LUNDS TEKNISKA
HÖGSKOLA
Lunds universitet

Institutionen för
REGLERTEKNIK

Market-driven System

Exam, May 27 2011 at 14–19

Points and grades

All answers must include a clear motivation. The total number of points is 25. The maximum number of points is specified for each subproblem. Preliminary grades:

Betyg 3: 12 – 16.5 points
4: 17 – 21.5 points
5: 22 – 25 points

Accepted Aid

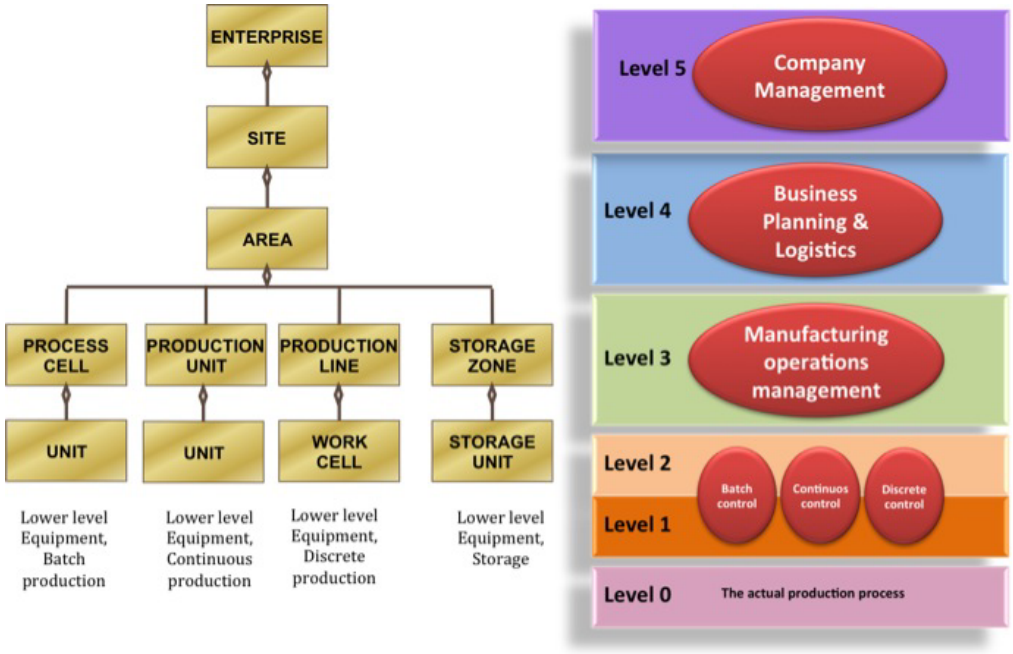
Accepted aids are: Standard mathematical tables and authorized "Formelsamling i reglerteknik", as well as pocket calculator.

Results

The result will be available Tuesday June 7 2011. The results will be shown on the notice-board at the Department of Automatic Control, 1st floor M-building.

1. Industrial production processes can be classified as being; continuous, discrete and batch. In breif, continuous processes have a continuous outflow, discrete processes have a discrete output, and the output of a batch process is refered to as a batch or lot. Present and explain two additional characteristics of each production type (3 p)

2. In order to help select software products and information systems in a company, a framework is needed. The framework can be used to structure the company and, among other things, locate where various functions should reside. A framework used for this purpose is the Purdue Enterprise Reference Architecture (PERA). PERA gives a structure to the physical hierarchies in a company, see figur 1 (left), the organizational hierarchies (not shown here) and the functional hierarchies, see figur 1 (right).



Figur 1 The physical hierarchy (left) and functional hierarchy (right) of the PERA model.

a. Describe the five functional levels. The description should contain explainations of at least two typical functionalities at each level. (2,5 p)

b. This problem is ONLY for the members of the project-group ”Rockwell”.
In this project a laboratory session was set up using hardware and software from Rockwell Automation (Allan Bradley). The task was to control a servo motor and/or a DC-motor. The software modules used in the project were; RSLinx Classic, RSLogix5000 and Factory Talk View Studio ME. Where in the functional hierarchy would you place thses software modules? Do not forget to motivate your answer. (1 p)

3.

a. Simplify the expression below as far as possible using Boolean algebra,

$$\overline{AB}(\overline{A}+B)(\overline{A}+A)$$

(1 p)

b. Prove your solution of **a** using a truth table. (1 p)

4. Two robots in a factory are grinding steel parts for cars. Their work cycles can be described as

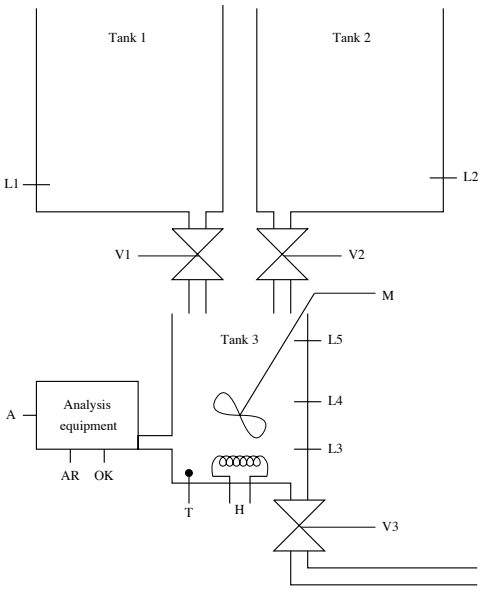
1. Pick up steel part from incoming conveyer belt.
2. Grind steel part.
3. Put steel part on outgoing conveyer belt.

Each robot has its own incoming conveyer belt but the outgoing conveyer belt is shared and thus only one robot at the time may put its finished part on it. The outgoing conveyer belt is thus a *shared resource*.

a. Draw a Petri net that solves the problem with the shared resource. You may have to include more states in the work cycle than above to solve the problem. (2 p)

b. This problem is ONLY for the members of the project-group ”Tetra Pak Packaging”
In this project the state-model of ISA88 was compared with the state-model currently used by Tetrapak Packaging. Explain what the state-model is used for and what the main differences between the two models are. (1 p)

5. The process XYZ consists of three tanks, see figure 2. Two of the tanks contain raw-materials and one tank takes care of the chemical reaction.



Figur 2 The process XYZ.

The two tanks with the raw materials are each equiped with a levelsensor (L1 and L2) that indicate when a tank has enough raw material for running a batch.

The tank taking care of the chemical reaction has three levelsensors (L3, L4 and L5), a heater (H), a temperaturesensor (T), an agitator (M) and instrumentation for analysis (A, AR and OK). The signal AR indicates that the analysis is done, OK indicates that the product is ready. The analysis, which is very quick, is started with the signal A.

The flows from tank-1 and tank-2 to tank-3 is controlled by the valves V1 and V2. The outflow of tank-3 is controlled by valve V3.

The operator interface is very simple and consists of two buttons (Start and Ack) and one error-indicator (Error).

A batch is started when the operator pushes the button Start. The production is then coordinated by a recipe impleneted by a Grafcet, see figure 3.

a. Explain what is happening during the execution of the batch.
Hint: All signals are boolean except for the temperature T which is real. In the Grafcet there is also a signal S9.T which is a timer that is resumed and started when the state S9 becomes active. (2 p)

b. This is a problem ONLY for the members of the project-group ABB.
In this project the task was to control a double-tank process using the harware and software supplied by ABB. The AC800M Controller Unit was used to implement the program. Explain what advantages/disadvantages you see in using a graphical language compared with a textual langage for implementing this program. (1 p)

6. Assume that you are working at a smaller production company as overall-responsible for the production (e.g., COO = Chief Operations Officer). The company is producing wooden furnitures. You are aware of how the production of wooden furnitures is done in general, but would like to get feedback from the actual production more often. As it is now, you only get weekly reports telling how successful/unsuccessful the production was during the last week. You have heard about Key Performance Indicators (KPIs) but the company is not using it today.

a. Explain the idea of Key Performance Indicators (KPIs). Also explain how you, as the COO, can use KPIs to get feedback from the production. (1 p)

b. You decide to introduce three (3) KPIs. Select and define three KPIs. You should also motivate why these three KPIs are of relevance for you as COO. (1,5 p)

c. Select one (1) out of the three (3) KPIs you presented in b). Explain how you would like to see this KPI being presented to you (e.g., in a graphical or textual way). (0,5 p)

d. This problem is ONLY for the members of the project group ”Alfa-Laval”.
In this project the task was to focus on the Overall Equipment Effectiveness (OEE). The definition of OEE is given in the standard-draft ISO 22400. Explain how OEE is calculated according to the this standard and where the main difference is compared with the currently definition used by AlfaLaval. (1 p)

e. This problem is ONLY for the members of the project group ”Tetra Pak Processing”'.
In this project the task was to suggest Green KPIs for Tetra Pak Processing. Tetra Pak would like use their KPIs to measure something of relevance for the Plant, Unit and/or Line. Give an example of one Green KPI and explain how it could be use at Plant, Unit and Line level. (1 p)

7. A company manufactures two different kinds of wooden furniture, tables and chairs, that are sold for prices,p_1 and p_2. The products are manufactured by sawing and assembling. The sawing for each table takes s_1 hours while the sawing for each chair takes s_2 hours. The assembling takes a_1 hours for each table and a_2 hours for the each chair. The total weekly amount of man hours available for sawing and assemling is t_s and t_a hours respectively.

a. State the linear program that maximizes the profit. (1 p)

b. Solve the problem in a) using the following parameters; $p_1 = 11$, $p_2 = 9$, $s_1 = 10$, $s_2 = 12$, $a_1 = 14$, $a_2 = 11$, $t_s = 20$, $t_a = 20$. (1 p)

c. Set $p_2 = \alpha p_1$ and solve resulting linear program in a) for all $\alpha >= 0$ using the parameters in b). (1 p)

d. From one week to the next the maximum increase in production is limited by Δ_1 and Δ_2 for the two products respectively. State the linear program that maximizes the profit over the following three weeks, taking this limitation into account. Denote the amount of products produced the previous week by x_1^0 and x_2^0 respectively. (2 p)

8. Two persons sharing a house needs to decide how much time to spend on cleaning. The rest of the time is spent watching TV. The payoff function for person i is given by

$$u_i = (t_1 + t_2) + (9 - t_i) + (9 - t_i)(t_1 + t_2)$$

Here t_i the time spent on cleaning for person i (where $0 \leq t_i \leq 9$ hours), the term $t_1 + t_2$ models the happiness from living in a clean house, the term $9 - t_i$ the TV time, and the last term the extra happiness of watching TV in a clean house.

a. Determine the best response functions $B_1(t_2)$ and $B_2(t_1)$ describing how much time should be spent on cleaning when knowing the other person's action. (1 p)

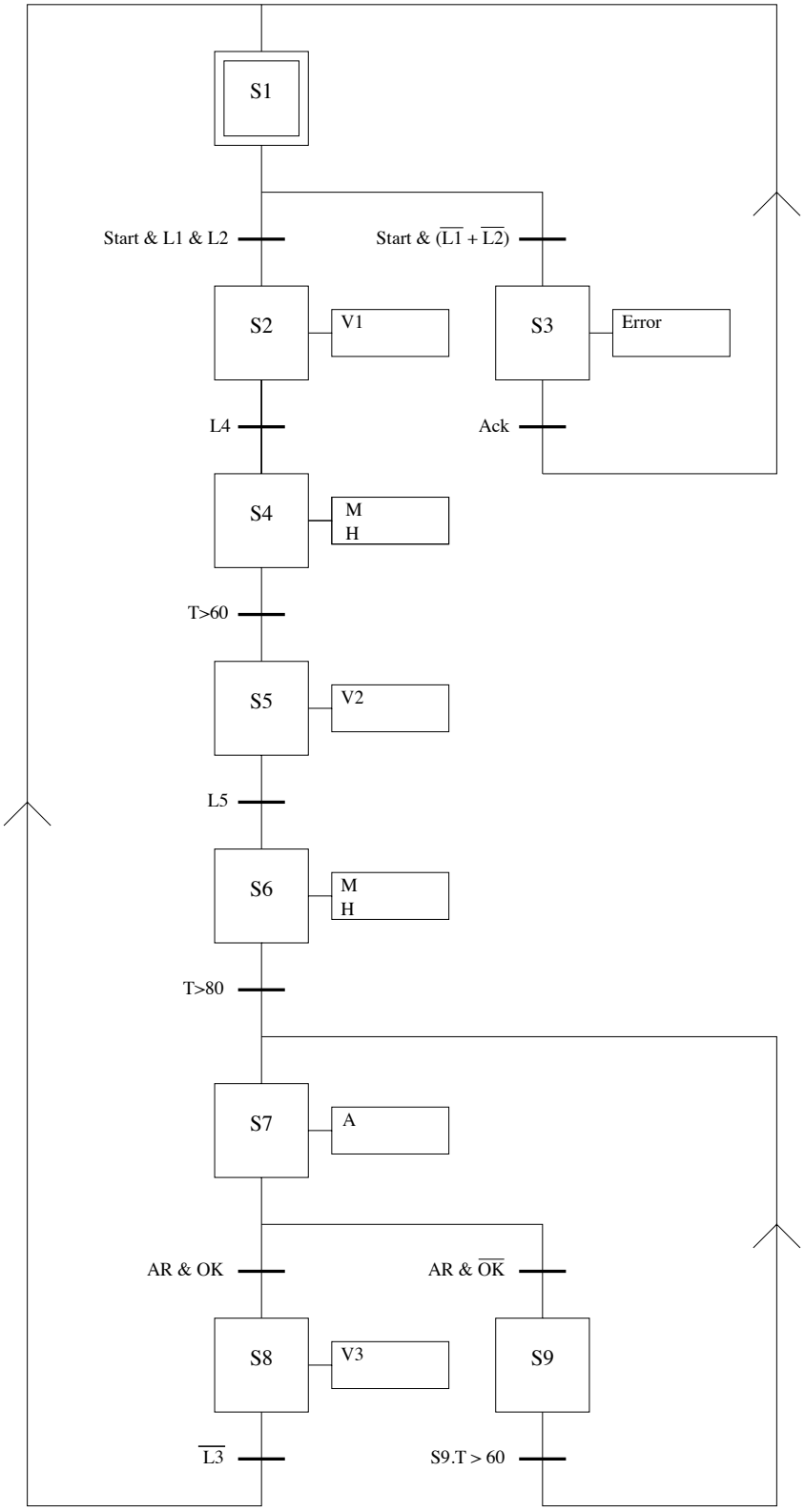
b. Find all pure Nash equilibria. (1 p)

c. Calculate cleaning time (t_1, t_2) optimizing the “total welfare”, i.e. $u_1 + u_2$. Is the solution the same as in b? (1 p)

9. Find the mixed equilibrium to the following zero-sum two player game

	Left	Right
Top	1	0
Bottom	0	3

where the row player tries to minimize and the column player to maximize. What is the value of the game? (1,5 p)



Figur 3 The recipe, presented as a Grafcet, for the process XYZ.