

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).

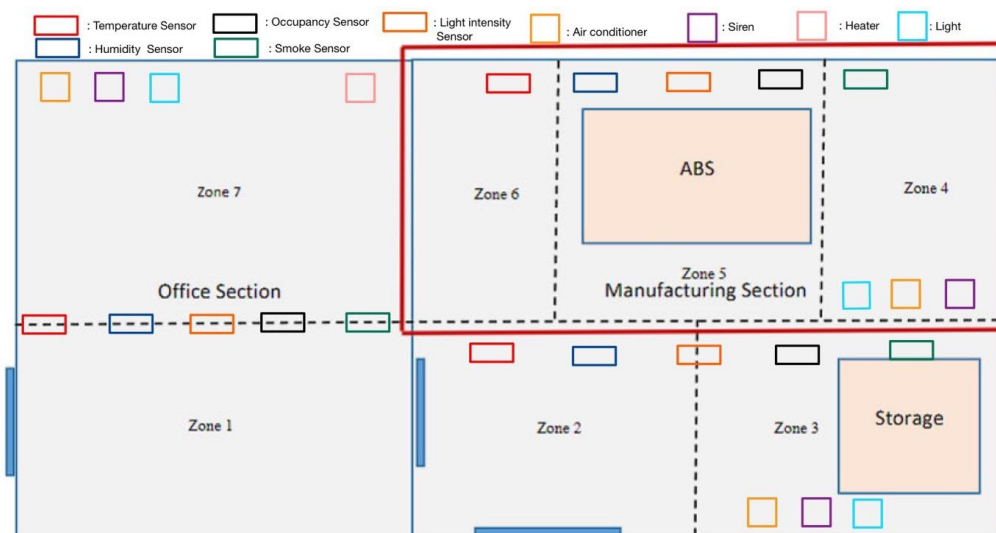


Fig.1. Facility zone

Functionalities

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%.

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.

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

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*

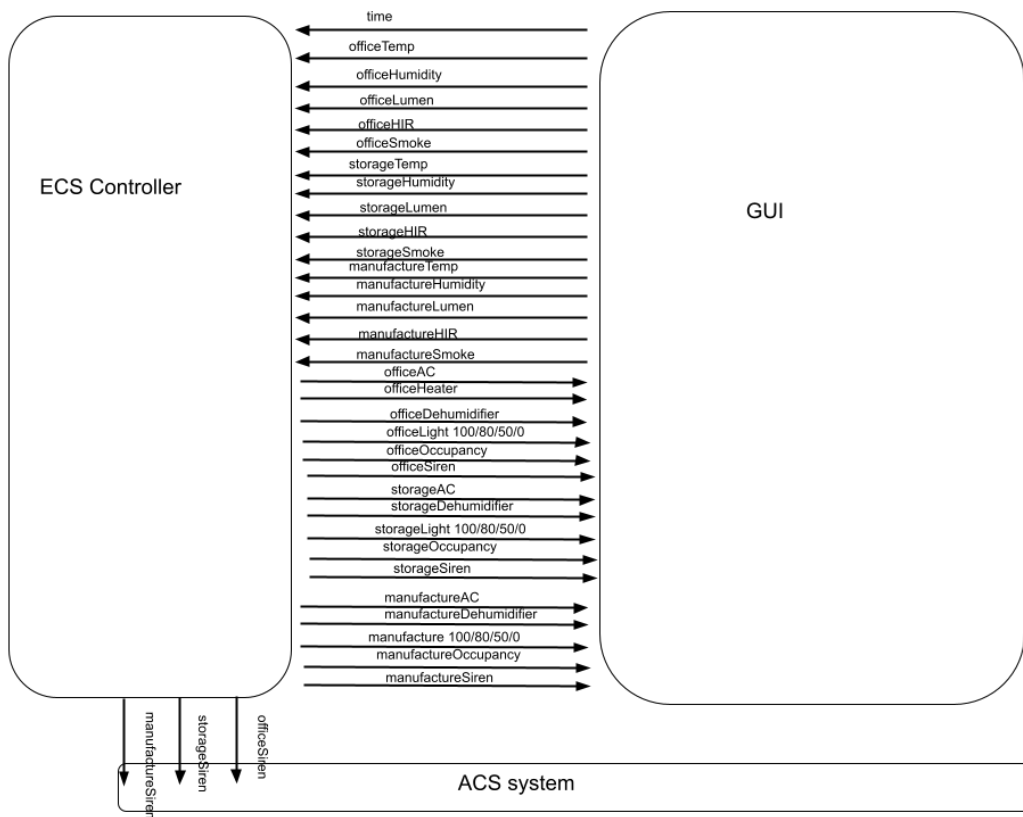


Figure 2: Conceptual diagram of ECS System

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.

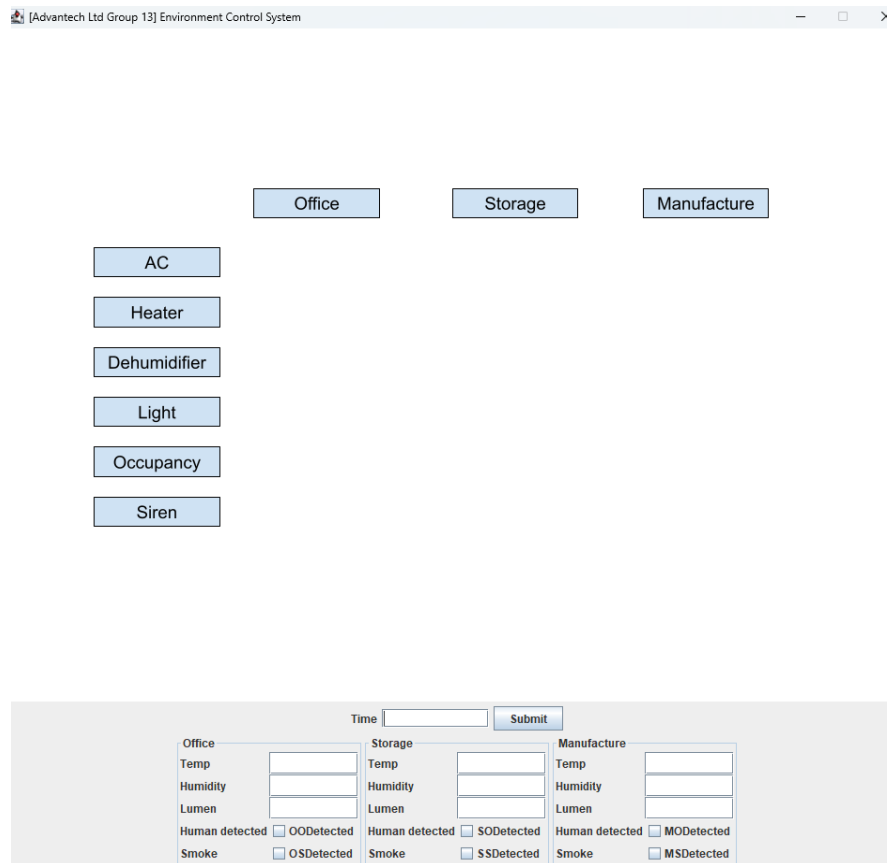


Figure 3. Implemented ECS GUI

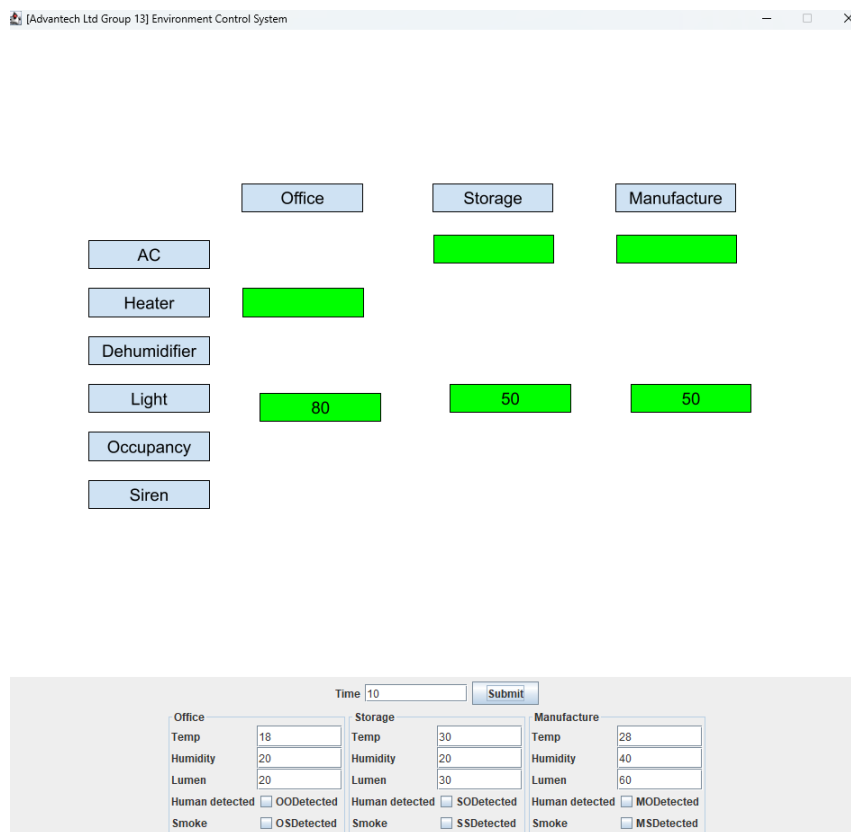


Figure 4. Implemented ECS GUI - office hour

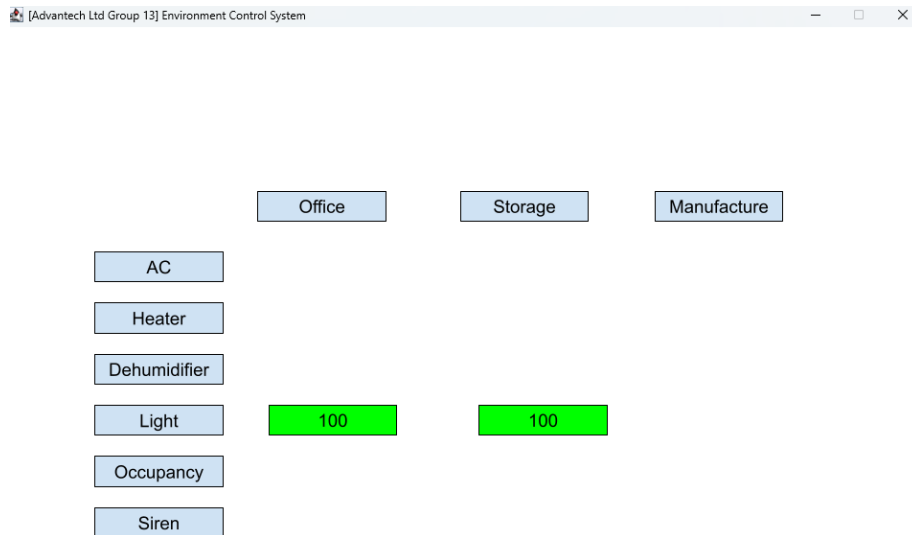


Figure 5. Implemented ECS GUI- non office hour

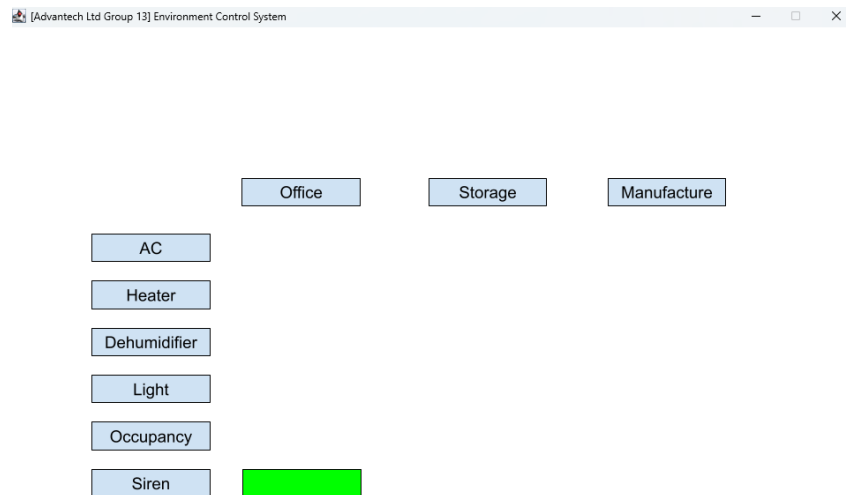


Figure 6. Implemented ECS GUI- smoke detection

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.