Industrial Automation, Communication and Data Management

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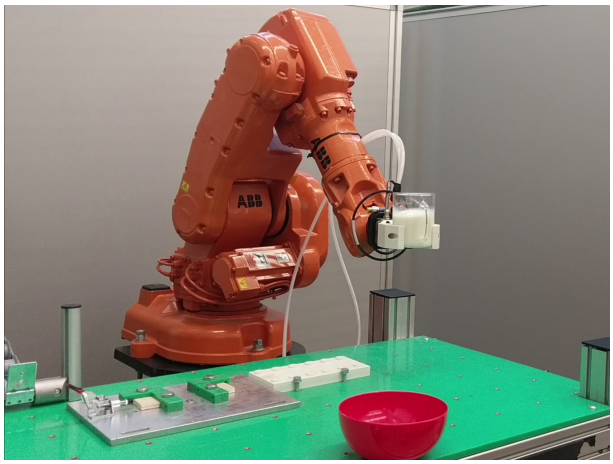
NAME:	
UNIVERSITY ID NUMBER:	
SIGNATURE:	_____

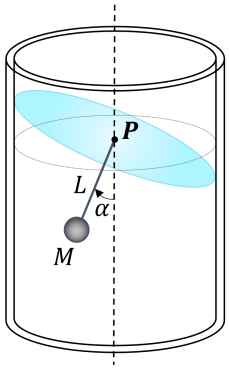
Warnings

- 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 robot carrying a glass with liquid sketched in the picture:



The robot should be moved in such a way to avoid spilling of the liquid from the container. In a first approximation, the sloshing dynamics of the liquid can be modelled with a pendulum, see the following picture:



For simplicity, assume that the pendulum moves on a vertical plane.

1. Explain what are the direct and the inverse kinematics problems for a robotic manipulator. How many solutions does the inverse kinematics for an anthropomorphic manipulator have?

2. Write the equations of a dynamic system that describes the motion of the pendulum (when the robot is still).

3. Write the general equation that allows to find the equilibrium states in a dynamic system. Apply such formula to find the equilibrium states for the pendulum at hand.

4. Describe what is a Pervasive System and what are, in your opinion, the main problems related to

data management in this type of systems.

5. **PoliPatents** is an organization granting technological patents to companies in America. Each patent may be assigned to multiple companies (i.e., the patent assignees) and is associated with one or more inventors; inventors are the people having participated in the invention that has been patented.

   UniPatents is a similar organization operating in Europe. UniPatents too allows multiple inventors per patent but, differently from PoliPatents, allows just one assignee per patent.

   PoliPatents and UniPatents refer to different geographic areas, and you can assume that patents, assignees and inventors in the two data sources are disjoint. The two organizations have now merged into a unique organization named **UniPoliPatents**, given the relational schemas of the two sources:

   PoliPatents:

   PATENT (PatentId, Title, GrantDate, Abstract, CPCCategory) *//The id of the patent is an alphanumeric string always starting with 'PP' (e.g., 'PP12345678'). CPCCategory is the category of the patent on the basis of the Cooperative Patent Classification (CPC).*

   CITY (CityName, Country)

   ASSIGNEE (AssigneeId, Name, CityName)

   INVENTOR (InventorId, Firstname, Lastname, CityName)

   PATENTASSIGNEE (PatentId, AssigneeId)

   PATENTINVENTOR (PatentId, InventorId)

   CITATION (CitingPatent, CitedPatent) *//A row in this table indicates that the document describing the citing patent cites the cited patent.*

   UniPatents:

   PATENT (PatentId, Title, Summary, GrantDate, AssigneeId, AssigneeCityName) *//The id of the patent is an alphanumeric string always starting with 'UP' (e.g., 'UP12345678'). UniPatents allows*

assignees to change city, so in different patents the same assignee may be associated with different cities.

PatentIPCCategory (PatentId, IPCCategoryName) *//IPCCategory is the category of the patent on the basis of International Patent Classification (IPC). CPC categories and IPC categories are different.*

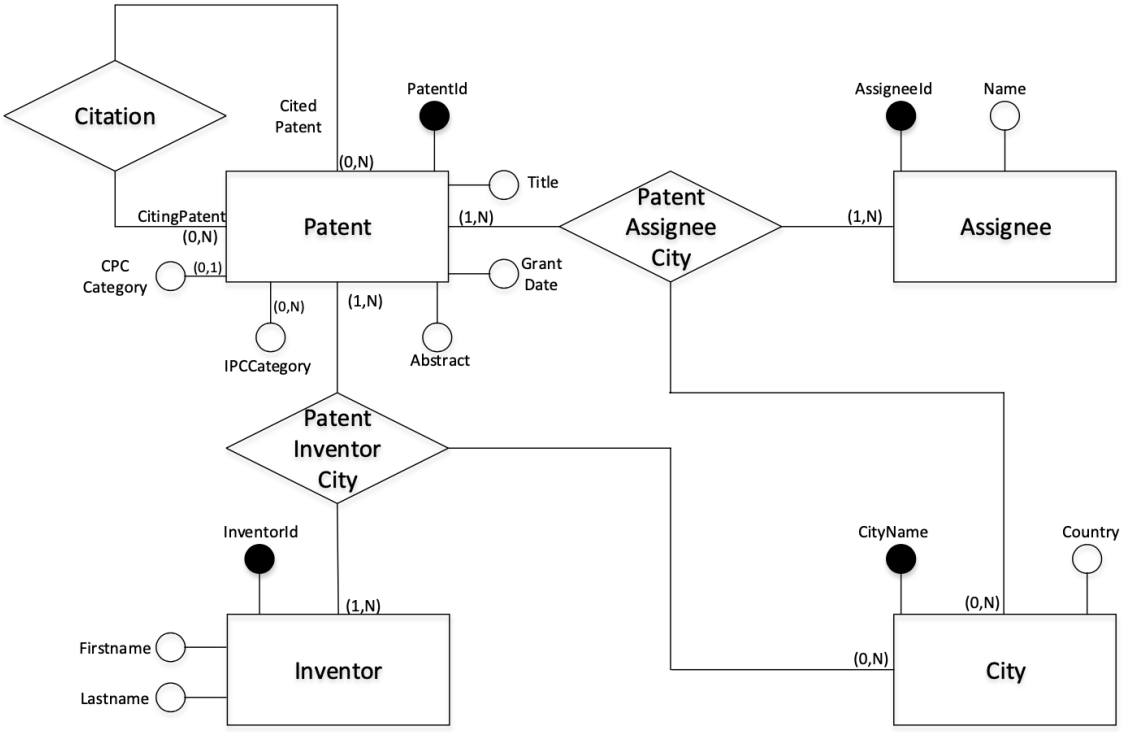
Assignee (AssigneeId, Name)

Inventor (InventorId, Name) *//Inventor names in UniPatents are represented in the form 'First-name#Lastname'.*

PatentInventorCity (PatentId, InventorId, CityName) *//UniPatents allows inventors to change city, so in different patents the same inventors may be associated with different cities.*

City (CityName, Country)

and the integrated conceptual schema of **UniPoliPatents**:



you are required to provide the GAV mappings for:

- the table Patent of UniPolipatents
- the table Assignee of UniPolipatents
- the table PatentAssigneeCity of UniPolipatents

6. Assume that the robot has Ethernet connection with the backend. Briefly describe the types of Ethernet-based communication standards commonly used in industrial environment with the related

features and key performance indicators in terms of complexity, backward compatibility and MCT.

7. The robot reports remotely via COAP the current displacement (x, y, z coordinates) of the robotic to an endpoint in the backend with a frequency of f=1 [kHz] (1000 samples/s). Describe a possible message exchange to support the periodic transmissions clearly defining the roles of COAP client and COAP server.

8. Referring back to the previous item, assume that the physical distance between the robot and the end point is d=500[m], Ethernet data rate is R=10[Mb/s], and COAP request and response messages are L=20[bytes] long. Find: (i) the nominal data rate of the information flowing from the robot to the end point; (ii) the round trip time (time from the transmission of the first COAP request to the reception of the first COAP response). Comment on the different delay contributions (hint: assume a propagation speed in Ethernet of v=200000km/s, neglect any processing delay involved).