ESC204 | Praxis III

Prototyping Skills Assignment | Design Concept Overview

Due Date: January 26, 2026

This Design Concept Overview provides information about the selected Design Concept which addresses the Need, Goals and Objectives identified in the RFP for the Prototyping Skills Assignment (PSA). It provides the key functions and features of the Design Concept and some justification for how they satisfy the outlined objectives.

This document is incomplete, in that it only includes the parts of a Design Concept Overview artifact that are important for you to complete the PSA. The other expected parts that you and your team will need to complete when you submit a Design Concept Overview for your Major Design Project in Phase 2 are highlighted with notes on what the expected content will be[1]. You do not need to add anything to this document or perform any additional design concept work for the PSA.

Contents

[1]Complete information about what is expected for the Design Concept Overview you will complete in Phase 2 will be specified in the handout for Submission #1 of the Major Design Project.

1 Design Concept Summary

Our concept, as shown in Figure 1, uses a modular approach to lighting to ensure that the system can be scaled to different greenhouse sizes. A key part of our concept is the lighting module (a sub-subsystem of the overall Greenhouse Lighting subsystem). It consists of three different lights (red, green, and blue) which are controlled by user input. Each module provides light to a subset of the plants in the greenhouse, and modules can be connected to each other to form an internet-of-things (IoT) network of modules within the greenhouse. In addition, energy management modules (another sub-subsystem of the Greenhouse Lighting subsystem) adjust the greenhouse lighting automatically based on plants' needs when users are not present.

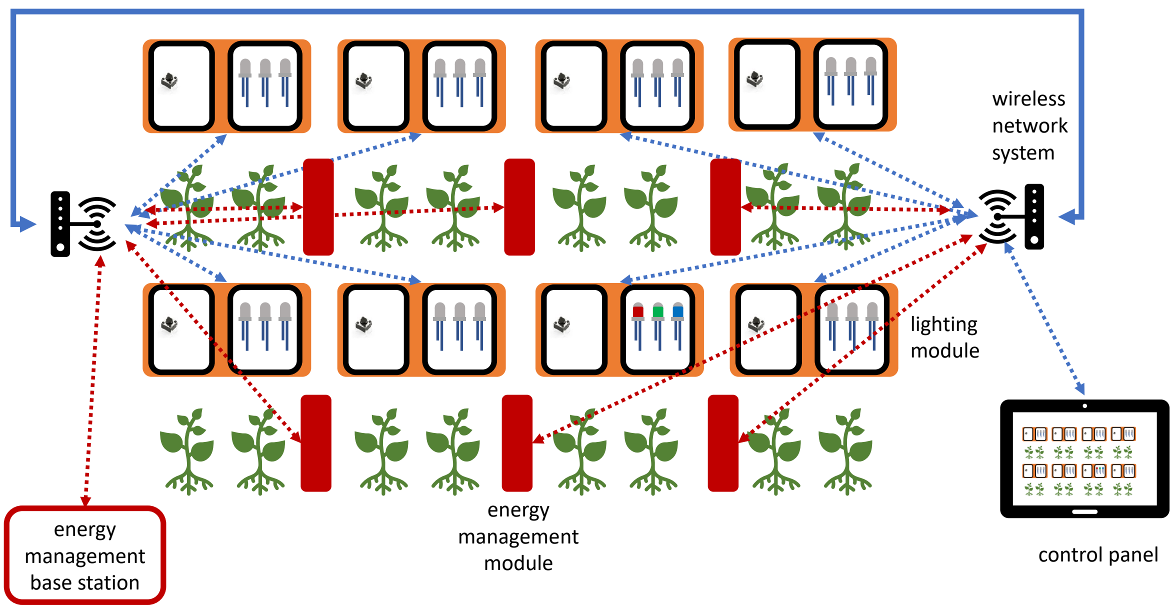

Figure 1: Design Concept representation showing a network of lighting and energy management modules within a greenhouse, the energy management base station, and a control panel for controlling lighting.

Our concept allows a user to manually select one of three modes for a lighting module: one where no light is provided because it is not needed, one that provides light for the plants only, and another that provides comfortable lighting for a person present when the plants need artificial lighting.

A user can control an individual lighting module directly by using one or more buttons located on-module as the user input[2], or they can control a set of modules (including an individual module) through a control panel that communicates with modules through a wireless network as shown in Figure 2. The direct control gives the user options, especially in a large greenhouse, to directly control the lights that they are physically close to instead of using the central control panel.

Where multiple modules are used, the user has to set up the control panel and modules to ensure that the layout on the control panel matches the module arrangement.

In addition to the manual lighting control by the user, we also have an energy management system

[2]We have intentionally not made a decision about the number of buttons to allow for exploration of different options through prototyping.

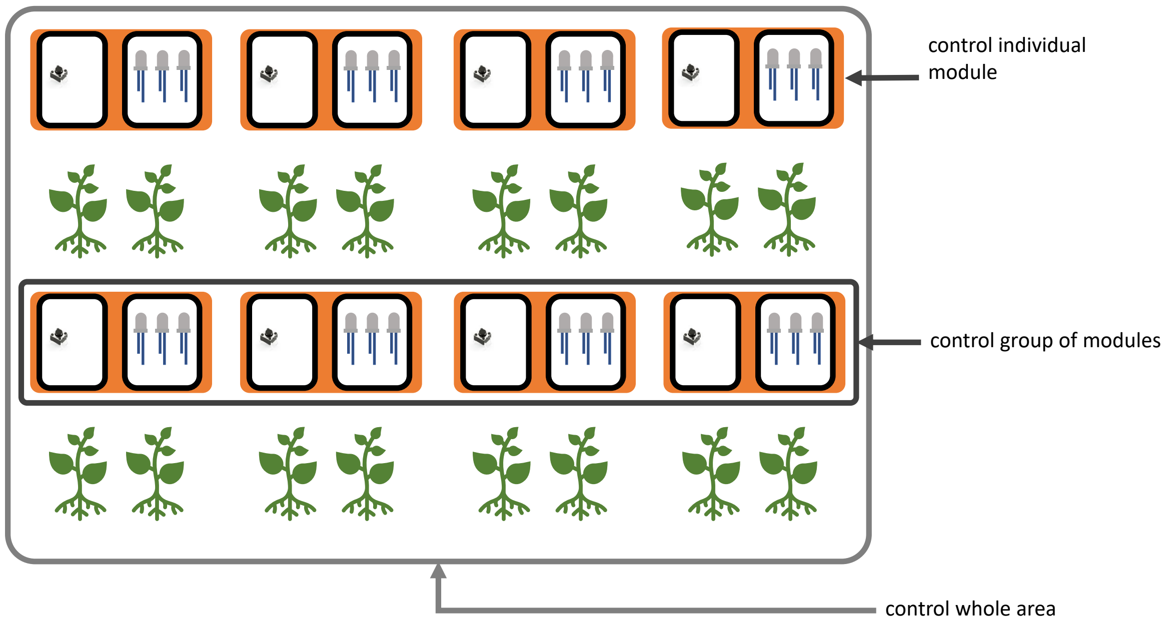

Figure 2: The different levels of control the user has over the behaviour of modules within the IoT network. Note that individual control can be achieved through the control panel or directly using physical buttons on each module.

that acts as a fail safe to user control. Through sensing, it can adjust the lighting in the greenhouse to the appropriate levels when users are not there.

1.1 Architecture

The system architecture is show in Figure 3. There are a number of lighting modules, energy management modules, an energy mangement base station, the control panel, and a wireless network that connects the modules, control panel and base station together.

At the **lighting module level**, there is the user input interface, the light output for the three different colored lights and a wireless network interface that allows the module to be part of the IoT network. The module needs power and has logic that interacts with the user interface, light output, and wireless network interface to implement the behaviour of the module.

The **control panel** has a user interface and wireless network interface. It also requires power and has logic that interacts with the user interface and wireless network interface to implement the control panel behaviour.

The **energy management system** consists of **modules** that have sensors for occupancy sensing and ambient light. The modules preprocess the sensor data (in their system logic) and send the outputs (through the wireless network interface) to the base station.

The **energy management base station** collects information from the energy management modules (through its wireless network interface connection to the IoT network) and combines the information from the various modules to make decisions (in its system logic) on whether to take automated action or not. The base station sends commands to the lighting modules to adjust the lighting through its wireless network interface.

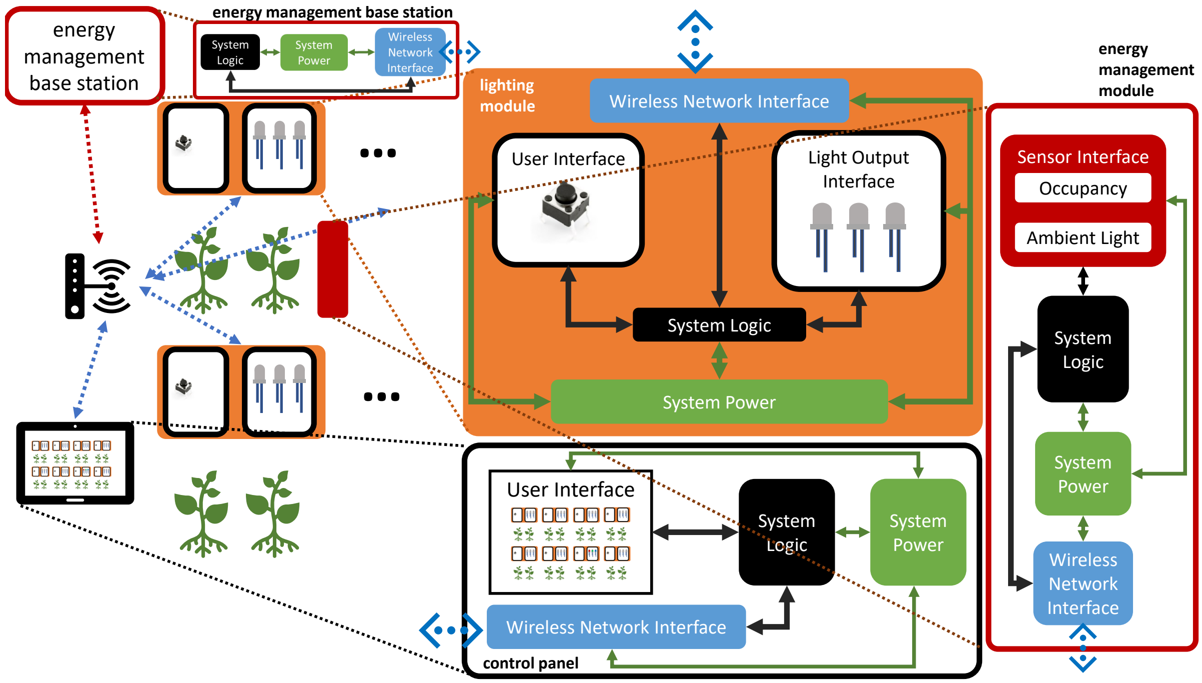

Figure 3: System architecture for the modular lighting system. An individual Lighting Module is shown with an orange background.

1.2 Behavior

At the **lighting module level**, our system consists of three modes as illustrated in Figure 4:

- **OFF** for when no light is provided by the system because adequate natural light is available.
- **PLANTS ONLY** for when only blue and red light are provided for the plants (satisfying objective O–1.1)
- **PLANTS AND PEOPLE** for when white light (a combination of red, green, and blue light) is provided for a person who is present when the plants are receiving artificial light and the person needs more comfortable lighting (satisfying objective O–1.2)

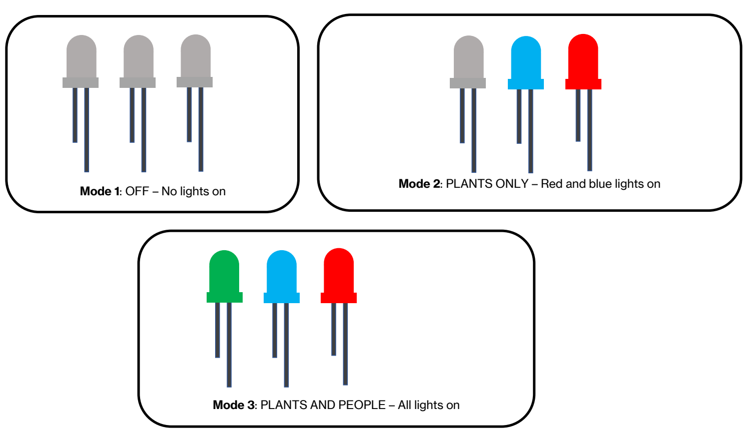

Figure 4: Modes of the Lighting Module.

As shown in Figure 5, for control of a collection of modules, the user can access a control panel that has the same layout as the greenhouse to select which collection of modules they want to switch modes. For local control of a module, the user can switch modes by pressing one or more buttons (only one button is shown in Figure 5 for illustrative purposes) on an individual module nearby.

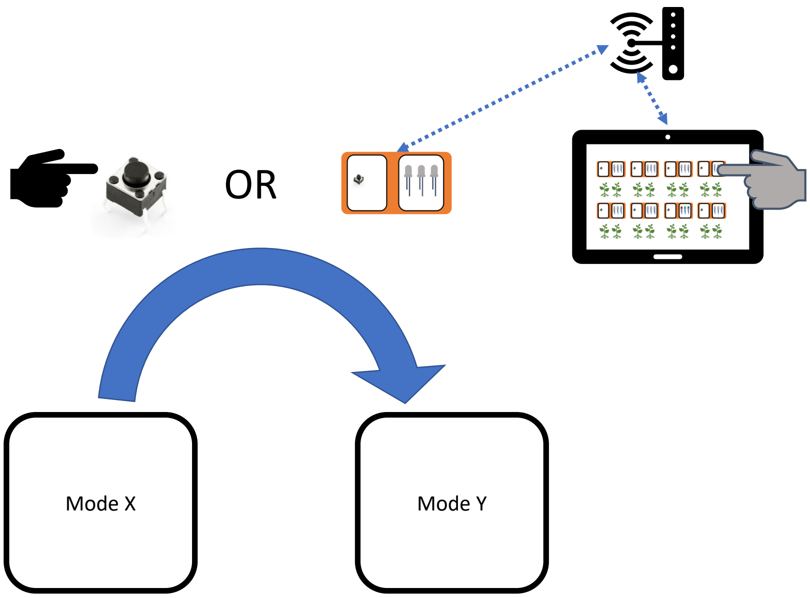

Figure 5: Button press to switch modes

As mentioned previously, the **energy managemement system** acts as fail-safe to user control. It uses occupancy sensing to determine if users are present in the greenhouse or not. If users are present in the greenhouse, it takes no automated actions. However, if it detects that users have not been in the greenhouse for a while, it uses ambient light sensing to determine if the plants need additional light or not and turns the blue and red LEDs on or off depending on what the current lighting situation is. The overall logic of this behaviour is illustrated in the state machine diagram in Figure 6.

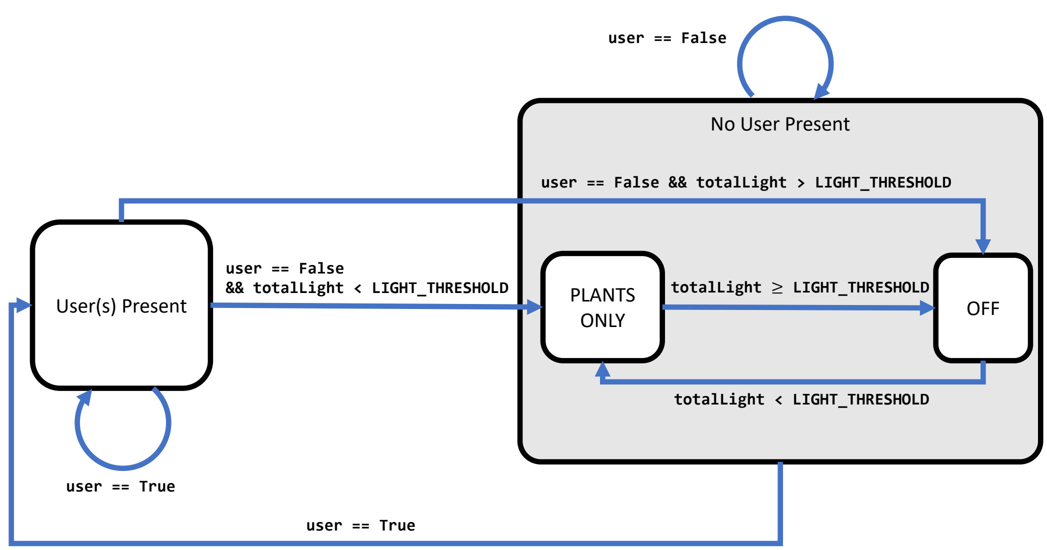

Figure 6: Energy management system behaviour represented as a state machine.

1.3 Connection to Objectives

Having separate lighting modes for when a worker is present and absent allows us to address O–1.1 and O–1.2. The PLANTS ONLY mode addresses O–1.1. In the PLANTS and PEOPLE mode, the red and blue lights stay on when the person is present and the green light is turned on, which ensures that plants still receive adequate light (O–1.1) while comfortable light is being provided for the user (O–1.2).

The use of three lighting modes also allows us to address the objective of being energy efficient (O–2.1), by only using the light necessary for each scenario as opposed to having the full spectrum of light be present all the time, which requires all three lights and therefore more power. In addition, by having each module be individually-controllable (and controllable in small groups), we can also save energy by only turning on lights for those modules that are necessary, adding to our energy efficiency. Lastly, the energy management module also helps with this requirement by adjusting the lighting when users are not presesnt.

We believe having the user select the mode can help with the objective of being easy to use (O–3.1) since the user has direct control of which mode the system is in when they are present.

We have not yet specified at the conceptual level ways to address objectives O–4.1 and O–4.2 as we would like to explore options during prototyping and refine the concept later based on what we learn. In addition, compliance with environmental standards is closely tied to detailed design decisions such as materials and components selection: for now, we have not considered the design of the modules at this level of detail, though we are confident that the enclosed, largely wireless modules we have proposed can be made to meet these objectives at a more detailed level of design.

2 Design Concept Development

NOTE: In the more complete Design Concept Overview document you will produce for your Major Design Project, you will provide information on the design process that led to the particular Design Concept you selected. This will include discussion of how you created a diverse set of design alternatives through divergence based on the objectives, and how you arrived at the selected concept through a convergence process, providing rationale for decisions made along the way. We have not provided this process here, as we do not wish to constrain the process that you end up following later in the course.