Foundations of Ubiquitous Computing and IoT Milestone 3: Smart Warehouse - Components

Marko Kadic, 12045128
Roland Bozi, 12045653

The Subsystem Concept - Overview:

Loading and Sorting of Boxes in a warehouse - setting:

A vehicle arrives at the loading dock. The system recognizes the approaching vehicle and “wakes up” the other systems. It also turns on an LED light as a signal to the workers.
The delivery person walks up to the warehouse product entrance and presses their RFID tag to the scanner. The system validates the delivery person, and locates the information about the delivery. It recognizes how many products are being delivered and locates the empty spaces in the warehouse for them to be stored. It maps the spaces to the boxes and prepares stamps to stamp the boxes accordingly.
The system then opens a small door for the boxes to be placed into and starts a revolving track for the boxes to be put onto.
The delivery person then starts to put the boxes onto the track.
The boxes are put onto the track and are passed by a distance measuring sensor that detects the SIZE of the box and sends a signal to the sorting mechanism to sort the boxes into trays accordingly.
The system stamps the boxes with the RFID tag with slot number of the free space that the boxes are supposed to go in, and the product type (on server).
A subsystem for automatic RFID tagging tags the boxes.
The box is then picked up by a moveable robot that takes the box to its slot.
The system makes sure that the same size boxes are close together in the warehouse.

The Submodules:

For this subsystem, we will use 3 different boards. 2 ESP32 boards and 1 ESP8266 boards.
We will also have a central server to take care of the warehouse and delivery, and sorting information.
All 3 of the boards will be connected to the main server through WiFi.

The first ESP32 board will feature:

- 1 RFID scanner: MFRC522 module
- 1 LED to note the state start (for the workers)
- 1 LED green to note the loading OK status (for the delivery people)
- 1 LED light to note STOP for the loaders
- 1 Ultrasonic Sensor to note the truck has arrived: HC-SR04
- 1 Servo motor to open door: SG90

The second ESP32 board will feature:

- 1 Ultrasonic sensor to check the box size: HC-SR04
- 1 LED green light to note the OK status
- 1 LED red light to note something is wrong
- 1 DC Electric motor to start the revolving track: 130 3-6V small DC motor
- 1 L298N Motor Driver
- 4 1.5V AA batteries

The second ESP8266 board will feature:

- 1 motion detection sensor as a mockup for 1 slot in the warehouse: SEN HC-SR-501
- 1 green LED light to note that the space is empty

The System Code/Communication:

1. **Slot detection board:**
    - The LED lights GREEN
    - If movement is detected:
        GET form server for this space
            If not OCCUPIED:
                Change occupied status to OCCUPIED
                Send PUT to server for this warehouse space
                LED off
            else:
                Change status to FREE
                LED green
                Send PUT to server for space

2. **Sorting board:**
    - Entrance board triggers incomingDelivery(), on IRQ.RISING
    - Incoming delivery:
        LED green - ON
        GET form server Delivery info:
        - Box sizes and RFID tags to tag them
        - Warehouse spaces for box types
        - Start Sorting Robots (Server)

        Notify the RFID tagging system to start
        loop:
            Measure box with distance sensor (distance < usual) +
            + amount of time + track speed
            Tag box with correct RFID + correct space in warehouse
            POST to server with box info
            if(something went wrong):
                Tag box: ERROR
                LED red ON
            LED green ON
            if(NO BOXES LEFT):
                trigger Stop on entrance system
                return

3. **Entrance/System Start Board:**
    - Set timer to measure Distance sensor every 5 seconds
    - If distance < usual:

        GET to server for Delivery people RFID
        loop:
            Wait for RFID read
            if RFID read == Delivery people:
                LED Green ON
                Open door
                Trigger Sorting board Incoming delivery
    - Stop():
        LED light off
        Close door

4. **The sorting robots:**
   Triggered from the server
   Drive to end on sorting line
   isAtSortingSpace = true
   GET form server the next box warehouse space
   When box drops:
      boxes left -1
      isAtSortingSpace = false
      Leave box at space
   if(boxes_left != 0):
      return to sorting space
5. **The Server:**
   Sort incoming deliveries with delivery people RFIDs
   Sort incoming boxes by size + tag
   Sort boxes into empty spaces
   GET from all systems empty spaces
   GET from all robots isAnyoneAtSortingSpace
      if not: Pause Sorting
6. **Black Box RFID Tagging:**
   RFID Tagging system: NOX-1 RFID Tags to be used
   System example: https://www.weber-marking.com/rfid.html

The Mockup Diagram:

- **Appended as Warehouse_Mockup**

The Circuit Diagrams:

- **Appended as Warehouse_Circuit_1/2/3**

List of Sensors/Datasheets:

- HC-SR04 x 2:
  https://datasheetspdf.com/pdf/1380136/ETC/HC-SR04/1
- MFRC522 module:
  https://www.elecrow.com/download/MFRC522%20Datasheet.pdf
- HC-SR-501 x 2:
  https://www.epitran.it/ebayDrive/datasheet/44.pdf
- L298N Motor Driver:
  http://www.handsontec.com/dataspecs/L298N%20Motor%20Driver.pdf
- 130 3-6V small DC motor

- SG-90 Servo motor: http://www.ee.ic.ac.uk/pcheung/teaching/DE1_EE/stores/sg90_datasheet.pdf

Prototype component materials:

- 3D printer for sensor and board casings, Gears for the revolving track, warehouse drop spot, sorting robot and door mockups
- Some rubber for the revolving track (we are not yet sure about this one, as the supermarket style revolving tracks seem unneccesary)

Further API development:

A system that has RFID readers and connects to a database at the load-in and the load-out that could store information about the products, quantities and weights stored, and could send out an alert or a notification if a product quantity is below a certain threshold or if a product is or is not selling well.
A system of movement/location sensors for every available space in the warehouse to keep track of available and taken space, to keep track of where products are, and to create a plan for where the product should be stored once it enters the warehouse. It could also track where products can be found.