Transparency Masters
for

Going Beyond
An Introduction to
Simulation Using GPSS/H

Unit G:
Groups
The GROUP Entity

• Another way (in addition to User Chains) to organize Xacts as sets is to have them be members of one or more Groups

• Whereas Xacts on a User Chain are inactive and are all in the same place both physically and logically, Xacts which are members of a Group can move about in a model individually and need not all be in the same place at the same time either physically or logically

• Groups provide a mechanism (the SCAN Block) making it possible for an Xact to inspect the Priority Levels and the values in integer-type Parameters of Group members

Examples

✓ An Xact can scan a Group looking for a member with a Priority Level that satisfies a specified condition (e.g., less than 10, or equal to 18, or greater than or equal to 25)

✓ An Xact can scan a Group looking for a member whose specified integer type Parameter satisfies a specified condition (e.g., not equal to 30, or less than or equal to 50)

✓ An Xact can scan a Group looking for the member with a minimum Priority Level

In the above cases, if such a Group member is found, its Priority Level or one of its integer-type Parameter values can be copied into an integer-type Parameter on the scanning Xact
• Groups also provide a mechanism (the **ALTER Block**) making it possible for an Xact to alter (replace) the **Priority Levels** and the values in **integer-type Parameters** of qualifying Group members

**Examples**

✓ An Xact can alter (replace) either the Priority Level or the value in a specified integer-type Parameter of one or more Group members having a specified Priority Level, (e.g., Priority Level less than 10, or equal to 18, or greater than or equal to 25)

✓ An Xact can alter (replace) either the Priority Level or the value in a specified integer-type Parameter of one or more Group members which have a specified integer type Parameter satisfying a specified condition (e.g., Parameter value not equal to 30, or less than or equal to 50)

✓ An Xact can alter (replace) either the Priority Level or the value in a specified integer-type Parameter of the Group member with the minimum value of a specified integer-type Parameter

• In addition to **Xact** Groups, there can also be **numeric** Groups
  (instead of being Groups of Xacts, numeric Groups are simply Groups of integer numbers)

• Only Xact Groups will be discussed here
The five Blocks provided with the Group entity are:

- JOIN
- REMOVE
- EXAMINE
- SCAN
- ALTER

All five of these Blocks apply to Xact Groups

(only JOIN, REMOVE and EXAMINE can be used with numeric Groups)

These Blocks are described in detail and their use is illustrated in a model in this unit

(these Blocks are also described in Chapter 5, "Summary of GPSS/H Blocks," in the GPSS/H Reference Manual)

Groups have one Standard Numerical Attribute. Its class name is G, and its value is the size (number of members) of the indicated Group.

For example, if 7 Xacts are members of the Group named WAITING, then G(WAITING) has a value of 7.

The names of non-empty Groups and the id numbers of Xacts which are members of those Groups are displayed as part of a standard Postsimulation Report

In Test Mode, the **display** command can be used to display Group names and Group member id's:

```
display grp
```
The **JOIN** Block

**Purpose:**
Put the Xact executing the **JOIN** Block into a specified Group

Which Group?

No error occurs if the Xact executing the **JOIN** Block is already a member of the indicated Group

An Xact can be a member of two or more Groups at the same time

Example
**JOIN** INVENTORY
The REMOVE Block in "Remove Me" Mode

Purpose:
If the Xact which executes the REMOVE Block in "Remove Me" Mode is a member of a specified Group, remove it from the Group.

Note that the B, C, D and E Operands are not used by the REMOVE Block in "Remove Me" mode.

Which Group?

Examples

REMOVE INVNTORY

REMOVE READY2GO,,,,NOTREADY

Note
If an Xact belonging to one or more Groups TERMINATEs, it will be removed automatically from those Groups.
The REMOVE Block in "Remove the First 'n' Members" Mode

Purpose:
Remove the first 'n' members from a specified Group

REMOVE Count
(ALL => empty the Group)

Which Group?

The order of removal is FIFO, because Groups are maintained in FIFO order

"The Group was empty in the first place" exit (optional F-Op)

Examples
REMOVE CRITCARE,8
REMOVE STOCK,5,,STOCKOUT
REMOVE CHILDREN,ALL

Note that the C, D and E Operands are not used by the REMOVE Block in "Remove the first 'n' Members" Mode
The REMOVE Block in "Remove Me and/or Remove Someone Else" Mode (Comparison-Based)

Purpose:
Remove up to a specified number of qualified Xacts from a Group

up to how many qualifying members of the Group are to be removed?
(REMOVE Count; ALL => all who are qualified)

Which Group?

The REMOVE Block's C-Op is not used for Xact Groups

use which member attribute in the comparison?
{PR, or integer-type Parameter, e.g. (TESTME)PF}

use which comparison operator?

L \leq E \leq NE \geq G

"none qualified" exit (includes case of empty Group) (optional F-Op)

compare member attribute to what?
e.g., PF(REMOVER), PR (of the REMOVER), 3*FN(NOW)+&CRITICAL

Group members are scanned in FIFO order

The Xact executing the REMOVE Block can but doesn't have to be a member of the Group
# Summary (with Examples)
of the Comparison-Based REMOVE Block

<table>
<thead>
<tr>
<th>Operation</th>
<th>Aux Op</th>
<th>Operand</th>
</tr>
</thead>
<tbody>
<tr>
<td>REMOVE</td>
<td>X</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>L; or LE; or E; or NE; or GE; or G</td>
<td>Group Identifier</td>
<td>REMOVE Count (can be ALL)</td>
</tr>
</tbody>
</table>

**Example 1**
Write a REMOVE Block to remove up to &MAX qualifying Xacts from the Group named WIDGETS.
To qualify for removal, a Groupie's COLOR PF must equal &WANTED.
If no Groupies qualify (or if the Group is empty), the REMOVE-Xact is to transfer nonsequentially to the Block labeled NUNFOUND.

<table>
<thead>
<tr>
<th>REMOVE</th>
<th>E</th>
<th>WIDGETS</th>
<th>&amp;MAX</th>
<th>(COLOR)PF</th>
<th>&amp;WANTED</th>
<th>NUNFOUND</th>
</tr>
</thead>
</table>

**Example 2**
Write a REMOVE Block to remove ALL qualifying Xacts from the Group named CARS.
To qualify for removal, a Groupie's PR must be less than 25.
No matter what the outcome, the REMOVE-Xact is to move sequentially from the REMOVE Block.

<table>
<thead>
<tr>
<th>REMOVE</th>
<th>L</th>
<th>CARS</th>
<th>ALL</th>
<th>PR</th>
<th>25</th>
</tr>
</thead>
</table>

**Example 3**
Write a REMOVE Block to remove ALL qualifying Xacts from the Group named DEFECTS.
To qualify for removal, a Groupie's BAD PF must equal or exceed the REMOVER's MAX PF.
No matter what the outcome, the REMOVE-Xact is to move sequentially from the REMOVE Block.

<table>
<thead>
<tr>
<th>REMOVE</th>
<th>GE</th>
<th>DEFECTS</th>
<th>ALL</th>
<th>(BAD)PF</th>
<th>PF(MAX)</th>
</tr>
</thead>
</table>
The REMOVE Block in "Remove Me and/or Remove Someone Else" Mode (MIN/MAX-Based)

Purpose:
Remove from a Group the (at most one) Xact that has the MINimum or MAXimum value of a specified attribute

use MIN or MAX?

Which Group?

Group members are scanned in FIFO order; ties are resolved on a "first found" basis

The B, C and E Ops are not used in this form of REMOVE Block

Note that the B Op, which specifies the REMOVE Count in the comparison-mode REMOVE Block, cannot be used in the MIN/MAX REMOVE Block (in the MIN/MAX context, the REMOVE Count is understood to be 1)

use which member attribute in the comparison? {PR, or integer-type Parameter, e.g. (TESTME)PF}
Summary (with Examples) of the MIN/MAX-Based REMOVE Block

<table>
<thead>
<tr>
<th>Operation</th>
<th>Aux Op</th>
<th>Operand</th>
</tr>
</thead>
<tbody>
<tr>
<td>REMOVE</td>
<td>X</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>MIN or MAX</td>
<td>Group Identifier</td>
</tr>
</tbody>
</table>

**Example 1**
Write a REMOVE Block to remove from the Group named JOBS the (or, in case of ties, a) Groupie with the MINimum value of DUEDATE PF. If the Group is empty, the REMOVE-Xact is to transfer nonsequentially to the Block labeled NOJOBS.

| REMOVE | MIN     | JOBS    | (DUE DATE) PF | NOJOBS |

**Example 2**
Write a REMOVE Block to remove from the Group named ORDERS the (or, in case of ties, a) Groupie with the MAXimum PR value. The REMOVE-Xact is to move sequentially from the REMOVE Block.

<table>
<thead>
<tr>
<th>REMOVE</th>
<th>MAX</th>
<th>ORDERS</th>
<th>PR</th>
</tr>
</thead>
</table>
The EXAMINE Block

Purpose:
Determine whether the Xact executing the EXAMINE Block is a member of a specified Group

Which Group?

in Xact Mode, the EXAMINE Block's B-Op is not used

EXAMINE

"not-in-Group" exit
(optional C-Op)

(C)

Example
EXAMINE NEWCARS,,OLDCAR

Note that it makes no sense to use the EXAMINE Block in Xact mode unless the optional C-Op is supplied
The SCAN Block in Comparison Mode

Purpose:
Scan a Xact Group for a qualifying member and, if found, optionally copy an attribute from the qualifying member into a Parameter of the SCANning Xact

Group members are scanned in FIFO order; ties are resolved on a "first found" basis

Which Group?

use which member attribute in the comparison?
(PR, or integer-type Parameter, e.g. (TESTME)PF)

A,B,C,D,E

SCAN

(F)

X

put the fetched value into which integer-type Parameter of the SCANning Xact?
(e.g., (MYCOPY)PF)

"none qualified" exit
(Includes case of empty Group)
(optional F-Op)

Use of the D and E Ops is optional; if not used, then no value will be fetched from a qualifying Group member

(In such a case, the purpose of the SCAN is simply to determine if there is a Group member having the indicated qualification)

use which comparison operator?
L
LE
E
NE
GE
G

fetch the value of which member attribute if a match is made?
(PR, or integer-type Parameter, e.g. (COPYME)PF)
## Summary (with Examples) of the Comparison-Based SCAN Block

<table>
<thead>
<tr>
<th>Op'n</th>
<th>Aux Op</th>
<th>Operand</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAN</td>
<td>X</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
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<tr>
<td></td>
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<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
</tr>
</tbody>
</table>

- **Op'n**: SCAN
- **Aux Op**: X
- **Operand**
  - **A**: one of L; LE; E; NE; GE; G
  - **B**: Group Identifier
  - **C**: Group Attribute to Inspect
  - **D**: Group Attribute to Fetch (D/E optional)
  - **E**: Receiving Parameter for Fetched Attribute (D/E optional)
  - **F**: Nonsequential Exit (optional)

### Example 1
Write a SCAN Block to find within the Group named ORDERS the (first, in case of ties) Groupie (if any) whose PR is greater than or equal to the SCANner's PR. If a Groupie qualifies, copy its ORDERNUM PF to the MYCOPY PF of the SCANning Xact. If no Groupie qualifies, the SCANning Xact is to transfer nonsequentially to the Block labeled NUNFOUND.

<table>
<thead>
<tr>
<th>SCAN</th>
<th>GE</th>
<th>ORDERS</th>
<th>PR</th>
<th>PR</th>
<th>(ORDERNUM)PF</th>
<th>(MYCOPY)PF</th>
<th>NUNFOUND</th>
</tr>
</thead>
</table>

### Example 2
Write a SCAN Block to find within the Group named TASKS the (first, in case of ties) Groupie (if any) whose DUEDATE PF is less than 30. If a Groupie qualifies, copy its TASKID PF to the HISTASK PF of the SCANning Xact. Whether or not a Groupie qualifies, the SCANning Xact is to exit the SCAN Block sequentially.

<table>
<thead>
<tr>
<th>SCAN</th>
<th>L</th>
<th>TASKS</th>
<th>(DUEDATE)PF</th>
<th>30</th>
<th>(TASKID)PF</th>
<th>(HISTASK)PF</th>
</tr>
</thead>
</table>
A Technique for Obtaining an Attribute from the First Member of a Group

- Suppose an Xact wants to obtain an attribute from the Xact which is currently the first member of a Group

- Remembering that the Xacts in a Group are SCANNed in FIFO order, this can be done by conditioning the scan on a qualification that the first (or perhaps each) member of the Group is known to satisfy

<table>
<thead>
<tr>
<th>Op'n</th>
<th>Aux Op</th>
<th>Operand</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAN</td>
<td>X</td>
<td>A: one of L; LE; E; NE; GE; G</td>
</tr>
</tbody>
</table>

Example

Each member of the nonempty WORK2DO Group has a PR of 75. Write a SCAN Block to copy the value of the CUSTID PF from the first member of this Group into the TEMP PF of the SCANning Xact.

| SCAN | E | WORK2DO | PR | 75 | (CUSTID)PF | (TEMP)PF |
**The SCAN Block in MIN/MAX Mode**

**Purpose:**
Find the member of a Xact Group having the MINimum or MAXimum value of an attribute, then copy one of this member's attributes into a Parameter of the SCANning Xact.

Which Group?

scan for the MIN or MAX of which member attribute?

{PR, or integer-type Parameter, e.g. (TESTME)PF}

In MIN/MAX mode, the SCAN Block's C-Op is not used

finding MIN or MAX?

put the fetched value into which integer-type Parameter of the SCANning Xact?

(e.g., (MYCOPY)PF)

"empty Group" exit (optional F-Op)

Group members are scanned in FIFO order; ties are resolved on a "first found" basis

fetch the value of which member attribute?

{PR, or integer-type Parameter, e.g. (COPYME)PF}
**Summary (with Examples) of the MIN/MAX SCAN Block**

<table>
<thead>
<tr>
<th>Op'n</th>
<th>Aux Op</th>
<th>Operand</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAN</td>
<td>X</td>
<td>A</td>
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<tr>
<td></td>
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<td>B</td>
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<td>C</td>
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<tr>
<td></td>
<td></td>
<td>D</td>
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<tr>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>MIN or MAX</td>
<td>Group Identifier</td>
<td>Group Attribute to Inspect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not Used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group Attribute to Fetch</td>
</tr>
<tr>
<td></td>
<td>Receiving Parameter for Fetched Attribute</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonsequential Exit (optional)</td>
<td></td>
</tr>
</tbody>
</table>

**Example 1**
Write a SCAN Block to find within the Group named ORDERS the (first) Groupie whose DUEDATE PF is the MINimum.
Copy this Groupie's ORDERNUM PF to the MYCOPY PF of the SCANning Xact.
If the Group is empty, the SCANning Xact is to transfer nonsequentially to the Block labeled NOORDERS.

<table>
<thead>
<tr>
<th>SCAN</th>
<th>MIN</th>
<th>ORDERS</th>
<th>(DUEDATE)PF</th>
<th>(ORDERNUM)PF</th>
<th>(MYCOPY)PF</th>
<th>NOORDERS</th>
</tr>
</thead>
</table>

**Example 2**
Write a SCAN Block to find within the Group named TASKS the (first) Groupie whose PR is the MAXimum.
Copy this Groupie's TASKID PF to the HISTASK PF of the SCANning Xact.
The SCANning Xact is to exit the SCAN Block sequentially.

<table>
<thead>
<tr>
<th>SCAN</th>
<th>MAX</th>
<th>TASKS</th>
<th>PR</th>
<th>(TASKID)PF</th>
<th>(HISTASK)PF</th>
</tr>
</thead>
</table>

G-16
The ALTER Block in "Alter the First 'n' Members" Mode

Purpose:
Alter (replace) the value of a specified attribute of the first 'n' Xacts that are members of a Group

up to how many members of the Group are to have an attribute altered?
(ALTER Count;
ALL => all Group members)

which member attribute is to be altered?
{PR, or integer-type Parameter, e.g. (ALTERME)PF}

what is the new value for the attribute being ALTERed?,
e.g., PF(ALTERER), PR (of alterer),
3*FN(NOW)+V(COUNT)

Group members are altered in FIFO order

Examples
ALTER ORDERS, ALL, PR, &NEWPR
ALTER WORKWAIT, 1, (MYCUST)PF, PF(TEMP)
The ALTER Block in Comparison Mode

Purpose:
Alter (replace) the value of a specified attribute of up to a stated number of qualified Xacts that are members of a Group

up to how many qualifying members of the Group are to be altered?
(ALTER Count; ALL => all who are qualified)

which member attribute is to be altered?
(PR, or integer-type Parameter, e.g. (ALTERME)PF)

what is the new value for the attribute being ALTERed?,
e.g., PF(ALTERER), PR (of alterer), 3*FN(NOW)+V(COUNT)

use which member attribute for comparison in the search for qualifying members?
(PR, or integer-type Parameter, e.g. (TESTME)PF)

Qualifying Group members are altered in FIFO order

Note
If PR is altered and the Group is on the CEC, it will be repositioned on the CEC as last in its (new) Priority Class and the Model's Status Change Flag will be turned on.

use which comparison operator?
L LE E NE GE G

compare member attribute to what?
e.g., &PF(ALTERER), PR (of alterer), 3*FN(NOW)+&CRITICAL
Summary (with Examples) of the Comparison-Based ALTER Block

<table>
<thead>
<tr>
<th>Op'n</th>
<th>Aux Op</th>
<th>Operand</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTER</td>
<td>X</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G</td>
</tr>
</tbody>
</table>

- **A**: Group Identifier
- **B**: ALTER Count
- **C**: Group Attribute to Alter
- **D**: New Value of Altered Attribute
- **E**: Group Attribute to Compare
- **F**: Comparand
- **G**: Nonsequential Exit (optional)

**Example 1**
Write an ALTER Block to assign the value of 5 to the PR of ALL qualifying Groupies in the Group named TASKS.
To qualify, a Groupie's PR must be greater than or equal to 8.
The ALTERing Xact is to exit the ALTER Block sequentially.

```
ALTER  GE  TASKS  ALL  PR  5  PR  8
```

**Example 2**
Write an ALTER Block to assign the value of &NEWDATE to the DUEDATE PF of up to three qualifying Groupies in the Group named ORDERS.
To qualify, a Groupie's DATEIN PF must be less than AC1+200.
If no Groupies qualify, the ALTERing Xact is to transfer nonsequentially to the Block labeled ALTPLAN.

```
ALTER  L  ORDERS  3  (DUEDATE)PF  &NEWDATE  DATEINC1 PF  AC1+200  ALTPLAN
```
The ALTER Block in MIN/MAX Mode

Purpose:
Find the member of a Xact Group having the MINimum or MAXimum value of an attribute, then alter (replace) the value of one of this member's (other) attributes.

Which Group?

ALTER
,C,D,E,,

Which member attribute is to be altered?
(PR, or integer-type Parameter, e.g. (ALTERME)PF)

What is the new value for the attribute being ALTERed?,
e.g., PF(ALTERER),
PR (of alterer),
3*FN(NOW)+&CRITICAL

"empty-Group" exit
(optional G-Op)

finding
MIN
or
MAX?

find the MIN or MAX of which member attribute?
{PR, or integer-type Parameter, e.g. (TESTME)PF}

Group members are scanned in FIFO order; ties are resolved on a "first found" basis

Note
If PR is altered and the Groupie is on the CEC, it will be repositioned on the CEC as last in its (new) Priority Class and the Model's Status Change Flag will be turned on.

Neither the B nor F Ops are used in this form of the ALTER Block
Summary (with Examples) of the MIN/MAX ALTER Block

<table>
<thead>
<tr>
<th>Op'n</th>
<th>Aux Op</th>
<th>Operand</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTER</td>
<td>X</td>
<td>A</td>
</tr>
<tr>
<td>MIN or MAX</td>
<td>Group Identifier</td>
<td>Not Used</td>
</tr>
</tbody>
</table>

**Example 1**
Write an ALTER Block to find the TASKS Groupie with the MINimum ORDENUM PF.
This Groupie is to have the value of FN(ADJUST) assigned to its PR.
The ALTERing Xact is to move sequentially from the ALTER Block.

<table>
<thead>
<tr>
<th>ALTER</th>
<th>MIN</th>
<th>TASKS</th>
<th>PR</th>
<th>FN(ADJUST)</th>
<th>(ORDENUM)PF</th>
</tr>
</thead>
</table>

**Example 2**
Write an ALTER Block to find the ORDERS Groupie with the MAXimum DATEIN PF.
This Groupie is to have the value of &NEWDATE assigned to its DUEDATE PF.
If the Group is empty, the ALTERing Xact is to move nonsequentially to the Block labeled MTGROUP.

<table>
<thead>
<tr>
<th>ALTER</th>
<th>MAX</th>
<th>ORDERS</th>
<th>DUEDATE(PF)</th>
<th>&amp;NEWDATE</th>
<th>(DATEIN)PF</th>
<th>MTGROUP</th>
</tr>
</thead>
</table>

G-2
A First Example for SCAN/ALTER Use

**Problem**
Assign the value of &NEWDATE to the DUEDATE PF of the ORDERS Groupie (or Groupies, in case of ties) having the MINimum PR.

...fetch a copy of the MINimum PR in the ORDERS Group...

```
SCAN MIN ORDERS,PR,,PR,(MINPR)PF
```

...store &NEWDATE into the DUEDATE PF of all Groupies whose PR equals the MINimum...

```
ALTER E ORDERS,ALL,(DUEDATE)PF,&NEWDATE,PR,PF(MINPR)
```
A Second Example for SCAN/ALTER Use

Scenario

Repairpeople are dispatched to customer sites to respond to service calls. If a repairperson is already at a customer’s site when a new service call comes in from another location at that site, the repairperson remains on site to respond to the new call (after finishing ongoing work). The repairperson-Xact is a member of the ONAJOB Group and carries in its PF(CUSTID) the ID number of the customer s/he is servicing, and in its PF(TASKTOT) a count of the number of calls that need to be serviced at that site.

A service-call Xact (the Xact representing the incoming call for service) carries in its CALLERID PF the customer ID for the incoming call.

Assuming there already is a repairperson on site, show how the service-call Xact can add 1 to the PF(TASKTOT) value of the repairperson-Xact.

...fetch the current PF(TASKTOT) value from the qualifying Xact...

SCAN E  ONAJOB,(CUSTID)PF,PF(CALLERID),(TASKTOT)PF,(MYCOPY)PF

...store the incremented task-count back into the qualifying Xact's PF(TASKTOT)...

ALTER E ONAJOB,1,(TASKTOT)PF,PF(MYCOPY)+1,(CUSTID)PF,PF(CALLERID)
Service-Call Dispatching System
(A Modeling Exercise for the Group Entity)

- In a certain organization, a pool of repair people is kept on the payroll to service customer calls for repair and maintenance of equipment bought or leased from the organization
  
  (e.g., Xerox is the organization and Xerox machines are the equipment)

- When a call for service comes in, it is handled in one of three alternative ways:

  ✓ if there is already a repair person at the customer's site, the call is assigned to that person (by adding 1 to that person's task count for that site)

  ✓ else if there already are one or more as-yet unassigned calls from that customer, the number of such unassigned calls is updated (by adding 1 to the corresponding count)

  ✓ otherwise, the call becomes the first as-yet unassigned call from that customer and is queued FIFO for assignment to a repairperson
A dispatcher-Xact monitors the situation continuously (that is, at the end of each Scan Phase) to see if there are one or more idle repairpersons and as-yet unassigned calls from one or more customers; if there are, repairpersons are dispatched to customer sites accordingly (using FIFO service order both for customers and for idle repairpersons)

A flow schematic for the system is shown on the next page

For given data, model the system and measure:

✓ service-call queuing statistics, both by individual customer and overall

(A service call is "in queue" from the time it is received until the time a repairperson starts to service that particular call)

✓ utilization of the repair people, both by individual repairperson and overall

(repairpeople are being utilized whenever they are not sitting at the home base, waiting for a call to be assigned to them)

✓ average, standard deviation, and distribution of the repairperson idle-time random variable

(repairperson idle time is elapsed time between the return of a repairperson to the home base and the next assignment of that person to a customer; note that in some cases idle time may be 0.0)
A Flow Schematic for the Service-Call Dispatching System

- **incoming calls for service**
  - **repairperson at customer's site?**
    - **yes**
      - update the workload for the repairperson currently at the customer's site
    - **no**
      - update the record of as-yet unassigned calls

- **as-yet unassigned calls**
  - dispatcher
  - home base
  - a customer's site
    - travel
    - repair-person cycle
    - travel
    - potential for multiple on-site jobs
Data and Assumptions
for the Service-Call Dispatching System

- There are 25 customers and the cases of 4, 5 or 6 repair people are to be tried

- Each customer is as likely to call for service as any other customer

- There are no distinctions made with respect to the type of service required
  (as a result, there is no need to represent a variety of skill categories among the repair people or a variety of alternative service-time distributions as a function of the type of service required)

- Service-call interarrival times
  (with respect to the entire customer population) are exponentially distributed with an expected value of 60 minutes

- The repair people are identical to one another
  (so there need not be a variety of alternative service-time distributions as a function of the particular repair person carrying out the service)

- Travel time to a customer's site is 20 minutes minimum, plus a normally distributed (mean: 40; standard deviation: 10) time increment, and is independent of the time of day

- The on-site time required to service a call is triangularly distributed with optimistic, most likely, and pessimistic values of 60, 120 and 240 minutes, respectively
Data and Assumptions for the Service-Call Dispatching System (continued)

- The time required to travel from a customer's site back to the office equals the realized time required to travel to the site in the first place, ± 15 minutes (uniformly distributed)

- These additional assumptions are to be made:

  ✓ the repair people are always on duty
    (none ever call in sick, etc.)

  ✓ the repair people never take breaks
    (coffee breaks, lunch breaks, etc.)

  ✓ discontinuities between consecutive
    8-hour workdays can be ignored
    (shift startup; shift winddown)

  ✓ except for the timings given above, the
    system operates in zero time

  e.g.,
  ■ the response to incoming calls is
    instantaneous;

  ■ it takes zero time to let an on-site
    repair person know that an additional
    service call has come in from that site;

  ■ it takes the dispatcher zero time to
    set an idle repair person up with a call;

  ■ the dispatcher knows instantaneously
    when a repair person has just returned
    to the office from a site
************ A Model Illustrating Use of the Group Entity ************
SIMULATE Allocation of Repair People to Service Calls
*
*
Priority Levels in the Model
=================================
*
75: Incoming Calls for Service
*
50: Repair People
*
25: Dispatcher
*
*
Groups in the Model
=====================
*
WORK2DO: Service-call Xacts which are as-yet unassigned
*
WORKWAIT: Worker-Xacts waiting to be assigned to a call
*
ONAJOB: Worker-Xacts who are on a call
(traveling to or working at a customer's site; workers traveling back to home base from a customer's site are not members of a Group)
*
*
User Chains in the Model
========================
*
WORK2DO: Chain of service-call Xacts which are as-yet unassigned
*
WORKWAIT: Chain of worker-Xacts waiting to be assigned to a call
*
*
Base Time Unit: 1 Minute
*

Compiler Directives (EQU, INTEGER; SYN)

**************

...let CALLERID, CUSTID and MYCUST be names
for one and the same Fullword Parameter...
(purpose: to support the use of alternative ways to refer to the customer while at the same time economizing on the number of needed Parameters, thereby saving computer memory {COMMON})

CALLERID EQU 1,PF
CUSTID EQU 1,PF
MYCUST EQU 1,PF

...also let NUMCALLS and WORKLOAD be names
for one and the same Fullword Parameter...
NUMCALLS EQU 2,PF
WORKLOAD EQU 2,PF

IDLE EQU 26,Q IDLE is the identifier for Queue 26
OVERALL EQU 27,Q OVERALL is the identifier for Queue 27

...for purposes of forcing LABELED output, give symbolic names to the dummy Facilities used to track worker utilization...
WORKER1 EQU 1,F
WORKER2 EQU 2,F
WORKER3 EQU 3,F
WORKER4 EQU 4,F
WORKER5 EQU 5,F
WORKER6 EQU 6,F

G-29
...&BUDDIES = 1 less than the number of repairpeople...
INTEGER &BUDDIES

TRUE SYN 1 TRUE is a Synonym for 1

Control Statements (BVARABLE; QTABLE; STORAGE)

...when MATCHUP is true, there is at least one waiting call and
at least one idle worker, so the dispatcher has work to do.
MATCHUP BVARABLE (CH(WORKWAIT)>0)AND(CH(WORK2DO)>0)

...table for distribution of worker idle time...
IDLE TIME QTABLE IDLE, 30, 30, 10

Model Segment 1 (Assigning or Recording of Incoming Calls)

...arrival of calls for service (set Priority at 75)...
GENERATE RVEXPO(2, 60., . . . , 75, 4PF, 2PL

...determine customer id at random...
ASSIGN CALLERID, RN2@25+1, PF

...update the service-calls Queue for this customer...
QUEUE PF(CALLERID)

...update the aggregate service-calls Queue for the system...
QUEUE OVERALL

...check for existing unassigned calls from this customer;
if one or more, fetch the unassigned-call count...
SCAN E WORK2DO, _ scan the WORK2DO Group
(CUSTID) PF, _ Groupie attribute to test
PF(CALLERID), _ compare to current CALLERID
(NUMCALLS) PF, _ copy NUMCALLS from Groupie
(TEMP) PF, _ to PF(TEMP) of the new call
NONE2ANS branch if there are no other
unassigned calls from this cust

...there are other unassigned calls from this customer,
so update this customer's unassigned-call count...
ALTER E WORK2DO, _ scan the WORK2DO Group (again)
() _ only 1 Groupie will qualify
(NUMCALLS) PF, _ alter this attribute
PF(TEMP)+1, _ new value of the attribute
(CUSTID) PF, _ Groupie attribute to test
PF(CALLERID) _ comparand (current CALLERID)

...new call has been taken into account; kill the messenger...
TERMINATE 0
...check for an existing worker at site of new call;
if worker on site, fetch the calls-to-process count...

NONE2ANS SCAN E ONAJOB, \text{scan the ONAJOB worker Group}
(MYCUST)PF, \text{worker attribute to test}
(PF(CALLERID))\text{, compare to current CALLERID}
(WORKLOAD)PF, \text{copy WORKLOAD from the worker}
(TEMP)PF, \text{branch if no worker is there}

...there is a worker at this site, so assign the new
call to this worker (update the worker's WORKLOAD)...  
ALTER E ONAJOB,- \text{scan the ONAJOB Group (again)}
1,- \text{alter an attribute of 1 worker}
(WORKLOAD)PF,- \text{alter this attribute}
(PF(TEMP)+1,- \text{new value of the attribute}
(MYCUST)PF, \text{Groupie attribute to test}
(PF(CALLERID)- \text{comparand (current CALLERID)}

...new call has been taken into account; kill the messenger...
TERMINATE 0

...initialize the number of unassigned calls
from this customer...

NO1THERE ASSIGN NUMCALLS, 1, PF

...join the WORK2DO Group...
JOIN WORK2DO

...go to the back of the WORK2DO User Chain...
LINK WORK2DO,FIFO

when a delayed response to a customer's call or calls
begins, the service-call Xact is routed here

...remove the service-call Xact from the WORK2DO Group...
DONE REMOVE WORK2DO

...the call(s) from this customer is (are) now being assigned;
kill the service-call Xact...
TERMINATE 0
* Model Segment 2 (Model Segment for Workers) *

...create a master worker (set Priority at 50)...
   GENERATE 0,,1,50,4PF,2PL

...split to create &BUDDIES more workers,
   with serial numbering in the Fullword Parameter WORKERID...
   SPLIT &BUDDIES,JOINUP,(WORKERID)PF

...join the Group of workers waiting for work to do...
   JOINUP JOIN WORKWAIT

...take out membership in the IDLE Queue...
   QUEUE IDLE

...wait on a User Chain...
   LINK WORKWAIT,FIFO

...this worker is being assigned to a customer;
   remove the worker from the WORKWAIT Group...
   STARTNEW REMOVE WORKWAIT

...join the group of workers who are doing jobs...
   JOIN ONAJOB

...resign membership from the IDLE Queue...
   DEPART IDLE

...turn on the aggregate worker-utilization tracker...
   ENTER WORKERUT

...turn on the utilization tracker for this worker...
   (use of a dummy Facility for statistical purposes)
   SEIZE PF(WORKERID)

...determine time needed to travel to the customer's site...
   ASSIGN TRAVLTYM,20.0+ABS(RVNORM(3,40.,10.)),PL

...travel to the customer's site...
   ADVANCE PL(TRAVLTYM)

...response to a call from this customer is starting;
   update the service-call Queue for this customer...
   NEXTCALL DEPART PF(MYCUST)

...update the aggregate service-call Queue for the system...
   DEPART OVERALL

...do the repair...
   ADVANCE RVTRI(4,60.,120.,240.)
...repair accomplished; update the count of service calls
this worker still has to do for this customer...
ASSIGN WORKLOAD-,1,PF

...move sequentially if this worker has no more calls
to respond to for this customer; else, branch back to
handle another service call for this customer...
TEST E PF(WORKLOAD),0,NEXTCALL

...remove this worker from the group of
workers currently assigned to a customer...
REMOVE ONAJOB

...travel back to the office...
ADVANCE PL(TRAVALTYM),15

...turn off the aggregate worker-utilization tracker...
LEAVE WORKERUT

...turn off this worker's utilization tracker...
RELEASE PF(WORKERID)

...go join workers waiting to be assigned to a customer...
TRANSFER JOINUP

******************************************************************************
* Model Segment 3 (Dispatcher) ******************************************************************************
*
...create a dispatcher (Priority = 25)...
GENERATE 0,,1,25,4PF,2PL

...wait until there is at least one idle worker
and a call or calls to be assigned...
REPEAT TEST E BV(MATCHUP),TRUE

...OK, there's an idle worker and calls to be assigned...
(the dispatcher now must get both the CUSTID and the
number of calls at that customer's site from the
oldest WORK2DO Xact and transfer this information to
the worker who has been idle the longest)

...get the CUSTID id first...
(the oldest waiting call will satisfy the SCAN criterion,
because Groups are scanned in FIFO order)
SCAN E WORK2DO,_ scan the WORK2DO Group
PR,_ Groupie attribute to test
75,_ comparison value
(CUSTID)PF,_ copy CUSTID from Groupie
(TEMP)PF to PF(TEMP) of the dispatcher

G-33
...now give the CUSTID to the first WORKWAIT worker...
(the first WORKWAIT worker has been idle the longest)
ALTER WORKWAIT,_ scan the WORKWAIT Group
 1, Alternate an attribute of 1 worker
(MYCUST)PF,_ alter this attribute
PF(TEMP) new value of the attribute

...get the NUMCALLS...
(the oldest waiting service-call Xact
will satisfy the SCAN criterion)
SCAN E WORK2DO,_ scan the WORK2DO Group
PR,_ Groupie attribute to test
75, comparison value
(NUMCALLS)PF,_ copy NUMCALLS from Groupie
(TEMP)PF to PF(TEMP) of the dispatcher

...now give the NUMCALLS to the first WORKWAIT worker...
ALTER WORKWAIT,_ scan the WORKWAIT Group
 1, Alternate an attribute of 1 worker
(WORKLOAD)PF,_ alter this attribute
PF(TEMP) new value of the attribute

...now send the WORK2DO Xact to its end...
UNLINK WORK2DO,DONE,1

...route the worker to the start of the work cycle...
UNLINK WORKWAIT,STARTNEW,1

...go wait (if necessary) to make another match...
TRANSFER ,REPEAT

**************************************************************************
* Model Segment 4 (Run-Control Transaction) *
**************************************************************************
* ...bring in an Xact after 10 40-hour work weeks...
  GENERATE 24000,,4PF,2PL
* ...end the Xact-Movement Phase...
  TERMINATE 1
...do one replication for each of three alternative numbers of repairpeople (4, 5, 6)...
DO &BUDDIES=3,5,1

...set the Capacity of the overall utilization Storage...
WORKERUT STORAGE &BUDDIES+1

...establish Initial Positions for RN1 through RN4...
RMULT 100000,200000,300000,400000

...launch the replication...
START 1

...clear for the next replication...
CLEAR

...call for the next number of repairpeople...
ENDDO

...end of Model-File processing...
END
Selected Output for the Case of 4 Repairpeople (Page 1 of 3)

RELATIVE CLOCK: 24000.0000  ABSOLUTE CLOCK: 24000.0000

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### Selected Output for the Case of 4 Repairpeople (Page 2 of 3)

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TRANSACTIONS IN GROUP ONAJOB
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AVERAGE VALUE OF OVERFLOW IS 394.9196

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### Selected Output for the Case of 5 Repairpeople (Page 1 of 1)

#### --AVG-UTIL-DURING--

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Selected Output for the Case of 6 Repairpeople (Page 1 of 1)

**--AVG-UTIL-DURING--**

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**RANDOM STREAM**

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### A Summary of Selected Results

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<td><strong>% of Workers Immediately Dispatched to Another Site</strong></td>
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Adding Realism to the Service-Call System

- Many simplifying assumptions have been made in the preceding description of the service-call system
  (the objective here is to focus on use of the Group entity, without having details that are extraneous for this purpose get in the way)

- What would you suggest be done to make the system (and model) more realistic?

- How much additional modeling effort (time) do you think would be required to include these additional details in the model?

- The purpose of the model presumably is to estimate customer service levels and repair people utilizations as a function of the number of repair people provided in the system; how sensitive do you think these measures would be to the various types of additional details (aspects of realism) you might add to the model?
  (Think and discuss...)

- Suppose it is your responsibility to animate a model of the service-call system; how would you choose to depict the system in terms of such an animation?
  (Think and discuss...)