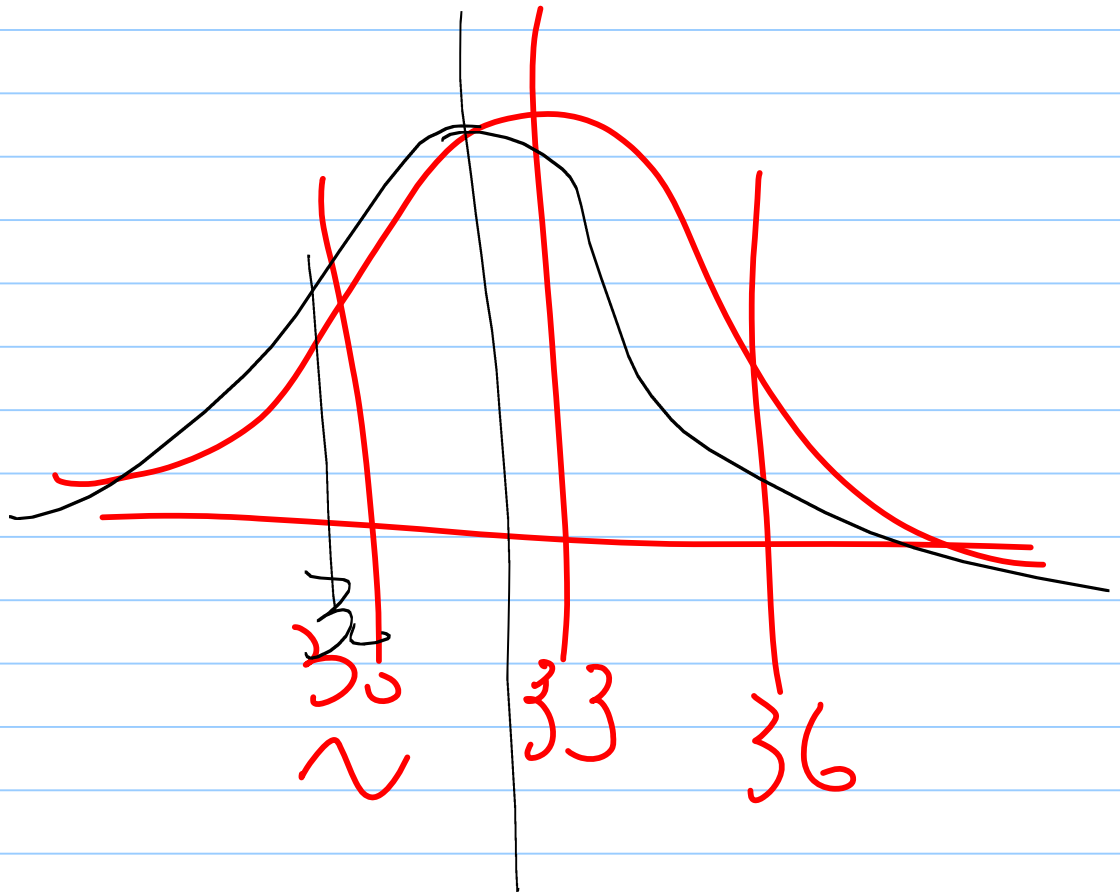
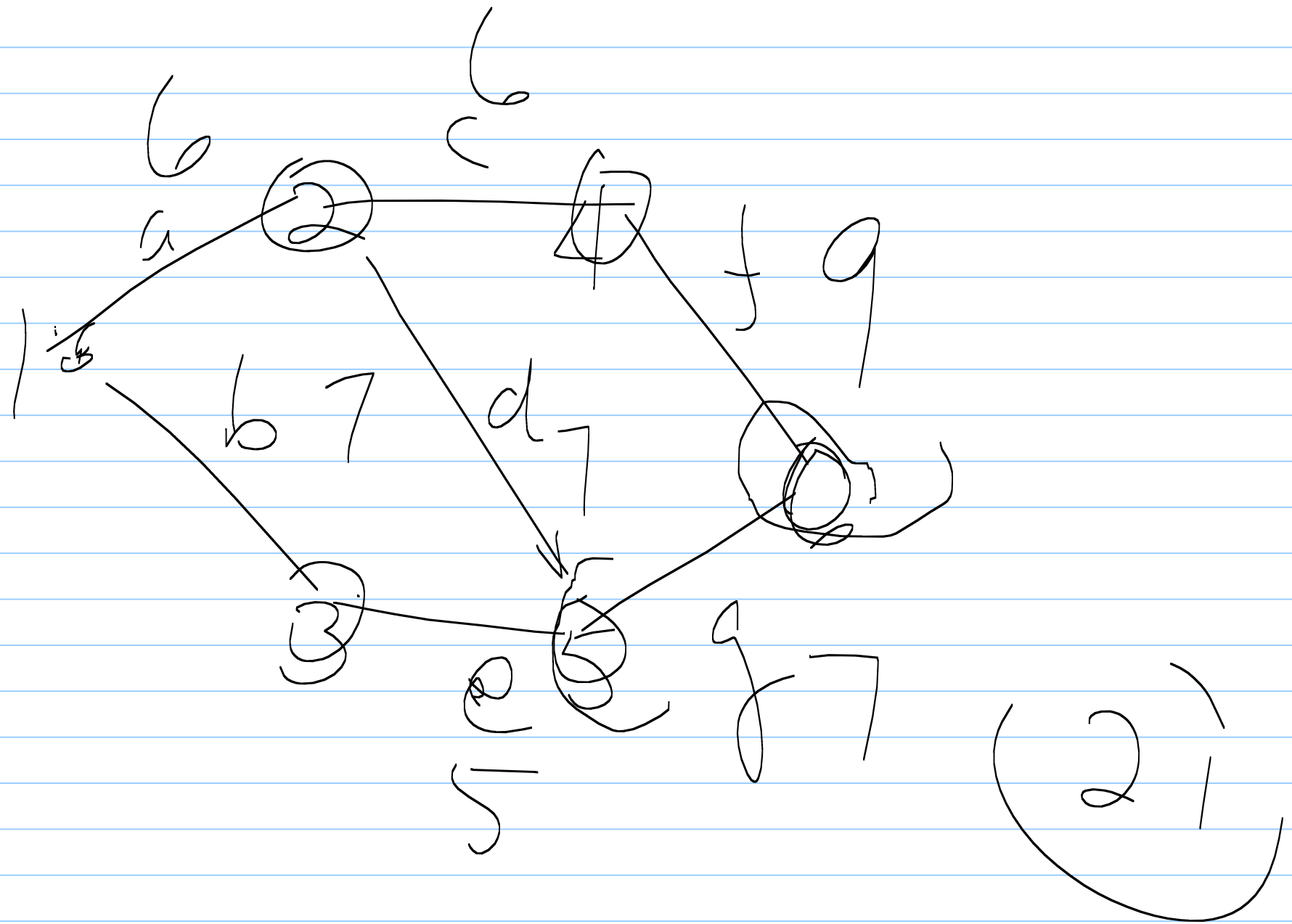
Note Title 3/1/2010





Session 13
University of Southern California
IOM455, March 01, 2010

Outline

- **Questions? Comments?**
- **Homework solution**
- **Give Assignment**
- **Session – Chapter 6 – Outline only**
  - **Crashing**
  - **Resource allocation problem**
  - **Resource Loading**
  - **Resource leveling**
  - **Constrained resource scheduling**
  - **Multi-project scheduling and resource allocation**
  - **Goldratt's critical chain**

Resource Allocation

- **Critical Path - Crashing**
- **Resource**
  - **Allocation**
  - **Loading**
  - **Leveling**
- **Constrained Resource Scheduling**
- **Multi-project Scheduling**
- **Goldratt**

Critical path - crashing

In CPM, one can specify two time/cost pairs – normal and crash

For example 5 days at $1000/day or 3 days at $2000/day

Resource availability must be considered

Expediting tends to create problems

Cost/Time slope =(crash cost – normal cost)/(crash time – normal time)

For the above example = $1000/(-2) = -$500/day

Frequent discontinuities in time and cost

Crashing

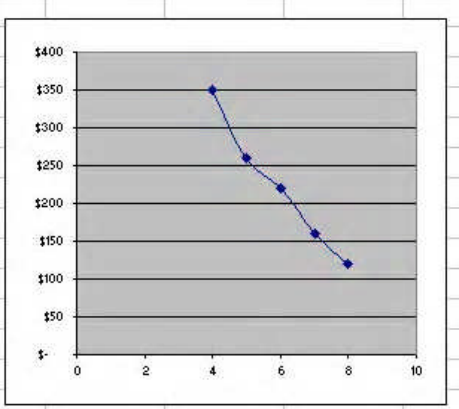
Start with the critical path

Crash selected activities, one at a time at minimum additional cost

		Duration		Cost									Paths			
Activity	Precedence	Normal	Crash	Normal	Crash	Slope	ES	EF	LF	LS	Slack	Crit.	a-b-e	a-c	a-d	
a		3	2	40	80	-40	0	3	3	0	0	1	8	5	7	Normal
b	a	2	1	20	80	-60	3	5	5	3	0	1	4	4	3	Crash all
c	a	2	2	20	20		3	5	8	6	3	0				
d	a	4	1	30	120	-30	3	7	8	4	1	0				
e	b	3	1	10	80	-70	5	8	8	5	0	1				
Finish	c,d,e	0	0	0	0		8	8	8	8	0					
	Total	14	7	$ 120	$380											

Cost to reduce one day		Cost to reduce two days		Cost to reduce 3 days		4 days	
a	$ 40	a-b	$ 100	e-a-d	$140	a-b-e-d	$ 230
b	$ 60	e-a	$ 110	e-b-d	$160		
Min	$ 40	e-d	$ 100	Min	$140		
		Min	$ 100				
Total	$ 160		$ 220		$260		$ 350

4	$ 350
5	$ 260
6	$ 220
7	$ 160
8	$ 120



Input

When one might chooses to crash a project? Is crashing a project common in the industry? Los Angeles earthquake example was an emergency situation. Do these kinds of situations arise in industry often? Which method is more commonly used in the industry for constrained resource scheduling: heuristics or optimization method?

As a due date for any activity approaches, people realize that they will have difficulty meeting it and attempt to accelerate their efforts. (As am I, sitting here this morning getting ready for today's classes) Thus, almost every project is crashed, even if people are unfamiliar with the term or the concepts.

Heuristics are much more common.

Fast tracking

Overlapping of activities – allow a successor to start before a predecessor is complete

Results

- **Possibly an earlier completion**
- **Increased change orders**
- **Loss of productivity**
- **Increased cost**
- **Loss of time**

Use when early steps are fairly routine

The Resource Allocation problem

Resource must be described specifically by

- **Individual labor**
- **Specific machines**
- **Specific facilities**
- **Specific materials**

Since time cannot be inventoried or renewed, the timing of the use of resources must be specified. It is not sufficient to say that I need a total of 50 hours this months and have a 160 available.

Almost all trade offs involve additional costs

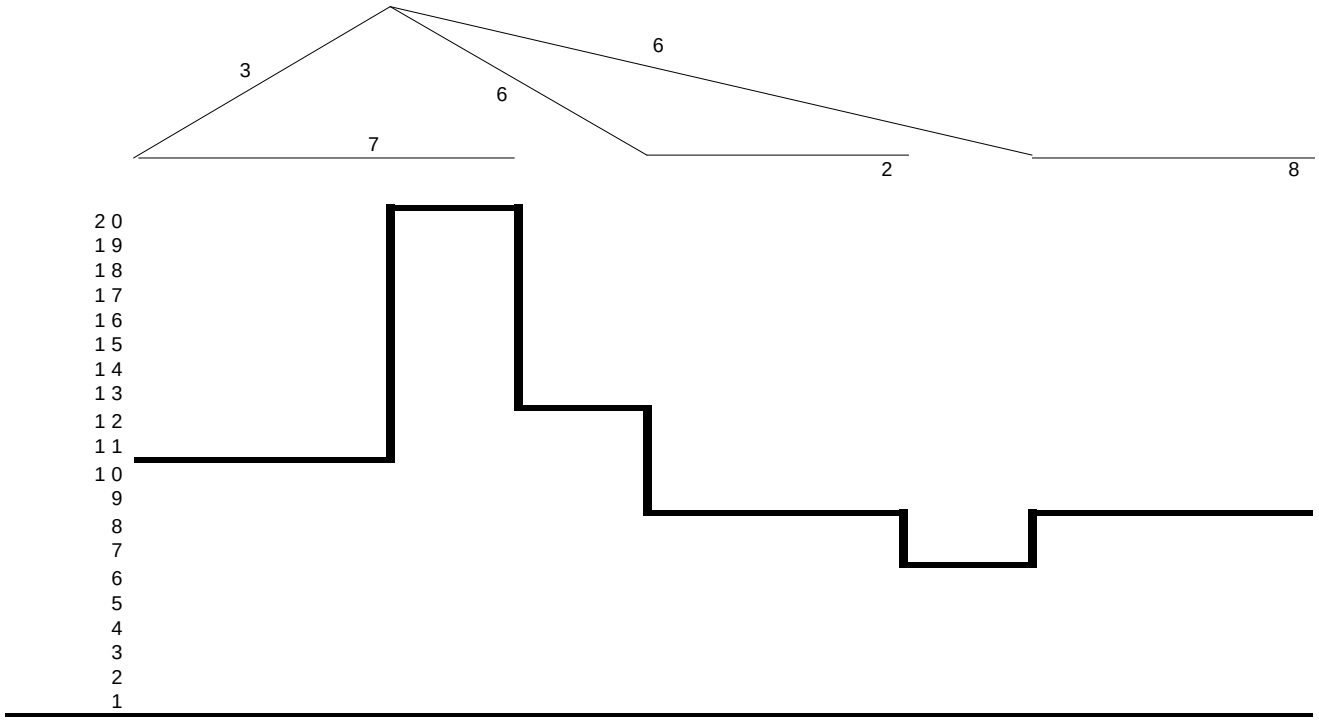
Two types: Time limited or resource limited

Resource loading and leveling

- Amount of a specific resource required by a project during a specific time (e.g. I am required for this class from noon until 1:50 on Mondays and Wednesdays)
- An example is in the next two slides – it assumes that the resources are interchangeable and can be measured by a common unit – Grocery store check-out clerks would be one example
- Large fluctuations in utilization are undesirable
- Leveling aims to reduce the variations by shifting tasks within their slack allowances
- Leveling resource usage also levels cash flow
- Do not schedule beyond 85 to 90% capacity due to uncertainties – the book implies that this is not necessary for manufacturing but experience says otherwise!

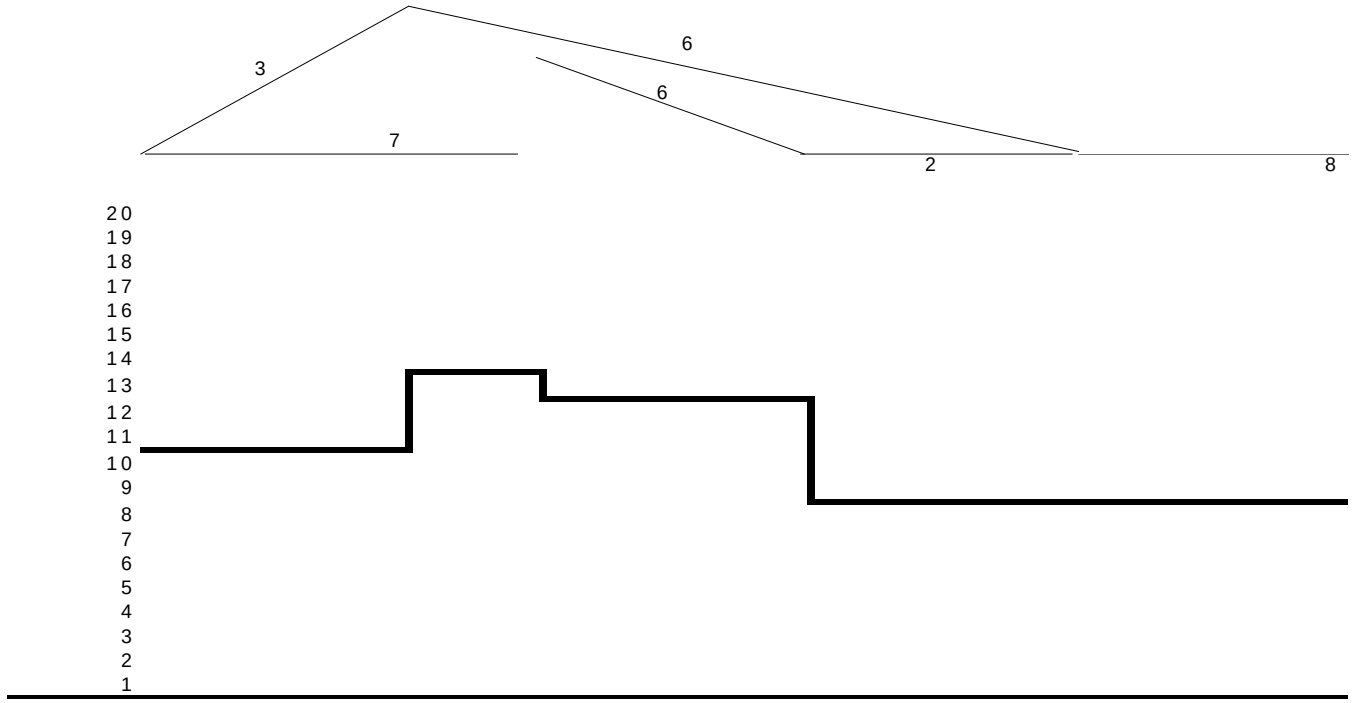
Resource Allocation

Assume a single resource, that is, people for each task:



Resource Allocation

By delaying tasks D and E to their latest start time, we can level the resource usage somewhat:



Heuristics and Optimization

Heuristic – accepted rules of thumb approaches that are believed to yield good results

Optimization –mathematical techniques that yield optimal solutions

Large, non-linear, complex problems can generally not be solved optimally in a reasonable amount of time

In effect, most heuristics are simulations based on priority rules:

When faced with a choice of which task to assign to a scarce resource, the choice is made according to apriori rules or on randomized choices of rules or randomly

Common priority rules

- **As soon as possible**
- **As late as possible**
- **Shortest first**
- **Most resources first**
- **Least slack first**
- **Most critical followers**
- **Most successors**
- **Random**

Higher priority project by definition or value to the client or organization

Heuristics

Simulation will end when:

- **All activities are scheduled**
- **Runs out of resources before all activities are scheduled**

Simulations are frequently run in reverse – back from the due date. If the latest start is before the current time, the project cannot be done on to time

Goldratt

Known for Theory of Constraints – One activity controls the throughput of a system

Problems:

1. **Project's scope is changed without consultation or warning, without change in schedule or budget**
2. **Due dates are set without regard to resources**
3. **Impossible to achieve objectives within budget**
4. **Work load and due dates set externally without regard to the nature of the project and resources required**
5. **Due dates are used as an incentive**

Goldratt't Critical Chain

According to an article in Wikipedia (http://en.wikipedia.org/wiki/Critical_chain) a Critical Chain is partially explained as follows:

> **A critical chain in project management is the sequence of both precedence and resource dependent terminal elements that obstructs a project from being completed in lesser time, given finite resources. If the resources are available in unbounded quantities, then a project's critical chain will be identical to its critical path.**
>
> **The Critical chain is used as another means to analyze a critical path. The major differences between critical chain and critical path are:**
>
> > **"*The use of (often implicit) resource dependencies*. Implicit means that they are not included in the project network but have to be identified by looking at the resource requirements."**
> >
> > **"*Lack of search for an optimum solution*. This means that a "good enough" solution is enough because:**

Goldratt't Critical Chain

"As far as is known, there is no analytical method of finding an absolute optimum (*i.e.* having the overall shortest critical chain)."

"The inherent uncertainty in estimates is much greater than the difference between the optimum and near-optimum ("good enough" solutions)."

***"The identification and insertion of buffers*:**

project buffer

feeding buffers

resource buffers."

Goldratt (cont)

What creates optimistic schedules?

- **Optimism without thinking**
- **Setting capacity near demand**
- **Postponing to start to latest start**
- **Switching between jobs**
- **Ignoring variation due to complexity**
- **Assuming people will work harder under impossible targets**
- **Padding estimates and responding by deleting requested resources**

Goldratt (cont)

Do early finishes cancel out late ones?

Not usually, because people will postpone the start of successors of predecessors that finish early

Input – "Student Syndrome"

In Section 6.6, Goldratt describes the "student syndrome", and states that it is common for activities with high slack to be delayed until the slack is gone. Based on your experiences, could this theory be used to justify scheduling project completion for an extremely optimistic time duration, in effort to prevent expending all of the project's slack?

I think you mean pessimistic- that way the duration will take the place of the slack. I don't think it will work because most people see through the ruse and delay the start anyway. Goldratt does suggest doing this.

"Never do today what you can postpone to tomorrow"

Goldratt – critical chain

Create buffer time at end of the project

Create buffer in front of the critical resource (keep it working)

Order tasks with resource dependencies sequentially