

Homework 2

Assistant for Recycling and Waste Management to Reduce Recyclables in Landfills

Noah Beach, Kevin Christensen, Emmet Cooke, Jacob Leno, Caleb Scott
CS361 Group 18 - Spring 2018

Contributions and Customer Meeting Summaries

The work was divided among our group for HW2 as follows: Noah Beach - Customer Meeting/Summary of Changes/Revised Specifications, Kevin Christensen -Prototypes, Emmet Cooke - Customer Meeting, Jacob Leno - Prototypes/Revised Definitions, Caleb Scott - Prototypes/Revised Definitions.

The group met with the customer on Thursday evening to present and discuss the first iteration of the requirements document as well as the prototypes that had been generated. The customer found the requirements to be adequate for their vision of the system's use, stating that "the use cases presented are exactly what I envisioned for the product." The customer only proposed minor changes to the system including user interface tweaks and the requirement of designing for security since the system will be network connected.

Requirements Definitions

Functional Requirements

- Participating manufacturers of recyclable products (both newly manufactured and recycled) will install a scannable identifier into all produced goods.
- The waste sorting facility shall be equipped with an automated system to scan and sort incoming goods.
- The automated system shall be able to determine if a good has a scannable identifier.
- The automated system shall be able to determine if a good does not have a scannable identifier.
- The automated system shall be able to correlate the scannable identifier to a recyclable material type.
- The automated system shall separate goods with an identifier from goods without an identifier.
- Goods without an identifier shall be sent to a manual sorting line to capture recyclable material from manufacturers not participating in the program or where a scannable identifier is impractical (such as newspaper).
- Goods with an identifier shall be sent to a secondary automated sorting line.
- The secondary automated sorting line shall sort materials into the appropriate category.
 - A third sorting will take place for goods that have subcategories such as plastics or glass.
- Landfill Location System will be equipped with a user interface
 - The user interface will have options for: reports, logs, diagnostics, and database interaction.
 - Logs option will output sort options for each RFID scanner/sorter
 - Reports option will output a report of recyclables processed in a selected period of time and sorting machine statistics
 - Diagnostics option will give options for technicians working on repairs and maintenance
 - Options include: Sort settings, current alarms, calibration, system info, and software update.
 - Database option will have the option to add new recyclables, search for recyclables already in the database, and an option to edit recyclables currently in the database.
 - Navigation between each page of the user interface will be "user friendly"
- Smart Bin System will be equipped with a user interface
 - The user interface will have options for: settings, diagnostics, reports, parameters, and a test mode.
 - Settings option will allow for adjustment of internet connection, emptying the bins and updating the software.
 - Diagnostics option will give information to assist in troubleshooting and maintenance
 - Reports option will give information on recyclables processed

- Parameters option will allow the user to set parameters such as lid open time, lid open speed, and a capacity limit
 - The test mode will allow for testing during troubleshooting and maintenance
- “Smart Bin” individual pre-sort machines will alert the user when an untagged or non recyclable item is placed into the bin.

Non-Functional Requirements

- The automated system shall be able to identify tagged versus non-tagged goods a minimum of 90% of the time.
- The system shall be scalable to increase or decrease waste throughput as required.
- The automated system shall have the ability to add or remove recyclable materials from its sorting capabilities.
- The automated system shall correctly identify tagged goods 95% of the time.
- The system shall not take longer than 2 seconds to identify a tagged good.
- The system shall provide a summary of sorted goods.
- The system shall have an intuitive user interface to provide access to diagnostic features.
- When the software connects to the internet for updates it shall have sufficient security in place to prevent hacking and attack from malicious software

Specifications

Functional Requirements

- Manufacturers of recyclable products (both newly manufactured and recycled) will install a passive RFID chip that identifies the product's recyclable category (waste paper, cardboard, plastic, metal, or glass).
- Waste sorting facility system will utilize short range RFID scanners to identify recycling category (waste paper, cardboard, plastic, metal, or glass) of waste. RFID scanners will send out RF energy which will activate the passive RFID chips, the chips then emits a specific signal which corresponds to a recycling category.
- Waste sorting facility system will utilize hydraulics, pneumatics, or robotics to automatically pre-sort and separate scannable goods from non-scannable goods.
- Waste sorting facility system will utilize hydraulics, pneumatics, or robotics to automatically sort and separate goods by their scanned recycling category.
 - A tertiary sorting will be performed, again utilizing hydraulics, pneumatics, or robotics, for goods that have subcategories such as plastics or glass.
- Waste sorting facility system will decode the signal received from the RFID chip by referencing a database of categories.
- Goods that are unscannable or report invalid scan data (based on database look up) shall be sent to a manual sorting line to capture recyclable material from manufacturers not participating in the program or where a scannable identifier is impractical (such as newspaper).
- Landfill Location System will be equipped with a local user interface (via touch screen on the device) as well as a remote user interface (via web application).
 - The user interface will have options for: reports, logs, diagnostics, and database interaction.
 - Logs option will securely query the system for logged data (saved in the database) for each RFID scanner/sorter
 - Reports option will output pre-generated reports by securely querying the database and running a query that pulls the recyclables processed in a selected period of time and sorting machine statistics
 - Diagnostics option will give options for technicians working on repairs and maintenance
 - Options include: Sort settings, current alarms, calibration, system info, and software update.
 - Database interface will be implemented such that INSERT queries can be performed to add new recyclables, SELECT queries to search for recyclables already in the database, and UPDATE and DELETE queries to edit and remove recyclables currently in the database.
- Smart Bin System will be equipped with a local user interface (via touch screen on the device)
 - The user interface will have options for: settings, diagnostics, reports, parameters, and a test mode.
 - Settings interface that will provide options for:
 - Internet connection settings (hard wired/wifi selection, DHCP/ manual IP selection (IP subnet, gateway, DNS server))
 - Basket fill level adjustment and emptying by controlling the variable that tracks bin fill level
 - Updating the software by overwriting the current version saved on disk with a newer version.

- Diagnostics interface will poll and report hardware and software status
 - Reports option have pre-generated reports that can be pulled, these pre-generated reports will perform queries against the database to gather information and display it in a user friendly format
 - Parameters option will allow the user to set parameters such as lid open time, lid open speed, and a capacity limit, all which will update the configuration file for the system that initializes these settings at start up.
- The Landfill Location System will provide a secure web interface for interested parties to see the statistics on the recycling performed by the system.
- The Smart Bin System will provide a secure web interface for interested parties to see the statistics on the recycling performed by all the Smart Bins owned by a single organization.
- Smart Bin Specifications
 - Smart bins will use actuators (hydraulics or pneumatic) to provide a movable system to deposit approved recycling material into the correct bin
 - The actuators for the Smart Bins lids will only open to the lid waste that has been scanned and approved
 - Smart bins will be connected to a database of recyclable materials
 - Smart bins will have secure communication to external systems

Non-Functional Requirements

- Since recyclable waste is now sorted by RFID tag at the sorting facilities the scale of the traditional compost/trash/recycle bins are no longer required as the majority of the incoming waste will be able to bypass the manual process.
- The accuracy of the RFID scanner and chips shall allow for a minimum of 95% scanning accuracy.
- The system must provide a way to update the database of possible recyclable items.
- The speed of the RFID scanner shall take no longer than 2 seconds to scan, recognize, and accurately determine the good's type.
- The system will record a information about each scan to a database for later analysis such as timestamp, tag id, good's recycling category.
- The system shall provide an interface for the user to maintain, update, and diagnose issues.
- The RFID scanner utilized on the Smart Bin System will have a scanning range of 2 meters
- The RFID scanner utilized on the Smart Bin System will be able to differentiate between multiple types of RFID chips from multiple vendors to ensure scalability of recyclables.
- The Smart Bin System will utilize both data at rest encryption as well as data in transit encryption to prevent unauthorized or malicious use of the system.
- The Smart Bin System will utilize hydraulics to sort the waste by scanned RFID tag
- The Landfill Location System will utilize hydraulics, pneumatics, or robotics to shift tagged recyclables from the main line to the individual
- The Transportation Sorting System will utilize an onboard sorting system utilizing hydraulics, pneumatics, or robotics so that waste is loaded into the truck and sorted prior to reaching the Landfill Location
- The Transportation Sorting System separates the RFID tagged waste from the non-tagged waste
- The Transportation Sorting System will be compartmentalized to allow the tagged recyclables to be sorted before arriving at the waste collection location

Summary of Definition and Specification Changes

Definition Changes:

The development team made several changes to the functional and non-functional definitions between this and the last revision of the requirements document. These changes were implemented to extend the definition to match the changes that were implemented via prototyping as well as customer feedback.

Several modifications were made to the Landfill Location use case definitions. The first of these changes was a tertiary level of sorting that will be utilized for goods that have a sub-category for recycling. Examples of this are plastics and glass that utilize different techniques for recycling, for instance green glass vs clear glass or HDPE (high-density polyethylene) versus LDPE (low-density polyethylene). Another change that was put in place was the implementation of a user interface that provides options for reports, logs, diagnostics, and database interaction. This will allow the owner of the recycler to perform maintenance, generate reports for stakeholders, as well as gather other diagnostic information.

Modifications to the Individual Pre-Sorting use case included a user interface that has similar feature scope as the Landfill Location use case interface, but with different implementation requirements since this use case has the system consumer facing versus the Landfill Location use case which is designed to be placed in an industrial setting. Features that the interface can be expected to have includes options for reports, logs, and diagnostics. The interface will also allow a technician to be able to update the software (including the recyclables database), run tests and diagnostics, and set parameters (lid speed, open percentage, capacity limits, etc).

A final change was made to the non-functional requirements that was requested by the customer. Since the system will a requirement to be network connected for database logging, report generation, etc, the customer wanted a documented requirement for the system to be designed with security in mind to prevent unauthorized or malicious use of the system.

Specification Changes:

Similar to the Definition changes, the development team made several changes to the functional and non-functional specifications between this and the last revision of the requirements document.

Several modifications were made to the Landfill Location use case specifications. The first of these changes was describing the technical details for the tertiary level of sorting that will be utilized for goods that have a subcategory for recycling. As described in the definitions, there must be a third level of sorting that will utilize hydraulics, pneumatics, or robotics to perform the sorting. Another change was the additional of the technical specifications for the user interface that provides options for reports, logs, diagnostics, and database interaction. This specification also described the details on the features of the interface the rely on system data and how that data will be queried/updated from/to the system.

Modifications to the Individual Pre-Sorting use case included describing the technical details of the user interface. This specification also described the details on the features of the interface the rely on system data and how that data will be queried/updated from/to the system. It also provided specifications on how the system will be configured for network connections. The changes implemented also described the technical details of the internals of the bins (movable system to deposit goods into correct bin).

Several non-functional requirements were added to the specifications including a scan range requirement for the RFID scanner, this ensures the scanner can be placed a variable distance from the waste being scanned, depending on environment. Other additions include technical definitions for the security requirements requested by the customer and requirement for being able to scan multiple vendor's RFID chips. The specifications were also expanding for the Transportation Sorting Systems to include describing the sorting system inside the truck.

Use Case: Recycling Assistant - Landfill Location

Actor: Recycling Assistant sorting robot

Preconditions:

- Trash to be sorted is loaded into recycling assistant conveyor belt/presort machinery
- Some of the trash contains recyclables with embedded RFID chips
- RFID chips are loaded with correct codes that correspond to Recycling Assistant software

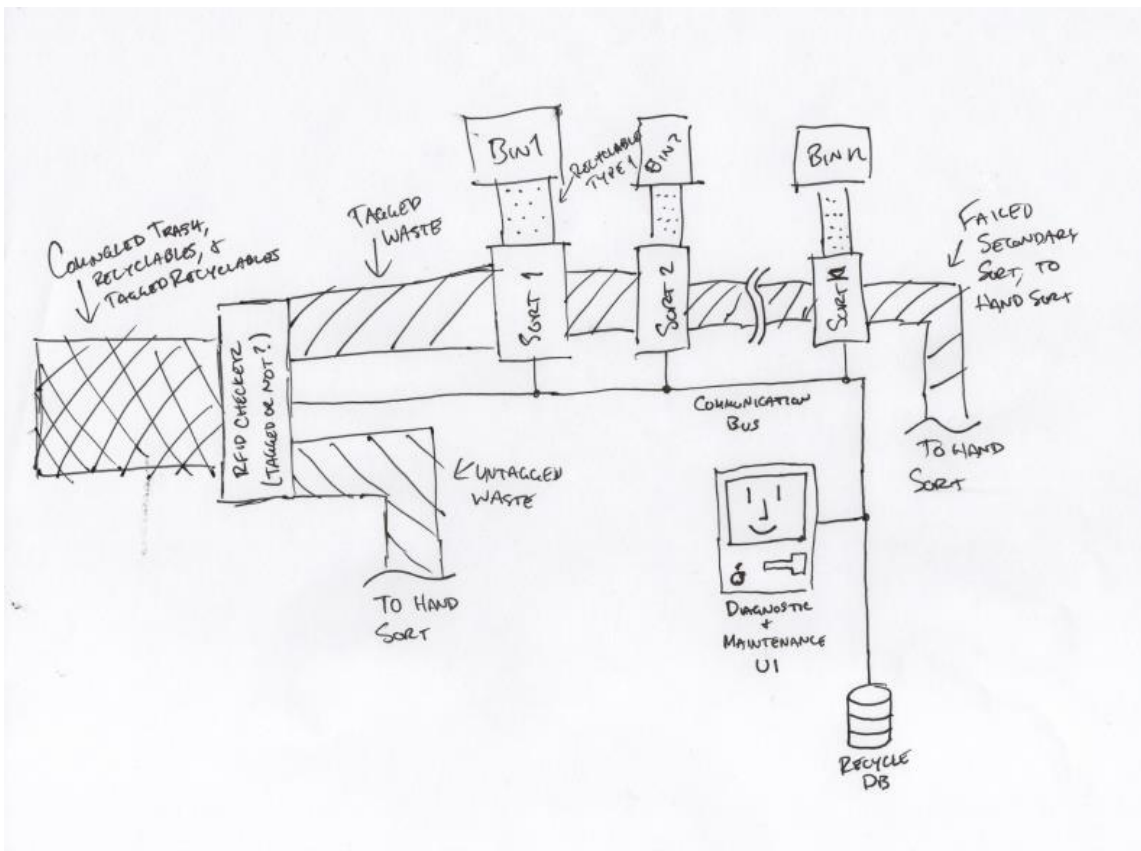
Postconditions:

- All trash that contains recyclable materials embedded with RFID chips is sorted and out of the waste stream
- Mixed trash/untagged recyclables exit the Recycling Assistant and move onto the 2nd line of defense for manual sorting
- Trash that has been sorted out of the waste stream is now in a post sort state
- Post sort recyclables undergo a second sort and are sorted into their main categories such as glass, plastic and paper
 - A third sort must take place to sort items with sub categories such as glass-blue and plastic-styrofoam
- The final state is the recyclable in its most specific category

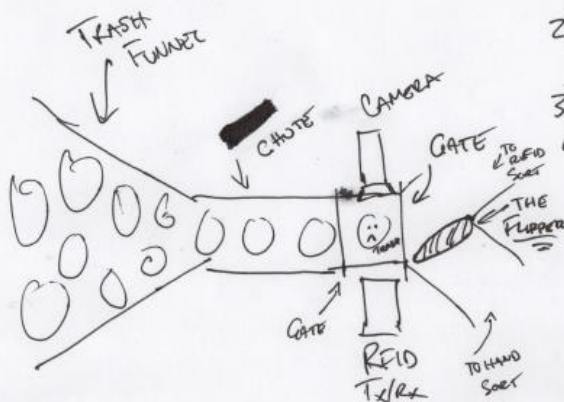
Flow of Events:

- Trash that contains unsorted RFID tagged recyclable materials enters the recycling assistant conveyor belt/presort machinery
- Trash/Recyclables mixture is funneled to the recycling assistant's material processing center and trash is separated from recyclables
 - First the recycling assistant scans each item via a RFID scanner
 - The scanner relays the RFID code to the software
 - The software checks its database to find out where to place the recyclable item
 - The software then sends a signal to actuate its sorting machinery
 - The "flipper" is actuated into the correct position to open the gate to the items corresponding type, either trash or recyclable.
 - Recyclables funneled down the their track would then be identified via another RFID camera and "punched" into the correct bin
- Items such as glass and plastic that have been removed then move on to the post sort process
- Leftover items in the waste stream are then manually sorted by people and non recyclable material is deposited in the landfill

Prototypes:

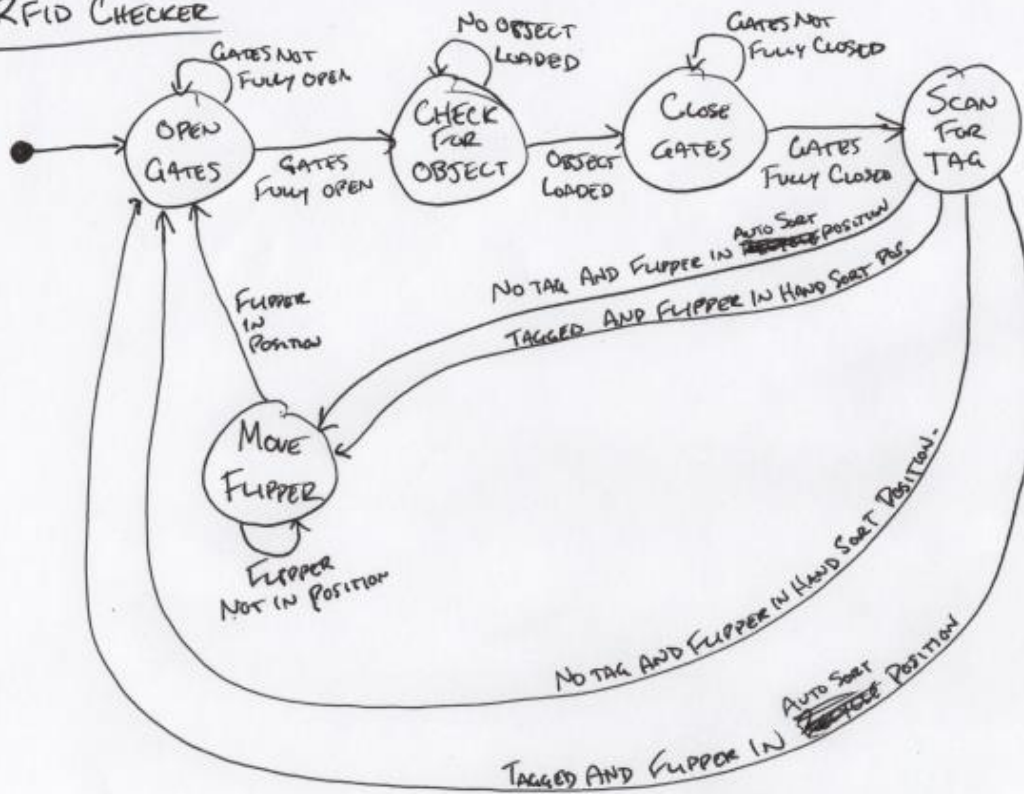


RFID Checker

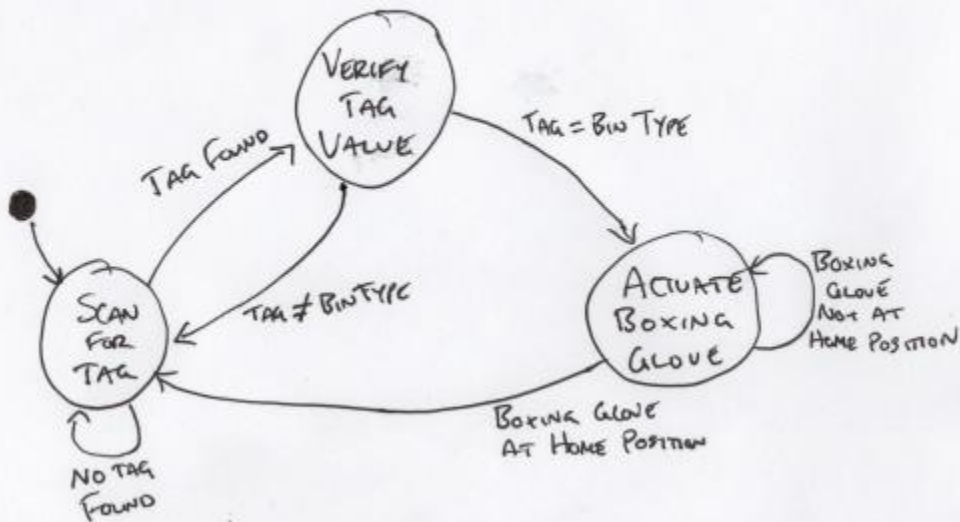


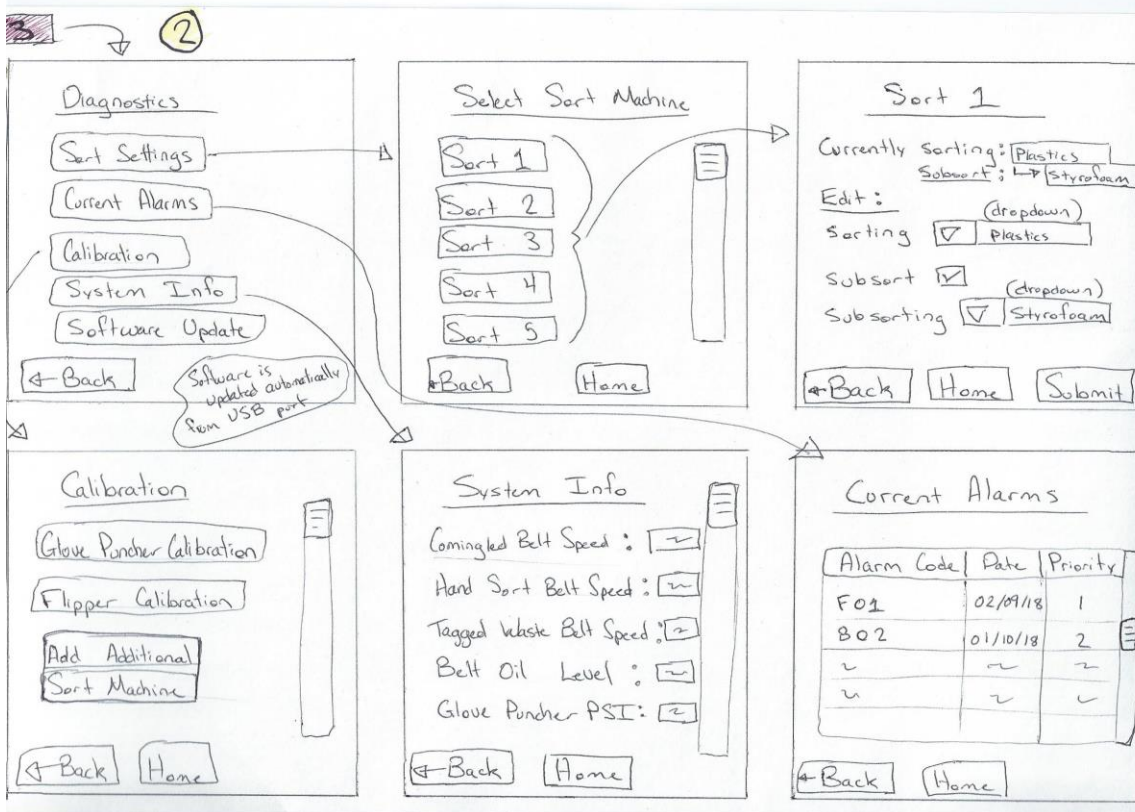
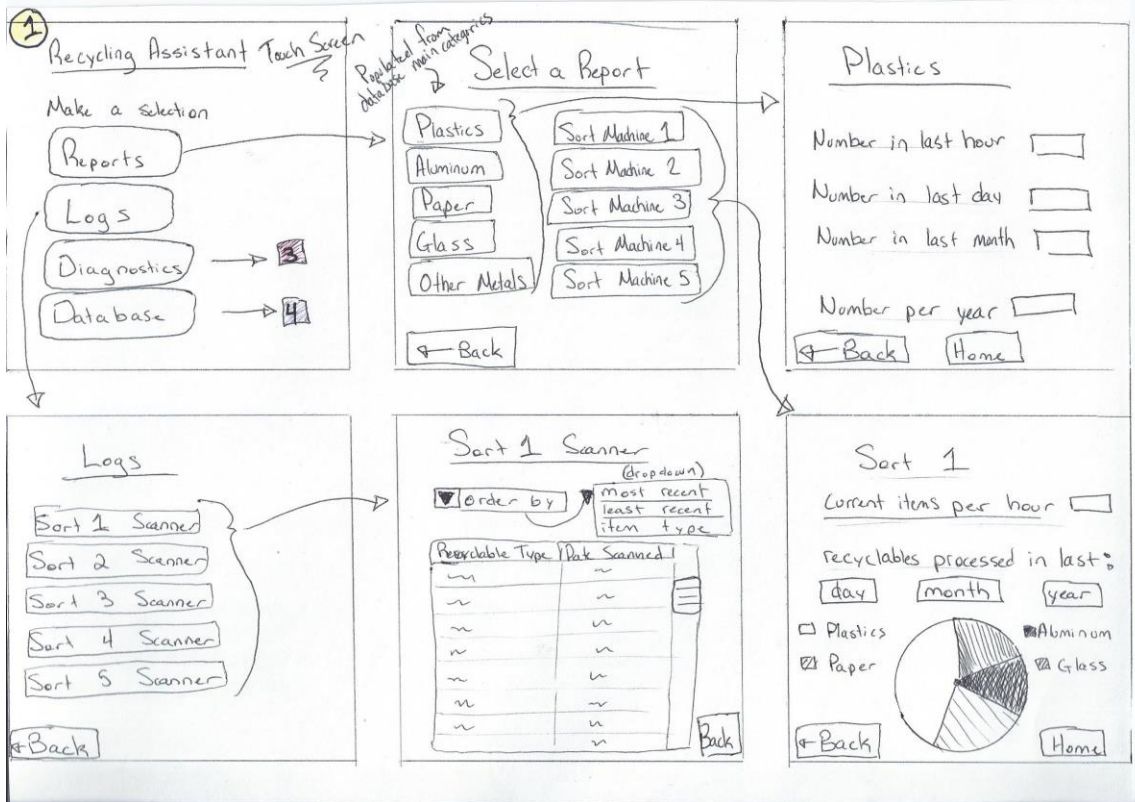
- 1) CAMERA DETERMINES IF OBJECT IS LOADED
- 2) RFID SCANNER CHECKS IF TAG IS PRESENT
- 3) FLIPPER IS MOVED TO PROPER POSITION,
- 4) GATES OPEN TO LET KNOWN OBJECT THROUGH, UNKNOWN OBJECT IN FOR ID.

RFID CHECKER



SORT 1-n





4

3

Database

Add New Recyclable

Search

Add Recyclable

Main Category? ☒

Type

Subtype of

Type Code

Back Home Submit

dropdown
opened only if
Main Category
is selected

Edit

prepopulated values

Main Category? ☐

Type

Subtype of

Code

dropdown
opened only if
Main Category
Selected

Search

Enter type title

Search

Results:

Name	Sub type	Code	
~	~	~	Edit
~	~	~	Edit
~	~	~	Edit
~	~	~	Edit

Back Home

Use Case: Recycling Assistant - Individual Pre-Sorting

Actor: Smart recycling bins

Preconditions:

- All recyclable material is embedded with passive RFID tags
- RFID tags are loaded with material type from Recycling Assistant software
- Recycling bins have multiple compartments with active RFID chips that scan the passive RFID tags and only open the correct compartment for the specific recyclable
- Anything without a tag will go into the waste bin to be sorted manually at the main recycling facility

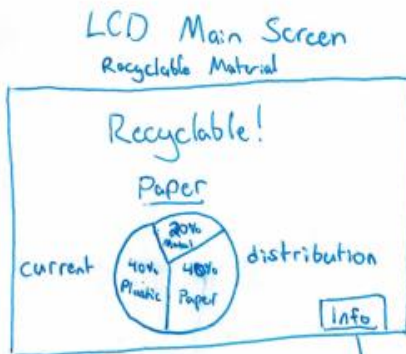
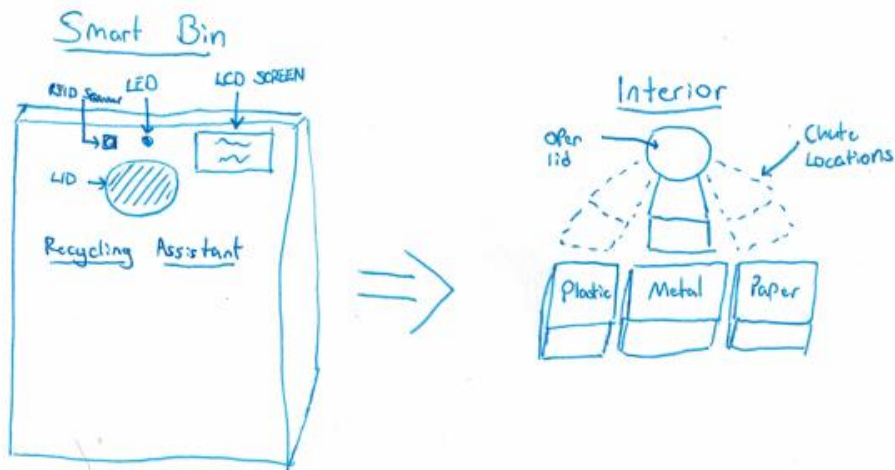
Postconditions:

- All waste containing RFID tags are counted and pre-sorted by the recycling assistant reducing the strain on the central sorting facility
- Waste without RFID tags are forwarded along to a central sorting facility to be sorted manually
- Initially sorted recyclables such as plastic can be sent to be further sorted into specific types; e.g. PET, HDPE, PVC, etc.

Flow of Events:

- Consumer creates waste whose packaging contains RFID tags and upon approaching a recycling bin the recycling assistant scans the waste
 - The RFID scanner reads the passive RFID tag
 - The Recycling Assistant software checks the database to determine the final location for the item
 - The software sends a signal to activates an LED light letting the consumer know the item is recyclable
 - An actuator is triggered to open the lid on the main recycling bin
 - The scanner detects when the object is placed into the bin
 - The item is logged into the database
 - A motor is activated to control a chute which directs the recyclable material into the appropriate bin
 - The lid actuator is triggered again to close the lid and reset to wait for the next item
 - Non-recyclable waste or non-tagged waste will be able to be disposed of next to the recycling bin for later sorting or disposal

Prototypes:



Recyclable Info

Thank you for recycling!
You've helped save
XX.XX amount of
(Metal Plastic Paper) today!

LCD Main Screen
Non-recyclable Material

Non-Recyclable

Please Use Adjacent
Waste Bin

Info

Non-Recyclable Info

Either this item is not
tagged or it is currently
not recyclable.

This Machine takes Plastic,
Paper, Metal

Smart Bin Control Menu

Settings

Diagnostics

Reports

Parameters

Test Mode

Settings

Screen Brightness 

Software Update v1.01

Empty Bins

Internet Connection

Database Connection

Update database

Diagnostics

Lid Position: CLOSED

Internet Connection: CONNECTED

Database Connection: NOT CONNECTED

Chute Position: LOAD

Bin 1 volume: 80%

Bin 2 volume: 20%

Bin 3 volume: 65%

Reports

Items Per hour: xxx

Rejected Items per day/week/month: xxx

Average time to capacity: xxx

Average # of items to capacity: xxx

Recyclable distribution per day/week/month

<u>xx%</u>	<u>xx%</u>	<u>xx%</u>
Metal	Plastic	Paper

Parameters

Lid Open Time: 5 sec

Lid Open Speed: 

RFID Scanner Power: 75%

Chute Limit Switch: X: Y: Z: Position

Chute default Position: 1

LCD Password: xxxx

Capacity limit: 100lb
Per bin

Test Mode

Open lid

Close lid

Test Internet
connection

Test database
connection

move chute:
to position

Load

2

1

3

Activate RFID Scanner

Measure Volume

Use Case: Recycling Assistant - Transportation Sorting

Actor: Recycling Assistant sorting robot within a truck

Preconditions:

- The Trash has been picked up and loaded into Recycling Assistant that is onboard the garbage truck
- Some of the trash that has been loaded into the truck contain embedded RFID chips
- The truck has been compartmentalized to allow the tagged recyclables to be sorted before arriving at the waste collection location

Postconditions:

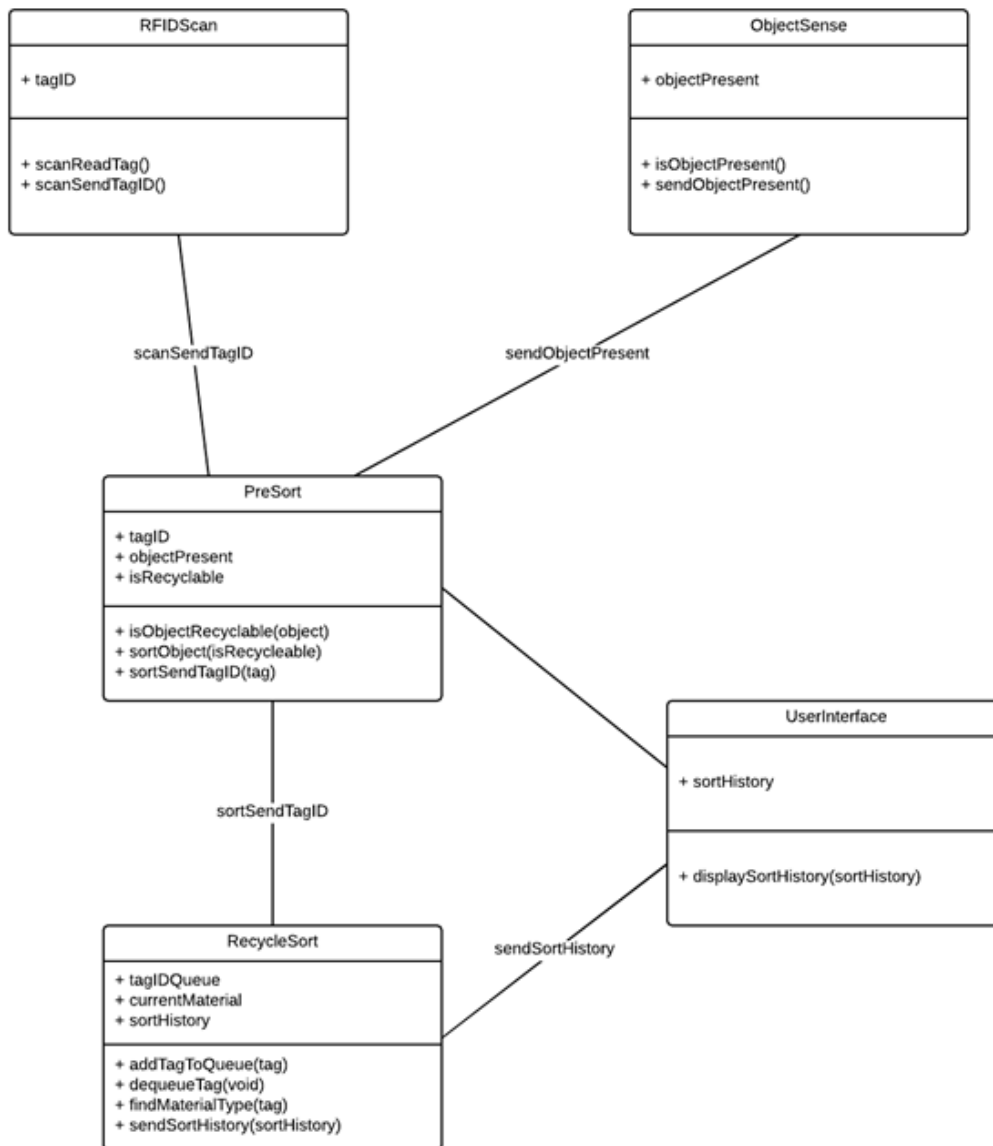
- The recyclables with embedded RFID chips within the truck have been sorted by the recycling assistant according to material
- Upon arrival at the waste collection location, the bins containing the different recyclable materials are removed and emptied
- Trash, or untagged recyclables, that were not sorted by the Recycling Assistant are sent to a second sorting line where it is manually sorted

Flow of Events:

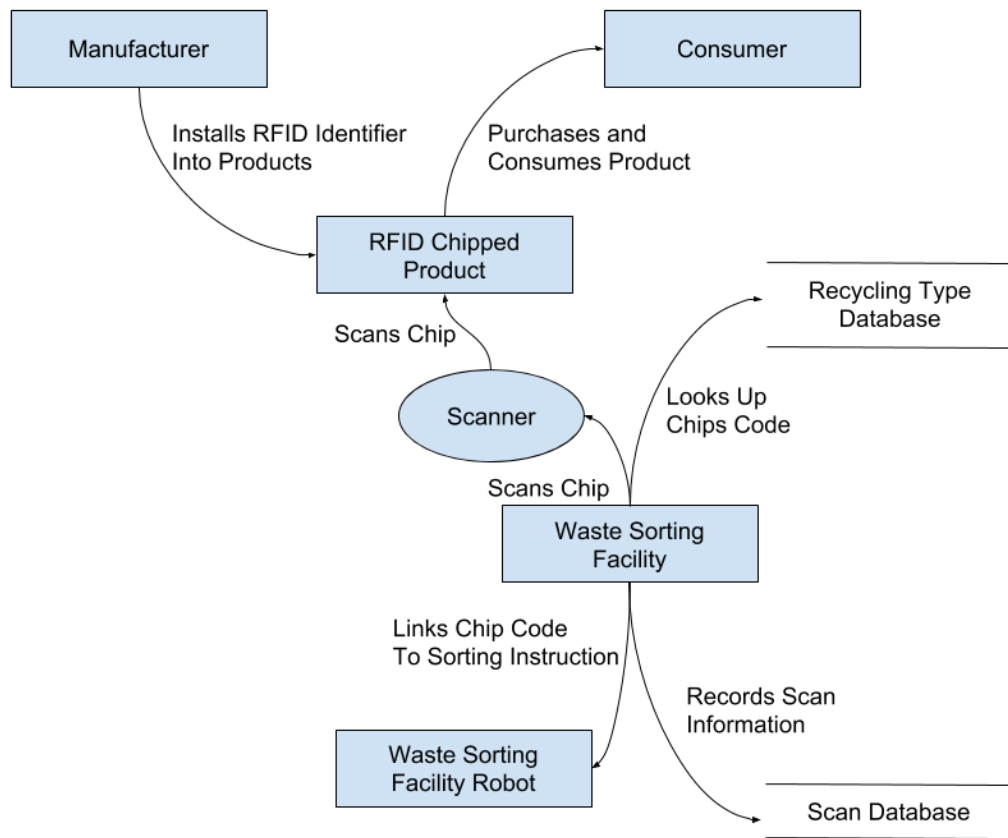
- Trash is continuously collected in the back of the garbage truck
- The onboard Recycling Assistant begins sorting through the available material
 - A scanner does a sweep over the top level of trash to see if it can locate any RFID chips
 - This scan relays the RFID code of the scanned chips to the Recycling Assistant
 - The Recycling Assistant then checks its database to see which container the material should be placed into
 - Once this has been determined, a robotic arm with powerful suction picks up the item and deposits it into a container for that type of recyclable towards the front of the truck
 - If there were no RFID chips discovered when scanned, the trash at the bottom of the truck is rotated to the top and the process begins again
- Once at the waste management center, the bins containing the sorted recyclable material are removed from the truck and delivered to their respective locations for processing
- Empty bins are placed into the truck for further use

Diagrams

Class Diagram

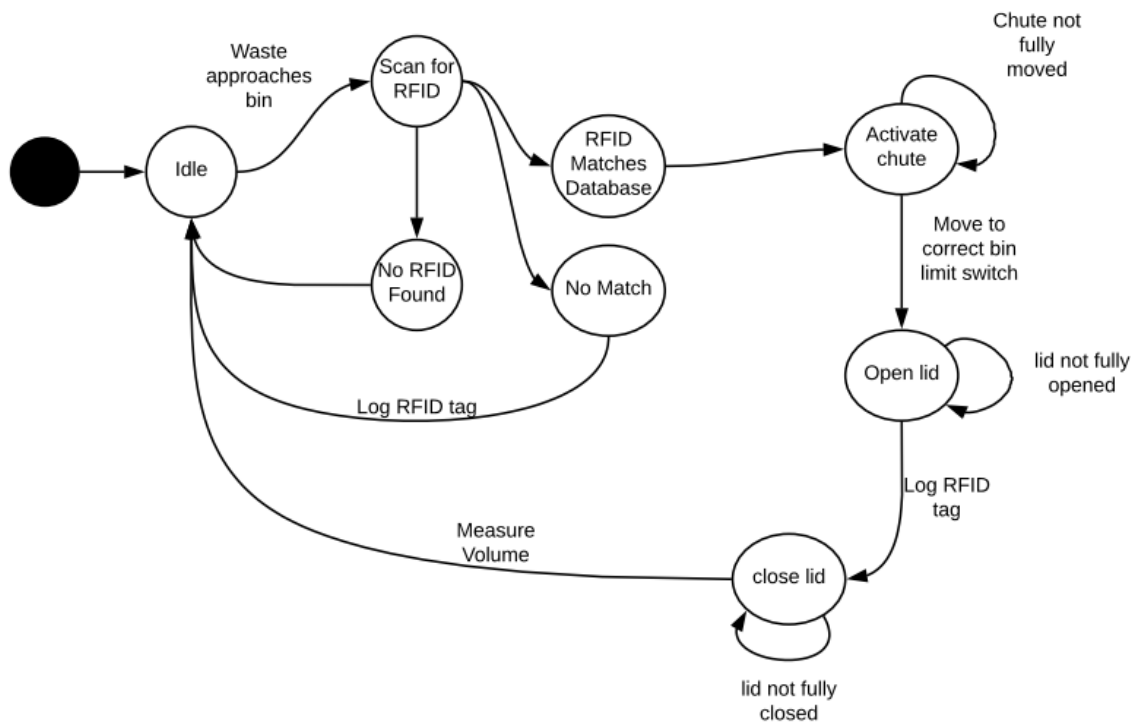


Dataflow Diagram

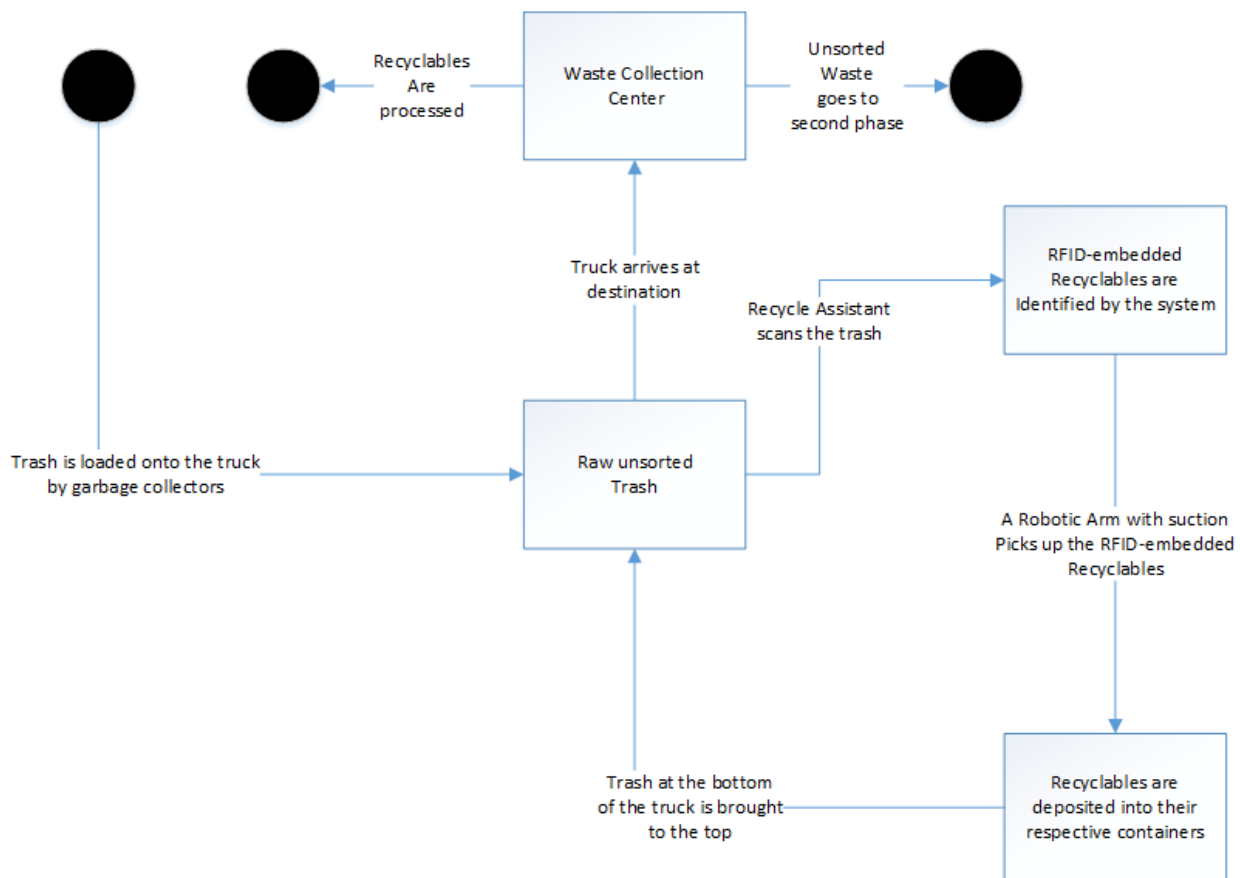


State Diagrams

Smart Recycling Bin



Transportation Sorting



Landfill Location

