Construction Planning, Equipment and Methods ENGI 8749 Fall Semester, 2008 Tutorial #2 – Resource Leveling using MS Project

Project Example Overview

Microsoft Project, in addition to scheduling calculations, can also track resources and consider cases of resource limitations in scheduling project activities. During our last lecture (Lecture 14) on resource allocation, we considered an example project that had a resource limitation. Without resource limitations we found that with a forward and backward pass on the project, it would take 12 days to complete.



We can see that a resource limit of 2/day has been imposed in this problem and we found that through a hand calculation that this limitation added an additional 2 days to the project timeline (14 days total). This occurs because after activity A is completed we see that 3 resources per day are required.

Before we get into resource allocation we set up MS Project from a blank project by adding the following data:

Task Name (Index)	Duration	Predecessors (Index)
A (1)	1	-
B (2)	2	A (1)
C (3)	2	A (1)
D (4)	3	A (1)
E (5)	4	B (2)
F (6)	5	C (3)
G (7)	4	D (4)
H (8)	1	E,C (5,3)
I (9)	3	G (7)
J (10)	1	H,F,I (8,6,9)

Starting Project

So that we can easily count project days, we'll start our project from the 1st of a 30 day month so that the dates reflect the days. We'll also make Saturdays and Sundays work days for this purpose. Additionally, we'll change the date bars to weeks and days from the start of the project. These steps were outlined in the previous tutorial.

- 1. Set project start date to April 1st
- 2. Define Saturdays and Sundays as work days (change standard calendar)
- 3. Change calendar bars to time from start of project
- 4. Add info in table.

After we complete these steps our schedule should appear as:

	6	Task Name	Duration	Start	Finish	Predecessors		Week 1					Week 2									
	Ŭ						-3	-2	-1	1	2	3	4	5	6	7	8	9	10	11 '	12	13
1		A	1 day	Tue 4/1/08	Tue 4/1/08						h											
2		в	2 days	Wed 4/2/08	Thu 4/3/08	1					Č.		h									
3		С	2 days	Wed 4/2/08	Thu 4/3/08	1					t		-		-		<u>.</u>					
4		D	3 days	Wed 4/2/08	Fri 4/4/08	1					<u>ک</u>			h								
5		E	4 days	Fri 4/4/08	Mon 4/7/08	2							t				6					
6		F	5 days	Fri 4/4/08	Tue 4/8/08	3							<u>ک</u>					-		_		
7		G	4 days	Sat 4/5/08	Tue 4/8/08	4								2	:			h				
8		н	1 day	Tue 4/8/08	Tue 4/8/08	5,3											*	╟		_		
9		I	3 days	VVed 4/9/08	Fri 4/11/08	7												Č				
10		J	1 day	Sat 4/12/08	Sat 4/12/08	8,6,9														1	5	

Here, we can see that the project is to be completed in 12 days. However, we can also see from the Gantt chart view that there are a number of days (2-8) when 3 activities will be occurring at the same time. Hence, we will require 3 resources on these days.

Next, we'll customize the network view but this can be skipped over if necessary. I had challenged myself to try this customization and wanted to document it.

Project Customization

We can also view our network view (**View** > **Network Diagram**) to confirm the network is the same as the example. Like many aspects of MS Project, it is very customizable. In fact, we can customize the network view to reflect the information we have in our problem. To do this we'll create a new template for the network view by following:

- 1. Change to network view (**View > Network Diagram**)
- 2. Select **Format > Box Styles ...** and the following dialogue box will appear

Box Styles	×
Style settings for:	Preview:
Critical Noncritical Critical Milestone Critical Milestone Critical Summary Noncritical Summary Critical Inserted Project Noncritical Inserted Project Critical Marked Noncritical External Noncritical External Project Summary	[Name] Start: [Start] ID: [ID] Finish: [Finish] Dur: [Duration] Res: [Resource Names]
🔲 Set highlight <u>f</u> ilter style	Show data from task ID:
Data template	
Standard	More Templates
Border Shape: Shape: Color:	Red 🗾 Width:
🔽 Show <u>h</u> orizontal gridlines 🗌 Show	vertical gridlines
Background Color: White Patter	n:
Help	OK Cancel

3. You'll note the Standard data template is in use. Select the <u>More Iemplates...</u> button to reveal another dialogue:

Data Template	25		×
<u>T</u> emplates in "N	etwork Diagram": —		
Standard		<u> </u>	<u>N</u> ew
Earned Value			<u>⊂</u> opy
Inserted Proj	ect		- 11
Milestone			Edit
Tracking			Import
Work		-1	Delete
1			
Preview			
Show data fro	m task <u>I</u> D:	-	
	[Name]		
	Start: [Start]	ID: [ID]	
	Finish: [Finish]	Dur: [Duration]	
	Res: [Resourc	e Names]	
			Close
			Close

4. Drilling deeper, we now create a new template by selecting the <u>wew...</u>. We'll call this template "Event Times" and put EST, EFT, LST, LFT in the corners of a 2x3 matrix we set out from the <u>cellayout...</u> button. From the "Choose Cell" area we can pull down the field variables we can add to the boxes to assemble the box we need

Data Templa	te Definiti	on				×
Template <u>n</u> ame	e: Event T	ïmes				
Format cells –						
Show data fr	rom task <u>I</u> D:	1 -				Cell <u>L</u> ayout
			Tue 4/1/08 A Tue 4/1/08	3 Tue 4/1/08 1 day 3		
	5):					
×						
Early Start		Early Finish				
Name		Duration				
Late Start			_ _]		
	Late Finish		· · · ·			
<u>F</u> ont	Late Start			cell <u>t</u> ext to:	1 line	•
	Level Assig	nments			·	
Horizontal al	Leveling Ca	an Split		now la <u>p</u> el in cell:		
<u>V</u> ertical align	Leveling De	elay		format:		T
	Linked Field	ls				
Help	Marked				ОК	Cancel
	Milectone					

5. Finally we apply this new template to the "Critical" and "Noncritical" box styles from the first dialogue box we encountered in step 2.

This produces a network view that compares to our original problem view as:



Defining Project Resources

A resource is traditionally defined as any of the people, equipment, and materials used to complete tasks that make a project. Material resources are differentiated from people and equipment resources, as they are not time dependent. Before we use resources in our activities we must create a resource list. One can follow the Resource \checkmark wizard from the Tasks menu but most of these steps are not necessary for our simple projects. To create a local resource list for our project change the view to **View** > **Resource Sheet** and add a new resource called R1. You'll get an entry as follows:

	0	Resource Name	Туре	Material Label	Initials	Group	Max. Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar	Code
1		R1	Work		R		100%	\$0.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	

Here, we need to make sure that the "Type" column is set to *Work*. This specifies that the people or equipment resource will be utilized while it is assigned and will be *prorated* across the activity time. We could specify an *hourly rate* for our resources if we were tracking cost or a lump sum cost each *use* of the resource.

You'll also note the resource can also use its own calendar that might be independent of the *standard* calendar. Finally, we can specify the maximum number of units for our resource. In this case we have been told in the problem that we have a maximum of 2-resource units per day so we change "Max. Units" to **200%**.

		0	Resource Name	Туре	Material Label	Initials	Group	Max Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar	Code
	1		R1	Work		R	(200%	\$0.00/hr	\$0.00/hr	\$0.00	Prorated	Standard	
							· · · ·							
듔														

There are lots of other ways to add resources to projects and modify them but this seems to be the base method. We can add any number of resources to this list if we are tracking a multi-resource project. These represent pools of resources we can draw from and therefore, have not been allocated for use at this point.

Allocating Resources

Once we have a pool of resources to draw from, we can assign these to various activities. This is done for each activity and can be done in the default Gantt chart view by selecting the resource required from the pull down menu in the "Resource Name" column.

Task Name	Duration	Start	Finish	Predecessors	Resource Names	Week 1 Week 2
						-2 -1 1 2 3 4 5 6 7 8 9 10 11 12
A	1 day	Tue 4/1/08	Tue 4/1/08			
в	2 days	Wed 4/2/08	Thu 4/3/08	1 R1		
С	2 days	Wed 4/2/08	Thu 4/3/08	1		
D	3 days	Wed 4/2/08	Fri 4/4/08	1		
E	4 days	Fri 4/4/08	Mon 4/7/08	2		
F	5 days	Fri 4/4/08	Tue 4/8/08	3		
G	4 days	Sat 4/5/08	Tue 4/8/08	4		
н	1 day	Tue 4/8/08	Tue 4/8/08	5,3		
I	3 days	Wed 4/9/08	Fri 4/11/08	7		
J	1 day	Sat 4/12/08	Sat 4/12/08	8,6,9		

We can also double click on any activity and select the "Resource" tab from the main Task Information dialogue as follows:

Task Information			x
General Predecessors Res	ources Advan	ced Notes	Custom Fields
Name: B		Duration: 2	d 📑 🗆 Estimated
Resources:			
Decourse Name	Acciment Owner	Lipita	Cost
Resource Name	Assignment Owner	100%	
			_
Help			OK Cancel

If we required more than 100% of a resource for a particular item, we would specify this in the units column of the Task Information or type the information in brackets in the Gantt chart view as R1[200%]. Commas separate multiple resource assignments.

For our project each activity uses 1 resource while it is scheduled so each row of the "Resource Name" column will have an **R1** entry.

Tracking Resources

Now that we have assigned resources we can track them to see how they are being allocated on our project. The best way to view resource utilization is through a split window view. Select **Window > Split** and maintain the Gantt View in the top window. Select the bottom panel and change this view to resource utilization by selecting **View > Resource Graph**. You should have a view as follows:



Here we see that for the resource R1 that we are using 1-unit on days 1, 9-12 while using 3 units for days 2-8. This corresponds to our earlier suspicion of resource over allocation and this over allocation is show by the <code>Overallocated ===</code> bars that show the maximum resource availability of 2 units. The red bars indicate days in which the resource is over allocated.

Note: if two resources were tracked in the Resource Graph then the scroll bar on the bottom left-side of the plot would be used to scroll through the various resources.

Resource Allocation

We note here that if we are limited with our resources to 2 units per day then we cannot do the project as we had initially planned. We are forced to delay activities until resources are free to undertake the activity. If we delay critical activities then the end date of the project will be extended. MS Project has a tool for allocating resources to minimize the impact on the project schedule.

Before using the resource leveling tool change to top panel to Leveling Gantt view by selecting the top view and selecting **View > More Views...** Select *Leveling Gantt*.



You'll notice here that a new column is added in this view called "Leveling Delay". There is not much hand leveling we could do with the exception of activity H. If we added a 1 day (elapsed day, eday) to activity H, we would reschedule activity H to day 9 from 8. The result would be a gradual resource reduction as follows:



If we disregard the 12 day end date of the project, we can reassign the tasks based on resources available. We had undertaken this by hand calculation in class (Lecture 14) using the ELS heuristic rule for deciding upon activities to schedule.

The leveling tool in MS Project is initiated by selecting **Tools > Level Resources...** from the top menus. This brings up the following dialogue box:

Resource Leveling X							
Leveling calculations C Automatic Look for overallocations on a Day by Day ✓ Clear leveling values before leveling							
Leveling range for 'Project3'							
Level entire project							
C Level Erom: Tue 4/1/08							
Io: Tue 4/15/08							
Resolving overallocations							
Leveling order: Level only within availa ID Only Level only within availa ID Only Standard Leveling can adjust ind Priority, Standard Leveling can create splits in remaining work Level resources with the proposed booking type							
Help Clear Leveling Level Now OK Cancel							

Leveling can be set to occur manually or automatically (I select manual to see the impact of changes I've made). The project can be leveled over the whole or only parts of the project. The main part of the dialogue is the Resolving overallocations section. In leveling order the heuristic rules for delaying activities are decided. For <u>ID only</u>, activities are assigned based on their ID (1 -> 10 in our example). In <u>standard</u>, the assignment is based on least total float (LTF) and later priority. In <u>Priority, Standard</u> mode, you can assign a priority from 1 -> 1000 in the Task Information dialogue box and this will be first used to select activities. Other options for level ordering constrain the solution to the project end date (1st option), allows leveling to adjust when a resource works on a task independent of the other resources working on the same task (2^{end} option), and allows tasks to split (3^{ed} option). Options 2 and 3 are checked by default.

The workflow here is to first clear leveling <u>Ger Levelng.</u>, change any of the required settings and then reschedule the work with the <u>Level New</u> button. The first result from our example yields a similar result to our hand calculation. However, the result is 15 days rather than 14 days as follows:



Here you should note the following:

- The green bars show the result of the previous leveling excise
- The blue bars show the current leveling result activities
- The brown lines to the left of the activity are the leveling delay imposed (C,E,F)
- The blue line to the right of the activities are the free float available (H,I)
- The ... indicates a split activity (I)

The result of leveling shows that project was extended the project by three days. However, resources on days 13 and 14 could be combined to reduce the schedule by one day. However, this would involve moving activity F back a day and rescheduling other tasks. This can be done by increasing the <u>priority</u> of F in the Task Information dialogue to 520. This is slightly higher then the 500 default level set for other activities.

Task Information		×
General Predecessors	Resources Advanced	Notes Custom Fields
Name: F		Duration: 5d 📑 🗖 Estimated
Percent complete: 0%		Priority: 520
Dates		
Start: Thu 4/10/08	▼ Einish: Mon 4/14	¥/08
🔲 Hide task <u>b</u> ar		
<u>R</u> oll up Gantt bar to summary		



If we now re-level the activities, we note that the Leveling Delay for activity F has been reduced from 4 to 3 days and the remaining activities scheduled accordingly.

With this change the duration of the project is reduced now to 14 days. This is the same result as was obtained in our hand calculation. We see from the resource graph that the work has been scheduled with maximum of 2 resource units. Given that activities A and J must occur alone, this is optimal result for the resource restriction.

Reducing Length of Project

If we examine the new critical path, we note substantial changes due to resource leveling. This is most often the case. Of course to reduce the duration B,C,E,F or H would require the addition of a new resource. Otherwise the only opportunity to reduce the project duration would be to reduce the durations of the beginning & end activities (A&J) by possibly utilizing 2 resource units on those days to reduce them to 0.5 days each. This would reduce the overall project to 13 days (only 1 greater than the original) and have a constant resource utilization of 2 units.





<u>Note</u>: Take care when changing the duration of or resources allocated to an activity. Activities become effort driven when resources are utilized. The default setting used is <u>constant units</u>. This means that a unit of resource effort has a constant capacity. If you decrease activity duration more resources are assign or the total effort (work) in the activity is reduced. If you assign more resources, this reduced activity duration or increases work effort.