CHAPTER 9

Resources

Contents

Resources are SIMUL8 objects whose only purpose is to restrict work centers from operating. Examples of work center constraints may include:

- Labor
- Special equipment or tools that are scarce within the system
- Time of day (limited operating hours)
- Space (square feet of floor space)

It may be helpful to think of work centers as machines, and resources as the people required to operate those machines. Machines are typically available 24 hours per day, but are unable to work during those hours when the operator is not present.

For many people, the term 'resources' conjures up the image of a Human Resources department. Accordingly, it is natural to mentally associate SIMUL8's resources with various staff titles and responsibilities. In many models, you can use resources in exactly this way, using them to represent skill sets available within various employee pools. There are many additional uses for resources as well, some of which are non-intuitive tricks that provide additional modeling flexibility.

Resource usage is often closely associated with shift patterns. Shift patterns (page 272) are simply blocks of time within a week when at least one resource will be available. It is helpful to think of shift patterns as belonging to the entire simulation model, just as a corporate Human Resources department supports all departments within a company. All

resources in the model refer to the same set of shift patterns, so be sure to remember that shift patterns are not unique to any one resource.

Why Use Resources?

For an example of the most basic use of resources, consider a simple manufacturing setting in which machines (work centers) are available 24 hours per day. The machines cannot run alone, and require the services of an operator. Unlike machines, though, the operators are not available 24 hours a day. Instead, they are only available during the morning (7 a.m. to 3 p.m.) and evening (3 p.m. to 11 p.m.) shifts. Resources and accompanying shift patterns can be associated with the work centers (machines) to model the operating limitations caused by resource availability.

Resources can also be used to model scarce equipment needed by a work center. For example, a job shop may have five machines (work centers) available for performing a particular step in the manufacturing process, with each machine requiring a specialized and expensive drill bit in order to function. Now, suppose there are only three such drill bits shared across the five work centers. You can model the drill bit as a resource, then mark each work center as requiring the drill bit resource.

Providing access to a corporate intranet is another example of using resources to model scarce, non-staff requirements. Suppose we are interested in modeling a particular corporate work group. In this scenario, imagine that the duties of the group involve multiple tasks, but that all employees need to periodically access a specialized computer program on the corporate intranet. Networked programs are usually licensed in such a way that the number of concurrent network users is limited to a specific number, for our case let's say fifteen. If a sixteenth person tries to access the software, they will be blocked until another employee has logged off. If we are interested in modeling the workflow of the group, we could model the software licenses as resources. Then each work center that involves a task requiring use of the software would have a license resource attached to it. Modeling the license use in this way would properly show the potential limits of workflow throughput that may result from the licensing arrangement.

Whether resources are staff or equipment-based, it is possible for a work center to require more than one of a given resource type, or for that matter, more than one resource type. In order to receive surgery, a patient requires an operating room, a surgeon, several nurses, and an anesthesiologist. Except for the operating room, each of these resources can float from patient to patient. During the surgery, all the required resources are marked as unavailable. As soon as the surgery is complete, the resources are released and are available to go to the next surgery.

Finally, you can also use resources to constrain more than one work center from operating at the same moment. We refer to this resource as a 'token.' When you create a single token resource, you can set each work center in the group to require that token

resource. The first work center to pull in a work item will 'grab' the token, making it no longer available to the other work centers in the group. This prevents the other centers from operating (even if they have a work item waiting for processing) until the first work center completes its work and releases the token. In other words, only one work center in the group can operate at any one time. In this way, token resources pass from one work center to another in order to control the workflow within a model.

Resource Properties

The easiest way to create a new resource is to click on the Resource button on the Build Tools toolbar. Place the resource on the screen in a location that you consider to be the resource's home base and double-click on it to open its Properties dialog (page Figure 9-2). Prior to the introduction of traveling resources in SIMUL8 (page 269), the exact placement of resources on the screen didn't matter. However, if you plan to include time for a resource to travel from its home base to a work center, or from work center to work center, you should carefully consider the location of the home base.

The Resource Objects Dialog

When you want to perform general resource management tasks, you might want to turn to the Resource Objects dialog (Figure 9-2) that is displayed when you choose the Objects/Resources menu option.

Figure 9-1
Manage the resources in your model with the Resource Objects dialog.

The Resource Objects dialog shares its format with the corresponding dialogs for other SIMUL8 object types. You will find a list of all of the resources you've defined so far in the main list area of the dialog. Select any resource in the list and SIMUL8 will highlight its screen position for you by circling it in red. Click on the Properties button to get more detail. You'll also see the Resource Properties dialog (Figure 9-2) when you click on the Add button. SIMUL8 gets you started with default information. Edit the properties to suit your own purposes. If you are no longer using a resource, you can remove it with the Erase button.

Resource Properties Dialog

A resource's basic properties (Figure 9-2) include the resource name and the number available.

Number of This Type of Resource Available

When none of the options are checked (default), the Number of this Type of Resource Available text field sets a constant number of available resources that does not change throughout the simulation, regardless of time of day or day of the week. Token resources often use static numbers.

> The maximum value for the number of resources available is 1000

When you want to set up more complicated availability patterns, you can use the Shift Dependent and Pool Resource options. For more information on using Shift Patterns to better reflect resource availability, please see page 272. We also discuss how to use Pooled Resources to study the effects of cross-training programs beginning on page 276.

Figure 9-2
Define individual resources with the Resource Properties dialog.

Auto Adjust Replicate Levels

If your resource is used by a replicated work center (page 162), you can allow SIMUL8 to automatically update the work center's replicate property so that it is in line with the number of resources currently available. This can help you to avoid the common error of adjusting the number of resources available but failing to provide them a place to work.

> The auto adjust feature only works as you exit the resource properties dialog. Your work center's replication will be set to the greater of its current replication value and the current number of resources available. Don't expect your work center's replication to be updated according to a shift pattern.

Results

As with other Object dialogs, you can easily access a Results dialog (Figure 9-3). From this dialog, you can obtain information about the resource's utilization, create a graph of its utilization over time, and add this information to the Results Summary. Please see page 91 in Automatic Results Collection for more information.
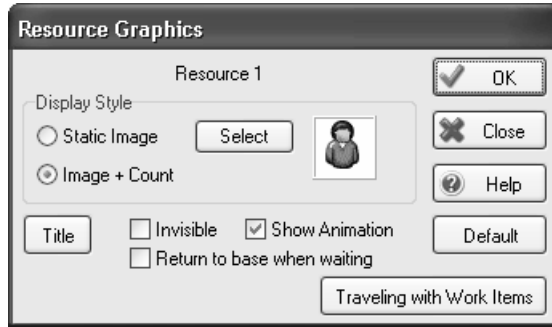
Figure 9-3
The Resource
Results dialog.
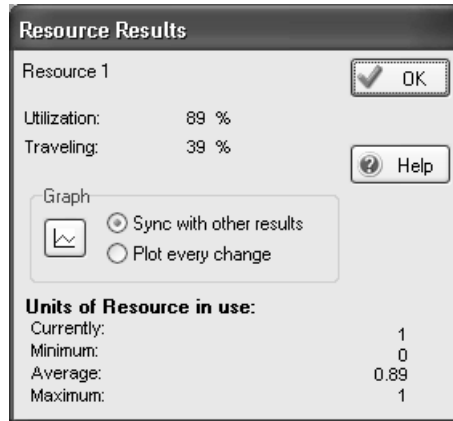
Travel

One of SIMUL8's most notable features is the ability to model traveling resources. This feature requires a more detailed discussion than we want to distract you with right now. We'll come back to this topic on page 269.

Graphics

With the exception of of two specialty checkboxes, a resource's graphics are similar to a work entry point or a work complete object. The Static Image option will simply display the image shown in the dialog (Figure 9-4). The default image is the bust of a person, but you can replace it with your own graphic. The Image + Count option will display the number of resources currently available above the image. The Title button and the Invisible checkbox are the same as the other SIMUL8 objects. For more information, please see the Graphics chapter on page 295.

Show Animation

This checkbox allows you to control a resource's animation. When checked, the resource will appear beside the work center that is using the resource.

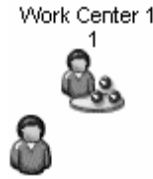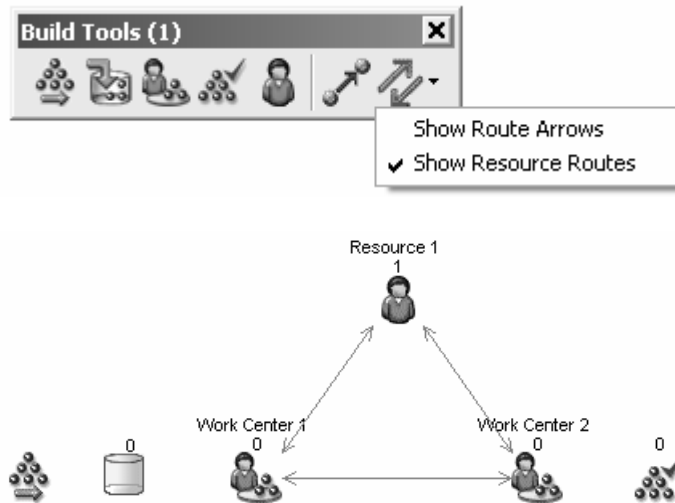**Figure 9-5**
Resource animation.

Figure 9-6 demonstrates the Show Resource Paths toolbar option. Clicking on the down arrow just to the right of the Show Routing Arrows button on the Build Tools (1) toolbar will display this option. When invoked, this option will display resource paths for which a travel time has been defined. In the lower portion of Figure 9-6 you can see that Resource 1 travels to, from, and between Work Center 1 and Work Center 2.

Figure 9-6
Show resource paths.

Traveling with Work Items

The options shown in Figure 9-7 are used to control the animation of the resource if it has been captured and is traveling with a work item. If you do not want to see this animation, disable the checkbox. Use the X and Y offset values to control the location of the resource's image with respect to the work item that captured the resource. Captured resources will be discussed in full on page 266.

Figure 9-7
Options for
displaying a
captured
resource.
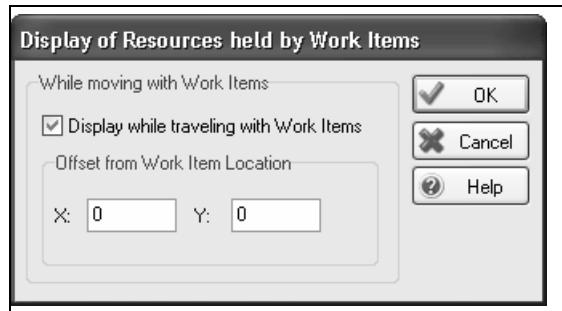
Requiring Resources at a Work Center

Adding a resource to your model will have no effect until you associate it with a work center. To add a resource as a constraint to a work center, open the work center's Properties dialog and click on the Resources button. This opens the dialog box that will allow you to add the necessary resources (Figure 9-8). Click Add to select from a list of model resources. If you haven't defined any resources yet, you can use the Resource Objects dialog to create one. When you'd like to remove a resource, simply highlight it in the Resources Required list and hit the Remove button.

We wish that we could tell you how to identify at a glance which resources are assigned to which work centers. Unfortunately, at the time of this writing, it can't be done. The closest substitute is to use the Find feature, available through the Edit menu. When you choose this option, you'll see the Find Objects dialog. Type in the name of a resource and a Found Objects dialog will list all of the objects that contain any reference to the Resource. See page 469 in the Debugging chapter for more information.
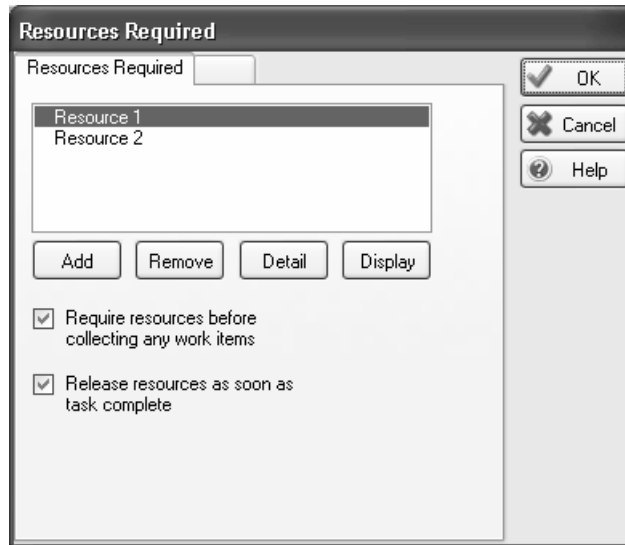
While many applications require only one resource, others require several resources (as in our surgery example). In Figure 9-8, both Resource 1 and Resource 2 are required.

You will also notice two checkboxes on the Resources Required tab. These allow you to fine-tune how the resource requirement will function in your model.

Require Resource Before Collecting any Work Items

The Require Resource Before Collecting any Work Items checkbox prevents the work center from pulling in work items until it has obtained all of the required resources. If you clear the box, the work center can bring in available work items while it waits for the necessary resources to become available. In both cases, the resources are still required before the processing time at the work center begins. No matter how you've set this option, the work center will not enter the busy state until it actually begins work. This option primarily affects the inventory level of the feeding simulation object.

Release Resource as Soon as Task Complete

The Release Resource as Soon as Task Complete checkbox allows the work center to free the resource even if the work center becomes blocked. When cleared, this box forces the resource to stay with the work center until the work item is able to leave.

Beware of clearing this box as it can cause a 'deadly embrace' within the simulation model. This can occur when the feeding work center has both the work item and the resource, but the downstream work center requires the resource before it can collect the work item it needs. The result is that the model becomes jammed in a permanent blocked state.

Resource Detail

The Detail button within the work center's Resource Requirement list provides access to the dialog shown in Figure 9-9.

Figure 9-9
Set the minimum and maximum resource requirements in the resource's Details dialog.

Number Required

The minimum and maximum fields allow you to set a range for the required number of resources, instead of a fixed number. If you do indeed want to use a fixed number, you should make the Min and Max fields equal. For example, setting Min=3 and Max=3 increases the number of resources required to (you guessed it!) 3.

If the value entered for the maximum is greater than the minimum, the work center behaves in a 'greedy' fashion and tries to obtain as many resources (up to the maximum) as are available at the same time that the work center is looking for work items and resources. As long as the work center obtains the minimum number of resources, it will begin work. The processing time will be governed by the distribution entered in the work center's Properties dialog as usual.

If the work center is successful in obtaining more resources, SIMUL8 will assume that any resources beyond the minimum serve to linearly decrease processing time. Let's say

for example that the task normally requires 2 resources, but 4 are obtained. SIMUL8 figures that since there are 4 resources doing the work of 2, the processing time should be 2/4, or 50%, of the normal time. In general, if you've set the minimum number of resources to k, but the work center obtains $n > k$ resources, the processing time will be equal to (k/n) times the amount sampled from the work center's processing time distribution.

Table 9-1 presents the effective processing times that will result in a work center that requires a minimum of 2 resources, but can make use of up to 5. Assume for simplicity that the processing time is fixed at 10 time units.

Table 9-1
Effective processing times in a work center requiring a minimum of 2 and a maximum of 5 resources and a processing time fixed at 10.

Resources Obtained	Process Time Fraction	Process Time Percentage	Effective Process Time
2	2/2	100%	10
3	2/3	67%	6.7
4	2/4	50%	5
5	2/5	40%	4

If you allow SIMUL8 to use additional resources, SIMUL8 will place an asterisk next to the resource's name in the Resources Required dialog. This is intended to serve as a reminder that the resource carries non-standard options, and that you should be aware of the effect it may have on the ultimate processing times for that work center.

Release Resource As

The Release Resource As option provides a powerful mechanism for controlling workflow within a simulation model. At the end of the processing time, when the work center is ready to release the resource, the work center can transform the resource into another resource type. When the resource is transformed, the number available of the source resource is decreased, and the number available of the destination resource is increased. This transformation is permanent, unless another work center transforms the resources back.

Token.s8

Before SIMUL8 expanded the functionality of groups (page 175), we often used this mechanism of transforming resources back and forth as a convenient way to manage the number of work items in a section of a model. In some cases, we still find transforming resources to be preferable to groups for this purpose. You can use whichever method you prefer. Please see the example model *Token.s8* for a demonstration of this trick.

Interrupt Other Work if Necessary

Particularly when using work items with long process times, it may be quite some time before a resource becomes available to other work centers in your model. The Interrupt

Other Work if Necessary option allows for a higher priority work center (161 to pull a resource away from a lower priority work center while it is processing a work item. The work center that is interrupted pauses its work until such time that the resource becomes available once again.

> The resource interruption option can distort the results of the work center that is interrupted. It seems that the duration of time that the resource has been pulled away for is recorded as working time for the work center.

Release Options

Table 9-2 defines the four resource release options for a work center.

Table 9-2
Work center options for releasing resources.

Normal: Require and release resource here	Forces the work center to capture the resource for the duration of the setup time + process time then release the resource when the work is completed.
Require here, but do not release the resource	Forces the work center to capture the resource as normal but the resource will become attached to the work item and travel with the work item until released by a down steam work center.
Only Release the Resource here	Releases previously captured resource.
Display Only (do not affect logic)	Used to graphical purposes only and will not affect the operating logic or timing of a work center.

Capturing Resources.s8

The first three options in Table 9-2 are used to capture a resource and attach it to a work item. This will allow you to easily model situations where an operator will move through a series of operations working on the same work item until it is completed. This will ensure accurate movement of the resources for work center to work center.

> SIMUL8 considers resources fully utilized the entire time in which they are captured. This will include time that the work item travels, waits in a queue, or is in process by both the capturing and releasing work centers.

The forth option, Display Only, allows you to graphically represent a resource beside the work center but will not act as a constraint to the work center and will not affect the work center's logic or results.

Resource Dependent Repair Times

SIMUL8 allows you to assign resources the task of repairing work centers or conveyors. SIMUL8 will ensure that the repair does not begin until the required resources are available. If you wish, you can also use pooled resources for this task. Once the resource starts the repair, the work center or conveyor will retain the resource for the entire duration of the object's stoppage.

It is easy to add a resource requirement to an object's repair task, but you'll have to dig down through a few dialogs. First click the Efficiency button in the object's main Properties dialog box, then click the detailed option button as shown in Figure 9-10. This will reveal several advanced options including the Time to Repair button.

Figure 9-10
Detailed view of a work center's efficiency dialog.

The Time to Repair button leads to a Length of Down Times dialog (Figure 9-11), where you will find the Resources button. Clicking on this button will reveal a simplified resource requirements dialog (Figure 9-12) that is similar to the work center's normal resource requirements dialog.

Figure 9-11
The length of
time that a work
center is down
during a
breakdown can
depend on
resource
availability.

Add as many resources as are required with the Add button. If you require more than one of a particular resource, click on the Detail button. This will produce the same resource details as shown in Figure 9-9.

Figure 9-12
Required
resources to
repair a failed
work center.

Resource Travel Times

In early releases of SIMUL8, resources instantaneously moved from one work center to the next. It was not possible to automatically reflect the travel time commonly consumed by mobile resources. If travel time was an important modeling consideration, the only choices were to approximate by including travel time in the resource's tasks, or to write complicated code. We are happy to report that you can now enter a fixed amount of time for the resource to travel from one object to another.

To enter travel times, click on the Travel button located in the Resource Properties dialog (Figure 9-2). This will display the Resource Travel Times dialog (Figure 9-13) that will allow you to enter a fixed travel time for each possible segment in your model. Choose a From object and a To object from the drop-down lists to define the segment. Then enter the appropriate fixed travel time, remembering to use the time units you've set up for the model. It is up to you to remember to click through every possible object combination that requires resource travel times.

Figure 9-13
Resources can
now take time to
go from one
work center to
another.

When the outbound and return trips are of equal duration, SIMUL8 provides a shortcut in the form of the Same Return button to prevent you from having to enter the trip information twice. For example, Figure 9-13 shows the user entering 3.5 minutes for Resource 1 to travel from WC 1 to WC 2. If you want to enter the same information for the trip from WC 2 to WC 1, simply press the Same Return button while the WC 1 to WC 2 trip is still selected. Note that when you click on this button you will not see anything happen. If the return trip does not have the same duration, you will need to uncheck the Always option and enter each of the legs of the journey individually.

Alternatively, you can enter travel times in the resource's journey time matrix (Figure 9-14) In this example, the matrix indicates that it takes 3 time units for Resource 1 to travel from its home base (Resource 1) to WC 1 and 4 time units to travel from the home base to WC 2. Once at either of the two work centers, the resource will simply shuffle between the two work centers taking 3.5 minutes for a one-way trip. In this case, the time it takes to go from WC 1 to WC 2 is the same amount of time it takes to go from WC 2 to WC 1.

Figure 9-14
Resource
journey time
matrix

Resource 1 Journey Time Matrix (Time units)				
Time From\To	Resource 1	wc 1	wc 2	
Resource 1		3	4	
wc 1			3.5	
wc 2		3.5		

Uncheck the Show Animation option if you want to graphically prevent the resource from running around your model. This will not affect the mathematics of the travel time. Note that this checkbox is the same checkbox that appears in the Resource Graphics dialog (Figure 9-4).

Instead of using the matrix you can also have the travel time proportional to your screen layout. Using the Update non-zero times when work center moves checkbox, will recalculate the travel time as you move the work center objects within the simulation window. To set the relative speed of the resource, enter the rate of speed (distance per time unit) in the unique speed field.

When using resource travel times, keep the following points in mind:

- Resources start out the simulation at home base but will not return after they are called upon by a work center for the first time. This includes shift changes.

- Once a resource has completed its task at a work center, it will remain at the work center (for travel purposes only) until called upon again by the same or different work center. A resource will not begin its journey to the next work center until the work center calls upon the resource.

- The same travel times apply whether the resource is traveling to repair a work center or to process work items.

- When it comes to traveling, resources have no forward thinking ability. It is quite possible that your resources will run around the model very inefficiently. In fact, you may even see your resources switching places in a model, losing valuable production time traveling. Be aware of this possibility if you use the travel time feature, especially when interpreting results.

Influences on Results

*Traveling
Resources.s8*

SIMUL8 categorizes resource travel time as utilized time. Therefore, your resources could potentially run around the model very inefficiently but appear highly utilized. Currently, SIMUL8 also classifies this travel time as working time for the destination work center. You'll need to be cautious to account for these facts in your interpretation of results.
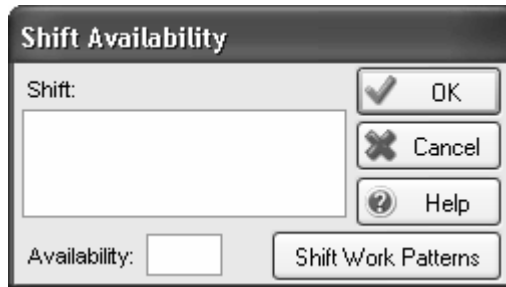
Shift Patterns

Sometimes, the basic assumption of a constant number of resources just isn't enough and more complicated patterns of availability are required. You could set up these patterns yourself by tracking the clock and using Visual Logic commands to change resource levels at appropriate intervals. Better yet, you could use SIMUL8's shift patterns to do the work for you.

It is important to keep in mind that the shift patterns you define are available for use by all of the resources in the model. Furthermore, these shifts can be overlapping. In our initial surgery example (page 258), the hospital as a whole could have several standard shifts available. Perhaps all members of the professional staff (physicians and nurses) work in 12-hour shifts, either a day shift that runs from 7 a.m. to 7 p.m. or a night shift that runs from 7 p.m. to 7 a.m. On each of these shifts, a certain number of physicians, surgeons, residents, and nurses may be scheduled. Each of these resource types uses the same shift patterns, but each is free to have its own independent level during any given shift, including zero.

Let's say that we now want to add a shift for hospital administration. Unlike the professional staff, the administration works a more standard 8-hour plus lunch workday of 8 a.m. to 5 p.m. We can simply add this additional shift pattern for administrators. Even though the start and stop times for the administrative shift overlap the professional shift times, SIMUL8 has no trouble keeping track. It is up to the modeler to specify zero levels for each of the professional workers during the administrative shift and similarly to specify zero levels for administrators during the professional shifts.

You can add shift dependence to your model by double-clicking on the resource of your choice to open its Properties dialog. Check the Shift Dependent checkbox and a second dialog box will open, called Shift Availability (Figure 9-15).

Figure 9-15
Use the
Resources
dialog to add
shift dependence
to your model.

To add a shift pattern, click on the Shift Work Patterns button. A Shift Patterns dialog box will appear (Figure 9-16). This dialog displays all previously defined shift patterns and allows you to add (New) or delete (Erase) patterns, as well as modify the properties of existing patterns.

Figure 9-16
Use the Shift
Work Pattern
button to add,
delete, or modify
a shift pattern.
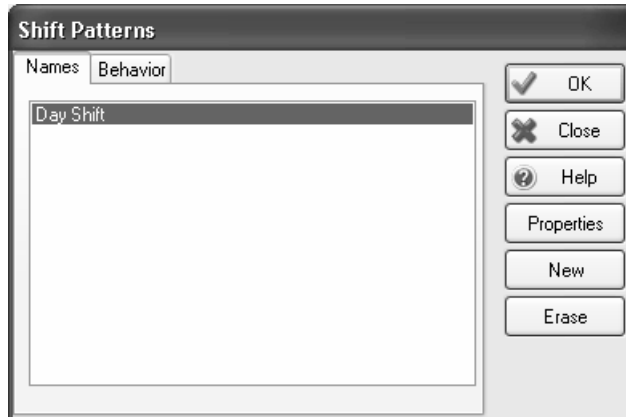
When you add a new shift pattern, SIMUL8 opens a Shift Details dialog (Figure 9-17) and suggests a name for your new addition. You can change the name to anything you'd like. To define the duration of the shift, edit the Start Time and End Time fields.

Next, consider the daily pattern of your shift. If you want your shift to run every day of the week, click on the Every Day button. If, on the other hand, you want your shift to run only on selected days of the week, click on the Weekly Pattern button. Doing so enables the day-of-week checkboxes to the right. Simply clear the boxes corresponding to any day of the week that you *don't* want your pattern to run.

SIMUL8 requires the shift pattern to have the same start and end time on each day of the week that it is in operation. If you have a more complicated pattern that has start and stop times differing by day of the week, you can model this by using a combination of separate shift patterns. In recent years, for example, nonstandard workweeks have become more common. Under one such schedule, employees work four 9-hour (plus lunch) days on Monday through Thursday, plus a half-day on Fridays. You can model this schedule by constructing one shift pattern that runs from 8 a.m. to 6 p.m. Monday through Thursday, and a second shift pattern that runs from 8 a.m. to 12 p.m. on Fridays only.

Returning to the Shift Patterns dialog, you will see a tab for shift behaviors. The Behavior tab (Figure 9-18) governs the way that all shift patterns behave. In most models, you will want to use the default options, but there are of course times when you may want to reconsider how these options are set.

Figure 9-18
Control a
resource's
behavior in the
Shift Patterns
dialog.
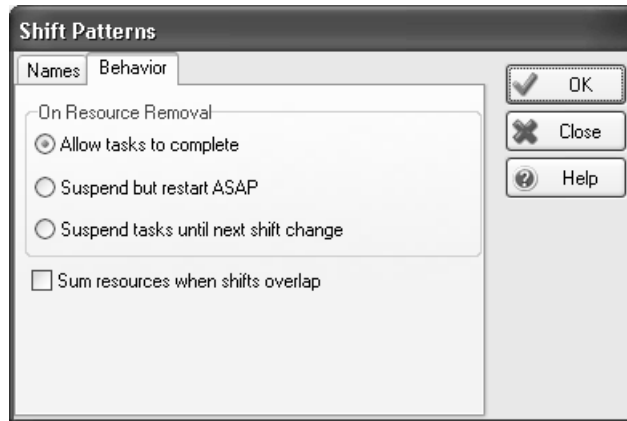
On Resource Removal

The first group of behavior options allows you to define how resources behave when a shift ends and resources are removed. In many real life situations, a resource will not abruptly stop service on the item it is currently helping, even if it is the end of the workday. Instead, the resource stays overtime long enough to complete that last task. For example, if a bank teller accepts a new customer ten minutes prior to the end of his shift, then finds that the customer's needs take twenty minutes to resolve, the teller will continue to service the customer even after the end of the shift time has passed. This is the default option in SIMUL8, set by clicking on the Allow Tasks to Complete radio button.

The second two options in the On Resource Removal group involve suspending the work immediately upon removing the resource. In the first case, Suspend but Restart ASAP, the work is immediately suspended, but SIMUL8 continues to look for new resources that may become available from another source. The last option, Suspend Tasks Until Next Shift Change, causes SIMUL8 to wait until a formal shift change occurs before it attempts to look for a replacement resource.

Sum Resources

The final behavior option tells SIMUL8 what it should do in the case of overlapping shift patterns. Recall that in our hospital example (page 272), we had overlapping shift patterns, but set the resource levels so that they were not used in overlapping shifts. There are times, usually in the presence of very complicated shift patterns, that your model will involve overlapping patterns, each of which contains non-zero levels of the same resource type. In this case, SIMUL8 needs instructions on what the level of that resource should be during the overlapped time period.

By default, SIMUL8 clears the Sum Resources When Shifts Overlap checkbox. This means that if SIMUL8 encounters this situation, it will look at each of the overlapping

patterns and set the resource level to the maximum level found across them. If the box is checked, SIMUL8 will instead sum up the resource levels found in each shift. Each version of this option is commonly used, and is largely dependent on the modeler's personal preference. It is simply up to the modeler to make sure that resource levels have been set among shifts with this particular preference setting in mind.

Shift Availability

Once you define all of the shifts and set the global shift behaviors, you can now define how many of each particular resource is available during the defined shifts in the Shift Availability dialog (Figure 9-19).

Figure 9-19
Simply select the appropriate shift, and type in the number in the Availability textbox.
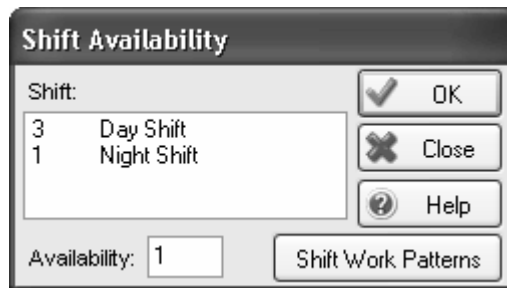
An important note when dealing with shift patterns: When you are using shift patterns in a model, we have found it best to set the simulation time units in terms of minutes. We also strongly recommend that you set the simulation clock to run for 24 hours, 7 days a week.

Using shift patterns in conjunction with limited simulation time (less than 24 hour days) can easily lead to error and confusion if you inadvertently create a shift pattern that falls outside of the daily clock running time.

Resource Pools

Resource pools provide the ability to substitute one resource for another in a work center's requirements, providing an "or" capability. Pools can be particularly effective in modeling cross-training.

If you want to create a pooled resource, there must be more than one resource defined within the simulation. A pooled resource is defined solely from a list of previously created resources, and does not directly use shift patterns or availability numbers itself. To create a pooled resource, select the Resource button on the main menu and create a new resource.

Figure 9-20
Create a pooled
resource based
on previously
created
resources.
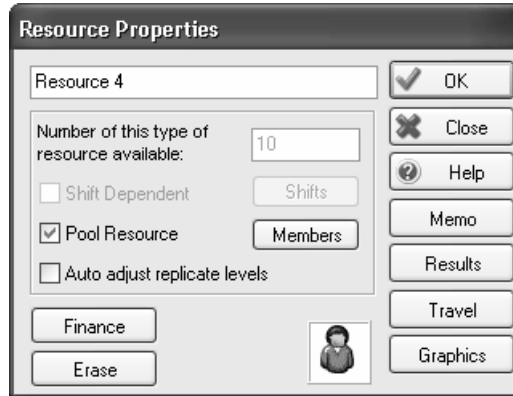
Within the Resource Details dialog box (Figure 9-20), selecting the Pooled Resources
checkbox will open the dialog shown in Figure 9-21.

Figure 9-21
Add or remove
resources from
the pool using
the Members
button.
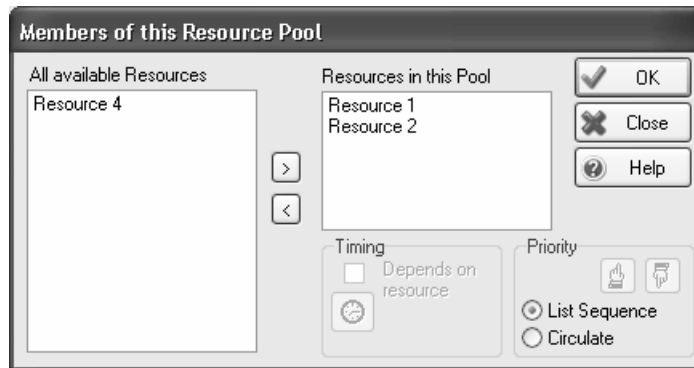
The Members of this Resource Pool dialog lists all of the resources in the simulation on
the left. You can add members to the pool by selecting a resource in the left-hand list and
clicking on the > button to put the resource in the Resources in this Pool list.

As you are building your pool, be sure to keep in mind that SIMUL8 considers this an
ordered list. If you'd like to change the order of your list, you can use the up and down
icons in the lower right-hand corner of the Members of this Resource Pool dialog.

There are two priority options to govern how SIMUL8 calls upon the resources in the
pool. You'll find these options in the bottom right-hand corner of Figure 9-21. The first
option, List Sequence, forces the resource selection to use a simple priority search. Each
time the pool attempts to fulfill a request, it will first try to select the resource that is first
in the list. If more than one resource is required, it will select as many as are available,
then progress down the list. This is the default option.

The second option, Circulate, will attempt to rotate the selection between all members of
the pool. In this case, SIMUL8 will remember the last resource that was selected from the

pool. The next time SIMUL8 draws from the pool, it will begin trying at the next resource in the list. Depending on the random availability of resources, the circulate option may or may not actually smooth the demand across the available resources.

We recommend that you spend a few minutes trying these options in your model to determine which option will work best for your specific situation. For example, suppose that the work center that is calling on the pool requires five resources from the pool. Now suppose that four of Resource 2 are available and four of Resource 1 are available. When the first resource request comes to the pool, the five resources will be made up of four of Resource 2 and one of Resource 1. Since Resource 1 was the last resource selected, the next time the pool is called upon, SIMUL8 will first try Resource 2. If this continues, the assignment from the pool will always be four of Resource 2 and one of Resource 1. This is contrary to what one might expect from the term Circulate.

Timing for Resource

As we've all witnessed on occasion, the processing time for a particular task may vary greatly depending upon who performs it. Let's say, for example, that you are using a pooled resource to resolve a technical support issue. If your pool consists of both expert and novice employees, it is reasonable to expect that the experts are likely to solve the issue faster than a novice. In other words, the processing time at the tech support work center should depend upon which of the pooled resource members it obtains.

You can ask SIMUL8 to allow the processing time to vary depending upon the resource obtained for the task. Set this up using the Timing for Resource option at the bottom of the Members of this Pool dialog (Figure 9-22). You can enter either a named distribution for each resource, or a fixed value delay factor. If the Use Fixed Value as a Delay Factor is unchecked, the processing time contained in the distribution replaces the distribution specified by the work center that is referencing the resource pool.

Figure 9-22
Use the Timing for Resource option to alter the processing time of a work center.

In order to check the box, the distribution must be set to fixed. If this is the case, the specified fixed value is multiplied by the sampled processing time contained in the work center. Therefore, a value of 2.0 doubles the work center's processing time and a value of 0.5 will halve the processing time if you select the particular resource from the pool.

While the Timing for Resource option is very convenient, you should use it with caution if your pooled resource is associated with multiple work centers. The Timing for Resource information is associated with each resource in the pool, and will therefore overwrite the timing information contained in every work center using that pool.

Learning Curve.s8

Advanced users may prefer to set up Visual Logic to change processing times according to the resource obtained. This is the option that we generally choose as it provides more flexibility and control. In addition, we find that setting up our own code allows us to keep better track of the required data, especially when dealing with large or complex models. Please see *Learning Curve.s8* for an example.

Sample Models

Table 9-3
Sample models-Resources.

Resource.s8

Change the order of the resource pool members as defined in the Shippers Resource Pool. How does the model change?

Token.s8

This model shows how to transform one resource into another to control the number of items within a system.

Traveling Resources.s8

Traveling resources are useful in understanding the vast amounts of time lost due to resources running back and forth between work centers.

Capturing Resources.s8

Capturing resources can be easily used to model resources that move through a series of operations with a work item.

Learning Curve.s8

The Learning Curve model looks at the effects of hiring, training, and attrition on the production output. Note that this resource sample model requires simple Visual Logic.

Resource Process Time.s8

It is a simple procedure to identify which resource was selected from a pool, and adjust a work center's process time accordingly. Please note this model also requires simple Visual Logic.

Test Your Understanding

Create a small model of an automobile garage with five bays for car maintenance. The garage opens at 8:00 a.m. and will continue accepting customers until 4:00 p.m. At this time, they will no longer accept new vehicles, but the staff will continue working until all vehicles are completed before leaving for the day.

Model the arrival and acceptance of vehicles with a work center drawing directly from a work entry point that is set to Unlimited Arrivals. Attach a shift dependent resource to control the ability for the work center to process items and set the process time of the work center to an average of 3.75 minutes. This time represents the interarrival time of vehicles.

Vehicles remain outside until one of the five bays becomes available. At this time, the vehicle is parked in an empty bay until the proper mechanic(s) are available to begin working on the vehicle. Once completed, a mechanic or an assistant removes the vehicle from the garage freeing the bay for the next vehicle. An assistant usually does this task but a mechanic could cover for the assistant if they are unavailable. The time required to park and remove vehicles is distributed according to a normal distribution with an average of 2 minutes and a Standard Deviation of 0.25 minutes.

Different mechanics are required in each bay before work can begin:

Table 9-4
Set the resources required based on the information in this table.

Bay #	Resource	Process Time
Bay 1	Mechanic	Average (10)
Bay 2	Mechanic	Average (10)
Bay 3	Assistant	Exponential (10)
Bay 4	Assistant	Exponential (10)
Bay 5	Assistant and Mechanic	Log Normal (10)

Three assistants and two mechanics all start work when the garage opens at 8:00 a.m. and take a 45-minute lunch hour at noon. Although the garage closes and does not accept new customers after 4:00 p.m., the assistants and the mechanics will work overtime to ensure all vehicles are serviced the same day they arrive. The basic flow of the model should resemble the following diagram. Set the clock format to minutes following a 24-hour day. Collect results for seven days with no Warm-up Period as the day starts and ends with no vehicles.

Figure 9-23
Test your
understanding of
resources.
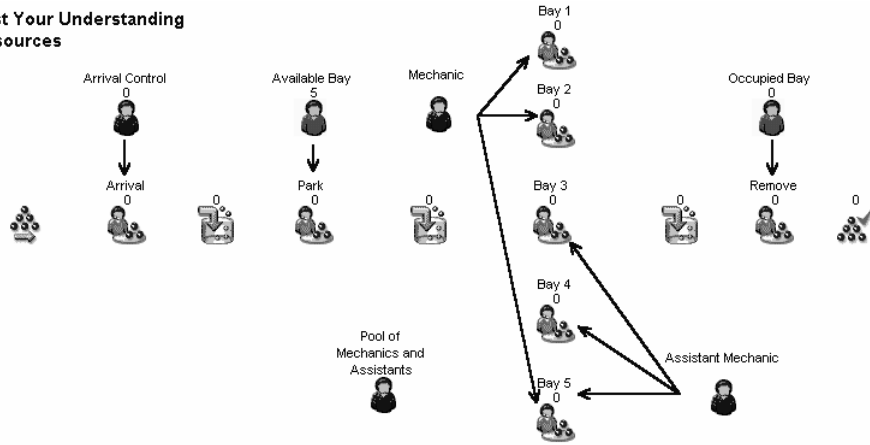
*Resource
Assignment.s8*

Q40.   Within 30 minutes, what is the earliest time the mechanics and assistants can
plan on leaving and be assured that no one was left waiting over night? Run the
simulation 5 times using different random numbers

Q41.   What is the maximum time in the system for the vehicles?

Q42.   What percentage of time do the mechanics spend parking cars?

Q43.   What is the overall utilization of the assistants and the mechanics?

Q44.   Verify that five were indeed the maximum number of vehicles in the garage.

Q45.   Enter the following Travel times for the mechanics and the assistants. How does
this affect the results of your model?

From\To	Park Cars	Remove Cars	Bays 1, 2, 3, 4, 5
Park Cars	-	0	3 min.
Remove Cars	0	-	1.5 min.
Bays 1, 2, 3, 4, 5	2 min.	0.5 min.	0 min.