

ISyE 6201: Manufacturing Systems
Instructor: Spyros Reveliotis
Spring 2007

Homework #4

Due Date: Thursday, 4/5/07

Reading Assignment:

As discussed in class, for this part of the course you are expected to read the material of Chapters 7-10 and 18, in parallel to the in-class developments.

This particular homework pertains especially to Chapters 7, 10 and 18.

You can also refer to the slides on Factory Physics posted at the course website:

http://www2.isye.gatech.edu/~spyros/courses/IE6201/Spring-07/course_materials.html

Problem Set:

A. Answer the following questions:

- 2, 3 and 5 at the end of Chapter 7 of your textbook
- 5 and 6 at the end of Chapter 18 of your textbook.
- Consider a CONWIP-controlled flow line consisting of four single-machine stations with corresponding mean processing times 4, 1.5, 2.5 and 4 minutes. The line is fed with raw material from another process that is currently very unstable, presenting very long outages, and as a result, the average WIP across the entire line has been at the level of 2 parts. If the initial intention was to run the line at a production rate of 12 parts per hour, explain why this objective is unattainable in the prevailing regime.

B. Solve the following problems:

- 1, 2, 3 and 6 at the end of Chapter 7 of your textbook.
- Problem 1 and 5 at the end of Chapter 10 of your textbook.
- Problem 27 on ALB provided in the attached pages (For part (b) interpret the “minimum number of stations” as the lower bound computed through the approach presented in class and also discussed in the textbook – as pointed out in class, this bound might not be attainable.)

C. Extra Credit (20%)

The current number of cards (i.e., WIP level), W , of a CONWIP line has been set to a level that enables the line to produce at 80% of its bottleneck rate, r_b .

i. Assuming that

- The current performance of the line is better than its “practical worst case” performance, and

- W is substantially greater than the critical WIP of the line, W_0 , so that an increase of the WIP level by ΔW will cause an increase of the cycle time ΔCT that is linearly related to ΔW ,

find the required relative increase of W in order to achieve a production rate equal to $0.85r_b$.

- ii. If we change Assumption (b) above so that the point (W, CT) characterizing the current performance of the line is still on the non-linear part of the curve that characterizes the line performance in the W - CT plane, do you expect the required WIP increase to be greater, lower, or equal to that computed in part (i)? Justify your answer.

Hints: For part (i) think what is the slope for the suggested linear relationship, and use this information together with Little's law. For part (ii) consider that the considered curve is convex.

Finally, in your study and your work on the homework, please, remember to consult the document with the errata regarding your textbook, that can be found at:

http://www.factoryphysics.net/factoryphysics/Documents/Errata_for_Second_Edition.pdf

An alternative choice is to stay with the six stations, but see if a six-station balance can be obtained with a cycle time less than 15 minutes. It turns out that for values of the cycle time of both 14 minutes and 13 minutes, the ranked positional weight method will give six-station balances. The $C = 13$ solution is

Station	1	2	3	4	5	6
Tasks	1	2, 3	6	4, 5, 7, 9	8, 10	11, 12
Idle time	1	1	1	1	4	0

Thirteen minutes appear to be the minimum cycle time with six stations. The total idle time of eight minutes resulting from the balance above is two minutes less than that achieved with five stations when $C = 16$. The production rate with six stations and $C = 13$ would be 32.3 units per day per operation. Increasing the number of stations from five to six results in a substantial improvement in the throughput rate.

In this section we presented the ranked positional weight heuristic for solving the assembly line balancing problem. Other heuristic methods exist as well. One is COMSOAL, a computer-based heuristic developed by Arcus (1966). The method is efficient for large problems involving many tasks and workstations. Kilbridge and Wester (1961) suggest a method similar to the ranked positional weight technique.

There are optimal procedures for solving the line balancing problem, but the calculations are complex and time-consuming, requiring either dynamic programming (Held et al., 1963) or integer programming (Thangavelu and Shetty, 1971). More recent interest in the line balancing problem has focused on issues relating to uncertainty in the performance times for the individual tasks. (See Hillier and Boling, 1986, and the references contained there.)

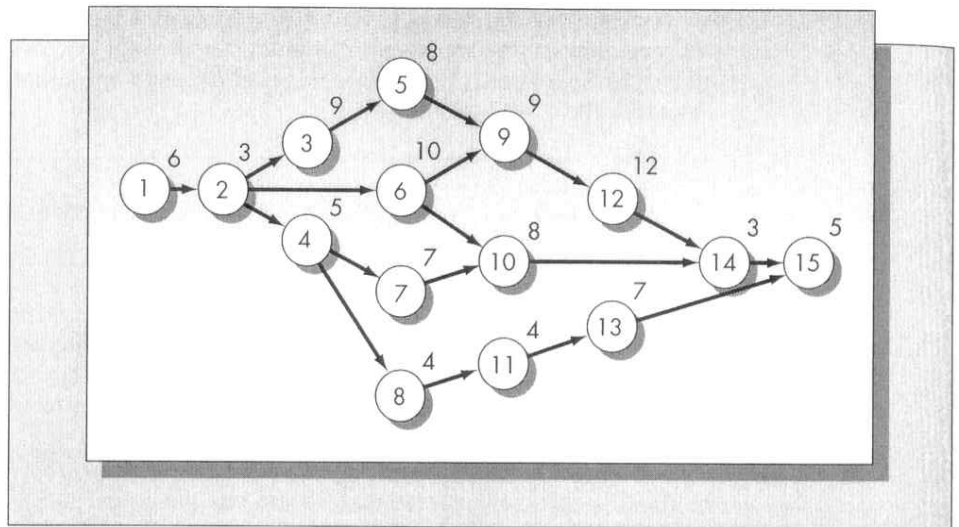
Virtually all assembly line balancing procedures assume that the objective is to minimize the total idle time at all workstations. However, as we saw in this section, an optimal balance for a fixed cycle time may not be optimal in a global sense. Carlson and Rosenblatt (1985) suggest that most assembly line balancing procedures are based on an incorrect objective. The authors claim that maximizing profit (rather than minimizing idle time) would give a different solution to most assembly line balancing problems, and they present several models in which both numbers of stations and cycle time are decision variables.

Problems for Section 8.10

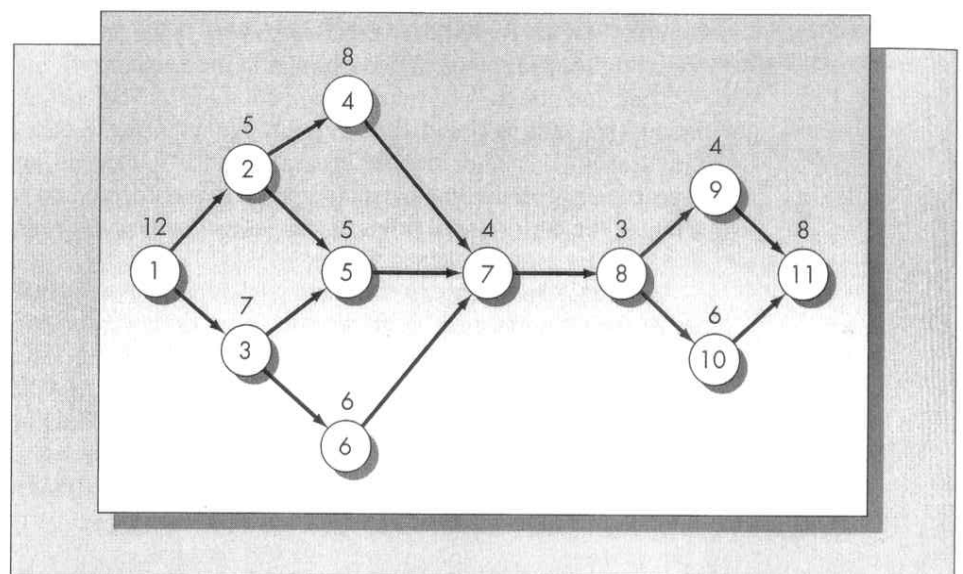
26. Consider the example of Noname computers presented in this section.
 - a. What is the minimum cycle time that is possible? What is the minimum number of stations that would theoretically be required to achieve this cycle time?
 - b. Based on the ranked positional weight technique, how many stations are actually required for the cycle time indicated in part (a)?
 - c. Suppose that the owner of the company that sells Noname computers finds that he is receiving orders for approximately 100 computers per day. How many separate assembly lines are required assuming (i) the best five-station balance, (ii) the best six-station balance (both determined in the text), and (iii) the balance you obtained in part (b)? Discuss the trade-offs involved with each choice.
27. A production facility assembles inexpensive telephones on a production line. The assembly requires 15 tasks with precedence relationships and activity times as shown in Figure 8-16. The activity times appear next to the node numbers in the network.

FIGURE 8-16

(For Problem 27)

**FIGURE 8-17**

(For Problem 29)



- a. Determine positional weights for each of the activities.
 - b. For a cycle time of 30 units, what is the minimum number of stations that could be achieved? Find the $C = 30$ balance obtained using the ranked positional weight technique.
 - c. Is there a solution with the same number of stations you found in part (b) but with a lower cycle time? In particular, what appears to be the minimum cycle time that gives a balance with the same number of stations you found in part (b)?
28. For the data given in Problem 27, determine by experimentation the minimum cycle time for a three-station balance.
 29. Consider the assembly line balancing problem represented by the network in Figure 8-17. The performance times are shown above the nodes.
 - a. Determine a balance for $C = 15$.
 - b. Determine a balance for $C = 20$.