Industrial Automation, Communication and Data Management

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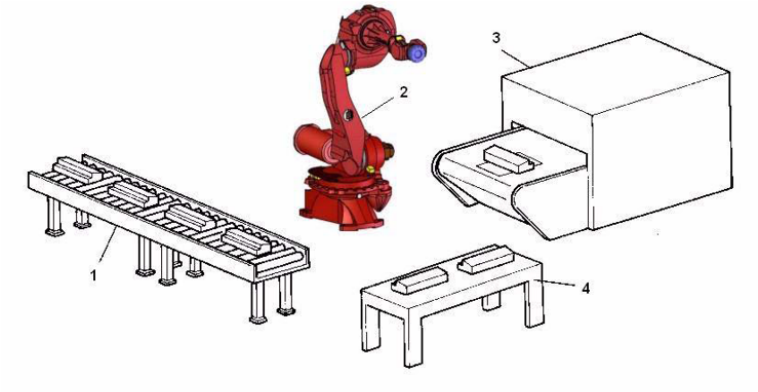
Warnings

- This file consists of **8** pages (including cover).
- During the exam you are not allowed to exit the room for any other reason than handing your work or withdrawing from the exam.
- You are not allowed to withdraw from the exam during the first 30 minutes.
- During the exam you are not allowed to consult books or any kind of notes.
- You are not allowed to use calculators with graphic display.
- Solutions and answers can be given **either in English or in Italian**.
- Solutions and answers must be given **exclusively in the reserved space**. Only in the case of corrections, or if the space is not sufficient, use the back of the front cover.
- The clarity and the order of the answers will be considered in the evaluation.
- At the end of the test you have to **hand this file only**. Every other sheet you may hand will not be taken into consideration.

Consider the robotic cell sketched in the picture:



1. Feeder
2. Robot
3. Discard Bin
4. Table

The robot (2) can move a piece from the feeder (1) to either the discard bin (3) or the table (4), depending on a signal that informs the robot whether it is a good piece or a bad piece. Another signal notifies the robot about the presence of a piece on the feeder.

1. Explain what a Programmable Logic Controller is and what is its role in an automatized industry. Cite at least two programming languages for a PLC.

2. Sketch a Sequential Function Chart (SFC) that might be used to represent the sequence of actions and related activations in the robotic cell represented above.

3. Explain what are the differences in programming the motion of a robot in the joint space or in the operational space.

4. Assume that the communication among the robot, the presence and sensors quality and the PLC is implemented via PROFIBUS technology with the PLC acting as master: the PLC polls the presence sensor to obtain the presence information, then the PLC polls the quality sensor to obtain the quality information and finally the PLC sends the corresponding signal to the robot which acknowledges the reception of the command. Assuming that: (i) the data rate of the PROFIBUS is 500[kb/s], (ii) the size of the polling messages, the acknowledgement and the presence message is 1 [byte], (iii) the size of the message notifying the quality and the size of the message carrying the operational command is 2 [bytes], (iv) propagation and processing delays are negligible, find the Minimum Cycle Time and the corresponding maximum number of pieces which can be processed by the robot cell.

5. Assuming that the PLC controlling the robot uses MQTT to communicate with the backhand information system the outcome of the processing action for each piece in production. The PLC has a MQTT client onboard communicating remotely with an MQTT broker. Describe a consistent MQTT architecture defining the type of *topics* used and sketching a possible content for the PUBLISH messages.

6. Describe at least three wireless communication technologies which could be used to connect the robot (PLC) with the backhand information systems. For each one of the three technologies highlights advantages and disadvantages.

7. Describe the main differences between materialized and virtual data integration, explaining advantages and disadsvantafges of each.

8. **PoliRobots** is an Australian startup which leverages the latest advances in Deep Learning-based computer vision to manufacture highly skilled aerial drones which are able to monitor and gather herds of cows in a completely autonomous way. **UniRobots** is a big multinational company which also produces robots (all kinds, not just aerial drones). Although UniRobots already holds a big share of the market, the company is interested in merging with PoliRobots in order to acquire and apply its cutting-edge deep learning technology to all robots in its production line.

   The CEO of the new company, **UniPoliRobots**, has just hired you to integrate the relational databases of the two original organizations into a unique relational database. You must perform the

integration ensuring to lose the least possible amount of information.

The original relational schemas of the two sources are reported below.

PoliRobots:

DRONE (DroneID, ModelName, ProductionCost, SellingPrice)

PRODUCTION (DroneID, StartTime, EndTime, OperatorSSN*, Status) *//There is just one assembly line for each model.*

UniRobots:

ROBOT (RobotID, Name, Version, Type, ManufacturingTime, ProductionCost, Price) *//Examples of values of the Type attribute are: "Robotic manipulator", "Logistic", "Aerial drone", "Water drone", etc.*

PIECECONSTRUCTION (PieceID, RobotID, StartTime, EmployeeSSN)

You can assume people and robots in the two sources to be disjoint.

(a) **Source schema reverse engineering**. Provide, for each input data source, the reverse engineering from the logical schema to the conceptual model (ER graph).

(b) **Schema integration**. Design an integrated global conceptual schema (ER graph) for UniPoliRobots capturing all the data coming from both PoliCharity and PoliEarth, and provide the corresponding global logical schema. In more detail, follow these steps:

i. Related concept identification and conflict analysis and resolution. Write a table as shown in the exercise sessions, using the following columns: "PoliRobots concept", "UniRobots concept", "Conflict", "Solution".

ii. Integrated conceptual schema (ER graph).

iii. Conceptual to logical translation of the integrated schema.

(c) **Mapping definition**. Write the GAV mappings between the schema of UniPoliRobots and the two sources using SQL.