Chain)
   - No: Merge this Transaction into the FEC (Future Events Chain)
A Basic View of the Interplay Between the User and GPSS/H in a Test-Mode Simulation
(Figure 2.20)

Examples of DOS gpssh Commands

Test Mode
gpssh model6a.gps tvtnw

Batch Mode
gpssh model6a.gps

User In Test Mode
(the user can turn interrupt conditions on/off and display information, then resume Model File execution or quit)

(1) from compilation

(2) Ready!

(3) interrupt

(4) resume

(5) quit

Stop

GPSS/H is poised to execute a START statement
The Test-Mode `display` Command

`display info_type`

Table 4.1
Selected types of information that can be displayed in Test Mode

<table>
<thead>
<tr>
<th>Display Modifier</th>
<th>Information Displayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>blo</td>
<td>Current and Total Block Counts</td>
</tr>
<tr>
<td>cec</td>
<td>Current Events Chain</td>
</tr>
<tr>
<td>clocks</td>
<td>Absolute and Relative clock values</td>
</tr>
<tr>
<td>fec</td>
<td>Future Events Chain</td>
</tr>
<tr>
<td>xact=xact_id</td>
<td>the properties of the Xact whose id is xact_id (e.g., xact=25)</td>
</tr>
</tbody>
</table>
The Simple step Command
(reviewed from Chapter 2)

step

When a step command is issued, GPSS/H:

(1) starts (or resumes) Xact movement,

(2) continues until one more Block has been executed, then

(3) gives control back to the user with a "poised at" message
### Figure 2.18, Screen 2

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>CURRENT</th>
<th>TOTAL</th>
<th>fig218.gps SOURCE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td>GENERATE 15.0,4.5 Transactions a</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td></td>
<td>TERMINATE 1 Transactions a</td>
</tr>
</tbody>
</table>

S/C: OFF  ABS CLOCK: 12.9327  REL CLOCK: 12.9327  TTG: 2

XACT: 1  CURBLK: 1  NEXTBLK: 2  CHAINS: CEC  PC:

MARK-TIME: 12.9327  MOVE-TIME: -----  PRIORITY: 0

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Ready!

Example of a "poised at" Interrupt Message

: step

XACT 1 POISED AT BLOCK 2.  RELATIVE CLOCK: 12.9327

:
Variations on the Simple step Command
(reviewed from Chapter 3)

\[ \text{step step\_count} \]

Here, \textit{step\_count} provides a count of the total number of Blocks that GPSS/H is to execute before returning control to the user, e.g.:

\[ \begin{align*}
\text{step} & \quad 2 \\
\text{step} & \quad 5
\end{align*} \]

The default value of \textit{step\_count} is 1, so \textit{step} and \textit{step 1} are equivalent:

\[ \begin{align*}
\text{step} \quad & \text{step 1}
\end{align*} \]

\textit{step} can be abbreviated to \textit{ste}, or \textit{st}, or \textit{s}, i.e.:

\[ \begin{align*}
\text{s} & \quad 2 \\
\text{s}
\end{align*} \]

Pressing \textbf{F10} causes a \textit{step 1} command to be issued
The trap scan and run Test-Mode Commands

• Issuing a step command has a twofold effect:
  Effect 1: an interrupt condition is established
  Effect 2: Xact movement is started (or resumed)

• Issuing a trap command has only the first of these effects, namely, an interrupt condition (a trap condition) is established

• For example, when a trap scan command is issued, the effect is to set a scan trap

  (the conditions under which a scan trap is sprung are shown in the next frame)

• The second effect (namely, starting or resuming Xact movement) is accomplished by issuing another command, a run command

• The following sequence of two commands has the combined effect, then, of setting an interrupt condition and causing Xact movement to start (or resume)

  trap scan
  run
If a scan trap is set, control is returned to the user at these points.

START

Simulated Time: 0.0
- Initialize the model's TC
- Initialize the model's GENERATE Blocks

From Box 2

Scan Phase
(update the model at the current simulated time)

TC > 0

Clock Update Phase
(advance to the next simulated time)

TC ≤ 0

Go on to produce the Postsimulation Report

to Box 4

(3) "Transaction Movement"
A Model File to Demonstrate GENERATE-Block Initialization
(Figure 4.7)

```
SIMULATE
*
BLOCK1 GENERATE 25,10
TERMINATE 1
*
BLOCK3 GENERATE 50,20,0
TERMINATE 1
*
START 2
END
```
Figure 4.8, Screen 1
The First of Eight Computer Screens Produced by Running the Figure 4.7 Model File in Test Mode

<table>
<thead>
<tr>
<th>BLOCK CURRENT</th>
<th>TOTAL</th>
<th>fig47.gps SOURCE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

the model's Termination Counter

---

S/C: OFF ABS CLOCK: 0. REL CLOCK: 0. TTG: 2

---

XACT: $SYS CURBLK: NEXTBLK: CHAINS: CEC+SYS PC:
MARK-TIME: MOVE-TIME: ----- PRIORITY: 2147483647

---

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Ready!

:: trap scan
:: run
"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).
Figure 2.22b Repeated as Figure 2.22bb
(Source, Status, and Dialog Windows Highlighted)
(reviewed from Chapter 2)

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>CURRENT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**fig218.gps SOURCE CODE**

| GENERATE | 15.0,4.5 | Transactions a |
| TERMINATE | 1 | Transactions a |

**Source Window**

S/C: OFF  ABS CLOCK: 12.9327  REL CLOCK: 12.9327  TTG: 2

XACT: 1  CURBLK: 1  NEXTBLK: 2  CHAINS: CEC  PC:

MARK-TIME: 12.9327  MOVE-TIME: -----  PRIORITY: 0

**Status Window**

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Ready!
: step

XACT 1 POISED AT BLOCK 2. RELATIVE CLOCK: 12.9327
:

**Dialog Window**
"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).

: display cec

Fresh Dialog

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td></td>
<td>---</td>
<td>0.</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 4.8, Screen 3

<table>
<thead>
<tr>
<th>BLOCK CURRENT</th>
<th>TOTAL</th>
<th>fig47.gps SOURCE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

S/C: OFF  ABS CLOCK: 0.  REL CLOCK: 0.  TTG: 2

---

XACT: $SYS  CURBLK:  NXTBLK:  CHAINS: CEC+SYS  PC:

---

MARK-TIME:  MOVE-TIME: ------  PRIORITY: 2147483647

---

2  BIRTH  BLOCK3  CEC  ---  0.  0

:display fec

Fresh Dialog

---

FUTURE EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>20.4059</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

:
<table>
<thead>
<tr>
<th>S/C</th>
<th>ABS CLOCK</th>
<th>REL CLOCK</th>
<th>TTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>0.</td>
<td>0.</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>$SYS</td>
<td></td>
<td></td>
<td>CEC+SYS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2147483647</td>
</tr>
</tbody>
</table>

2 BIRTH BLOCK3 CEC
: display fec

**FUTURE EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td></td>
<td>20.4059</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

: set tv off

(Fresh Dialog
("set tv off" keyed in, but not yet executed)
Figure 4.8, Screen 5
(screen after "set tv off" has been executed)

Recovered Dialog

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Ready!
: trap scan
: run

"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).
: display cec

CURRENT EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td>---</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
: display fec

FUTURE EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>20.4059</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
:
### Figure 4.8, Screen 6

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td>---</td>
<td>0.</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

: display fec

**FUTURE EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>20.4059</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

: display cec fec

**CURRENT EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td>---</td>
<td>0.</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**FUTURE EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>20.4059</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>XACT</td>
<td>CURBLK</td>
<td>NXTBLK</td>
<td>CHAINS</td>
<td>SDPGFT**</td>
<td>MARK-TIME</td>
<td>MOVE-TIME</td>
<td>PRIORITY</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>---------</td>
<td>-----------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td>---</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

: display fec

**FUTURE EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
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</tr>
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<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>20.4059</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

: display cec fec

**CURRENT EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td>---</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**FUTURE EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>20.4059</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

: set tv on

**Fresh Dialog**

("set tv on" keyed in, but not yet executed)
### Recovered Source and Status Windows

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>CURRENT</th>
<th>TOTAL</th>
<th>fig47.gps SOURCE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

----------

<table>
<thead>
<tr>
<th>S/C: OFF ABS CLOCK: 0.</th>
<th>REL CLOCK: 0.</th>
<th>TTG: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>XACT: $SYS</td>
<td>CHAINS: CEC+SYS PC: 0</td>
<td></td>
</tr>
<tr>
<td>MOVE-TIME: ----</td>
<td>PRIORITY: 2147483647</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td></td>
<td>---</td>
<td>0.</td>
<td>0</td>
</tr>
</tbody>
</table>

**FUTURE EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td></td>
<td>---</td>
<td>20.4059</td>
<td>0</td>
</tr>
</tbody>
</table>
# The Role of the Function Keys in Scrolling

*(Table 4.2)*

<table>
<thead>
<tr>
<th>Function Key</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td><strong>Zoom</strong> to the topmost line of dialog still in computer memory</td>
</tr>
<tr>
<td>F3</td>
<td><strong>Zoom</strong> to the bottom (most recent) line of dialog</td>
</tr>
<tr>
<td>F5</td>
<td><strong>Scroll</strong> 20 columns to the left in the Dialog and Source Windows</td>
</tr>
<tr>
<td>F6</td>
<td><strong>Scroll</strong> 10 columns to the right in the Dialog and Source Windows</td>
</tr>
<tr>
<td>F7</td>
<td><strong>Scroll</strong> up (one line) in the Source Window</td>
</tr>
<tr>
<td>F9</td>
<td><strong>Scroll</strong> down (one line) in the Source Window</td>
</tr>
</tbody>
</table>

```
display pf
```
### Other Function-Key Roles

<table>
<thead>
<tr>
<th>Function Key</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>F2</td>
<td>Issues a <code>set tv off</code> command</td>
</tr>
<tr>
<td>F4</td>
<td>Issues a <code>set tv on</code> command</td>
</tr>
<tr>
<td>F10</td>
<td>Issues a <code>step 1</code> command</td>
</tr>
</tbody>
</table>

`display pf`
Zooming in the Source Window

- Recall that *scrolling* up and down in the Source Window *one-line-at-a-time* can be accomplished with the F7 and F9 keys, respectively.

- Zooming in the Source Window can be accomplished by issuing this command:

```
  ds Block_identifier
```

where `Block_identifier` is either:

1. the *Label* attached to the Block on which the Source Window is to be *centered*, or

2. The *number of the Location* occupied by the Block on which the Source Window is to be *centered*

- `ds` can be remembered as an abbreviated form of "display source"

  (but the spelled-out words "display source" cannot be used in issuing this Test-Mode command)
Context of the Scan Phase and Clock Update Phase
(a review, per Figure 4.5)

(3) ("Transaction Movement")

**START**

Simulated Time: 0.0
Initialize the model's TC;
Initialize the model's
GENERATE Blocks

Scan Phase
(update the model at the
current simulated time)

TC≤0

Clock Update Phase
(advance to the next
simulated time)

TC>0

Go on to produce the
Postsimulation Report

to Box 4

from Box 2
The Scan Phase Logic in Simplified Form
(Figure 4.9)

1. If a scan trap is set, give control to the interactive user

2. Is there an Xact at the front of the CEC?
   - No
   - Yes

3. Move this Transaction as far along its path as possible

4. Nonzero ADVANCE => put this Xact on the FEC
   TERMINATE => destroy this Xact

5. Is the model's Termination Counter ≤ 0 ?
   - Yes
   - No

6. Is there a sequential Transaction on the CEC?
   - Yes
   - No

Clock Update Phase

Simulation Report
The Logic of the Clock Update Phase
(Figure 4.10)

Clock Update Phase

Set the clock's value to the Move Time of the Transaction at the front of the FEC

Transfer this Transaction from the Future Events Chain to the Current Events Chain

If the FEC is empty, issue Error Message 410, "No Next Event in System," and stop

Merge the Transaction into the Current Events Chain as the last member in its Priority Class

Does the Move Time of the Xact now at the front of the FEC match the Clock?

Yes

No

Scan Phase
A Model File to Demonstrate the Scan and Clock-Update Phases
(Figure 4.11)

```
SIMULATE
*
BLOCK1 GENERATE 10
BLOCK2 TERMINATE 1
*
BLOCK3 GENERATE 10,0,5
BLOCK4 ADVANCE 10
BLOCK5 TERMINATE 1
*
START 3
END
```
### Figure 4.12, Screen 1
The First of Eight Computer Screens Produced by Running the Figure 4.11 Model File in Test Mode

<table>
<thead>
<tr>
<th>BLOCK CURRENT</th>
<th>TOTAL</th>
<th>fig411.gps SOURCE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

S/C: OFF  ABS CLOCK: 0.  REL CLOCK: 0.  TTG: 3

XACT: $SYS  CURBLK:   NEXTBLK:   CHAINS: CEC+SYS  PC:

MARK-TIME:   MOVE-TIME: -----  PRIORITY: 2147483647

WOLVERINE SOFTWARE CORPORATION
4115 ANNANDALE ROAD
ANNANDALE, VIRGINIA 22003, USA

Ready!

:: trap scan
:: run

"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).
WOLVERINE SOFTWARE CORPORATION
4115 ANNANDALE ROAD
ANNANDALE, VIRGINIA 22003, USA

Ready!
: trap scan
: run

"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).

: display cec fec

**Fresh Dialog**

<table>
<thead>
<tr>
<th>CURRENT EVENTS CHAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>XACT</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FUTURE EVENTS CHAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>XACT</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>
Fresh Dialog

XACT 2 POISED AT BLOCK 4 (BLOCK4). RELATIVE CLOCK: 0.
: display cec fec

CURRENT EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BLOCK3</td>
<td>BLOCK4</td>
<td>CEC</td>
<td>0.</td>
<td>0.</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

FUTURE EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>10.0000</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>FEC</td>
<td>---</td>
<td>10.0000</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Note the two-way Move-Time tie
### Figure 4.12, Screen 4

<table>
<thead>
<tr>
<th></th>
<th>BIRTH</th>
<th>BLOCK1</th>
<th>FEC</th>
<th>---</th>
<th>10.0000</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>XACT</td>
<td>CURBLK</td>
<td>NXTBLK</td>
<td>CHAINS</td>
<td>SDPGFT**</td>
<td>MARK-TIME</td>
<td>MOVE-TIME</td>
</tr>
<tr>
<td>3</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>FEC</td>
<td>---</td>
<td>10.0000</td>
<td>5</td>
</tr>
</tbody>
</table>

:step

**Fresh Dialog**

XACT 2 PLACED ON FEC AT BLOCK 4 (BLOCK4). RELATIVE CLOCK: 0.

:display cec fec

**FUTURE EVENTS CHAIN**

<table>
<thead>
<tr>
<th></th>
<th>BIRTH</th>
<th>BLOCK1</th>
<th>FEC</th>
<th>---</th>
<th>10.0000</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>XACT</td>
<td>CURBLK</td>
<td>NXTBLK</td>
<td>CHAINS</td>
<td>SDPGFT**</td>
<td>MARK-TIME</td>
<td>MOVE-TIME</td>
</tr>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td>---</td>
<td>10.0000</td>
<td>0</td>
</tr>
<tr>
<td>XACT</td>
<td>CURBLK</td>
<td>NXTBLK</td>
<td>CHAINS</td>
<td>SDPGFT**</td>
<td>MARK-TIME</td>
<td>MOVE-TIME</td>
</tr>
<tr>
<td>3</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>FEC</td>
<td>---</td>
<td>10.0000</td>
<td>5</td>
</tr>
<tr>
<td>XACT</td>
<td>CURBLK</td>
<td>NXTBLK</td>
<td>CHAINS</td>
<td>SDPGFT**</td>
<td>MARK-TIME</td>
<td>MOVE-TIME</td>
</tr>
<tr>
<td>2</td>
<td>BLOCK4</td>
<td>BLOCK5</td>
<td>FEC</td>
<td>0.</td>
<td>10.0000</td>
<td>5</td>
</tr>
</tbody>
</table>

**note the three-way Move-Time tie**

---

---

---
"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).
REMAINING STEP COUNT = 1
: display clocks

RELATIVE CLOCK: 10.0000  ABSOLUTE CLOCK: 10.0000
: display cec fec

CURRENT EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td></td>
<td>0.0000</td>
<td>10.0000</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>BLOCK4</td>
<td>BLOCK5</td>
<td>CEC</td>
<td></td>
<td>0.0000</td>
<td>10.0000</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>CEC</td>
<td></td>
<td>0.0000</td>
<td>10.0000</td>
<td>0</td>
</tr>
</tbody>
</table>
### Figure 4.12, Screen 6

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BLOCK4</td>
<td>BLOCK5</td>
<td>CEC</td>
<td>0.</td>
<td>10.0000</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>XACT</td>
<td>CURBLK</td>
<td>NXTBLK</td>
<td>CHAINS</td>
<td>SDPGFT**</td>
<td>MARK-TIME</td>
<td>MOVE-TIME</td>
<td>PRIORITY</td>
</tr>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>CEC</td>
<td>---</td>
<td>10.0000</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

---

**Fresh Dialog**

XACT 3 POISED AT BLOCK 4 (BLOCK4). RELATIVE CLOCK: 10.0000
: step

XACT 3 PLACED ON FEC AT BLOCK 4 (BLOCK4). RELATIVE CLOCK: 10.0000
: step

XACT 2 DESTROYED AT BLOCK 5 (BLOCK5). RELATIVE CLOCK: 10.0000
: step

XACT 1 POISED AT BLOCK 2 (BLOCK2). RELATIVE CLOCK: 10.0000
: step

XACT 1 DESTROYED AT BLOCK 2 (BLOCK2). RELATIVE CLOCK: 10.0000
: step
**Figure 4.12, Screen 7**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>FEC</td>
<td></td>
<td>---</td>
<td>20.0000</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>BLOCK4</td>
<td>BLOCK5</td>
<td>FEC</td>
<td></td>
<td>10.0000</td>
<td>20.0000</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>FEC</td>
<td></td>
<td>---</td>
<td>20.0000</td>
<td>0</td>
</tr>
</tbody>
</table>

_Fresh Dialog_

Future Events Chain
"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).
REMAINING STEP COUNT = 1
: display clocks

RELATIVE CLOCK: 20.0000  ABSOLUTE CLOCK: 20.0000
: display cec fec

CURRENT EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>BIRTH</td>
<td>BLOCK3</td>
<td>CEC</td>
<td>---</td>
<td>20.0000</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>BLOCK4</td>
<td>BLOCK5</td>
<td>CEC</td>
<td>10.0000</td>
<td>20.0000</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>CEC</td>
<td>---</td>
<td>20.0000</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
Zero Interarrival Times at a GENERATE Block

Example 1:
Limit Count = 1, Arrival Time = 0

GENERATE 0,,1
ADVANCE 40,10
...etcetera...

Example 2:
Limit Count > 1, Arrival Times = 0

GENERATE 0,,3
ADVANCE 40,10
...etcetera...

Example 3:
Limit Count > 1, Arrival Times > 0

GENERATE 0,,250,5
ADVANCE 40,10
...etcetera...
A Chain-Oriented View of a Transaction's Location
(Figure 4.13)

Transaction Creation

- (put the Xact on the FEC if its interarrival time > 0)

Transaction Destruction

Future Events Chain

- (Move Time = Clock Time)

Current Events Chain

- (*TERMINATE*)

(Nonzero ADVANCE)
A Model File to Demonstrate
Zero Interarrival Times
at a GENERATE Block
(Figure 4.14)

<table>
<thead>
<tr>
<th>BLOCK1</th>
<th>GENERATE</th>
<th>0,3</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPEAT</td>
<td>ADVANCE</td>
<td>40,10</td>
</tr>
<tr>
<td></td>
<td>TRANSFER</td>
<td>,REPEAT</td>
</tr>
<tr>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLOCK4</td>
<td>GENERATE</td>
<td>480</td>
</tr>
<tr>
<td></td>
<td>TERMINATE</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure 4.15, Screen 1
The First of Nine Computer Screens Produced by Running the Figure 4.14 Model File in Test Mode

<table>
<thead>
<tr>
<th>BLOCK CURRENT</th>
<th>TOTAL</th>
<th>fig414.gps SOURCE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S/C: OFF</th>
<th>ABS CLOCK: 0.</th>
<th>REL CLOCK: 0.</th>
<th>TTG: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XACT: $SYS</th>
<th>CURBLK:</th>
<th>NEXTBLK:</th>
<th>CHAINS: CEC+SYS PC:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MARK-TIME:</th>
<th>MOVE-TIME: -----</th>
<th>PRIORITY: 2147483647</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WOLVERINE SOFTWARE CORPORATION
4115 ANNANDALE ROAD
ANNANDALE, VIRGINIA 22003, USA

Ready!

:: trap scan
:: run

"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).
Ready!
: trap scan
: run

"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).

: display clocks

**Fresh Dialog**

<table>
<thead>
<tr>
<th>RELATIVE CLOCK:</th>
<th>0.0000</th>
<th>ABSOLUTE CLOCK:</th>
<th>0.0000</th>
</tr>
</thead>
</table>

: display cec fec

CURRENT EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BIRTH</td>
<td>BLOCK1</td>
<td>CEC</td>
<td>---</td>
<td>0.0000</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

FUTURE EVENTS CHAIN

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>BIRTH</td>
<td>BLOCK4</td>
<td>FEC</td>
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</table>
### Fresh Dialog

**XACT 1 POISED AT BLOCK 2 (REPEAT).** RELATIVE CLOCK: 0.

: display cec fec

**CURRENT EVENTS CHAIN**

<table>
<thead>
<tr>
<th>XACT</th>
<th>CURBLK</th>
<th>NXTBLK</th>
<th>CHAINS</th>
<th>SDPGFT**</th>
<th>MARK-TIME</th>
<th>MOVE-TIME</th>
<th>PRIORITY</th>
</tr>
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<tbody>
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**FUTURE EVENTS CHAIN**

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XACT 1 PLACED ON FEC AT BLOCK 2 (REPEAT). RELATIVE CLOCK: 0.

: display cec fec

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<tbody>
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Fresh Dialog

XACT 3 POISED AT BLOCK 2 (REPEAT). RELATIVE CLOCK: 0.
: display cec fec

CURRENT EVENTS CHAIN

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### Fresh Dialog

```plaintext
: step

XACT 3 PLACED ON FEC AT BLOCK 2 (REPEAT). RELATIVE CLOCK: 0.
: display cec fec

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Fresh Dialog

XACT 4 PLACED ON FEC AT BLOCK 2 (REPEAT). RELATIVE CLOCK: 0.

: display cec fec

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2  BIRTH  BLOCK4  FEC    ---  480.0000  0
"SCAN" TRAP TAKEN (SYSTEM POISED TO BEGIN CEC SCAN).
REMAINING STEP COUNT = 1
: display clocks

RELATIVE CLOCK: 35.4059  ABSOLUTE CLOCK: 35.4059
: display cec fec

CURRENT EVENTS CHAIN

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