System Design Document

Occupancy Management System

Made for the Industry Project in semester 3

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11/03/2021

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Terms, Abbreviations

Abbreviation/Term	**Meaning**
SDD	System Design Document
OMS	Occupancy Management System
System administrator	A person, charged with looking after and controlling the system

1. Introduction

The occupancy management system is a system of cross-communicating electronic subsystems for monitoring and restricting the flow of people in a building and ensuring their safety and comfort. The system is able to give directions, warnings and recommendations to the visitors and occupants to ensure quick and bottleneck-free movement in and out of the building and provide safe levels of occupancy at all times.

2. System description

2.1 Safety

The system goal is to guarantee the safety of the people in the building. The systems will communicate constantly to monitor the movement and number of people throughout the building. Each gate of the building is designed to detect the people coming through and its level of users per minute. Each gate is independent enough, so that if the management system or any other system fails, the gate will not malfunction and further hinder the correct functionality of the whole system. In the case of wireless network failure, a back-up communication network using an industry standard CAN bus is optionally included in the system.

2.2 Main Functionality

Each gate takes input from a person entering/exiting through it and increments/decrements the number of occupants in the building value and communicates that with every other subsystem where the value is also updated. When the maximum occupancy threshold is reached, the gates will restrict access to the building. There is a control panel that should be situated in a security/administration room, from where a building administrator can get information about the current state of the building and gates.

2.3 Additional Functionality

In addition to providing entry and exit, the gate subsystem also has a display, providing information about the people coming to enter. For example, it can redirect people to other gates, should the current one be overloaded - this is decided by the system by using a distance sensor that determines the length of the queue in front of the gate(also part of the gate subsystem). Another feature is the website of the building that is getting input from the occupancy management system and provides the web page visitors with information about the current busyness of the building and possibly provide a graph showing in which hours the building is least busy.

3. System Design

3.1 Use cases

In this section use cases and corresponding requirements are described.

Use Case ID: UC_001	**Use Case:** Help button
Description	When a person coming through a gate encounters an error, he/she presses a help button located in a visible place
Actor:	A gate user
Basic path:	1. User encounters an obstacle at the gate 2. User presses the button 3. Button sends signal to control panel
Pre-conditions:	1. Gate is connected to the system

Use Case ID: UC_002	**Use Case:** Adding a new access point
Description	When a system administrator needs to add a new access point to the system, he adds it through the control panel
Actor:	System administrator
Basic path:	1. The administrator connects an access point to the electricity network 2. The administrator connects the access point to the wireless communication network 3. The administrator activates the access point using the control panel
Pre-condition:	1. The gate subsystem communication is functional 2. The hardware for the gate is installed at the desired location

Use Case ID: UC_003	**Use Case:** Disconnecting a gate
Description	When a system administrator needs to disconnect a gate from system completely, he does that through the control panel
Actor:	System administrator
Basic path:	1. The system administrator deactivates the gate 2. The administrator disconnects it from the network
Pre-condition:	1. The gate is not the only functional one in the whole building 2. The gate is not being used by anyone 3. The gate is locked
Pre-condition:	1. The remaining number of gates is not low enough to endanger the occupants of the buildings safety in case of emergency

Use Case ID: UC_004	**Use Case:** Access restriction due to max occupancy
Description	When the system reaches maximum occupancy of the building, people are not allowed through the gates and are shown a notification on a display

Actor:	The system
Basic path:	1. Number of people inside the building reaches the maximum threshold for occupancy 2. The system prevents the gates of letting more people in 3. The system issues a warning onscreen about the situation
Pre-condition:	1. The number of people in the building has reached the threshold for max occupancy 2. The system hasn't already forbidden the entry

Use Case ID: UC_005	**Use Case:** System detects person entering the building
Description	A person passes through a gate to enter the building and the gate takes input
Actor:	A gate user
Basic path:	Person goes through the gate Gate detects the person going inside System increments the number of current occupants
Pre-condition:	1. Gate is open

Use Case ID: UC_006	**Use Case:** System detects person exiting the building
Description	A person passes through a gate to exit the building and the gate takes input
Actor:	A gate user
Basic path:	1. Person goes through the gate 2. Gate detects the person going out 3. Gate decrements the number of current occupants
Pre-condition:	1. Gate is open

Use Case ID: UC_007	**Use Case:** Person receives information from a display
Description	The system shows relevant information on a display in front of a gate
Actor:	A gate user
Basic path:	1. Gate receives relevant information from the system 2. The gate subsystem displays the information on the screen in front
Pre-condition:	1. Information for the occupants is received from either sensor input, threshold reached or as input from control panel

3.2 User requirements

A user requirement describes what a user expects the system to do.

Requirement ID	Description	Use Cases
UR_001	User shall be able to go through a gate	UC_005, UC_006
UR_002	User shall receive information timely and in comprehensive way	UC_007
UR_003	User shall be able to inform personnel about gate error	UC_001
UR_004	System administrator shall be informed about number of occupants and states of gates in real time	UC_005, UC_006
UR_005	System administrator shall be informed about unauthorized access to the building	UC_005
UR_006	System administrator shall be able to add or remove gates from the system	UC_002, UC_003
UR_007	System administrator shall be able to indicate to users which access point should be used using the control panel	UC_007
UR_008	System administrator shall be informed whether there is somebody left in the building after closing hours	UC_005 UC_006

Table 1. User Requirements

3.3 Functional requirements

Functional Requirement ID	Description	Use Case/UR
FR_001	The system must be able to take input from a person passing through a gate	UC_005, UC_006/ UR_001
FR_002	The system must be able to keep count of people	UC_005, UC_006
FR_003	The system must restrict entrance to the building if the max occupancy reached	UC_004
FR_004	The system must open gates	UC_004
FR_005	The system must lock gates	UC_008
FR_006	In case of emergency, the gate state control of the system must be overridden to open all gates	
FR_007	The system must detect the direction of a person passing through a gate	UC_005, UC_006
FR_008	The system must show on a display in front of a gate number of occupants and any other access points that should be used instead	UC_007/UR_002
FR_009	System must be able to sound warnings for gate users	UC_004/UR_003
FR_010	The system must be able to issue an alarm signal	

FR_011	The system must signal a warning if more than 1 person tries to pass through a gate at the same time	UC_005/UR_005
FR_012	The system must be able to detect unauthorized access in the building or room	UC_005/UR_005
FR_013	Each gate must communicate with the control application	UC_001, UC_002, UC_003, UC_004/UR_4, UR_005, UR_006,
FR_014	A gate can be disconnected from the control panel of the system	UC_003/UR_006
FR_015	A new gate can be connected to the system through control panel	UC_002/UR_006
FR_016	The system must indicate to system administrator that some gate experiences issues	UC_001/UR_003
FR_017	The system should be able to determine if there are any people in a certain room (e.g. toilet)	UR_008
FR_018	The system must be able to detect CO2 levels in the atmosphere	

Table 2. Functional Requirements

3.4 Non-functional requirements

Non-functional Requirement ID	**Description**	**Use Case/UR**
NR_001	The system must remain functioning in case one or more gates disconnect	UC_001/UR_006
NR_002	The people should only be able to pass through the gates one at a time	UC_005, UC_006/ UR_001
NR_003	The system should adhere to civil codex regulations about safety	UC_001/UR_003
NR_004	The systems emergency response should be autonomous and instant	
NR_005	Each subsystem should be independent in its functionality	
NR_006	The communication network should be robust	

Table 3. Non-functional Requirements

3.5 Requirements traceability matrix

	UC_001	UC_002	UC_003	UC_004	UC_005	UC_006	UC_007
UR_001					X	X	
UR_002							X
UR_003	X						
UR_004					X	X	
UR_005					X		
UR_006		X	X				
UR_007							X
UR_008					X	X	

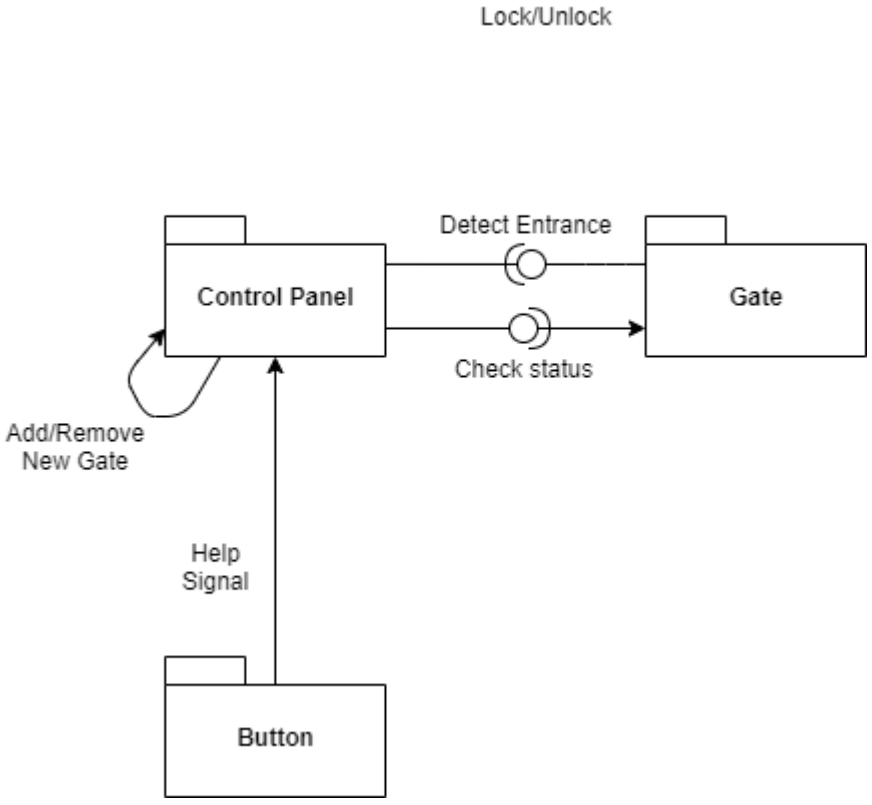
Table 4: Use cases vs user requirements coverage

	UR_001	UR_002	UR_003	UR_004	UR_005	UR_006	UR_007	UR_008
FR_001	X							
FR_002								
FR_003								
FR_004								
FR_005								
FR_006								
FR_007								
FR_008		X						
FR_009			X					
FR_010								
FR_011					X			

FR_012					X			
FR_013				X	X	X		
FR_014						X		
FR_015						X		
FR_016			X					
FR_017								X
FR_018								

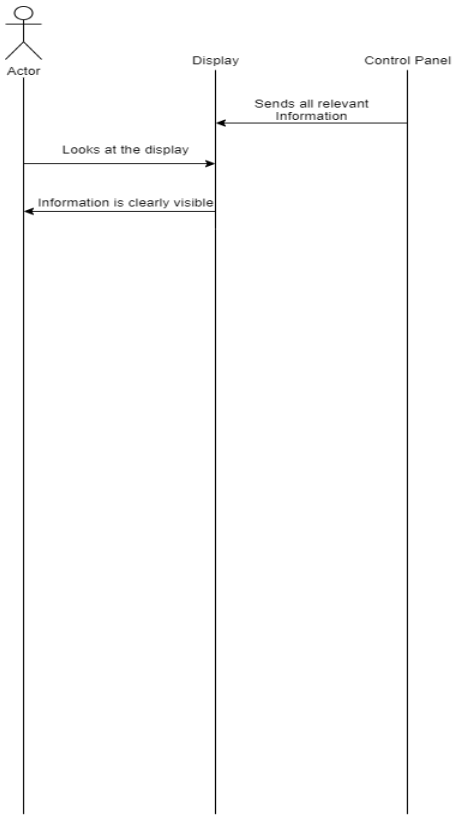
Table 5: Functional requirements vs user requirements coverage

3.6 system architecture diagram

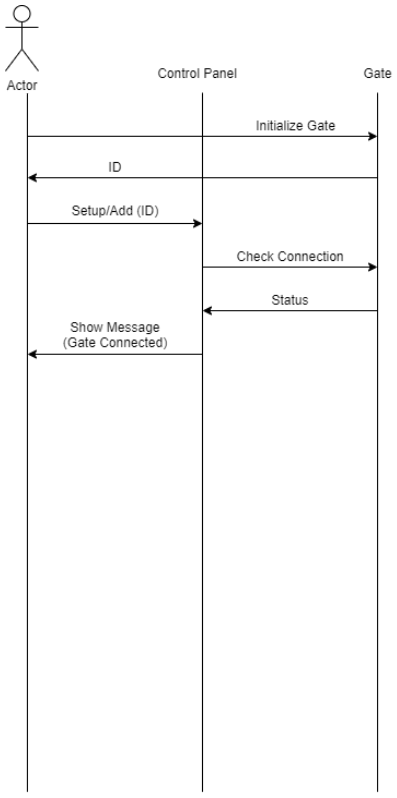


3.7 Sequence Diagrams

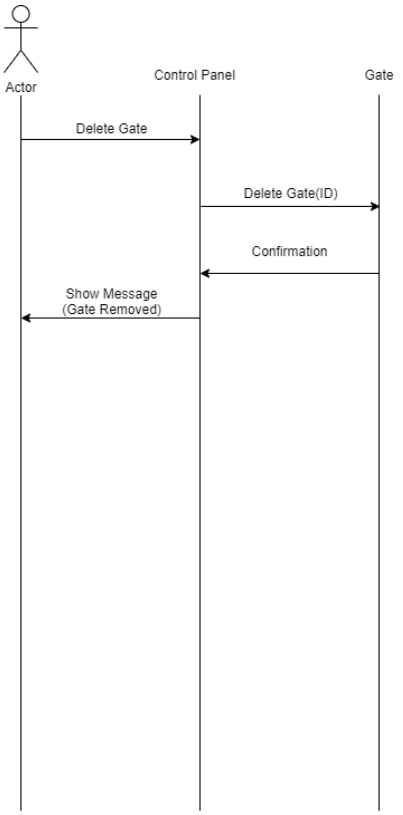
1. Person receives information from display



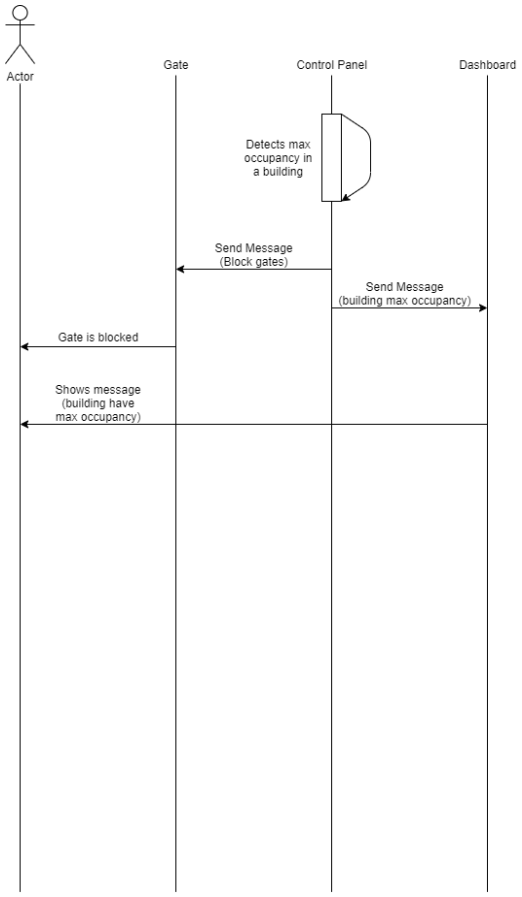
2. Connecting a gate to the system



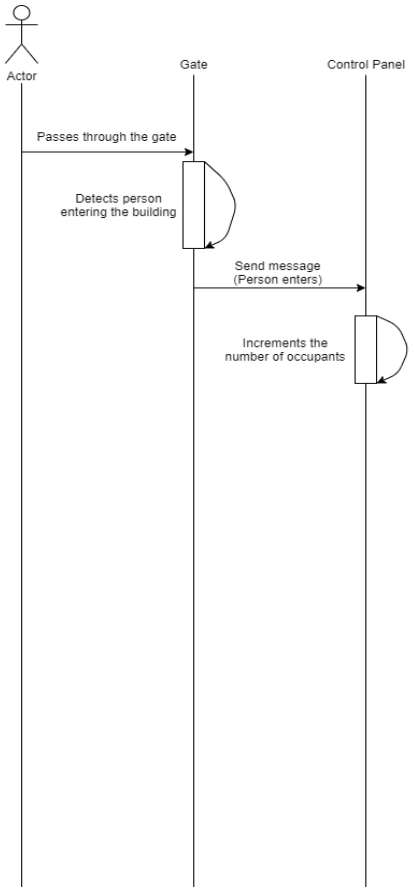
3. Disconnecting a gate from the system



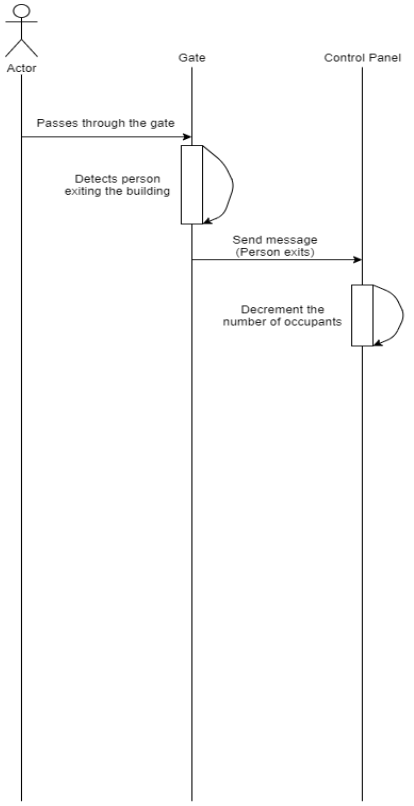
4. Restricting access due to max occupancy



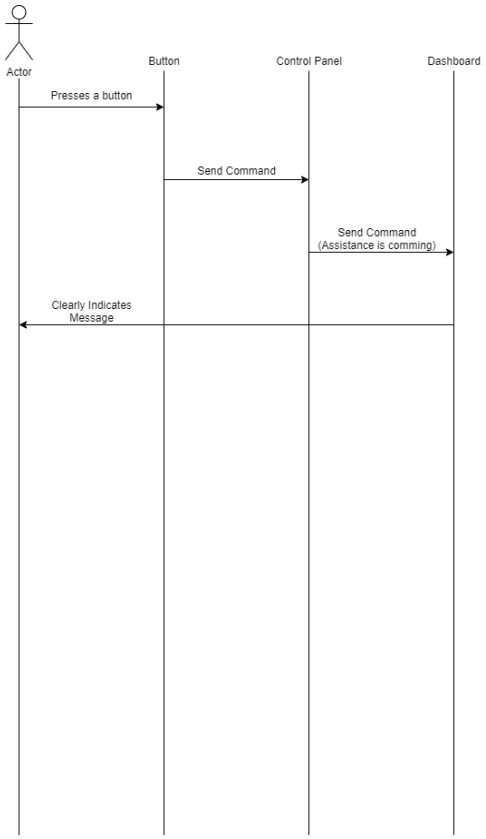
5. Detect a person entering through a gate



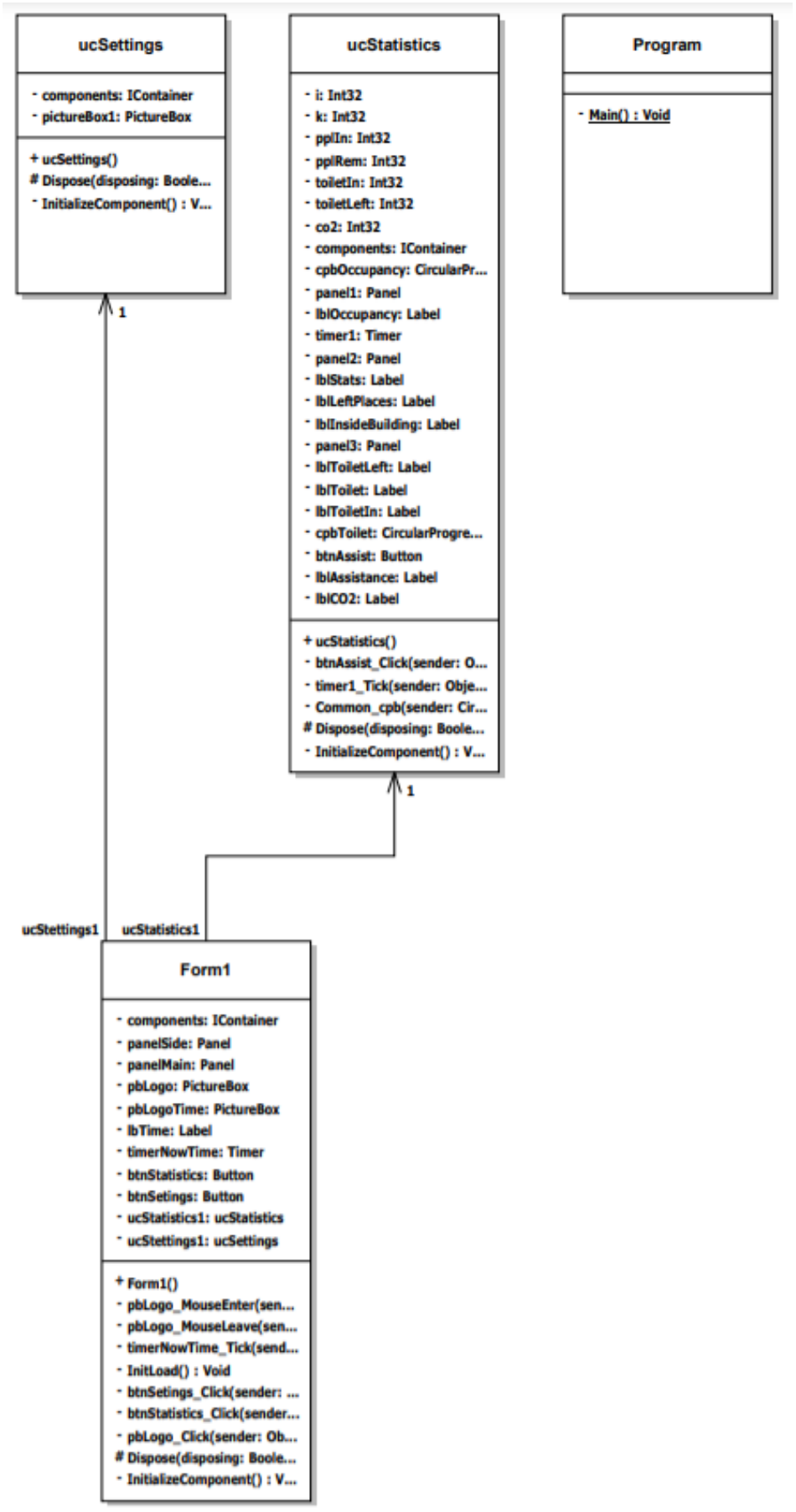
6. Detects a person exiting through a gate



7. Help button press



3.8 class diagram for control panel application



4. System structure

Module name	Responsibilities
Gate	Let people in and out and count them. Includes a display for info
Control Panel	Provides the building admin with info and control over the system
Website	Provides info for anyone interested in the busyness of the building online

Table 6. System structure modules and their responsibilities

5. Recommendations and conclusion

The first thing that should be improved in the system hardware are the gates. If they are switched to rotating ones, that will allow for higher accuracy for detection of the number of people passing through them. Another thing that will also facilitate the flow of visitors is the queue length detection hardware. Instead of the current solution with the distance sensor, a camera could be installed and the system can be taught to recognize people from the camera input and that way determine queue length with higher accuracy. In addition, the control panel application can be improved to provide the building administrator with higher control over the entire system if needed, and/or provide him with more information collected by all subsystems. Also, better hardware is advised to be used as gate MCP, since the ESP32 is getting a bit overloaded pin wise with all the sensors and also having to maintain a mesh network.