**ECE 479/579**
**Spring 2022**

# Semester Project

**Due: April 27 (11pm), 2022 via D2L**
**Documents to be submitted**

1. **Brief summary of your design and instructions on how to run your system.**
2. **Requirements document**
3. **UML diagram of the system architecture**
4. **Code (in python, matlab, or c/c++) in a zip file.**

This semester project is intended to reinforce the theoretical concepts covered in class. It will provide you with flexibility and freedom to be creative and implement concepts in ways which the teams feel are most effective, and at the same time valid.

The following problem will serve as the basis for it.

## Problem:

Consider a task of designing an integrated, AI-based system for supporting the operation of an imaginary bottled water distribution company. In the description below, we focus only on some selected aspects of the system's operation but you are free to introduce your own constrains and design parameters as long the operational principles are consistent with the problem statement. (For instance, assume the existence of a dispatch center.)

In each customer's home, the company installs the ThirstAId system which has:

- a water column that consists of a water stand --- the water stand is either a regular stand or a chilled water stand --- and a bottle that could be a clear glass or a plastic bottle with a choice of two capacities (4 gallons or 6 gallons) for either type of bottle,
- a robot (bottle changer) that can be either a mobile robot or a fixed location robot,
- a vertical *full-bottle shelf* in which up to three bottles can be stacked up,
- a vertical *empty-bottle shelf* in which up to two bottles can be stacked up,
- a management unit that monitors and controls the system,
- a transceiver that connects the system to the company's monitoring station,
- system software.

## Overall Goal

Design and implement a software-based model and simulate the operation of the system along the following steps.

**Step 0**

Based on the description below (please read to the end) define a set of requirements and constrains for this system (the minimal requirements are given in this description but you are free to introduce your own).

**Step 1**

So far, the company has five customers whose codes are A, B, C, D, E. To help the dispatcher optimize the distribution routes, ThirstAID will be using the TSP and search for an optimal route based on distances between the customers.

*Task:*

implement and test a module which allows you to enter distances between the customers and generates the optimal path using one of the search algorithms you have studied.

**Step 2**

*Task*

develop the system architecture using the UML notation. This architecture must have attributes that characterize the components' properties.

**Step 3**

One of the components of ThirstAId is an AI Production System (AIPS) that has the following specifications:

The AIPS monitors the system by checking state variables. It takes certain actions.

The AIPS issues the Replenish command if there is only one bottle left on the full-bottle shelf and the water level in the bottle on the water stand drops below 1/4 gallon.

The AIPS controls the water temperature by issuing on/off commands which are sent to the cooler (only if the stand is a chilled water stand). The proper operating temperature is to be 42F +/- 2F.

The AIPS issues the Replace Bottle command if the bottle on the water stand is empty.

The AIPS issues the Alarm command to the dispatch center if it detects a leak.

*Replenish* command: results in two filled bottles being dropped off (by a technician) at the full-bottle shelf. These bottles are placed on the floor next to this shelf. Empty bottles are collected (by the technician) from the empty-bottle shelf. At the same time, the robot (bottle changer) is directed to re-stack the full-bottle shelf --- all three full bottles must be in the vertical shelf, stacked on top of one another.

*Replace Bottle* command: results in the robot placing the empty bottle on the empty-bottle shelf, picking a full bottle from the full-bottle shelf, and placing it on the water stand.

(Please note, the robot has no ability to pull a bottle out of the middle or bottom of the shelves.)

*Alarm* command: a signal is sent to the dispatch, which sends a technician to fix the leak.

*Task*

a) define and implement the AIPS according to the above specifications.
b) define and implement a procedure for detecting a leak so that Alarm can be issued when appropriate.

**Step 4**

*Task*

define and implement an optimal plan for the robot to re-stack the full-bottle shelf, i.e., all three bottles must be in the vertical shelf, stacked on top of one another. The bottle that is already in the shelf must now be on the very top of the stack (to preserve water freshness).

<u>You are to:</u>

a) use predicate logic to define the appropriate state descriptions
b) use the four operations, i.e., pickup, putdown, stack, and unstack as defined in class to generate the plan using a forward production system.

**Step 5**

*Task*

Integrate all the elements into a software-based model that can simulate the operation of this system over time for the five households. You will need to introduce the concept of simulated time and events that can take place in the system per the broad requirements above (and any additional constraints that you may introduce).

Assume that the initial state is the five households with water columns and shelves that are empty. Thus, the dispatch must send, through the optimal route, the adequate number of bottles to be placed on the full-bottle shelf and the water stand (i.e., four per household). You can assume that this initial "loading" is done by a technician.

You need not design GUIs but some form of a user interface to illustrate the state of the entire system, each household, and the operation of the system is expected.