Benefits of Using Advanced Scheduling Technology With Primavera P6 Versus Resource-Leveling Only

INTRODUCTION

Primavera P6 Enterprise Project Portfolio Management is a powerful, robust, and easy to use solution for globally prioritizing, planning, managing and executing projects, programs and portfolios. Primavera P6 Enterprise Project Portfolio Management is an integrated project portfolio management (PPM) solution comprising role-specific functionality to satisfy each team member's needs, responsibilities and skills. It provides a solution for managing projects of any size, adapts to various levels of complexities within a project, and intelligently scales to meet the needs of various roles, functions, or skill levels in your organization and on your project team.

Primavera P6 provide a
resource leveling
capability with graphical support to assist users better understand resource usage and optimize resource utilization *by hand*.

The goal of *resource leveling* in Primavera P6 is to provide the user with *a* valid resource loaded schedule that does not have any over allocated resources. Primavera P6 does not try to optimize the allocation of resources in order to generate the shortest resource leveled schedule. Even though Primavera does not purport to providing and optimize schedule, is likely that many users of Primavera P6 are NOT aware that the results from the resource leveling process are not optimal, and could be improved upon significantly.

So in this Whitepaper,

- *resource leveling* will refer to the functionality provided in Primavera P6 and other commercial project management software, and
- *advanced scheduling technology* will refer to resource-constrained scheduling that attempts to optimize the utilization of resources to minimize the project duration.

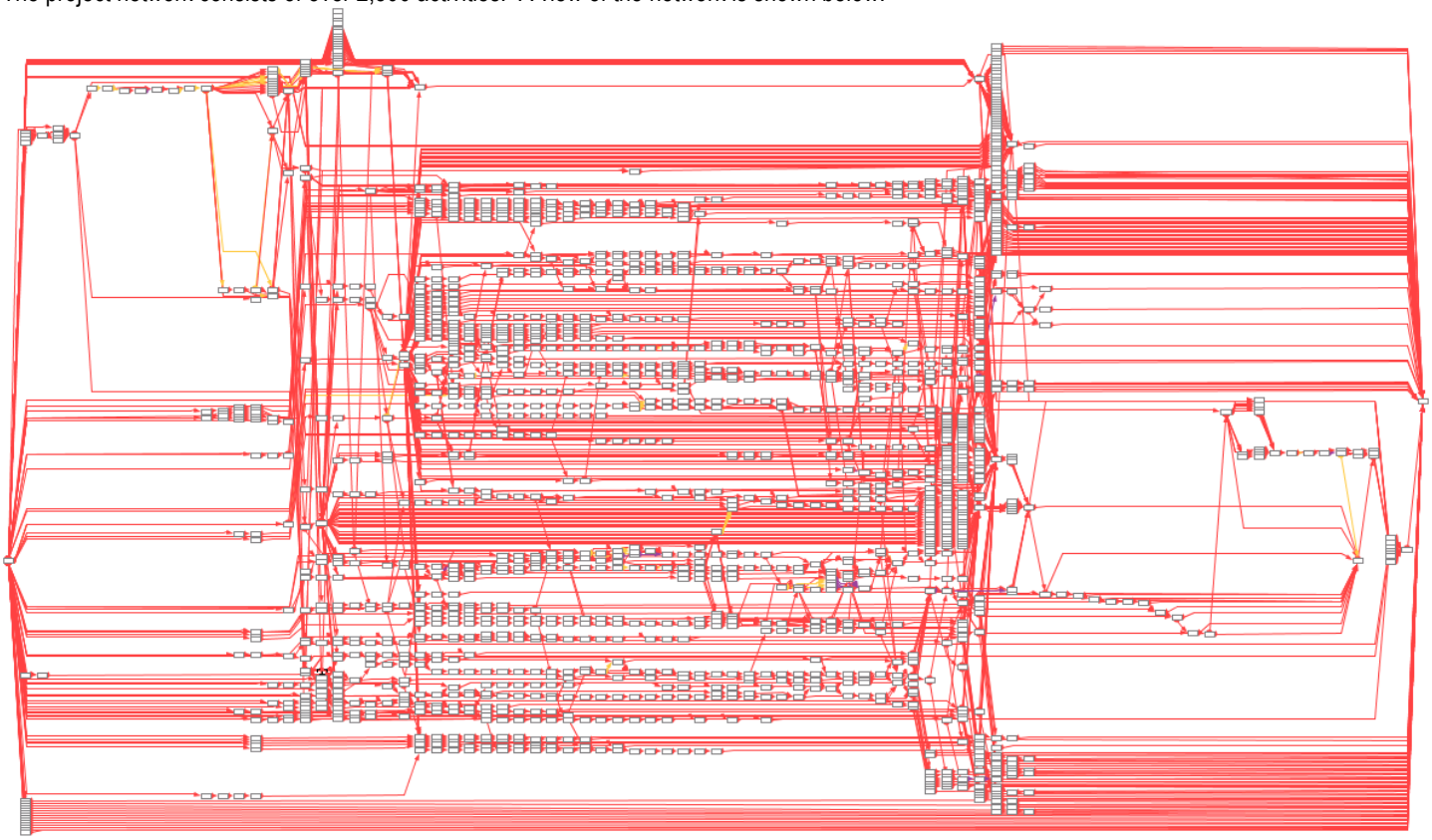
For projects that are time critical/resource intensive, advanced scheduling technology can significantly shorten project duration. Aurora is an intelligent advanced scheduling engine that can be utilized with Primavera P6 to generate shorter schedules. This whitepaper will illustrate these benefits via the analysis of a real refinery turnaround project. In addition, another example from manufacturing will demonstrate that similar results occur for other resource-loaded schedules.

1. Refinery Turnaround Leveraging Advanced Scheduling Technology

Stottler Henke and a respected P6 consulting company worked in conjunction to analyze a real-world oil refinery turnaround project via

- Primavera P6 only (utilizing its resource-leveling capability), and
- Primavera P6 leveraging Aurora's advanced scheduling technology.

The project network consists of over 2,500 activities. A view of the network is shown below.



The results of the analyses are a follows:

Primavera P6 resource-leveling	**67 days, 3 hours**	**= 67.125 days**
Primavera P6 leveraging Aurora Advanced Scheduling	**56 days, 6 hours, 30 minutes**	**= 56.27 days**

The difference is absolute terms is over 10.5 days. There are a few ways to compare these results; the simplest is to simply compare overall durations, using the Aurora Advanced Scheduling results as the basis:

Primavera P6 resource-leveling is	**19.3% longer** than Aurora	(67.125 - 56.27) / 56.27

Using the P6 resource-leveling as the bases:

Aurora Advanced Scheduling is	**16.2% shorter** than Primavera P6 resource-leveling	(67.125 - 56.27) / 67.125

Another valuable perspective is comparing the resource-constrained result with the Critical Path that is the situation assuming unlimited resources. Why is this perspective valuable? Because the Critical Path is the best case scenario, and the valid schedule when considering resources must always be longer than the Critical Path, so the length longer than the Critical Path is the only portion of the total project duration that the resource-leveling or advanced scheduling can effect.

The Critical Path for the refinery turnaround project is **46 days**.

Primavera P6 resource-leveling results longer than Critical Path	**21.125 days**	
Percent longer than Critical Path	**45.9 %**	21.125 / 46
Primavera P6 leveraging Aurora Advanced Scheduling results longer than Critical Path	**10.27 days**	
Percent longer than Critical Path	**22 %**	10.27 / 46

The percent difference between days more than Critical Path for resource leveling and advanced scheduling is
105.70% (21.125 - 10.27) / 10.27

All the results demonstrate the significant benefit of leveraging Aurora Advanced Scheduling in conjunction with Primavera P6. Recall that everything besides the method for scheduling is that same in both cases. Leveraging Aurora saved over 10.5 days, and all the associated costs with all the resources that are needed, as well as the lost revenue from the refinery being unavailable.

Of course the cost savings and other benefits of leveraging Aurora are huge for the initial plan, but even more potential benefit comes in the execution phase of the project, where unexpected circumstances need to be dealt with. By leveraging Aurora with Primavera P6 rescheduling can by done quickly and the updated schedule will be shorter than if one used resource-leveling only. Therefore, every time a re-schedule is performed the overall benefit of leveraging Aurora increases.

Work Process when leveraging Aurora's Advanced Scheduling Technology with Primavera P6

The user works in Primavera P6 just as they always have when leveraging Aurora. That is, the model is developed in Primavera P6 during planning, the results of the scheduling is viewed and analyzed in Primavera P6, the execution updates are also all done in Primavera P6, and everything else is done Primavera P6 as it has always been done.

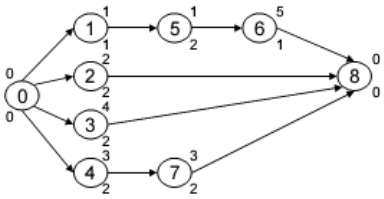
So where are the changes when leveraging Aurora with P6? The only changes come when the user wants to schedule, that is, only when a user would formerly select resource-level. The plan is to provide a menu below the current resource-level menu option called *Schedule with Aurora* that will seamlessly schedule the project with Aurora's scheduling engine and seamlessly update the schedule in Primavera P6. At the time of the writing of this Whitepaper, the user needs to export the project as XML, import into Aurora, schedule in Aurora, and then export the project as XML, import into Primavera P6.

Why is Scheduling Difficult?

Starting with the non-resource constrained situation helps illustrate the resource constrained situation. In the NON-resource constrained case (infinite resources) the scheduling engine needs to take into account all the technical/temporal constraints when determining the schedule. In the mathematical sense, this problem is solvable and every project management software package should output the same result. However, once resources are introduced the problem becomes much more complex. This can be understood intuitively by considering all the resources that could be required to complete an activity. A single real-world activity could require multiple people each needing specific skills and access to specific pieces of equipment in limited supply, furthermore the space were the activity occurs is shared by other activities so this activity can not occur when some or all of those other activities. There could be other types of constraints that may to be considered also. It is obvious that the resource constrained situation is significantly more complex than the purely temporal case. Mathematically, the resource-constrained project scheduling problem is NP-hard (nondeterministic polynomial-time hard). This means that there is realistically no way to guarantee that the result provided is the optimal result.

It is likely that many *users of commercial project management software are NOT aware that the results from the resource leveling process are not optimal, and could be improved upon significantly*. It is ironic or at least disappointing, that project teams that have put in the significant effort and cost to create a resource-constrained model could reap huge time and cost savings simply by running there already built model through a different scheduling engine.

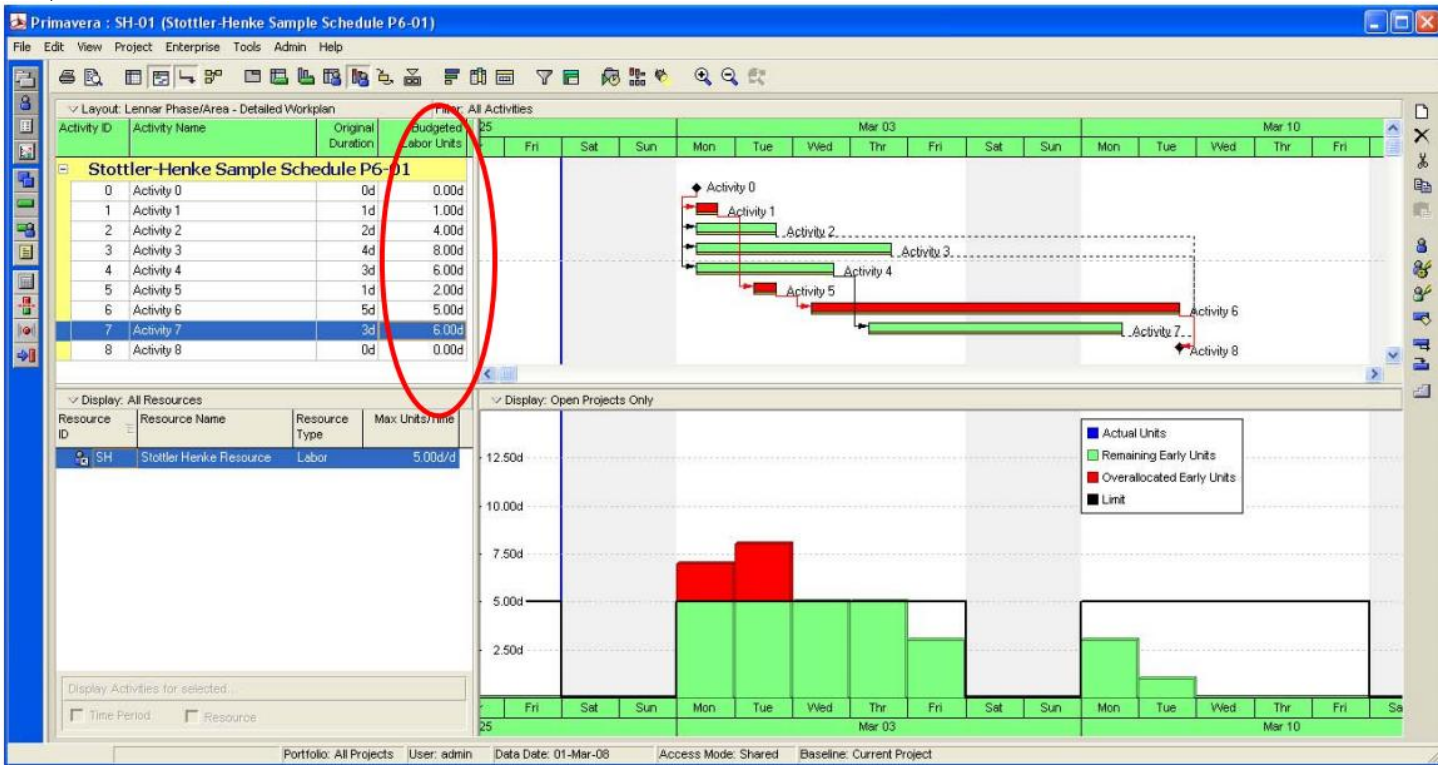
To illustrate the difficulty of resource-constrained scheduling a small project network will be used. It is fortunate that these effects can be seen at this scale because due to the inherent complexity of the resource constrained scheduling problem, it is difficult/impossible to visualize what is occurring for larger networks. The illustrative network is from Demeulemeester, E., Herroelen, W.S., Simpson, W., Baroum, S., Patterson, J.H. and Yang, K.-K. (1994). European Journal of Operational Research, 76, 218-228.



The information in the figure (on the left) is defined as follows:

- Task name/number: # inside circle
- Activity duration in days # above node
- Resource units required: # below node.

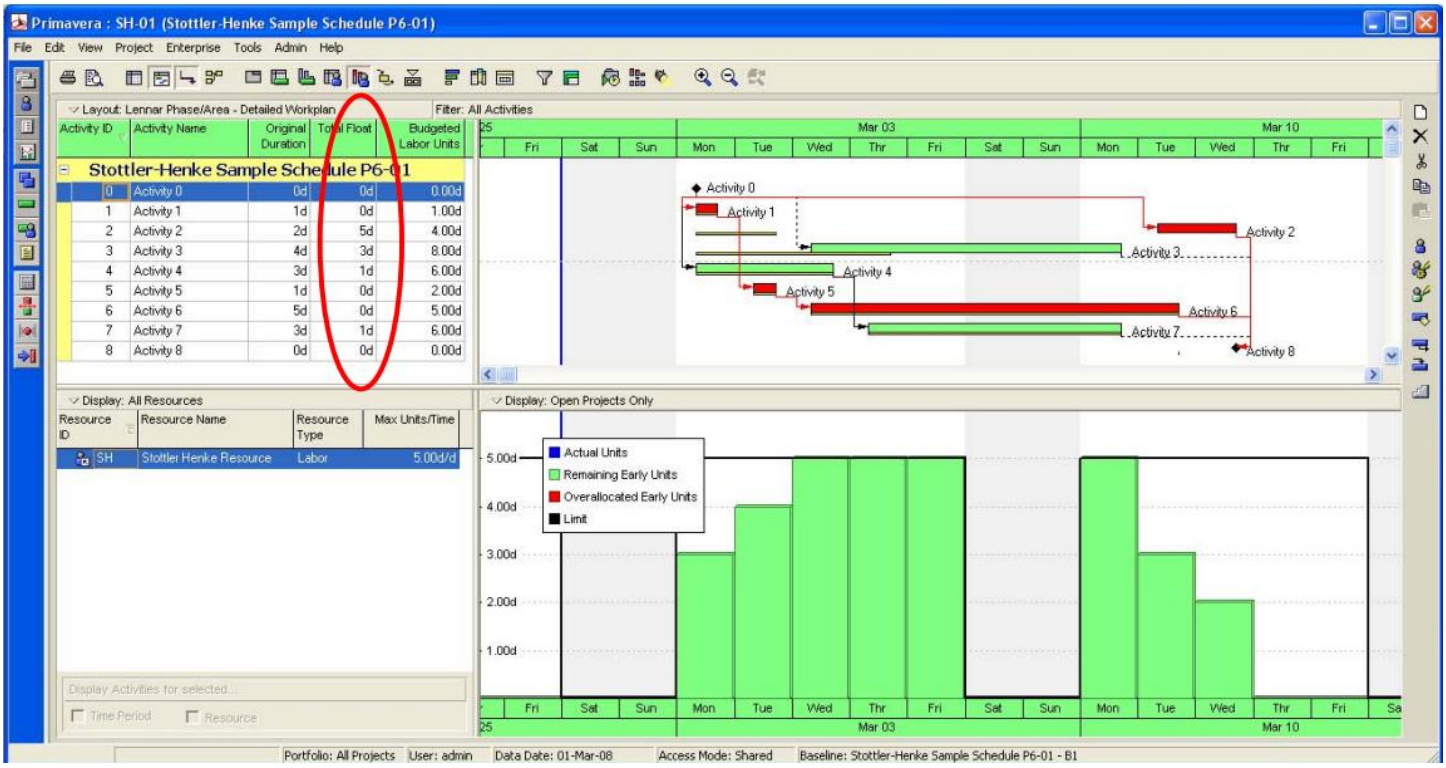
The Critical Path (i.e., scheduling assuming infinite resources) is 7 as shown in the Primavera P6 Gantt chart above (assuming a five-day work week).



Next a resource limit is set.

- 5 units of resource available.

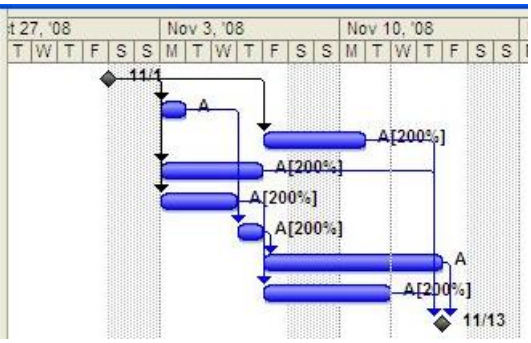
Resource-leveling in Primavera P6 results in the following



So the resource-leveled result is 8 days for Primavera P6.

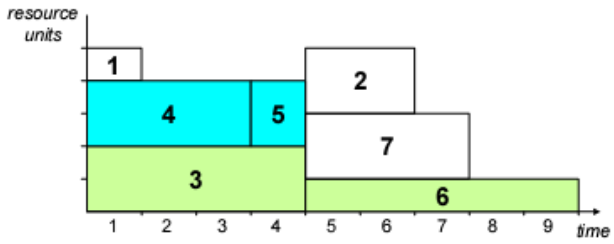
If this same problem is resource-leveled in MS Project 2003 or 2007 the result is 9 days as shown below.

	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	T0	0 hrs	Sat 11/1/08 12:00 AM	Sat 11/1/08 12:00 AM		
2	T1	8 hrs	Mon 11/3/08 8:00 AM	Mon 11/3/08 5:00 PM	1	A
3	T2	16 hrs	Fri 11/7/08 8:00 AM	Mon 11/10/08 5:00 PM	1	A[200%]
4	T3	32 hrs	Mon 11/3/08 8:00 AM	Thu 11/6/08 5:00 PM	1	A[200%]
5	T4	24 hrs	Mon 11/3/08 8:00 AM	Wed 11/5/08 5:00 PM	1	A[200%]
6	T5	8 hrs	Thu 11/6/08 8:00 AM	Thu 11/6/08 5:00 PM	2	A[200%]
7	T6	40 hrs	Fri 11/7/08 8:00 AM	Thu 11/13/08 5:00 PM	6	A
8	T7	24 hrs	Fri 11/7/08 8:00 AM	Tue 11/11/08 5:00 PM	5	A[200%]
9	T8	0 hrs	Thu 11/13/08 5:00 PM	Thu 11/13/08 5:00 PM	7,8,3,4	

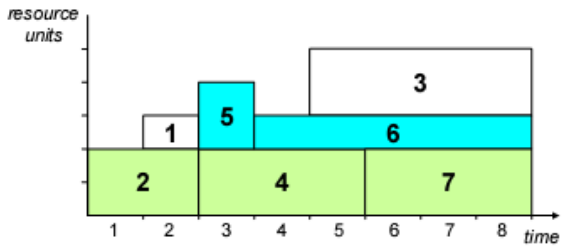


Looking at the Gantt charts you can see that each program lays out the tasks quite differently.

The image below provides another way of looking at the MS Project results.

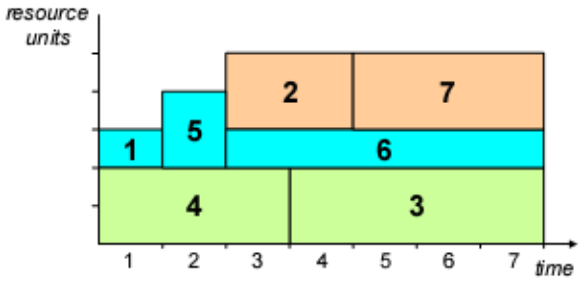


Aurora also finds a result that takes 8 days, Aurora's solution is shown below.



Again, notice how different the results are.

Since the problem is small enough the actual globally optimal schedule can be found and it is illustrated below, the minimum resource loaded project duration is 7 units of time.



Note that this problem only dealt with one type of resource. The problem of scheduling while taking into account resources is non-trivial, even for small projects.

This illustration should hint at the level of complexity that occurs as many more different types of resource constraints are introduced. For example, in many domains, such as refinery turnaround and aircraft assembly there can be multiple resources per task, for example there are numerous space-related issues (only so many workers will fit in a given area, and some actions may permanently eliminate possible workspace), so space becomes a significant resource that needs to be managed.

Brief Aurora History

Aurora evolved out of the needs of NASA and later the United Space Alliance, and finally in its application to industry. Aurora evolved over many generations, and the latest generation is the result of a major re-design, where Stottler Henke systematically looked at every planning and scheduling system Stottler Henke had ever developed, and looked at all the decisions that a planning and scheduling system has to make and

designed and implemented an architecture such that it was easy to customize every one of those decisions. This latest evolution has been chosen by the United Space Alliance as the onboard planner / scheduler for astronauts to use on the Crew Exploration Vehicle (the replacement for the Space Shuttle), and industry operational use includes Boeing for the final assembly of the Boeing B787 Dreamliner.

Aurora is used in the planning and scheduling of extremely complex processes involving thousands of operations. Each operation can require a combination of resources (facilities, equipment, personnel). Aurora is adaptable to different domains that each have their own set of additional constraints, examples include the safety limitations and floor plan layout coordination involved in preparing components for the International Space Station (ISS); non-concurrency and offset constraints to allow necessary safety and practicality controls over scheduling astronaut time; and physical space constraints, including addition and removal of these constraints, and ergonomic constraints involved in airplane assembly. Finally, Aurora has evolved to meet the real-world challenges of endless changes to the schedule caused by late deliveries, other delays (e.g., launches), and malfunctioning equipment.

CONCLUSIONS

Consider the amount of work that is put into developing a project network, days, weeks, months before selecting resource-level option. Presently there my be significant amounts of time and effort put into optimizing the results of the Primavera P6 resource-leveling results to derive a shorter project Now with a trivial amount of additional effort after the network development, a shorter duration project can be calculated automatically saving the significant amounts of time and effort put into optimizing the results of the Primavera P6 resource-leveling results. Or put another, leveraging Aurora saves effort and provides better results.

In this paper we have shown that resource constrained schedules and therefore resource constrained project management is greatly affected by the underlying resource-leveling / scheduling engine – more so as the project becomes larger and includes larger numbers of resource requirements and other non-temporal constraints. It is unfortunate that project teams that have put in the significant effort and cost to create a resource-constrained model may not know that they could potentially reap huge time and cost savings simply by running there already built model through a different scheduling engine.