Gayeon Kim gkim902

Environment Control System (ECS)

When designing an Automated Bottling System (ABS), it is essential to consider the environment control system to ensure an optimal working environment across different zones of a facility. ECS is in charge of maintaining temperature, humidity, and lighting at desired levels to provide a comfortable and safe environment. It is also responsible for detecting smoke and fire threats and triggering alarms when necessary.

Different zones

ECS has several functionalities. Firstly, it maintains temperature and humidity at the target levels in each zone. The facilities are divided into 7 different zones and they are grouped into 3 major sections, office section, storage section, and manufacturing section.
The assumption made here is that the same temperature will be maintained for zones 1 and 7 (office section), zones 2 and 3 (storage sections), and zones 4, 5, and 6 (manufacturing sections), therefore three actuators (air-conditioners in the manufacturing, office, storage section) and one heater (in the office section) will be used. For the humidity control, three actuators (dehumidifiers in the manufacturing, office, and storage section) are used. Furthermore, for the lighting and smoke/fire control, three occupancy sensors(HIR sensors in the manufacturing, office, and storage section), three light intensity sensors (One Light sensor for each section) and three smoke detection sections will be used (One smoke sensor for each section).

Sensors and actuators used in ECS

Sensors
Temperature sensor: Responsible for measuring the temperature in the vicinity of the device. Provides readings in degrees Celsius.
Humidity sensor: Responsible for measuring the humidity in the vicinity of the device. Provides readings in %
Light intensity sensor: Responsible for measuring the light intensity in the vicinity of the device. Provides readings in lumens
Occupancy (Human presence) sensor: Responsible for indicating movement of persons in its range using HIR (passive infrared)
Smoke/ Fire sensor: Responsible for detecting the smoke or fire
Actuators
AC: can be switched ON/Off with the target temperature setting
Heater: can be switched ON/OFF with the target temperature setting
Dehumidifier: can be switched ON/OFF with the target humidity setting
Lightbulb: Can be switched ON/OFF with a desired light intensity
Siren: Can be switched ON/OFF
Dehumidifier: can be switched ON/OFF with the target humidity setting

The diagram below shows the placement of each sensor, air conditioner, heater, light and alarm for smoke/fire detection.

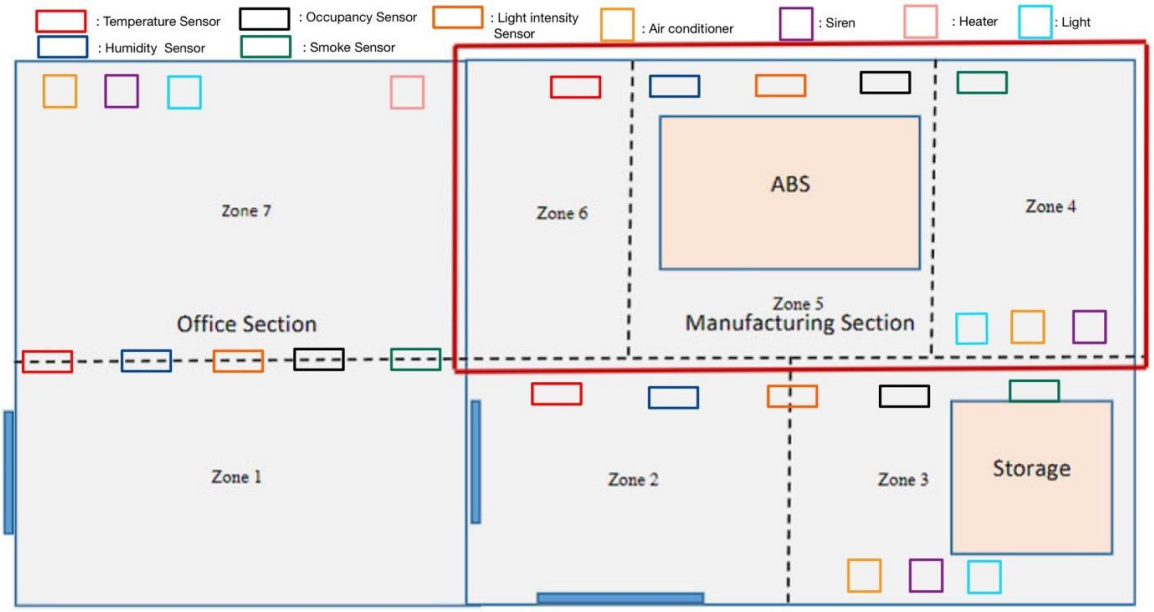

Fig.1. Facility zone

Temperature and humidity control

The sensor nodes should be used to monitor each zone's environmental conditions (temperature and humidity) and the current measurements have to be taken into account when turning the air conditions, heaters and dehumidifiers ON/OFF with the set temperature and humidity.

For the office, storage and manufacturing sections, the air conditioners and heaters will only operate during office hours (9 am-5 pm) to maximise energy efficiency. When to turn the air conditioners and heaters ON/OFF not only depends on the time of the day but also on indoor measurements.
For each office, storage and manufacturing section specific threshold levels have been set to trigger the activation of the respective actuator. Across all three sections, the air conditioner will be activated if the temperature reading by the temperature sensors exceeds 23 degrees Celsius.
The office section benefits from the additional usage of a heater to ensure a comfortable work environment during colder periods. The heater is activated when the temperature falls below 23 degrees Celsius. Assuming that it is necessary to maintain a cool environment for storage and manufacturing sections, heaters are not used for these two sections. For the humidity control, dehumidifiers of all three sections will become operational when the humidity is over 60%.

Light control

The ECS also has the responsibility to monitor and control lighting conditions (light intensity) in each of the zones, depending on the time of the day and the light intensity measurement. During office hours, the light intensity sensors are active, taking the readings to determine the appropriate light bulb intensity settings.
During office hours, across all three sections, if the light intensity reading is less than 30 lumen, the lights will be turned on at 80% bulb intensity. Otherwise, the lights will be on at 50% intensity.
Furthermore, as occupancy of the spaces will be taken into account, outside of office hours, when the occupancy sensor detects humans, the light will be turned on with 100% intensity. The intensity of 100% here is used outside of the office hours assuming that it would be darker than the office hours.
This strategy of activating light bulbs at variable light intensity not only aims to achieve the finest lighting conditions but also to optimise energy consumption.

Fire/Smoke control

Moreover, ECS should be able to detect fire/smoke and it should be able to alert the personnel of the situation. It will be detected by the smoke sensor and trigger the alarm to alert people. It should also stop the ABS system when the alarm is triggered by communicating with the Safety and Access Control System (ACS).

SystemJ implementation

Each section will be controlled with different sensor nodes and there will be different input and output signals for each section to control the environment factors. The common signal that is being used for all three sections is a time signal which indicates the time.

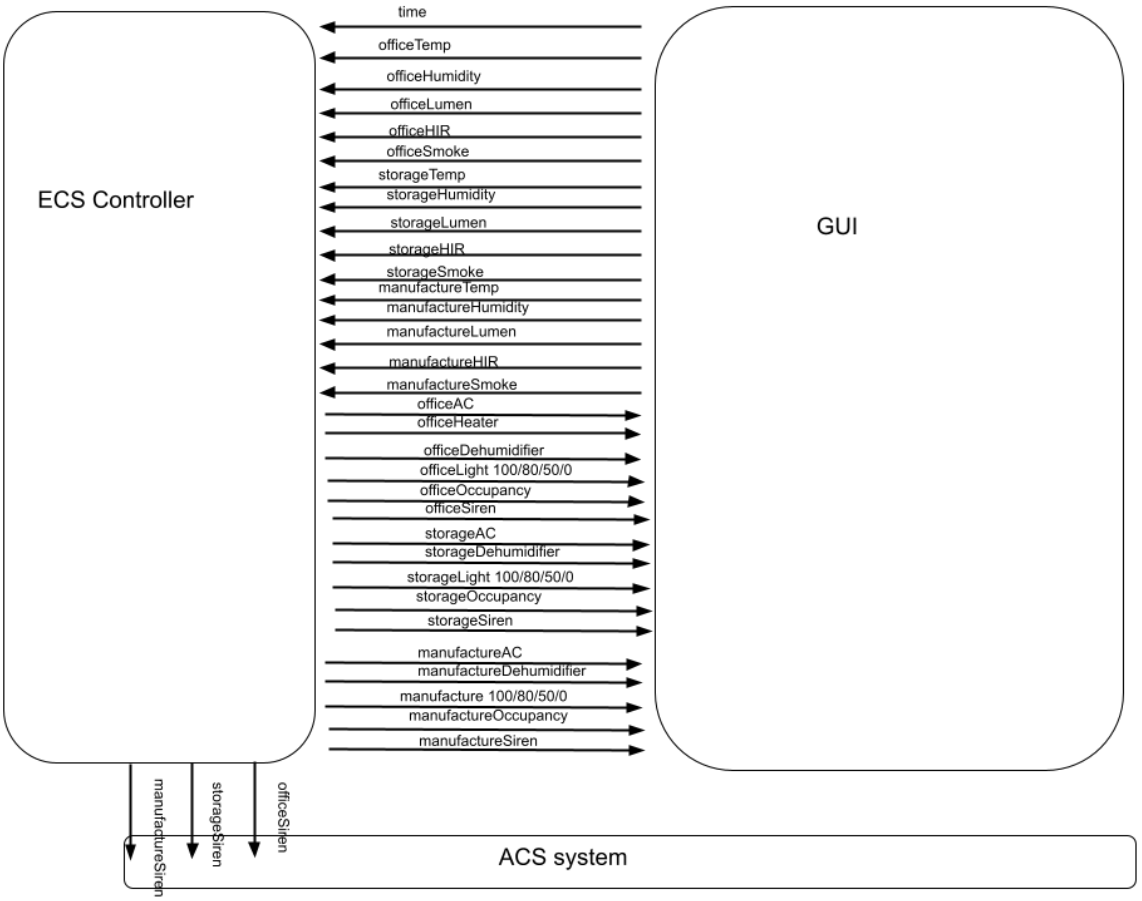

Fig. 2. SystemJ signals

Common input signal: time

For the office section (Zone 1 and 7)

Input signals: *officeTemp, officeHumidity, officeLumen, officePIR, officeSmoke*
Output signals: *officeAC, officeHeater, officeDehumidifier, officeLight100, officeLight80, officeLight50, officeLight0, officeOccupancy, officeSiren*

For the storage section (Zone 2 and 3)

Input signals: *storageTemp, storageHumidity, storageLumen, storagePIR, storageSmoke*
Output signals: *storageAC, storageDehumidifier, storageLight100, storageLight80, storageLight50, storageLight0, storageOccupancy,storageSiren*

For the manufacturing section (Zone 4,5, and 6)

Input signals: *manufactureTemp, manufactureHumidity, manufactureLumen, manufacturePIR, manufactureSmoke*

Output signals: *manufactureAC, manufactureDehumidifier, manufactureLight100, manufactureLight80, manufactureLight50, manufactureLight0, manufactureOccupancy, manufactureSiren*

In the facility, an input signal *time* is a common signal across all sections which will be used as a 24-hour clock system. This will be used to determine the office hours and perform actions depending on the time. The emission of output signals*: officeAC, officeHeater, officeDehumidifier, officeLight100, officeLight80, officeLight50, officeLight0, storageAC, storageDehumidifier, storageLight100, storageLight80, storageLight50, storageLight0, manufactureAC, manufactureDehumidifier, manufactureLight100, manufactureLight80, manufactureLight50, manufactureLight0* will depend on the *time* signals, whether it is office hour or not. The light signal could have been an integer signal which I will discuss in the further development part of this report.

In the office section, the *officeTemp* and *officeHumidity* signals will constantly sense the ambient conditions, ensuring a comfortable environment for the employees. When the temperature or humidity is over or below the set threshold (23 celsius degrees, 60% humidity), the *officeAC, officeHeater, officeDehumidifier* signals will be activated. Additionally, the *officeOccupancy* signal keeps track of the presence of personnel in the office, controlling the *officeLight100* signal.

The 'officeSmoke' will sign any hazards related to smoke or fire and the ‘officeSiren’ will be activated. If the ‘officeSiren’ is activated, the ‘officeSirenA’ will be sent to the ACS system so that it can take further action to disable the ABS manufacturing process.

For the storage and manufacturing section, the signals operate in a similar way as the office section, apart from that it does not have the heater signal.

The output signals of each section will be sent to the GUI of ECS and the state of each actuator will be shown in the screen. The ECS GUI is discussed in the next section.

ECS system GUI

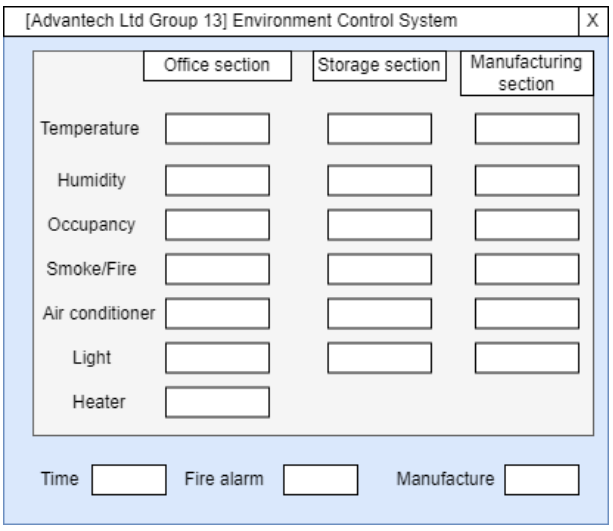

Fig. 3. Mock ECS GUI

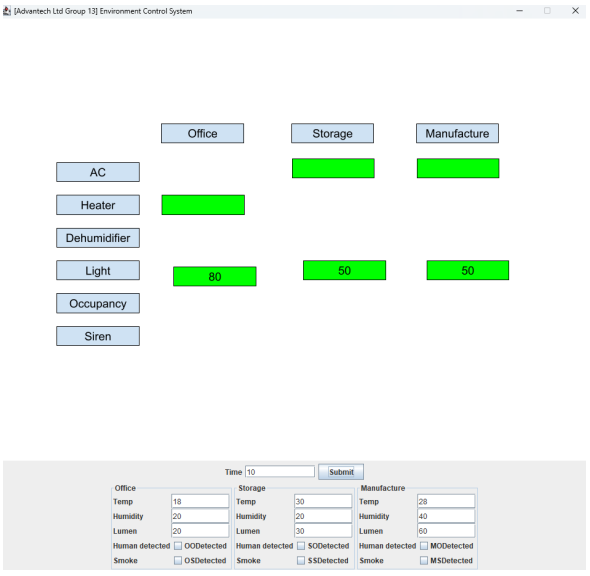

Fig. 4. Implemented ECS GUI

The state of each air conditioner, heater, dehumidifier, light, and smoke/fire control will be shown in the ECS GUI.

The time input in this GUI will be from 1-24, which indicates a 24-hour clock system. For each office, storage, and manufacturing section, as shown in the diagram above, temperature, humidity, light intensity, occupancy state, and smoke detection state can be entered by the user via text boxes and tick boxes. Once the numbers have been filled in the text boxes, pressing the submit button will activate the GUI.

Change of design

Several adjustments were made to improve the system's efficiency and responsiveness during milestone 2 compared to milestone 1.

Lighting condition: In milestone 1, the lighting condition depended on three distinct periods: office hours, one hour before and after office hours, and non-office hours. In milestone 2, the system has changed to incorporate light intensity measurements making it more reasonable and energy efficient.

Smoke alarm: In milestone 2, the smoke alarm triggers the siren the manufacturing process was immediately stopped with the activation of the sire. In milestone 2, it has been updated to communicate with the SACS system instead. Furthermore, only one siren was used initially to alert people in emergency conditions but in milestone 2, one siren for each section is used. This is to clearly indicate the specific facility affected by the smoke or fire, ensuring safety and response efficiency.

Further improvements

For the lightbulb intensity control, different signals such as *officeLight100, officeLight80, officeLight50* are used. This was to test individual signals and states with the intention of transitioning to the use of integer output signals. However, due to time constraints, the use of integer output signals was not implemented. Therefore, the improvement that could be made here is to change to integer output signals for more refined control.

Moreover, the occupancy detection could be done by communicating with ACS rather than having a separate PIR human detection sensor. ECS could receive information such as the presence of individuals and the number of people in a given section to manage the lighting conditions appropriately.