Center for Edge Power   Center for Edge Power Publications

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POW-ER Documentation (for POW-ER 2.0 with 3.4 extensions)

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Courtesy of the Center for Edge Power
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C H A P T E R 1

Your first POW-ER Project

Your Story: Soulful Food Company is planning to automate their falafel making process. Your reputation as an organizational design consultant has reached their ears and their management team has decided to hire you as a consultant to help them setup their falafel making facility as quickly as possible. They have sent you the following brief and asked you to prepare for a design session. You decide to take a stab at an initial model that you can use as a basis for your forthcoming design session.

The Falafel Manufacturing Plant (FMP) needs to install the following machines:

Fava Bean Dispenser (takes 4 days to install)

Bean soaking machine (takes 7 days to install)

Bean skinning machine (takes 4 days to install)

Bean grinding machine (takes 3 days to install)

Sesame injection machine (takes 2 days to install)

Deep frying machine (takes 4 days to install)

Pita Stuffing Machine (takes 3 days to install)

The soaking, skinning, grinding and sesame injection machines all need to be installed in sequence.

The people involved:

Dispenser Contractor
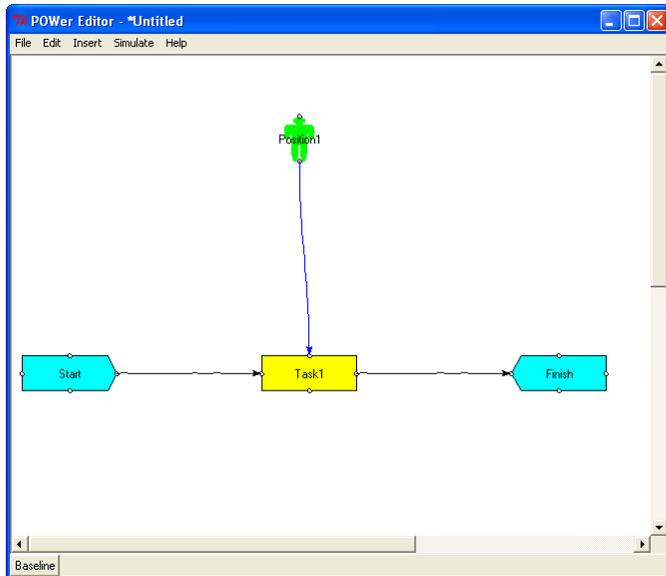Installs Fava Bean Dispenser

General Machine Contractor
Installs Soaking, Skinning, Grinding and Sesame Injection Machines

Frying and Stuffing Machine Contractor
Installs the frying and stuffing machines

The First Task

When Power is launched, it starts with a default single-task project with a Start and Finish element and a position assigned to the task, as shown in the figure below.

The project has a single task, identified here as "Task1." Double click on Task1 to popup the Property Panel for this task. Let's begin by defining a single project task, "Install Fava Bean Dispenser."

Enter the following values:

Task	**Install Fava Bean Dispenser**
	Name of the task.
Effort	**4 days**
	Your belief about the duration of this task, given a typical (medium) level of the required skill (specified in Required Skill)
Effort Type	**Work-volume**
	The "work volume" is the number of FTE days taken by an individual or a subteam to complete the task if they get it right the first time. We shall go with work-volume for all our examples.

> **A Full Time Equivalent (FTE):** One person dedicated full time to a task. An FTE is assumed to work 8 hours a day. When positions are created, their availability is expressed in terms of FTEs, which may be fractional. e.g. A Project Manager manages two projects equally while also getting some admin work done, so her FTE on a single project might be 0.45.

Work-duration is the amount of work required for a task, irrespective of the number of FTEs assigned to it. In other words, even if 10 people are assigned to a task, they'll take the same amount of time as 1 person. Work duration is another way of deducing work volume.

$$\frac{\text{Work Volume}}{\text{Number of FTEs}} = \text{Work Duration}$$

Max-duration is the total amount of work on the task which cannot be exceeded. For example, a contractor on a time-critical contract is hired for two weeks to perform a task. After two weeks, irrespective of whether the task is complete or the contractor's had the time to work on it, the work on the task stops.

Required Skill	**Generic**
	The primary area of expertise needed to perform this task. The default skill is "Generic," indicating that the task requires only those abilities possessed by the average worker. You could also select a specific skill if it has been defined. In our case, we haven't defined any skills yet, so we shall go with the default option.
Learning-Days	**0**
	The amount of days it takes to learn this work.
Priority	**Medium**
	If the person assigned to this task has another task that conflicts, which will have precedence? If one task is to have precedence over another, we would select high for the former and medium or low for the latter. For now, select medium as we only have one task.

Leave the other fields with their default values for now. We shall now proceed to add other tasks.

Multiple Tasks
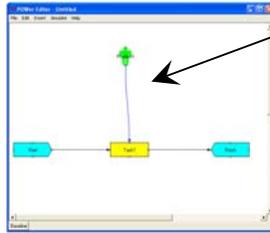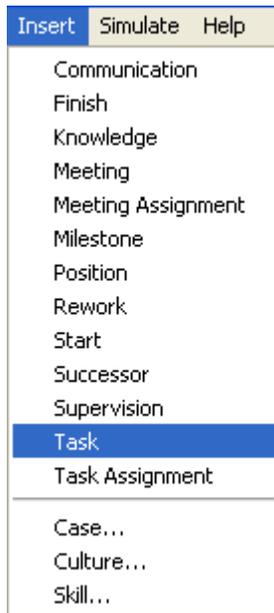
Model Canvas

This is where you can create and edit your model.

On the Insert menu, select Task. The cursor should change to a diamond. Click in the model canvas to drop a task in. Double click the task and add the duration for each task as follows:

| Name of Task	Work Volume
Install Soaking Machine	7 days
Install Skinning Machine	4 days
Install Grinding Machine	3 days
Install Sesame Injection Machine	1 day
Install Deep Frying Machine	4 days
Install Pita Stuffing Machine	3 days

All the other fields contain the same values as the first task.

Adding Successor Links

We shall model the tasks sequentially. Select the option Insert->Successor, click on the right edge of "Install Fava Bean Dispenser" and drag the mouse over to the left edge of "Install Soaking Machine." Proceed to create successor links as follows:

Make sure the "Start" milestone connects to "Install Fava Bean Dispenser" task. The last task, "Install Pita Stuffing Machine" must feed into the "Finish" milestone.
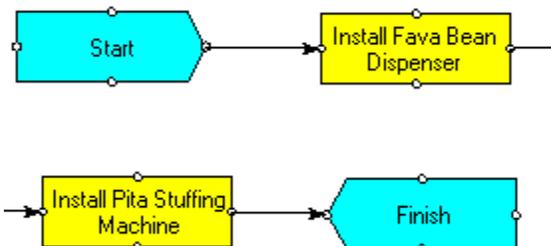
Modeling the Organization

We shall now try to model the organization involved in executing the project. We do this by creating positions that are responsible for tasks and staffing them with FTEs.


A position represents an individual or a team of people. They can be assigned a role within the project, which determines how decisions are made. We shall henceforth refer to a position as an actor. The three roles that an actor can take are Subteam (st), Subteam Lead(sl) or Project Manager (pm). We shall use the default subteam role for all the actors in our model.

Click on the default position (the green person icon) and change its title to "Dispenser Contractor" and leave it's FTE as 1.0.
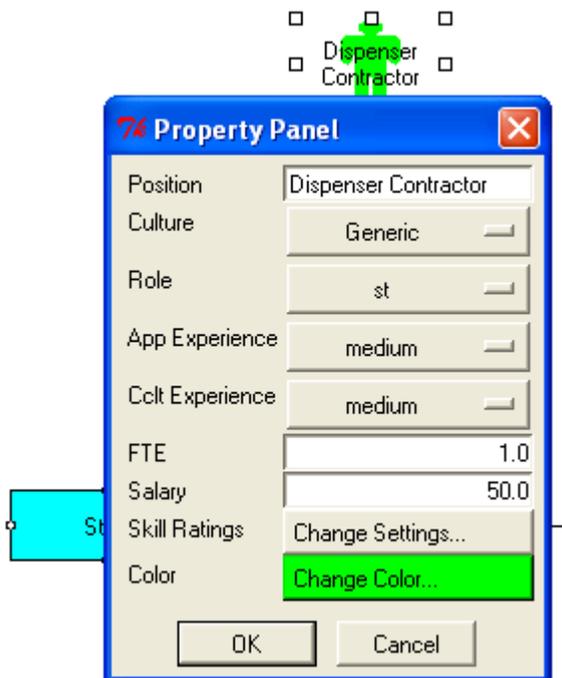
Create two more positions from the Insert menu (Insert->Position). Label them "General Machine Contractor" and "Frying and Stuffing Machine Contractor."

The "General Machine Contractor" position will have "Task Assignment" links to "Install Soaking Machine," "Install Skinning Machine," "Install Grinding Machine" and "Install Sesame Injection Machine." You can create these links from the Insert Menu (Insert->Task Assignment). Click on the position and drag it to the task being assigned.
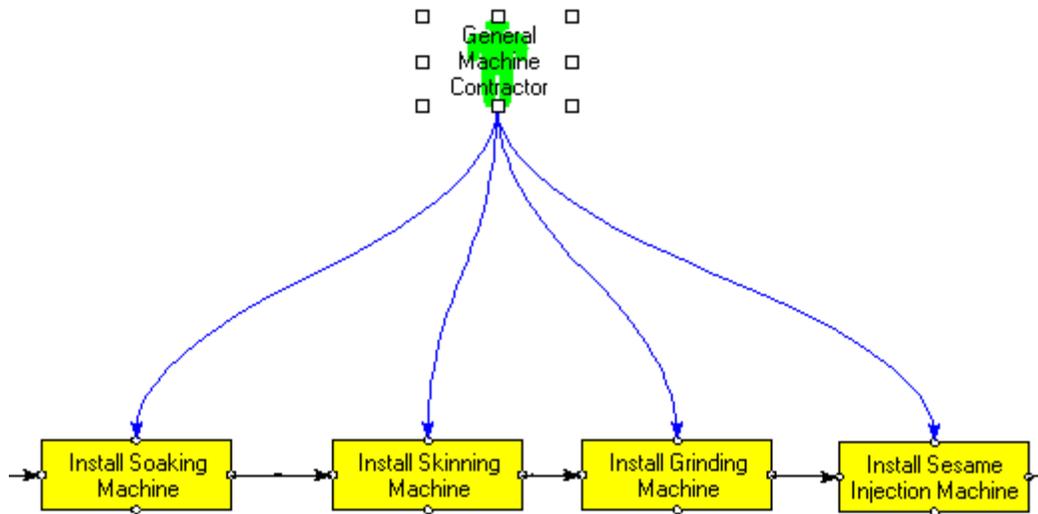
Similarly, assign "Install Deep Frying Machine" and "Install Pita Stuffing Machine" to the "Frying and Stuffing Machine Contractor."
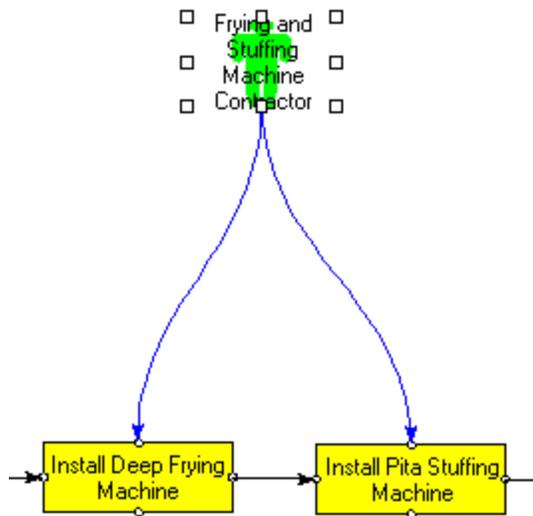
Organizational Configuration

Double-click on the model canvas and a "Property Panel" box will popup for the entire project. This lets you define the characteristics of the project organization.

Change the Project Title to "Falafel Manufacturing Plant" and leave all the other attributes at their default values.

Note that the work-day is set at 480 minutes (60 minutes x 8 hours). The work-week is set at 2400 hours (480 x 5 days). You can vary these numbers to customize the model to your environment. Note that when you increase the work day or work week, you will also need to account for worker fatigue. In a later chapter, we will demonstrate this by modifying error rates in the project. For now, we will go with the default values.

We are now ready to simulate this model.

Simulate the Model

We shall now run the simulation from the menu option Simulate -> Simulate Case. This opens up the following Gantt chart.
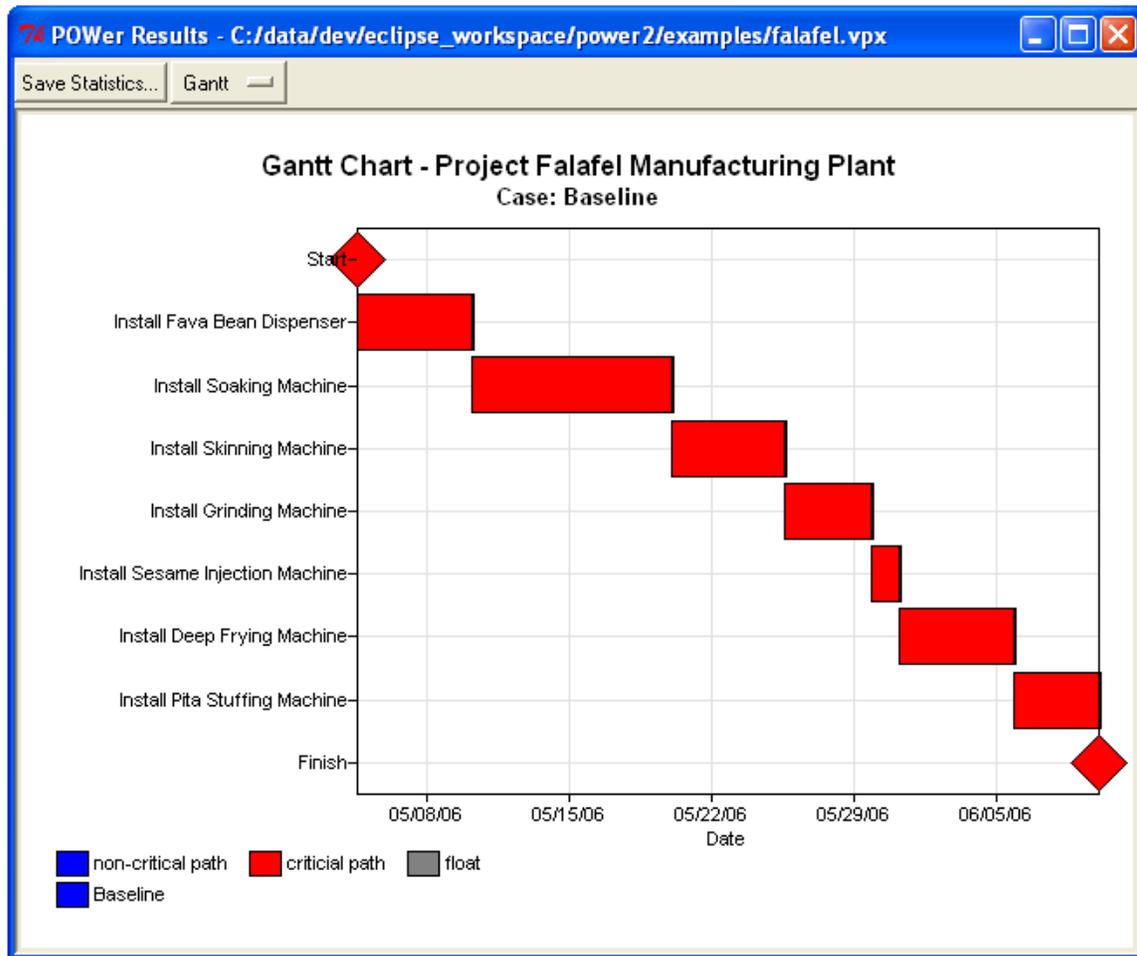
As this project has been modeled with tasks in sequence, every task is on the longest or "critical path" and hence colored red. The end date is indicated to be around the 9th of June, if the project has begun on the 4th of May. You can change the start date through Edit->Case Properties in the model canvas window.

Create a new Case

We can treat the model just created as a baseline and build on it. Select Insert->Case and use the name "parallel." We will try to parallelize the tasks to explore the outcomes for alternative work process or organization configurations. Add successor links from Start to "Install Soaking Machine" and "Install Deep Frying Machine" in addition to the existing link to "Install Fava Bean Dispenser." Also, add successor links from "Install Sesame Injection Machine" and "Install Fava Bean Dispenser" to Finish in addition to the one from "Install Pita Stuffing Machine." Your new work process should look like the one below. Simulate this case.
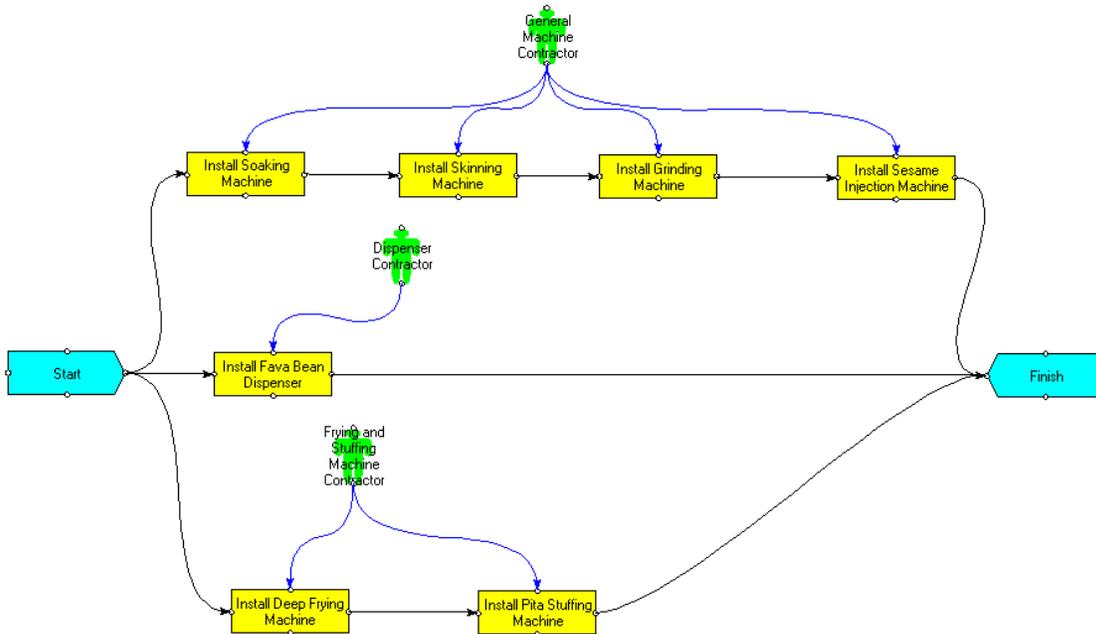
The results have two colors in them, as shown below.
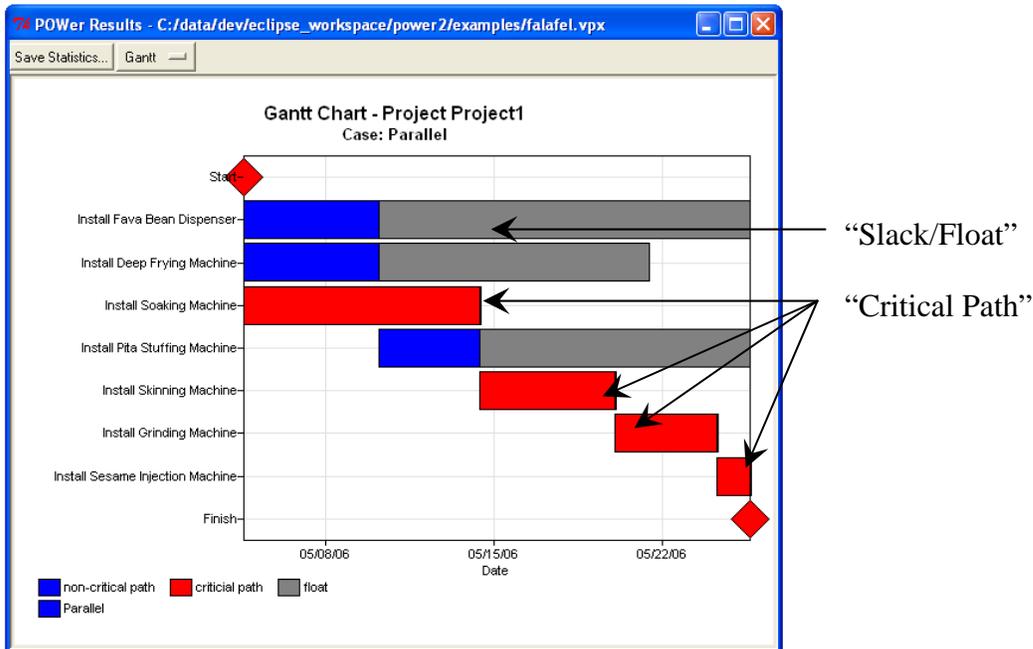
Blue indicates that a task is not on the critical path. Note that the blue bar turns grey after a point. This indicates "slack" or the amount of delay this task can absorb without delaying the entire project. In the field of construction management, "slack" is also termed "float."

The results show that a parallel work process is likely to finish by the 25th of May, if it began on the 4th of May. In other words, the project takes 21 days to complete in the parallel organization as opposed to 36 days in the sequential mode.

Comparing two cases

A powerful feature of Power is the ability to compare multiple cases. We will try to compare how the parallel organization compares to the sequential one. Select Simulate->Simulate All. You can also use Simulate->Simulate Some to pick the cases you're interested in.
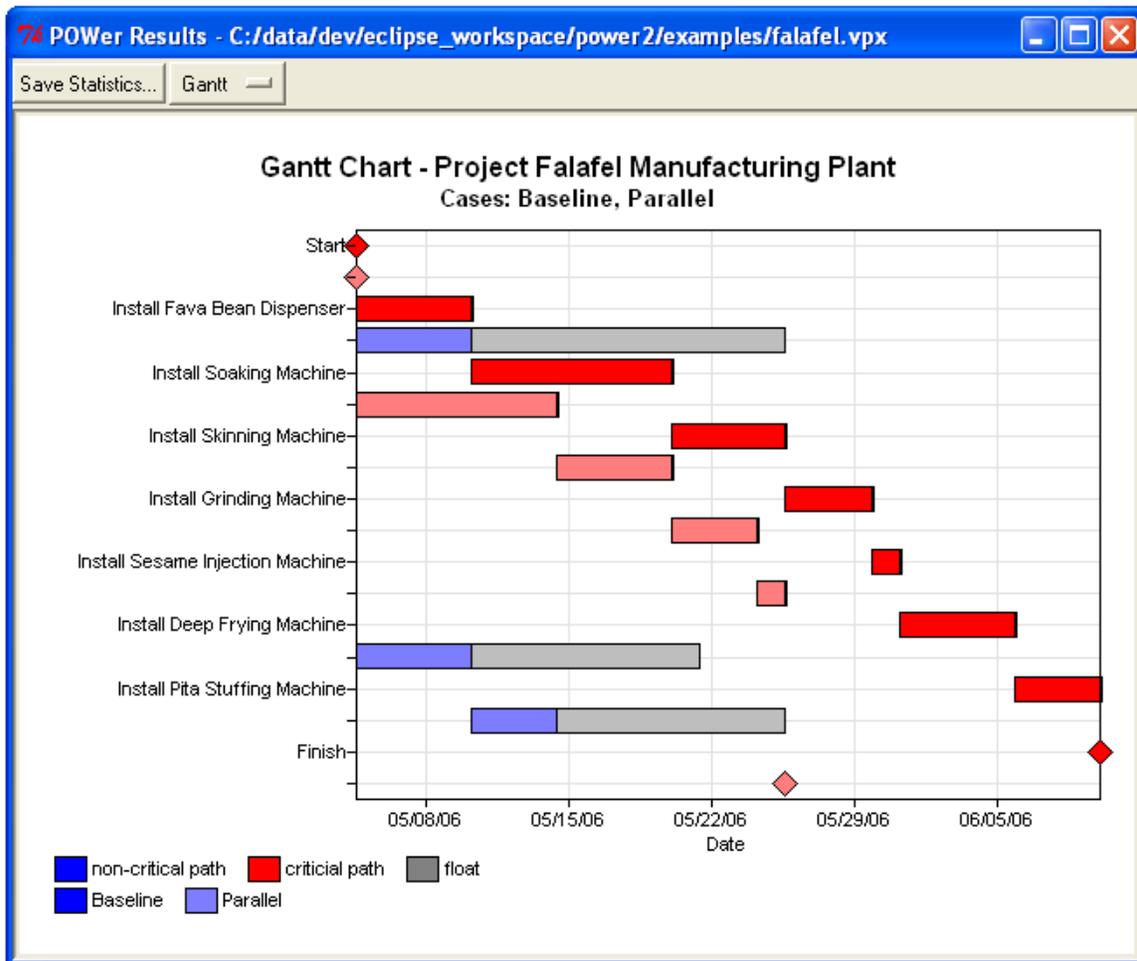
This graph clearly shows which tasks have been taken off the critical path – they are the tasks that have changed from red to blue.

Digging Deeper

The simulation results give us more information than just the Gantt charts.
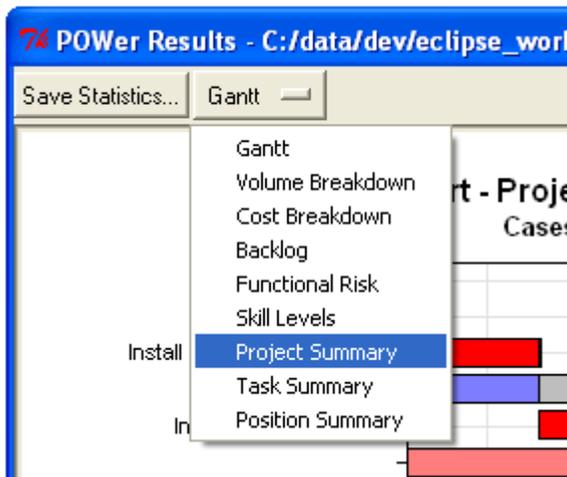
You don't need to calculate the number of days each case will take. You can look this up in the Project summary. We will look at the distinction between CPM and Simulated Duration in a later chapter.

The Task Summary is also interesting for this example.

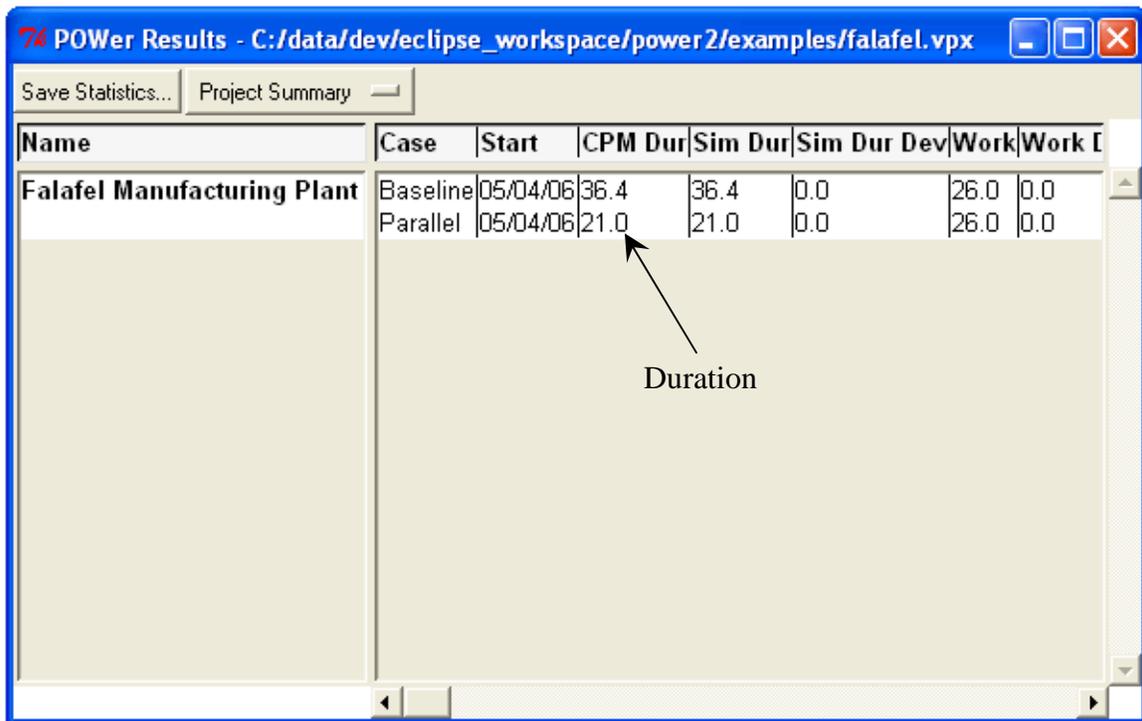| Name	Case	CPM Start	CPM Dur	Sim Start	Sim Dur	Sim Dur Dev
Install Deep Frying Machine	Baseline	05/31/06	5.6	05/31/06	5.6	0.0	
	Parallel	05/04/06	5.6	05/04/06	5.6	0.0	
Install Fava Bean Dispenser	Baseline	05/04/06	5.6	05/04/06	5.6	0.0	
	Parallel	05/04/06	5.6	05/04/06	5.6	0.0	
Install Grinding Machine	Baseline	05/25/06	4.2	05/25/06	4.2	0.0	
	Parallel	05/20/06	4.2	05/20/06	4.2	0.0	
Install Pita Stuffing Machine	Baseline	06/06/06	4.2	06/06/06	4.2	0.0	
	Parallel	05/10/06	4.2	05/10/06	4.2	0.0	
Install Sesame Injection Machine	Baseline	05/30/06	1.4	05/30/06	1.4	0.0	
	Parallel	05/24/06	1.4	05/24/06	1.4	0.0	
Install Skinning Machine	Baseline	05/20/06	5.6	05/20/06	5.6	0.0	
	Parallel	05/14/06	5.6	05/14/06	5.6	0.0	
Install Soaking Machine	Baseline	05/10/06	9.8	05/10/06	9.8	0.0	
	Parallel	05/04/06	9.8	05/04/06	9.8	0.0	

From the table above, it is clear that there is no inherent change in the tasks themselves (as we haven't modeled any uncertainty yet). The benefit comes primarily from ordering the tasks differently. If it is valid to assume that the three contractors can work in parallel, that would be better than having them work in sequence.

Name	Case	FTE	Work	Rework	Coord	Wait	Total Work	Total W
Dispenser Contractor	Baseline	1.0	4.0	0.0	0.0	0.0	4.0	0.0
	Parallel	1.0	4.0	0.0	0.0	0.0	4.0	0.0
Frying and Stuffing Machine Contractor	Baseline	1.0	7.0	0.0	0.0	0.0	7.0	0.0
	Parallel	1.0	7.0	0.0	0.0	0.0	7.0	0.0
General Machine Contractor	Baseline	1.0	15.0	0.0	0.0	0.0	15.0	0.0
	Parallel	1.0	15.0	0.0	0.0	0.0	15.0	0.0

The position summary above tells us how many days each contractor will take. In this example, it is the same for both the baseline and the parallel case.

C H A P T E R 2

Integration, Communication, Rework

It is Friday, 10:15 AM and you have just finished presenting the two models you prepared in the previous chapter. The CEO of Soulful Foods and the three contractors have nodded their heads and agreed with your parallel representation of the work process. As you pause for questions, the General Machine Contractor (GMC) is the first to raise her hand.

GMC: I like your model very much. It makes the visualization very easy. However, I think it is too simplistic to be useful.
You: Why do you think so?
GMC: Well, at the end of our parallel progress, we need to integrate to produce one working system.

You realize that this is a good opportunity to do some real-time modeling as your laptop is connected to a projector. You can get feedback immediately and make some quick progress. You decide to seize the opportunity.

You: Alright, let's model this in real-time. Who will be performing the integration? How long will it take?

GMC: I will, as I am installing the most number of machines, it is best that I handle this task. It is important to note that the integration involves communication across the other three machine installation tasks. It can easily take 3 weeks.

You: Would you then say that there are three separate integration tasks, one for each of the other machines, and they all take five days (3 weeks = 15 working days = 5 days x 3 tasks)?

GMC: Yes, that would be a good characterization.

As all eyes turn to the screen, you proceed to model the integration tasks.

Enter the model canvas and drop three new tasks into the Parallel case. The tasks are titled, "Integrate Fava Bean Dispenser," "Integrate Pita Stuffing Machine" and "Integrate Deep Frying Machine." Take successor arrows from "Install Sesame Injection Machine" into the three integration tasks, and corresponding successor links from the integration tasks to the Finish Milestone. **This implies that the GMC will not begin integrating until she is done installing all of her four machines.** Leave the number of days at the default (5 days).

Reconnect the successor links from "Install Fava Bean Dispenser" and "Install Pita Stuffing Machine" to their respective integration tasks (instead of the "Finish" milestone). Finally, add a new successor link from "Install Deep Frying Machine" to "Integrate Deep Frying Machine." Finally, assign the General Machine contractor to each of the integration tasks. When you're done, you should see a model like the one on the following page.

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*You proceed to run this case and find that it takes 42 days to complete this project (look under the **Sim Dur** field in Project Summary). The **CPM Duration** is 28 days.*

Simulated Duration
This is the time taken with the hidden work factored in.

CPM Duration
This is the time taken without any hidden work.

CEO: Can you help me understand why the simulated duration is 42 days as opposed to 28 days?

You: There could be many reasons, but I think we'll find the answer to this one in the Backlog chart. *(You switch to the backlog chart)* As you can see, the GMC's backlog will be as high as 11 days. It will come down eventually, but the current organization of the work makes him the bottleneck as he has to do the bulk of the integration on his own. We can cross-check this from the fact that integration activity begins around 5/25/06 *(you show the task summary at this point)*, and the spike in the GMC's backlog starts from that date. It is primarily because the three integration tasks are taken in parallel, and there is only one person doing it, so it is as if they were in sequence.

As the contractors nod to indicate their satisfaction, you decide to go deeper.

You: It is time to talk about rework. Rework is the percentage of work you will have to redo due to errors. Based on your experience, how much rework did you have to do on similar projects in the past?

The Contractors confer amongst each other

GMC: This kind of a project typically involves 25% rework.
You: Let's talk about the rework involved in integration. Do you think the integration tasks have higher than average, same or lower than average rework involved? By average, I mean 25% rework, the number that you just gave me.

GMC: That's easy. In my experience, the integration tasks usually have higher than average rework.

You: Alright, let's proceed to model this.
You create a new case called "Adding Comm. Links"(Insert->Case)

Project Exception Probability

This is a measure of belief on the part of the stakeholders based on past experience about problems (or exceptions) that can come up while work in this project is executed. For instance, a project exception probability of 0.25 indicates a 1-in-4 chance that there will be an interface problem between two tasks. We shall call this an **exception**.

An exception causes rework in the task being performed. The amount of time taken to complete the rework depends on the skill level of the "actor" who is on the job.

Double-click anywhere on the model canvas to bring up the Project Properties dialog, and you should find Project Exception Probability in it. Enter 0.25, based on the conversation you had with the GMC.

Solution Complexity

As the project exception probability is an average measure of belief, it can suffer from the flaw of averages. There might be specific tasks that cause higher-than-normal exceptions (or lower-than-normal exceptions). These can be specified by setting the solution complexity of the task to high (or low). The default mode assumes a 20% increase in exceptions for high and a 20% decrease in exceptions for low. In other words, if we thought there was a 1-in-4 chance of project exceptions occurring, then setting the integration of the deep frying machine to high would indicate a belief that this task would have a 3-in-10 chance (0.25 x 120/100 = 0.3) of project exceptions. The amount of increase (20%) can be altered in the behavior file, which is an advanced topic to be covered later.

Double-click the integration tasks and set the Solution complexities to high.

The above two parameters will not take effect until rework links are added. Rework links help you identify task interfaces along which rework can happen and their effect on other tasks. We shall get to them after we are done with Communication Links.

You now proceed to add communication links in between the other three machines and their corresponding integrations tasks as the GMC will be communicating with the other contractors on these tasks.

Communication Links

They imply a design or implementation dependency but not necessarily a direct interface. A communication link between two tasks indicates that the people assigned to them will need to talk to each other.

To add a communication link, select Insert->Communication and click on the task, "Install Fava Bean Dispenser." Without releasing your mouse, drag to connect to "Integrate Fava Bean Dispenser." The communication links show up in **green**. In general, we suggest a convention of connecting the bottom edges of the two tasks that involve communication. After you're done, your model should look like the image shown below.
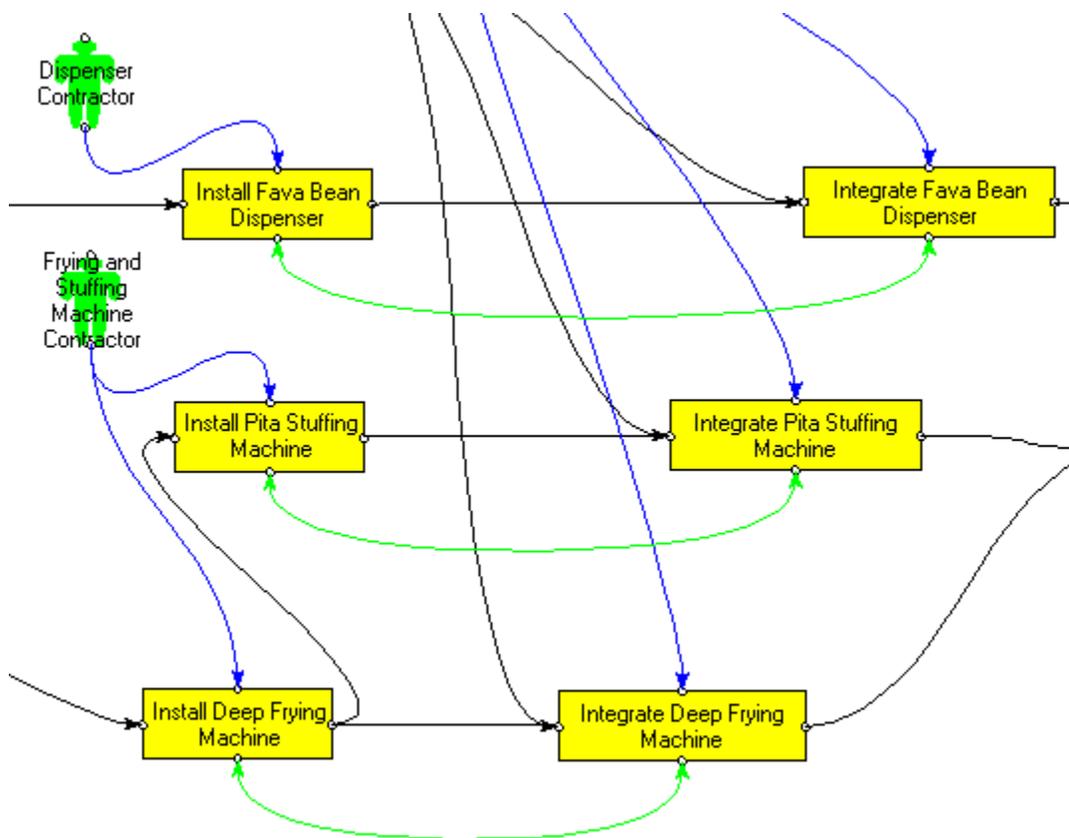
You: Now that we have represented the integration tasks, we need to understand the rework it causes in the corresponding installation tasks when problems arise. What is the amount of rework in days that 1 day of rework in "Integrate Fava Bean Dispenser" can cause to the "Install Fava Bean Dispenser" task?

The GMC and the Dispenser Contractor(DC) confer.

DC: As the interconnections from the dispenser are fairly complex, I'd say 2 days of rework.

You: What about the other two tasks, "Install Deep Frying Machine" and "Install Pita Stuffing Machine?"

The GMC and the Frying and Stuffing Machine Contractor (FSMC) confer.

FSMC: I think they'd take 2 days and 1 day respectively.

You now proceed to add rework links. But first, you create a case called Adding Rework Links.

Rework Links

They help you identify the flow of exceptions from the primary task to the secondary task. Rework links are therefore unidirectional.

To add a rework link, select Insert->Rework and click on the primary task, "Integrate Fava Bean Dispenser." Without releasing your mouse, drag to connect to the secondary task, "Install Fava Bean Dispenser." The rework links show up in **red**. In general, we suggest a convention of connecting the top edges of the two tasks that involve rework. After you're done, your model should look like the image shown below.
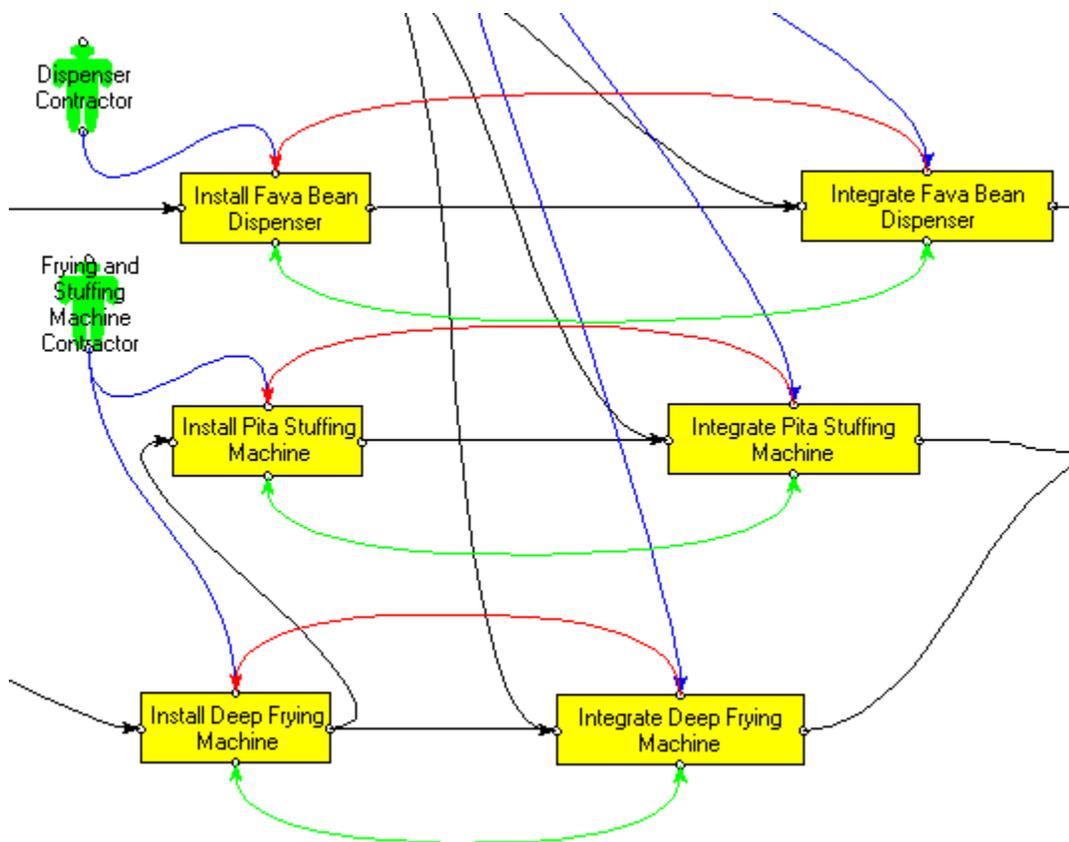
Rework Strength

A rework link has a default strength of 1.0. This implies that 1 day of rework in the source task will cause 1 day of rework in the target task.

Double-click each link and fill in its corresponding rework

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strength values:
Fava Bean Dispenser (Integrate->Install): 2
Deep Frying Machine (Integrate -> Install): 2
Pita Stuffing Machine (Integrate -> Install): 1

> **Note:** Communication links have no effect on the simulation without rework links. However, once rework links exist, communication links add "communication overhead" to the rework. As a test, you can try creating a case with just rework links, a second case with both rework and communication, and a third with only communication links and simulate all cases to compare the project end dates.
> Revised note: this statement appears to be incorrect.

Everyone is on the edge of their seats to see the result of the simulation. You run the model and find that the project now has a"Simulation Duration" of 46 days. It turns out that the contractors' belief about the rework has added 4 days to the project. In order to explain the results better, you proceed to show the volume breakdown.

Task Volume Breakdown Chart - Project Project1
Case: Rework Links
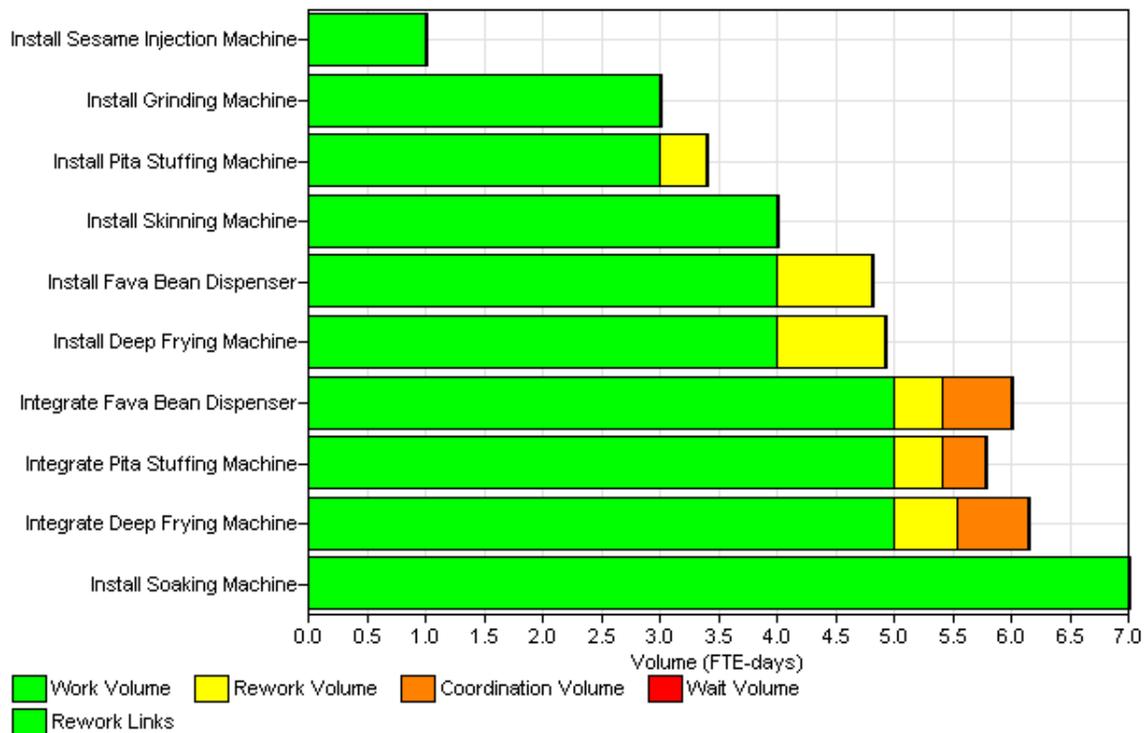
You: As you can see from the Volume Breakdown chart, the yellow box shows the rework volume in each task. Rework in the integration tasks have cascaded into the three installation tasks they were associated with and increased their total duration. Co-ordination volume has also increased the total duration of the integration tasks.

GMC: It looks like I'll be doing an awful lot of work.
You: Let's get a better picture of your backlog.

You switch over to the Position Backlog chart.

Position Backlog Chart - Project Project1
Case: Rework Links
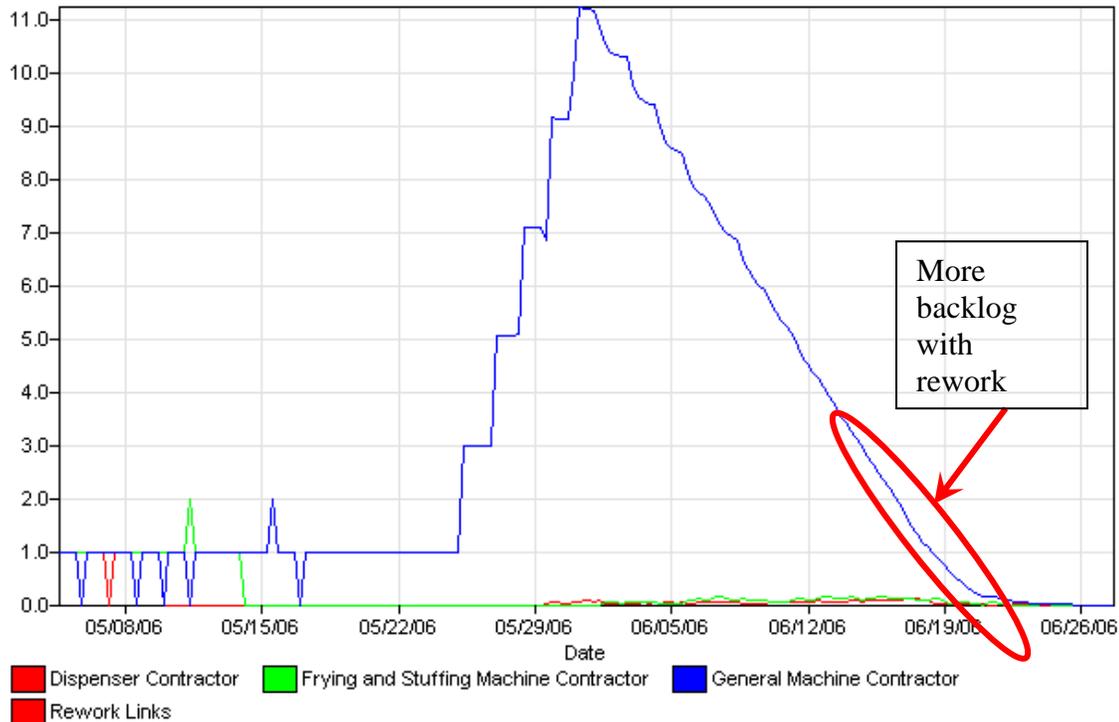
You: We find from this graph that the General Machine Contractor will be backlogged by almost 11 days toward the beginning of June. That backlog will fall by the middle of June. The other two contractors do not have a significant backlog – it stays at zero except for the first two weeks of the project, when it develops to at most two days. This is quite similar to the earlier backlog picture we saw before adding rework, except for the fact that backlog now continues a week longer as the project end date has moved from 06/15 to 06/26.

CEO: These findings are most interesting and are helping us understand the implication of our beliefs. Can you help us test ways of reducing the project duration from 46 days? The National Falafel Tasting Competition begins in 35 days and they have given us a major order that we must fulfill. We need to get our plant operational in 30 days so we can produce enough falafels for this event.

All participants in the meeting look at you expectantly, hoping you can do some magic to make this happen. You will need to use your organizational intuition to come up with interventions that could help reduce the time taken to complete this project.

CHAPTER 3

Designing Interventions

You decide to use "Adding Rework Links" as the base case from which you will test interventions. In other words, every time you try a new intervention, you will first select "Adding Rework Link" and then select Insert->Case.

You: Let's start at the most obvious place – staffing the General Contractor's position. The data suggests that the work in this position is more than what one person can handle. Let's try staffing more people here.

You create a new case titled, "Adding more FTEs," and increase the number of FTEs in the General Contractor position to 2.
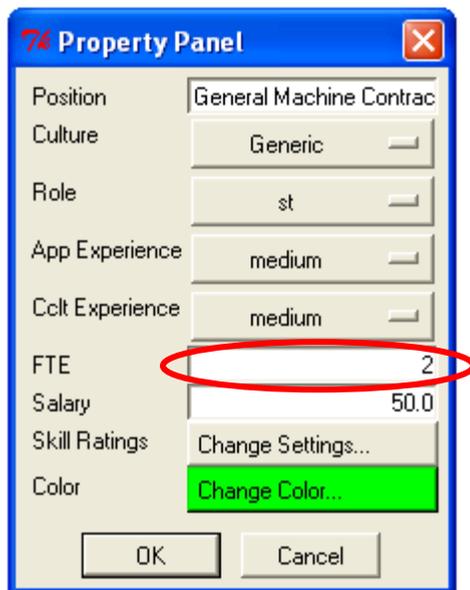
You proceed to run the simulation(Run All) so you can compare the results.

Name	Case	Start	CPM Dur	Sim Dur
Falafel Manufacturing Plant	Baseline	05/04/06	36.4	36.4
	Parallel	05/04/06	28.0	42.0
	Add Rework	05/04/06	28.0	45.7542708333
	Add Comm	05/04/06	28.0	46.0260416667
	Add more FTEs	05/04/06	14.0	22.5956481481

You: We find that adding more FTEs drops the duration of the project to 22.5 days.
GMC: Can you help me understand this result? Does that mean two people who work exactly like me will take this amount of time?

You: Yes.

GMC: But that assumption is not valid. If we have another person working in this position, it will have to be a subcontractor who won't have the same level of experience and will report to me.

You: Let's model that. If you decide to subcontract part of the work, what can you tell me about the subcontractor's expertise?

GMC: He is very well-trained and has a lot of expertise in the field.

You: Has he built falafel manufacturing units before?

GMC: Well no, but we've worked together in the past integrating pizza manufacturing machines.

You: Would it be fair to say that he has a lot of technical experience but this application is new to him?

GMC: Yes.

You: And does that apply to you as well?

GMC: Yes – this is the first time I am doing a falafel manufacturing system.

The Dispenser Contractor (DC) and the Frying and Stuffing Machine Contractor (FSMC) chime in.

DC: It's the first time for me as well. I've handled coffee bean dispensing machines before but this is a new application area for me.

FSMC: Me too. I have made stuffing machines for lentils into burritos in the past, but this is the first time I am doing falafels into pita.

You: This alters our state of information. I will set the application experience to low and run the simulation again.

You delete the case you created, and go back to the previous one – "Adding Comm Links." Here, you select "low" in the App Experience field for all three positions and run the simulation.
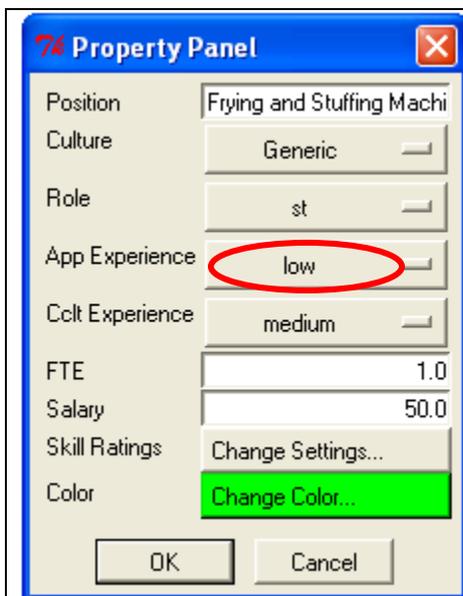
<table>
<tr>
<td>

</td>
<td>

The Application Experience describes the experience of a person filling a position (also termed **actor**) in the application area. An actor can be very skilled for the activity, and yet lack experience working on the specific application type.

In our example, the contractors are skilled and have installed similar machines before. However, none of them have experience with the application area and this is an innovative type of project.

This usually implies a higher rate of exceptions that will need to be handled.

</td>
</tr>
</table>

You: The duration has now gone up to 65.5 days, up by almost 20 days from our last estimate of 46 days. This is a more realistic representation of the ground situation. It is time to add a subcontractor position.

GMC: I think we can bring this down by having a subcontractor do the soaking and skinning machines.

You decide against expressing your intuition and instead opt for a participatory dialogue approach by showing the effects of the suggestion. You create a new case called "Add Subcontractor." You then drop a position, label it accordingly and assign it to the first two GMC tasks, "Install Soaking Machine" and "Install Skinning Machine." You delete the earlier assignments of the GMC to these tasks. You also add a supervision link (Insert->Supervision) from the GMC to the subcontractor. Your model canvas should look like the one below:

BEFORE ADDING SUBCONTRACTOR
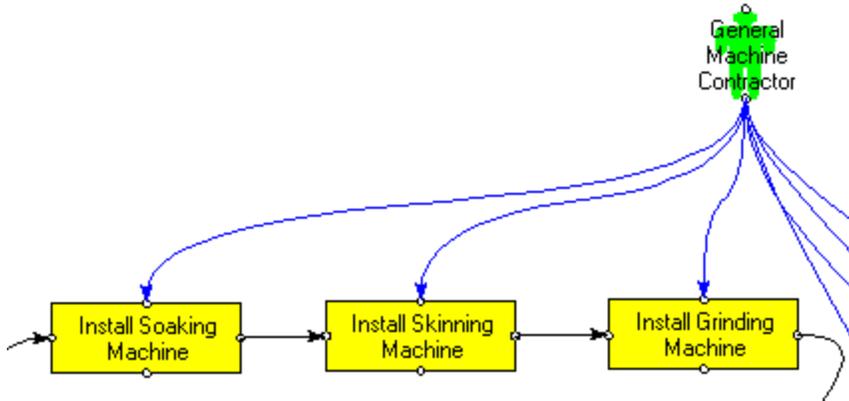
AFTER ADDING SUBCONTRACTOR
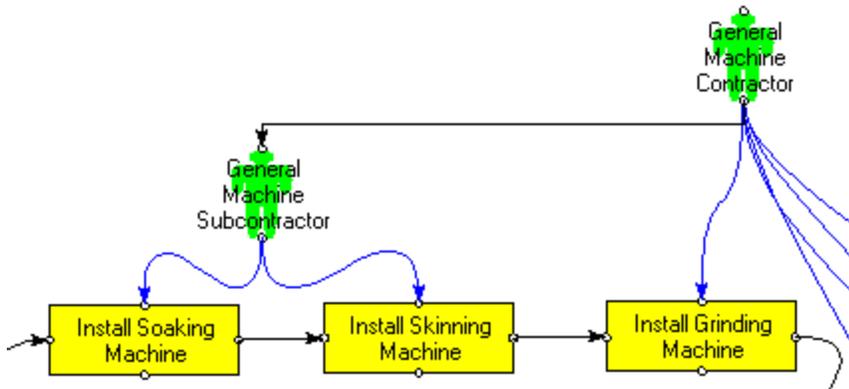
You run the simulation and the results are almost identical at 65.5 days. As your audience is shocked, you offer the explanation.

You: The duration remains pretty much the same at 65.5 days and this intervention has offered no substantial benefit. This is because the way the work is structured, the four machines the GMC has to implement are all in series and the subcontractor is not expected to work any faster than the GMC. We will have to wait the same amount of time if the subcontractor does it, as when the GMC does it. The real benefit of adding a position in this project is when we handle tasks in parallel, for that is where the GMC's backlog begins, given there is only one person for all the parallel integration tasks. If there were more than one, then we would have true parallelism.

You create a new case titled "Reassign Subcontractor." You then delete the assignments from the General Machine Subcontractor (GMS) and restore the GMC's assignments to the two tasks. You then assign the GMS to "Integrate Fava Bean Dispenser." You then proceed to run the simulation.
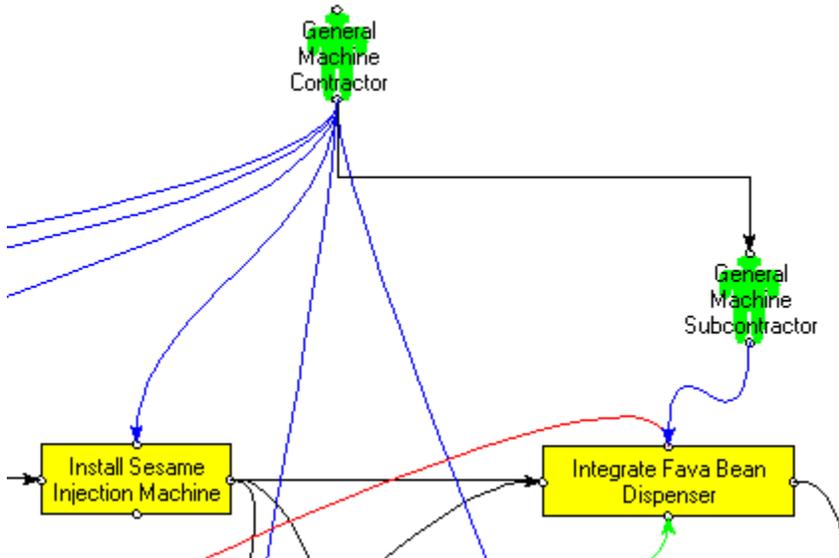
Name	Case	Start	CPM Dur	Sim Dur
Falafel Manufacturing Plant	Reassign Subcontractor	05/04/06	28.0	53.9323958333

You: Voila! The duration has now dropped to 53.93 days and the GMC's
CEO: This is most intriguing. It is very helpful to see this visually.

All the contractors in the room nod their heads.

You: Indeed. Power was designed to make the organization design process collaborative and participatory. We cannot collaborate over what we can't see. Let's compare the backlogs from the earlier case to get a better understanding of the work.

BEFORE ADDING SUBCONTRACTOR:

Position Backlog Chart - Project Project1
Case: Add Subcontractor

GMC

GMC's backlog has dropped from 17 to 10 days

Dispenser Contractor
Frying and Stuffing Machine Contractor
General Machine Contractor
General Machine Subcontractor
Add Subcontractor
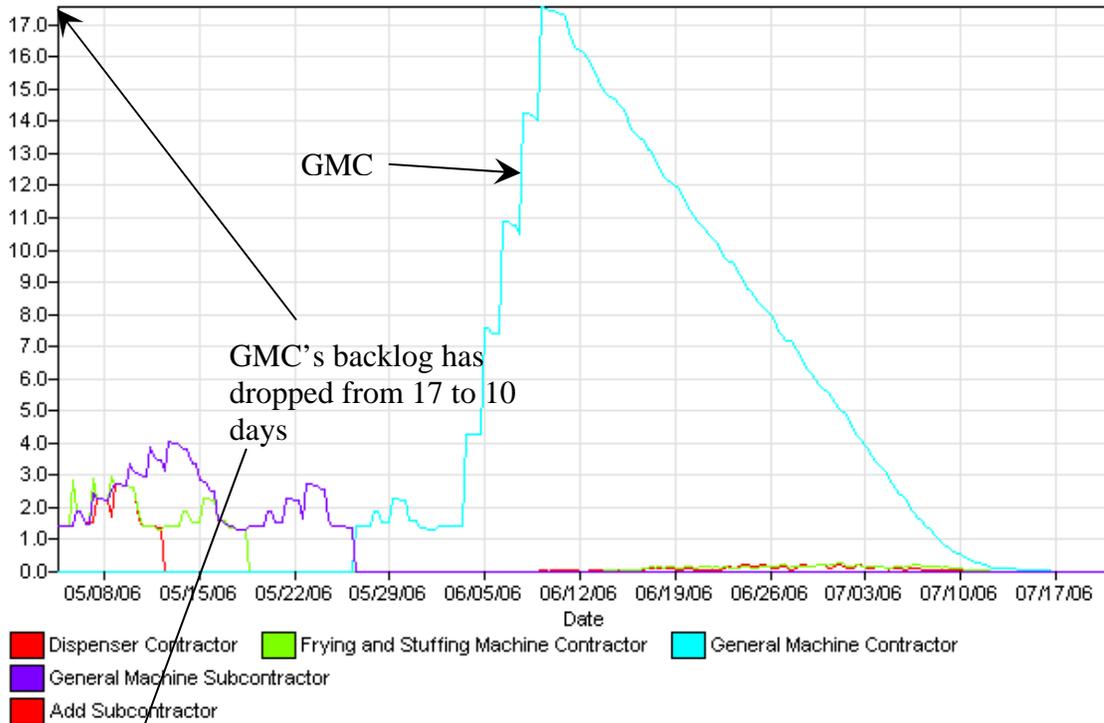
AFTER ADDING SUBCONTRACTOR:

Position Backlog Chart - Project Falafel Manufacturing Plant
Case: Reassign Subcontractor

GMC

Subcontractor

Dispenser Contractor
Frying and Stuffing Machine Contractor
General Machine Contractor
General Machine Subcontractor
Reassign Subcontractor
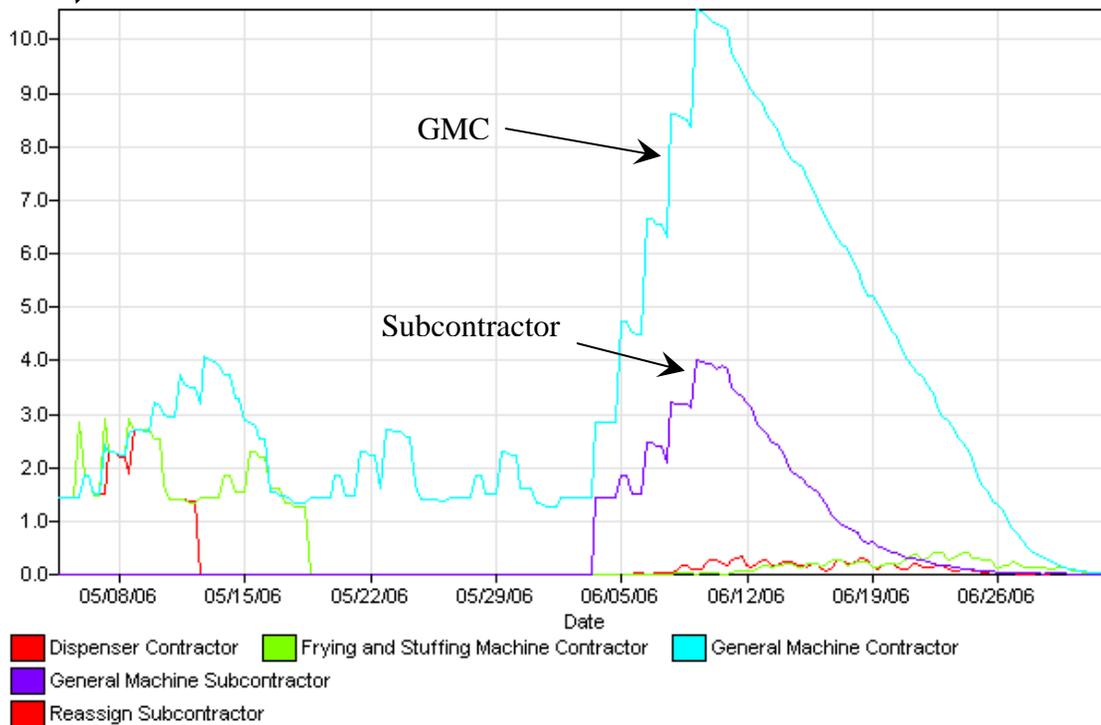
CEO: I am eager to get some intuition around how you know where to look for an intervention, or is it just gut-feeling?

You: It is definitely more scientific than gut-feeling. Power has a certain gold mine that tells me where to try an intervention. It is the Gantt chart that first opens up when you run a simulation. More than the dates on the axes, it's the colors that you want to look at. They tell you which tasks are on the critical path. If we can reduce the duration of these tasks or get them off the critical path, we can have a direct impact on the duration. Let's look at the Gantt chart again.

You: From this chart, we see that the three biggest tasks on the critical path are "Install Soaking Machine," "Integrate Deep Frying Machine" and "Integrate Pita Stuffing Machine." We'll start by looking at the first one, which is part of a series currently assigned to the GMC. Can we challenge that assumption? Given that we're talking about a subcontractor, is it possible to do some of these machines in parallel?

GMC: Well, since the inter-machine interfaces have been defined, we could do the soaking and skinning machines in parallel. However, the grinding and sesame injection machines can only be installed after the soaking and skinning machines are set up, as there are too many interconnections.

You: Let's try modeling this.

You start by creating a new case titled "Parallelize GMC Tasks." You proceed to introduce parallelism in the GMC's tasks by deleting the successor connection from the soaking to the skinning machine. You add a successor connection instead from the

soaking machine directly to the grinding machine. You also add a successor from Start to the skinning machine.

BEFORE PARALLELIZATION:
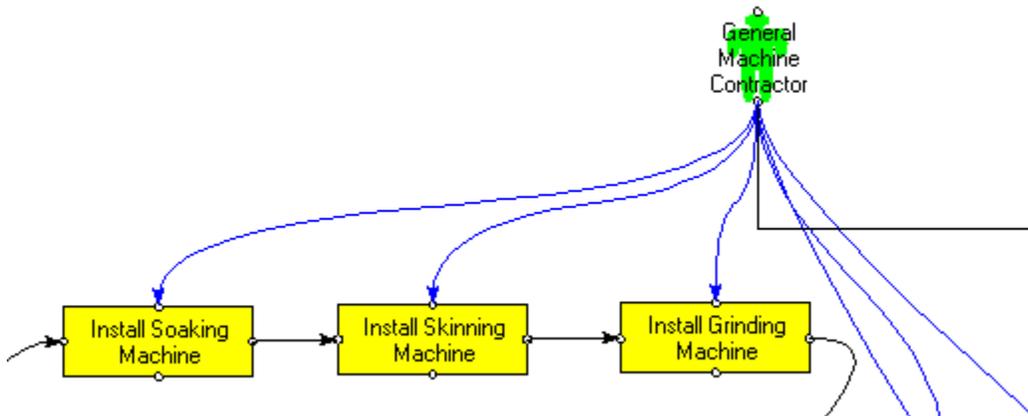
AFTER PARALLELIZATION:
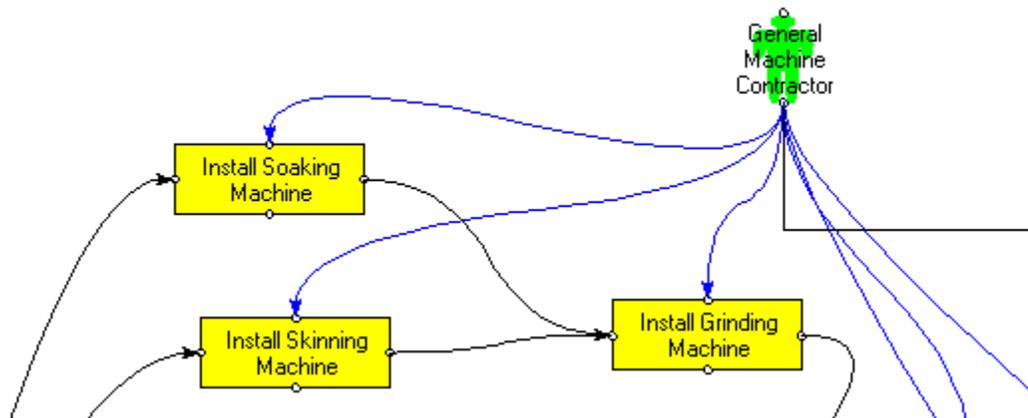
Finally, you assign the subcontractor to the Skinning machine task and run the simulation.

Name	Case	Start	CPM Dur	Sim Dur
Falafel Manufacturing Plant	Parallelize GMC Tasks	05/04/06	22.4	46.1460648148

Gantt Chart - Project Falafel Manufacturing Plant
Case: Parallelize GMC Tasks

This is no longer on the critical path

Legend:
- non-critical path
- critical path
- float
- Parallelize GMC Tasks
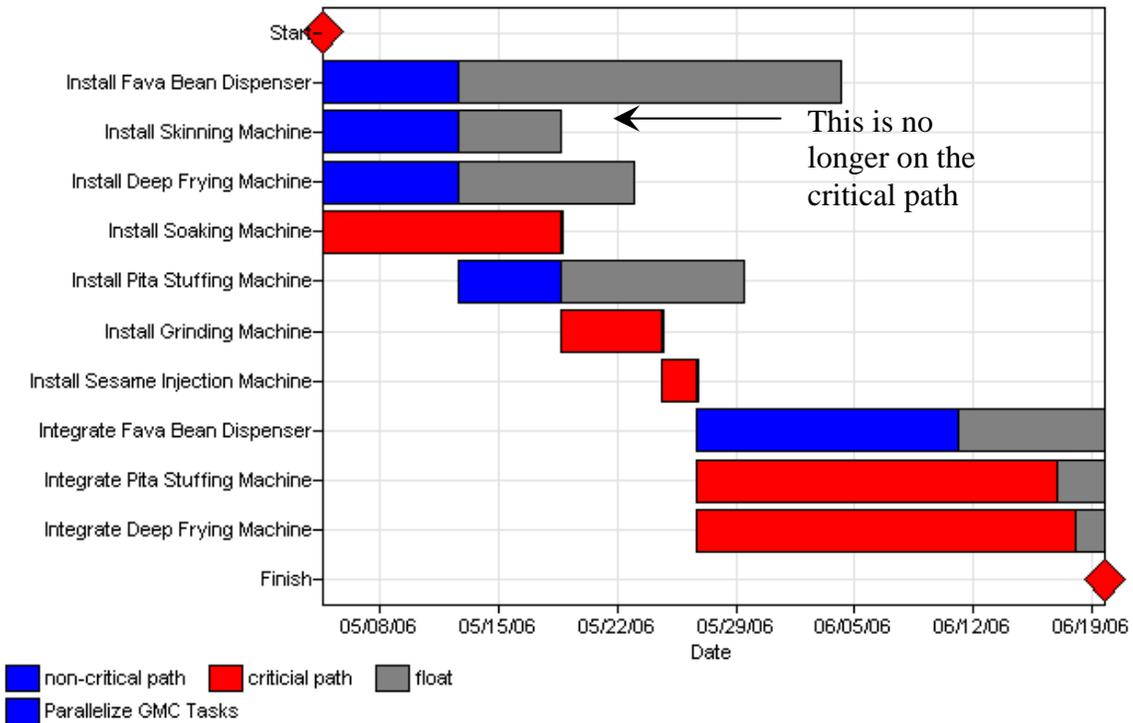
You: As you can see, the project duration has dropped to by almost 8 days to 46.1 days. Looking at the Gantt chart, we find that "Install Skinning Machine" is off the critical path, as the longer task, "Install Soaking Machine," consumes it. In other words, until the soaking machine is installed, you can't move on to the grinding machine, regardless of how quickly you finish the skinning machine.

GMC: I think I am getting the feel of this. Here is an intervention we could try. Although the Grinding Machine and the Injection Machine both depend on the Skinning and Soaking machines being installed, they don't depend on each other and so I think we can do them in parallel.

You: That's a great suggestion. This is a great time to show you the use of a powerful construct – the milestone. We need it to indicate that we're ready to start off multiple tasks in parallel just like we do with the Start element (which is a milestone).

You create a new case titled "Parallelize Grinding and Injection." You proceed to add two milestones, "Foundation Laid" and "Ready to Integrate." (Use the menu option Insert->Milestone). You rewire the tasks so they look like the snapshot on the next page (note that the assignments are not shown for simplicity). You then run the simulation. Assign the GMC to "Install Grinding Machine" and the GSMC to "Install Sesame Injection Machine."

Milestones
A milestone is a significant point in development. It is an invaluable tool in Power that lets us communicate work models better. There are some situations that cannot be represented easily without a milestone. The example used here is one such situation, where two parallel tasks must both complete, before two more tasks start off in parallel.

BEFORE ADDING MILESTONE:
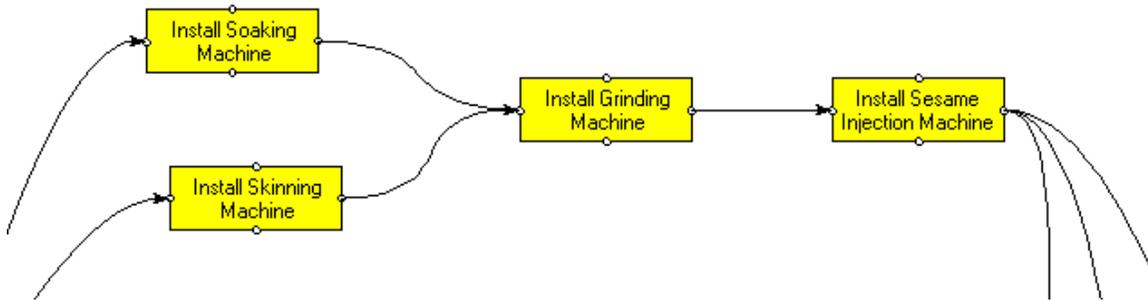
AFTER ADDING MILESTONE:
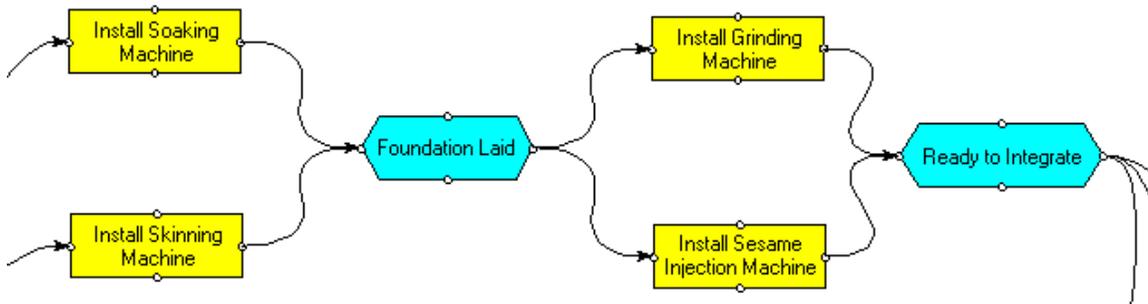
You proceed to run the simulation.

Gantt Chart - Project Falafel Manufacturing Plant
Case: Parallelize Grinding and Injection

This is no longer on the critical path

| non-critical path | critical path | float |
| Parallelize Grinding and Injection | | |
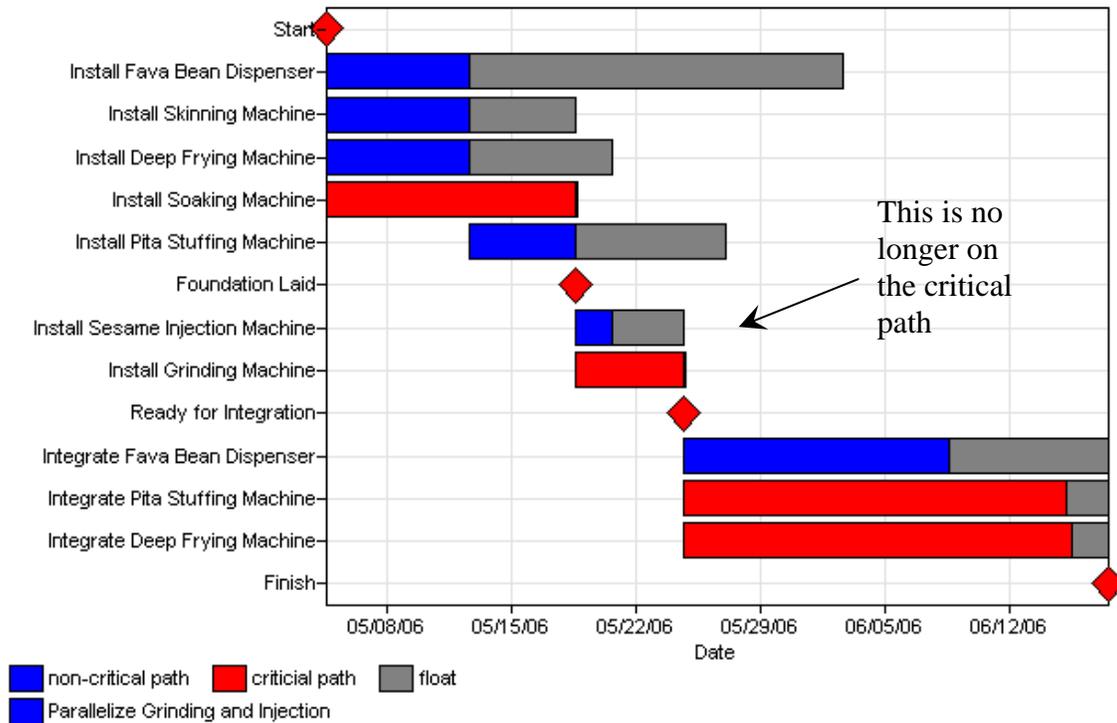
Name	Case	Start	CPM Dur	Sim Dur
Falafel Manufacturing Plant	Parallelize Grinding and Injection	05/04/06	21.0	43.91493055556

You: As you can see, the duration has dropped to 43.9 days. We need to figure out a way of reducing 14 more days. The key candidates are the two tasks on the critical path – the integration of the deep frying and pita stuffing machines. How could we turn these into parallel tasks?

The Dispenser Contractor jumps in.
DC: Well, if I was given a clear understanding of the integration interface, I could do the integration in parallel.
GMC: Oh, but you would need some training to complete this part.
You: And how long would such training take?
GMC: It would take a week with our machine architect.
You: Is that possible?
GMC: Come to think of it, we might be able to pull this off. Our machine architect will be done with his critical work by the time we begin the project, so you could spend the first week with him, and delay your work by that much time as you're not on the critical path.
DC: Yes, I could start later.
GMC: In that case, we could reassign the General Machine Subcontractor. Instead of integrating the dispenser, he could integrate the Pita Stuffing Machine.
You: Yes. We can also ask the Dispenser Contractor to give higher priority to his installation task over the integration task. Let's see what all this does to our projections.

As the excitement mounts in the room, you proceed to model these changes. As always, you create a new case titled "Training and Reassignment." You add a 5 day "Integration Training" task in between "Start" and "Install Fava Bean Dispenser," and assign the Dispenser Contractor to it. Then, you assign the Dispenser Contractor to "Integrate Fava Bean Dispenser," while removing the "General Machine Subcontractor" from it. You also set the priority on "Install Fava Bean Dispenser" to "High."
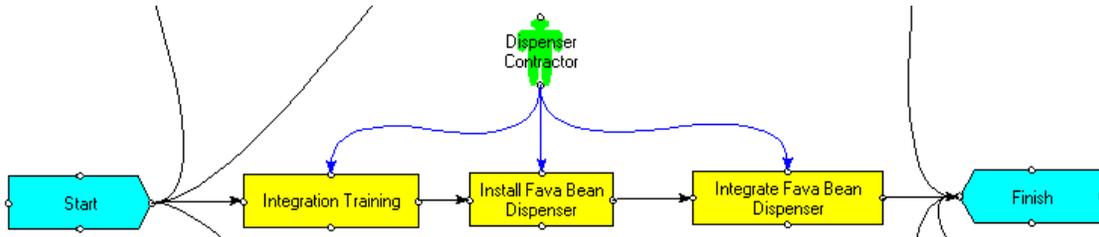
You now assign the General Machine Subcontractor to "Integrate Pita Stuffing Machine," while removing the GMC from it. As the room waits with abated breath, you run the simulation.

Name	Case	Start	CPM Dur	Sim Dur
Falafel Manufacturing Plant	Training and Reassignment	05/04/06	21.0	35.4508217593

The room bursts into applause. You've come very close to 30 days. However, from your experience, you know you can't stop at this point.

You: We are close to reaching a workable plan but we're not there yet.

CEO: What do you mean? I can see that we're down to less than 36 days. Surely, we can bring it down by another 6 days if people work a little overtime.

You: There are a couple of issues with this line of reasoning. First, our simulation assumes people are working eight hour days. If people work longer, they are prone to making more mistakes and the project exception probability will increase. What do the contractors think as a reasonable estimate for the increase in errors due to fatigue?

GMC: I would estimate a 20% increase in errors.

You: That raises the project exception probability to 30% (0.25 x 120/100).

You modify the project exception probability and run the simulation.

You: The simulated duration has now increased to 37.13 days making it worse. The second problem is that a good schedule should contain some slack. This implies that a practical schedule for us should end in less than 30 days.

You restore the project exception probability back to 0.25.

CEO: You're right. I've seen too many projects miss their targets due to unforeseen problems.

You: That is a serious danger for this project, as it's the first time all the contractors are building a Falafel Manufacturing Plant. Let's continue by visiting the Gantt chart again

Gantt Chart - Project Falafel Manufacturing Plant
Case: Training and Reassignment
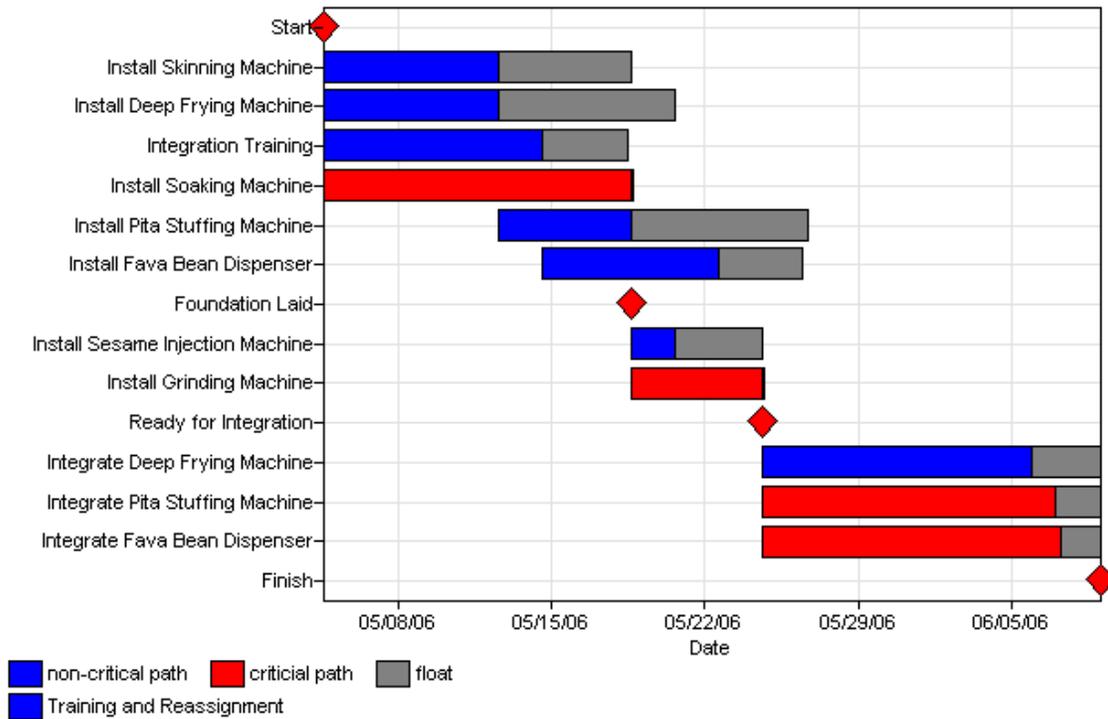
You: The soaking machine is taking up a lot of time on the critical path. Is there any alternative to the technology that is currently planned that might make it faster?

GMC: Well, I was planning to use our current-generation technology to do this, but we have been developing a new system that will reduce the installation time for both the soaking and grinding machines to one day. It passed our stringent tests last week. We could use it though this wasn't in our initial contract, and it's going to cost more. We'd be happy to provide it for an additional $20,000.

You: Let's see what that does to the schedule.

You create a new case titled "New Machines." You modify the duration of the soaking and grinding machine to 1 day each and simulate. The duration drops to 32.03 days and the two machines are off the critical path.

You: Now, I'd like the CEO to tell us if a saving of 3 days is worth $20,000.

CEO: Well, getting to the conference is worth several millions to us, so we'd be happy to pay this amount.

You: Great! Let's look at the Gantt chart again.

Gantt Chart - Project Falafel Manufacturing Plant
Case: Reassessment
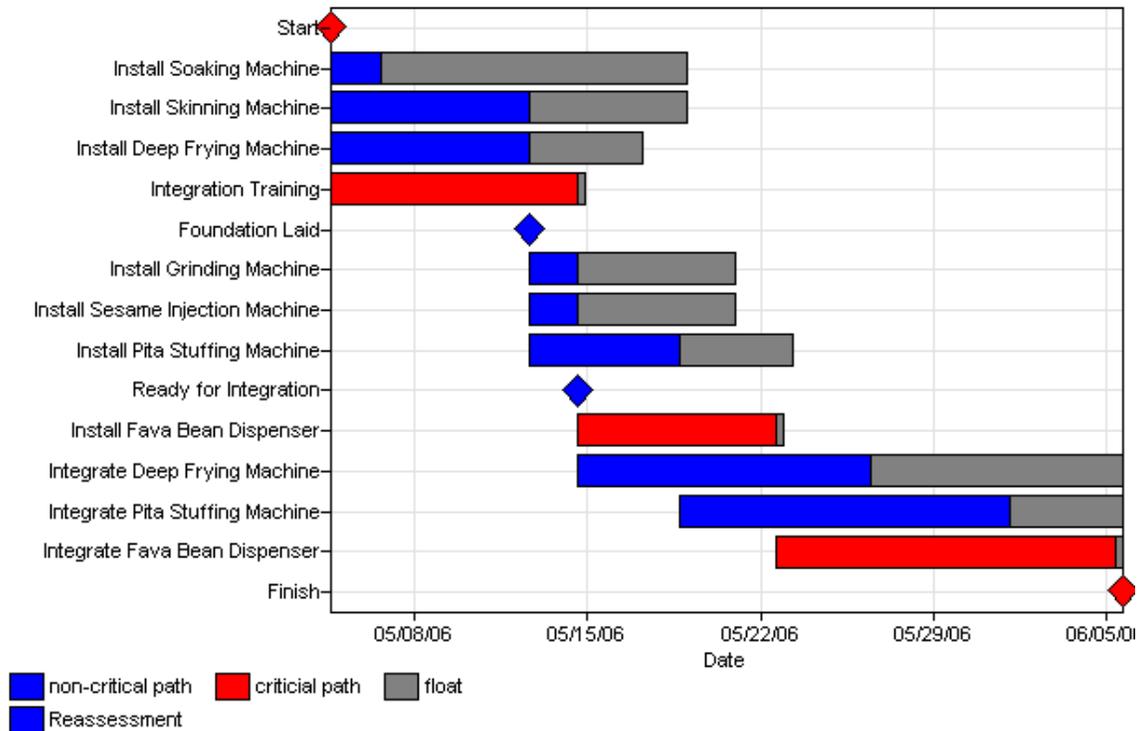
You: We can see that Integration Training is now on the critical path with 5 days. The installation of the Fava Bean Dispenser takes 4 days. What can the Dispenser Contractor do to reduce them?

GMC: Well, I think the integration training can be packed into 4 days. That shouldn't be too hard.

DC: And, I could hurry up the delivery of my engine parts from our supplier so the machine can be installed in 3 days instead of 4. I'd have to pay for express shipping which would come to $5,000.

CEO: No problem, go ahead. We'll foot the bill.

You create a new case titled "Critical Path Optimization." You modify the duration of the two tasks, Integration Training and Install Fava Bean Dispenser to 4 and 3 days respectively. The duration drops to 29.13 days and the audience bursts into applause.

You: Thank you. We're not done yet, though.

CEO: What do you mean? We're below 30 days.

You: True, but we need to model an important aspect of our work – the amount of time we spend in meetings. Imagine a project without meetings – anyone been on one of those?

GMC: You are right – we usually have tons of meetings to ensure we're on track.

CEO: All of my time is spent in meetings, like this one right now.

DC: Me too! I could actually get a lot of work done if I didn't have to attend so many meetings.

FSMC: I think meetings can be counter-productive beyond a certain point, but they are essential to keep people on the same page.

You: All great points. Meetings imply more communication, discovery of misunderstandings and early rework that helps avoid later and more expensive rework. However, you could easily spend all your time in meetings and get little done. We shall model an agile form of management where we have short meetings everyday, for half an hour. But first, we will look at the Position Summary.

Name	Case	FTE	Work	Rework
Dispenser Contractor	Training and Reassignment	1.0	12.0	1.28875
Frying and Stuffing Machine Contractor	Training and Reassignment	1.0	7.0	1.5575
General Machine Contractor	Training and Reassignment	1.0	7.0	0.665
General Machine Subcontractor	Training and Reassignment	1.0	10.0	0.455

You: Looking at the spread of the rework, we see that most of it will affect the Dispenser Contractor and the Frying and Stuffing Machine Contractor. We will compare our post meeting results with these numbers.

Meetings

Meetings lower the rate of future errors on a project. However, they take time. Hence, there is a constant tension balancing the upside and the downside. An important part of the model is that people can miss meetings if they're too busy. If that happens, the value of the meeting reduces for even those participants who attend it, as they cannot properly co-ordinate due to missing meeting participants.

You create a new case titled "Meetings." You insert a meeting and make a meeting assignment from all the positions to this spot. The meeting start milestone is the start of the project and the end milestone is when the system is ready for integration. The meeting occurs every day for half an hour.
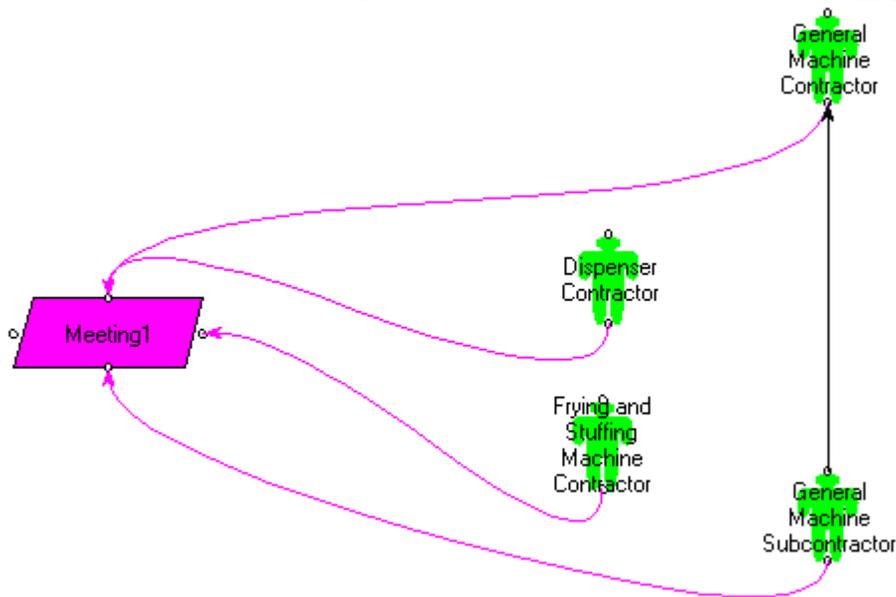
Simplified View of meeting assignments

You go to Edit->Case Properties and adjust the number of runs to 1000 and the seed to 0. This will help you run a truly random simulation and the increased number of trials gives you a larger sample size to assess the results. You make the same changes in the previous case, "Critical Path Optimization" and run a comparative simulation. The duration drops from 29.41 days to 29.37 days. This is not noticeably significant, and it is likely that further runs might yield different results.

We can however notice some trends in the Position Summary.

Name	Case	FTE	Work	Rework	Coord
Dispenser Contractor	Critical Path Optimization	1.0	12.0	1.257125	0.9972125
	Meetings	1.0	12.0	1.22075	1.05384166667
Frying and Stuffing Machine Contractor	Critical Path Optimization	1.0	7.0	1.431	0.658372916667
	Meetings	1.0	7.0	1.331	0.69859375
General Machine Contractor	Critical Path Optimization	1.0	7.0	0.5623125	0.8498375
	Meetings	1.0	7.0	0.52225	1.04115416667
General Machine Subcontractor	Critical Path Optimization	1.0	10.0	0.4995	0.277414583333
	Meetings	1.0	10.0	0.474875	0.34401875

You: As you can see, the rework for all positions has decreased. The way meetings work is that they lower your project exception probability, or the chance that there will be an exception flowing from one task to another. This is because when people communicate, they have a better understanding of each other's work interfaces. There is also a tension between the number of meetings people attend and the time that takes away from doing work. The coordination volume has increased after adding on meetings, as can be seen clearly in the "Coord" column. A healthy balance should be struck or people will spend most of their time attending meetings.

CEO: I am worried that even after all this design, we're still clocking around 29 days. That leaves us very little room for slack when we want to deliver within 30 days. And it does look like we've done all we could.

You: You're right. I think we should now try to account for the fact that people learn over time and get better at what they do. My intuition is that this will shorten the project duration.

CEO: Are you telling me that you can actually simulate how people learn over time?

You: *(Grin)* Yes.

C H A P T E R 4

Skills and Learning

You: We're ready to go up a notch in our simulation to incorporate the best knowledge available in learning theory. We intuitively included this in our model when we assigned the Dispenser Contractor to a training session. However, we did not fully model the effects of that session. In addition, we also want to model the effects of the team learning over time.

We shall start by modeling individual skill levels. I will now create two skills – "Machine Installer" and "Machine Integrator."

You start by creating a new case – "Learning." You turn on the Power Skill Model by going to Edit->Case Properties and selecting "Power" for the "Skill Model." You then create the two skills by using the menu option Insert->Skill twice, and entering "Machine Installer" and "Machine Integrator."
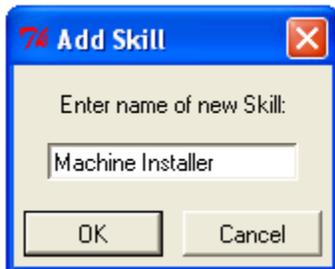
You: We can now model each position in terms of their individual skill levels. Let's start with the GMC.
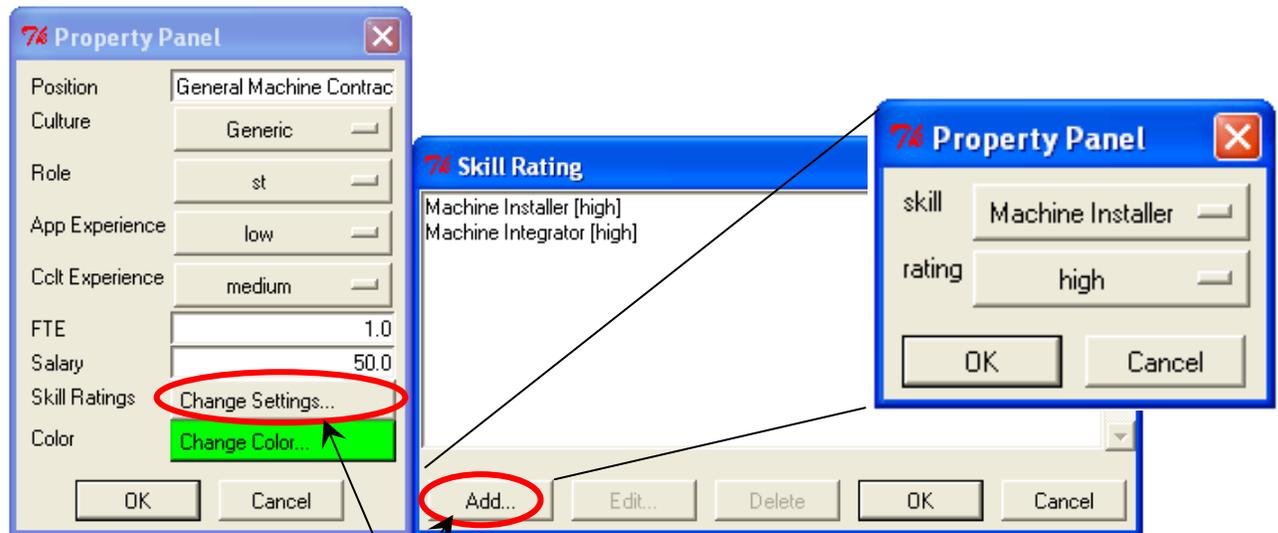
Click here

You double-click the GMC icon and then click on the "Skill Ratings" button in the property panel. You then proceed to click the Add button in the Skill Rating box. This lets you pick a skill and specify the proficiency of this position in the chosen skill. You use the following table to assign skills.

| Position	Skill	Level
General Machine Contractor	Machine Installer	High
	Machine Integrator	High
General Machine Subcontractor	Machine Installer	High
	Machine Integrator	Medium
Dispenser Contractor	Machine Installer	High
	Machine Integrator	Low
Frying and Stuffing Machine Contractor	Machine Installer	High
	Machine Integrator	Low

You: Finally, we get to the task descriptions themselves. We shall do this in two phases. First, we shall specify the skill associated with each task. We have a clear separation of task types as they are either of the Installation or Integration type. We will also specify 0 as the number of learning days for all the tasks at this moment, which indicates that learning does not occur, neither does forgetting. This is useful to model experts who are not expected to forget much of what they know and are constantly performing their work.

You click on the Install Soaking Machine task and select "Machine Installer" as the Required Skill. You also specify the Learning Days to be 0 as this task
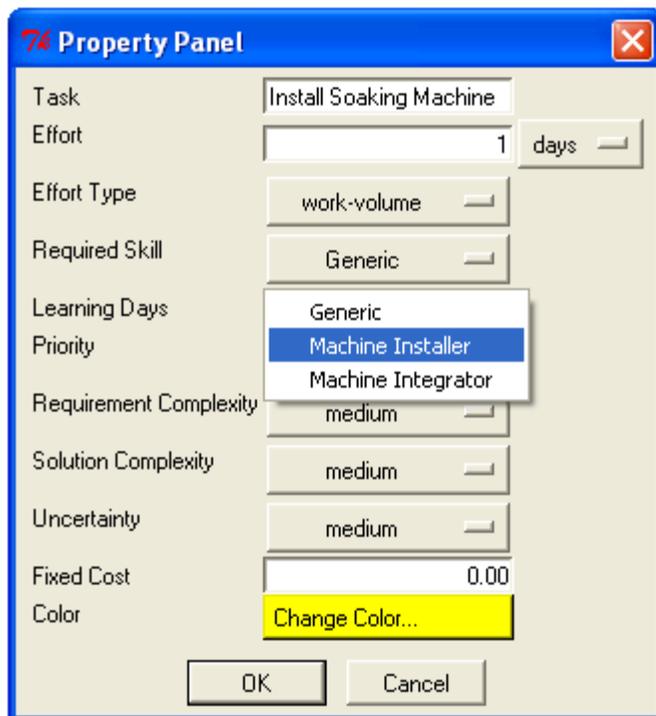
You repeat the process by associating all "Install.." tasks with the "Machine Installer" skill and zero learning days. All "Integrate.." tasks are associated with the "Machine Integrator" skill. "Integration Training" also comes in this category.

You: Second, for those tasks where learning can happen, we estimate how many days it would take for a novice to become a journeyman (or move from a low to a medium level of skill). This is what we term "learning days." In the case of "Integration Training," we shall estimate this at "4 days," the full length of the training. We will assume that the Dispenser Contractor has a medium skill level in handling the integration task that is to follow.

DC: That sounds like a fair estimate.

You: Given that the General Machine Subcontractor has a medium level of skill, we could assume that he will learn and get quicker as he completes, "Integrate Pita Stuffing Machine." In order to represent this, let's estimate 3 learning days. As there's learning involved in "Integrate Deep Frying Machine," we'll represent this by 3 days as well. Let's simulate this now.

Name	Case	Start	CPM Dur	Sim Dur	Sim Dur Dev
Falafel Manufacturing Plant	Learning	05/04/06	16.8	27.2597106481	3.04390046296

You: The simulated duration has dropped to 27.25 days, after modeling the impact of learning.

CEO: A day and a half of slack in a 30 day project is quite precious. Good to know that we have a better chance of meeting our goal.

You: Well, incorporating learning theory has another impact. People forget in a rate that is the reverse of the rate of learning.

You jump to the whiteboard and sketch the following curve and proceed to explain it.

The rate of forgetting is determined by where you are on the learning curve. If you've spent enough time practicing, then you are higher up on the learning curve and forget at a decreased rate.

The corresponding point on the forgetting curve is fairly flat and won't make much of a difference to your skill level.

However, if you've just started learning when you start giving a break to your practice, you're somewhere here.

The corresponding rate of forgetting is quite high and if you keep having a gap, your learning will be rendered useless and you will have to retrain.

You: This leads us to consider if we could shorten the gap between "Integration Training" and "Integrate Fava Bean Dispenser." Any thoughts?

DC: Hmm.. What if we parallelize "Install Fava Bean Dispenser" and "Integrate Fava Bean Dispenser" like we did earlier?

You: That's a great idea. What you're saying is that you will try to spend some time each day on installing the dispenser and integrating it. Let's try it and see what it does.

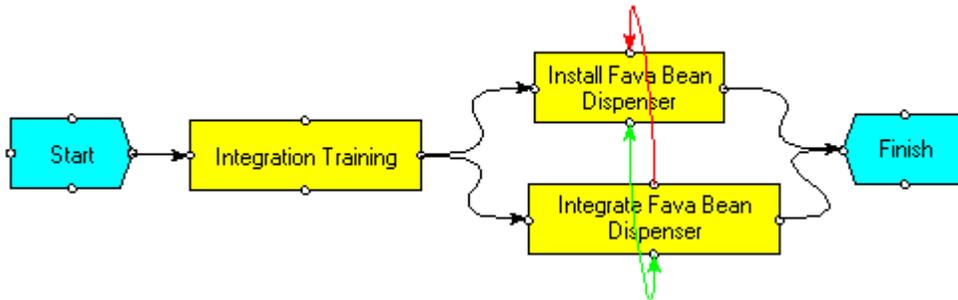*You start by creating a case titled "Learning2." You then proceed to parallelize the "Install Fava Bean Dispenser" and "Integrate Fava Bean Dispenser" tasks as shown in the figure below, keeping all the other relationships intact.*

You proceed to simulate.

Name	Case	Start	CPM Dur	Sim Dur
Falafel Manufacturing Plant	Learning	05/04/06	16.8	27.2597106481
	Learning2	05/04/06	16.8	27.0029050926

You: As is evident, we have dropped the duration by a quarter day by parallelizing the effort. This is due to increased efficiency as the Dispenser Contractor remembers more of what he has learned by applying it sooner. In order to cement our understanding, let's look at the Skill Level Summary in the report.

Skill Chart - Project Falafel Manufacturing Plant - Position Dispenser Contractor
Case: Learning2

DC's Machine Installer skill is intact

DC's Machine Integrator skill level rises with the training and practice. It settles down at a level higher than the starting level.

Generic   Machine Installer   Machine Integrator

Learning2

Skill Chart - Project Falafel Manufacturing Plant - Position General Machine Subcontractor
Case: Learning2

The GMSC starts off at a medium integration skill. The level rises as he gets better with the task. However, it is clear from the final level that he will need to practice more for him to reach and maintain the level of "expert," at 1.5 (in green)

Generic   Machine Installer   Machine Integrator

Learning2

Skill Chart - Project Falafel Manufacturing Plant - Position General Machine Contractor
Case: Learning2

The GMC starts off at a high skill level. Due to the "Integrate Deep Frying Machine" task, his skill level rises higher. It then settles down by the time the project ends.

Legend:
- Generic
- Machine Installer
- Machine Integrator
- Learning2

C H A P T E R 5

Knowledge Networks and Trust

You: How are we doing?

CEO: This is pretty amazing. I'll bet we can't get any more sophisticated than this. This is pretty close to real life.

You: Not quite. There is an important element that's missing.

CEO: And what would that be?

You: In real life, we often form relationships with co-workers and develop perceptions about their skill levels. Depending on our perceptions, we select who we can ask for help.

CEO: That is so true! When I go to my local video store, I look for my favorite attendant who knows the store inside out, and avoid the newer ones.

You: By modeling this in POW-ER, we can get a better picture of the work physics.

CEO: Hmm... I like the term "work physics."

You: Yes, and note that "work chemistry" would be another dimension, which we'll get to when we cover trust.

CEO: Oh boy, you also model trust! Ok, let's get started – this sounds most interesting.

You: To begin, we must first introduce the notion of "Functional Exception."

Functional Exceptions
A functional exception is made by an actor working on their own task. These exceptions do not affect any other task, but may involve rework on the part of the actor to correct. The actor may go up the hierarchy to get help with the error, if their supervisors have the time. Otherwise, they will ignore it, causing the project quality to go down.

Functional Exception Probability
This probability is used to generate functional exceptions and is similar to the Project Exception Probability.

You: How much would you estimate is the rework you do on your own task that does not propagate out?

GMC: (after discussing with other contractors) We think it's 2 out of 10.

You start by creating a new case titled "KN." You proceed to double-click on the model canvas and open up the Project Properties. Here, you define the functional exception

probability to be 0.2. You then proceed to run a comparative simulation (Simulate Some) between KN and Learning2. You find that the simulated duration over 1000 runs has gone up from approximately 27 to approximately 29.5 days. You then open up the Functional Risk chart to show some interesting results.

Task Functional Risk Index - Project Falafel Manufacturing Plant
Cases: Learning2, KN
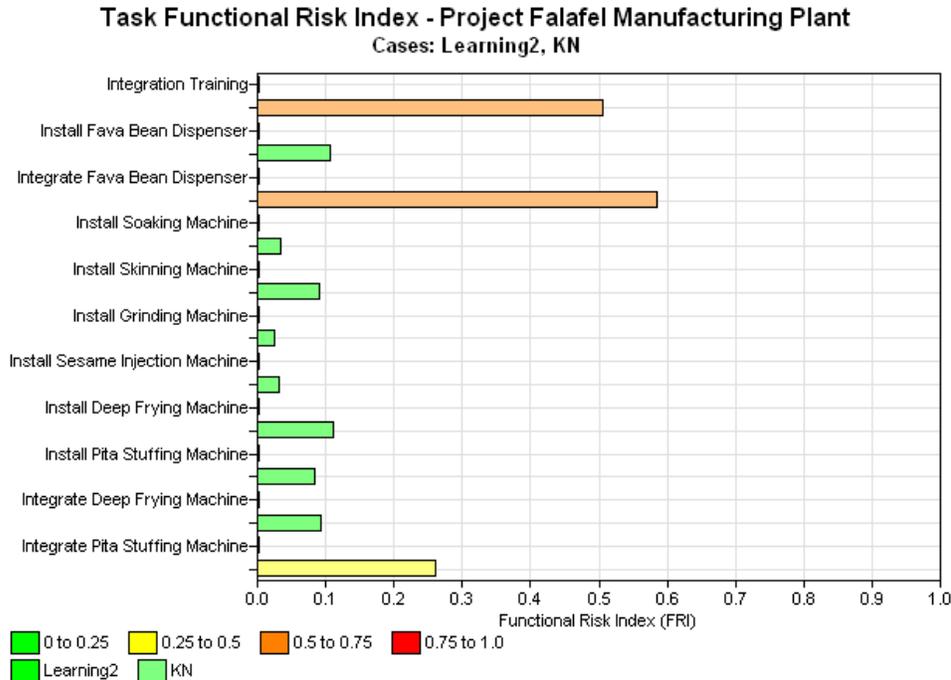
You: As this basic simulation shows, without knowledge networks, people will be making decisions that compromise quality. The Functional Risk Index shows the level of risk associated with each task. Empirically, any risk about 0.5 is serious and we need to do some further analysis of the impact of failure of this task on the value of the project.
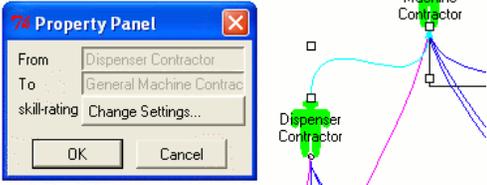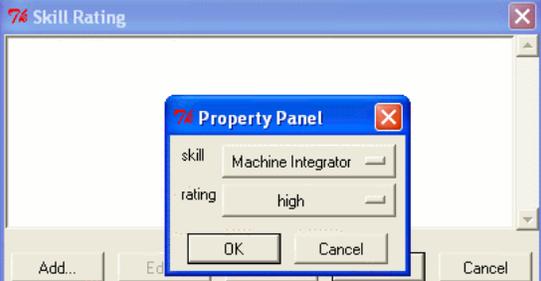

Functional Risk Index

$$\text{Functional Risk Index} = 1 - \frac{\text{functional exception rework volume}}{\text{functional exception volume}}$$

If all functional exceptions are reworked, the Functional Risk Index would be 0. However, due to lack of knowledge links, this may not be the case, leading to exceptions being ignored, thus increasing the functional risk index.

DC: The graph seems to show that my integration task will have the highest risk. That is not good news, though it is intuitive and I am impressed that your tool was able to bring it out.

You: The good news is that we don't just stop at uncovering the risk. We will try to mitigate it using Knowledge Networks. A knowledge network at its simplest represents the perceptions of one actor about the skill levels of another actor. We shall create a knowledge link from the Dispenser Contractor to the General Machine Contractor.

	Click on Insert -> Knowledge. Then click on the Dispenser Contractor and drag the other end of the arrow to the General Machine Contractor. Double click on the cyan arrow to open up the Property Panel. Click on the Change Settings button to set the skill-rating.
	In skill, select "Machine Integrator" and go for a "high" rating, to represent that the DC thinks the GMC has a high machine integration skill level.

Simulating a 1000 times now, you find that the simulated duration has gone up from 29.5 to 32.5 days. However, the functional risk has climbed down (compare with the graph on the previous page).
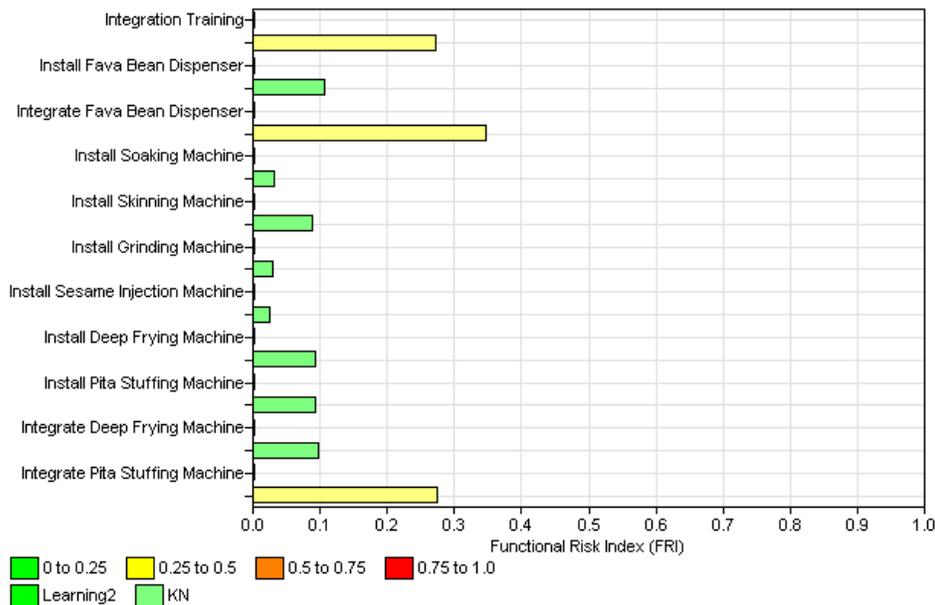
CEO: This is a matter of concern – we are now over 30 days again.

You: Let's see what we can do. Since the DC will be trained by the Architect in our GMC's organization, is it fair to assume that the DC could go to the Architect to get help?

GMC: Oh yes. My architect is very approachable and helpful.

You: Well, we will then add him to our knowledge network as well.

You create a new position called Architect under the GMC's supervision and create a knowledge link from the DC to the Architect, with the same skill rating as before. Simulating again, you find the simulated duration for KN has come down to 31.1 days.

You: We can further tweak this by letting the DC go exclusively to the Architect, by taking out the link between the DC and the GMC. That would make sense as it would free up the GMC from having to deal with questions from the DC.

GMC: That makes sense.
You remove the link between the DC and the GMC and simulate again. The simulated duration over a 1000 trials has come down to 30 days.

CEO: That's great! I can see the value of doing this – we wouldn't have seen the bottleneck caused by not involving the architect some more until we'd been hit by the problem. I really like this planning process.

You: Me too! So, are you ready to model trust?

CEO: You bet!

To activate the trust feature of Power, open the case properties and change the Actor Model to "PTW" (Perceived TrustWorthiness). This will cause the probability of communication and priority of responding to communications to be adjusted based on the level of trust between the sender and recipient. This trust level is a function of the extent to which the actors share skill sets, cultures, organizations, and roles.

C H A P T E R **6**

Impact of Culture

National Culture has an impact on organizations in more ways than one. Through research conducted at CRGP, we have modeled the effects of Japanese and American culture on the work they do. Japanese decision makers will have a higher willingness to communicate with their superiors while American decision makers will have a higher tendency to make decisions themselves. The Japanese model tends to be more centralized and works well when actors higher up the chain are highly skilled in resolving exceptions. The American model works well when actors have a reasonable level of skill and expertise.

Culture determines the following parameters:
1) Decision-making policy
2) Type of decision (rework, correct, or ignore)
3) Tolerance in waiting for decisions
4) Attendance to communication
5) Response volume of communication
6) Information demand for communication

Decision Making Policy
In the American model, subordinates expect to be consulted. In the Japanese model, subordinates expect to be told what to do.[1] Japanese firms tend to be more centralized and cognizant of formal authority. Decision making behavior has therefore been modeled to be more centralized.

Type of Decision
Japanese firms have been classified to be high in "Uncertainty Avoidance" or requiring precision. Thus, they have fewer "Ignore" decisions when faced with an exception. They will also have more "Rework" decisions than countries that rank low in uncertainty avoidance. They will tend to have more "Correct" decisions implying they'd like to correct mistakes they see.

Tolerance of Waiting Time
Japanese firms will tend to have a longer tolerance when waiting for a decision, which is opposite to a "typical" American firm's style of functioning.

Attendance to Communication
Japanese firms will have higher attendance to communications. American firms will generally have less attendance to communication.

Response Volume of Communication
Japanese firms will tend to have a higher formalization level leading to more formal meetings informal information exchange.

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[1] Power Distance is the term used in the literature to describe power structures across difference cultures.

Information Demand for Communication

Japanese firms will have a higher demand for information to be communicated amongst team members than American firms.

Modeling

To specify the cultural assumptions, click on the actor of interest, and select Culture.
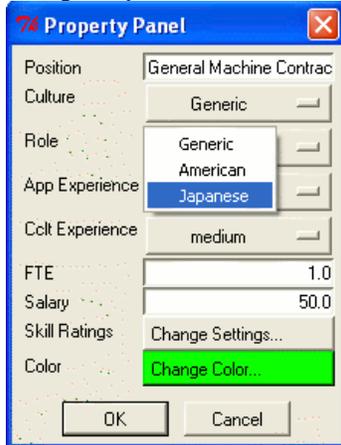
From the drop-down box, select the culture you'd like to specify. The Generic culture corresponds to the American culture.

C H A P T E R 7

Events and Branches

1. EVENT

An event allows us to introduce events whose occurrence is determined stochastically.
We shall demonstrate this with an example.
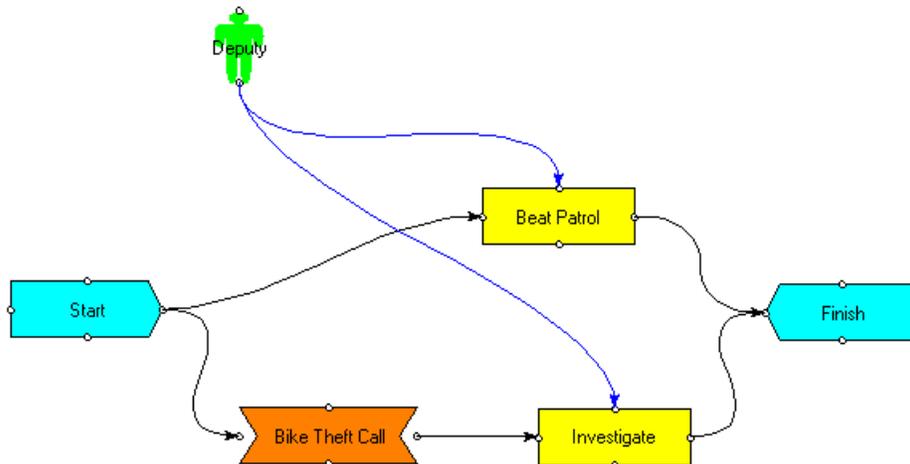
In the model above, a deputy is assigned to a beat patrol lasting 5 days. The deputy could
also be called in to respond to a bike theft call that occurs anytime over the next 2 days.
The theft call is equally likely to occur over this two day period. *Mathematically
speaking, the probability of the bike theft call coming in is uniformly distributed over two
days*. Once it occurs, the deputy investigates the theft for half a day.

In order to model this, we would use max-duration to represent the most time that could
be spent on a beat patrol in terms of calendar days. That is, the task would cease to exist
after the given number of days, regardless of whether any time is spent on it.

Max Duration
The total amount of time a task can be worked on in calendar days, beyond which the task
will cease to exist, regardless of incomplete volume.

Then, we'd need to drop in an uncertain event – in this case, a Bike Theft Call. We do
this from Insert->Event. We shall also specify a time span of 2 days, which is the period
over which the uncertainty of the event occurring is distributed. This means that the event
is guaranteed to happen, within the next two days.

An event is like a milestone and when it occurs, the flow of the simulation passes on to a
successor task. In our example, we shall follow up a bike theft call with an "Investigate"
task that is assigned to our deputy on the beat. Investigate needs to be set to a higher
priority if we'd like the officer to handle the theft call as and when it comes up, by
leaving the beat.

It is important the deputy be modeled as a project manager to give full attention to the priority task. Regular sub-team members will only work on priority tasks 10% of the time. This assumption can also be justified as actors in edge organizations tend to be project managers unto themselves, making important decisions. Our model above represents a typical edge organization where actors on the edges are empowered to make important decisions.

2. BRANCH

A branch allows us to specify different decision pathways which are selected in a random manner based on a distribution.

Continuing with our previous example of the deputy responding to a bike theft, we shall try to make it more realistic. Our deputy may elect not to respond to the bike theft due to the chance of occurrence of more serious crimes. The deputy may leave it to the detective to follow up at a later time. However, the deputy may also decide to investigate, depending on the work load.

Suppose that we are talking about the Fall Quarter, and the deputy has a lot more coverage to provide through the beat patrol. So, our deputy responds to bike theft calls 20% of the time (according to the best beliefs of the modeler). We can represent this situation through the powerful branch construct.
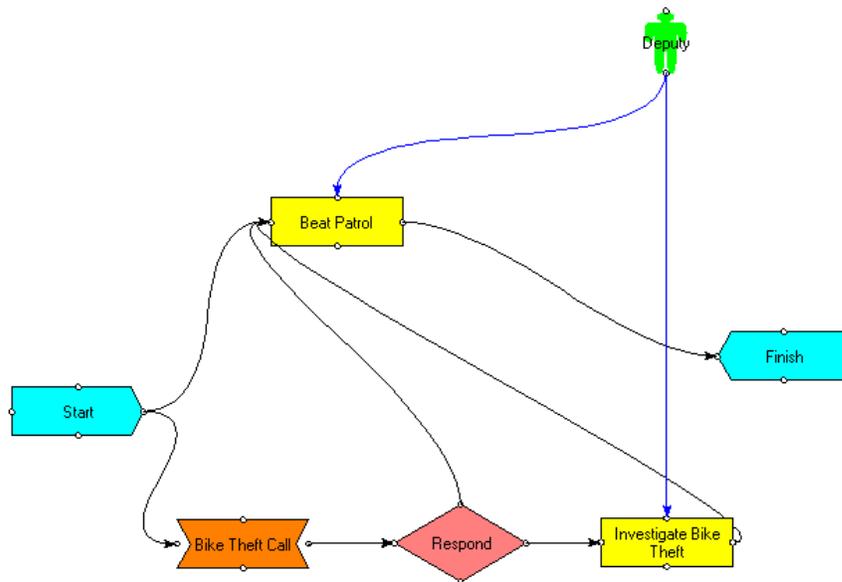
The branch node follows the Bike Theft Call event. A branch can result in two outputs, a "yes" or a "no." In Branch Properties, we specify 0.2 as the probability of getting a "yes." This means that we obtain a uniform random number between 0 and 1. If it is less than 0.2, we will assume that we have a "yes," otherwise it is a "no."

When we get a "yes," this leads down a separate decision pathway, resulting in the deputy conducting an investigation. In our implementation, **the "yes" branch always leads to the right, and the "no" branch can be either up or down.** After the

investigation is complete, the deputy will return to the beat patrol. If the branch results in a "no" (which happens 80% of the time), the deputy will continue on the beat patrol.

Sometimes, you may choose not to have either "yes" or "no" successors. It is perfectly legal to represent a branch node with a single successor.