# Building an Automatic and Scalable Tool for Improving Environmental Recycling: ELARA

Marcela Melara '12
Advisors: Marc Corliss, John Vaughn
Hobart and William Smith Colleges, Geneva, NY
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## Crowdsourcing

### What is Crowdsourcing?

- **Definition – *Crowdsourcing*:** The concept that large groups of people handle tasks that have traditionally been associated with a specialist or a small group of experts.[1]

  ⇨ Virtually anyone has the potential to contribute valuable information[1]

- **Numerous crowdsourcing systems are on the world-wide web:**
  - ▶ Wikipedia
  - ▶ Linux, Apache
  - ▶ Facebook, LinkedIn, Myspace
  - ▶ many, many more…
- Four key challenges crowdsourcing systems face: How to recruit contributors? What are they allowed to do? How to combine their contributions? How to manage abuse?

### How this project uses crowdsourcing

- **Hardware and software specifications will be open-source so anyone can build a machine and become part of the system network**
- **Any registered user can contribute information about a recyclable or regular garbage item, which will then be stored in the database**
- **Database entries are reviewed by trusted registered users who rank other users according to the quality of their entries**
- **Users can view their recycling profile and compare it to their city or state's progress → motivation to participate through competitive atmosphere**

## Overview

- **Project goal: design and create a system that will help improve environmental recycling**

- **Motivation: People often mistakenly put recyclable items into the regular garbage bin and vice versa, reducing the amount of items that go back into the recycling stream**

- **How this project approaches to solve this issue:**
  - ⇨ Use other people's knowledge about recyclable items to help others make the correct choice of where to put their items
  - ⇨ Small computer at a garbage station draws on this "wisdom of crowds"[2] and acts as a recycling assistant (ELARA machine)

- **Major tasks of project:**
  1) conduct a literature search on crowdsourcing
  2) design and build a database for information about items and registered users
  3) create a web interface for an ELARA machine and the server (simulation)
  4) write the basic software application to run on an ELARA machine
  5) begin building the system website, begin designing a hardware prototype

- **Future tasks of project:**
  1) finish the system website
  2) build a hardware prototype of an ELARA machine, create the GUI for the ELARA software application
  3) develop a smartphone App to act as a portable ELARA

## The ELARA machine

- **ELARA stands for "Environmental Liaison And Recycling Assistant"**
- **Many institutions already have garbage sorting stations where there are separate bins for different kinds of waste**

  ⇨ An ELARA is an automated tool that is meant to be set up at such an existing garbage station as additional aid to improve waste separation

- **Hardware components of an ELARA:**
  - ✱ **Touchscreen computer as the user interface**
  - ✱ **Barcode scanner to identify the waste items via their unique UPC**
  - ✱ **Optionally waste bins if creating standalone ELARA station**
- **Every ELARA is going to be connected to the Internet so it can retrieve the necessary information about an item from the database on the server**
- **Users who wish to build their own ELARA for their institution or organization can construct their machine as they see fit → creativity factor**



Fig. 1 Example of waste station (Ferry Building, San Francisco, CA): An ELARA could be installed at such a station

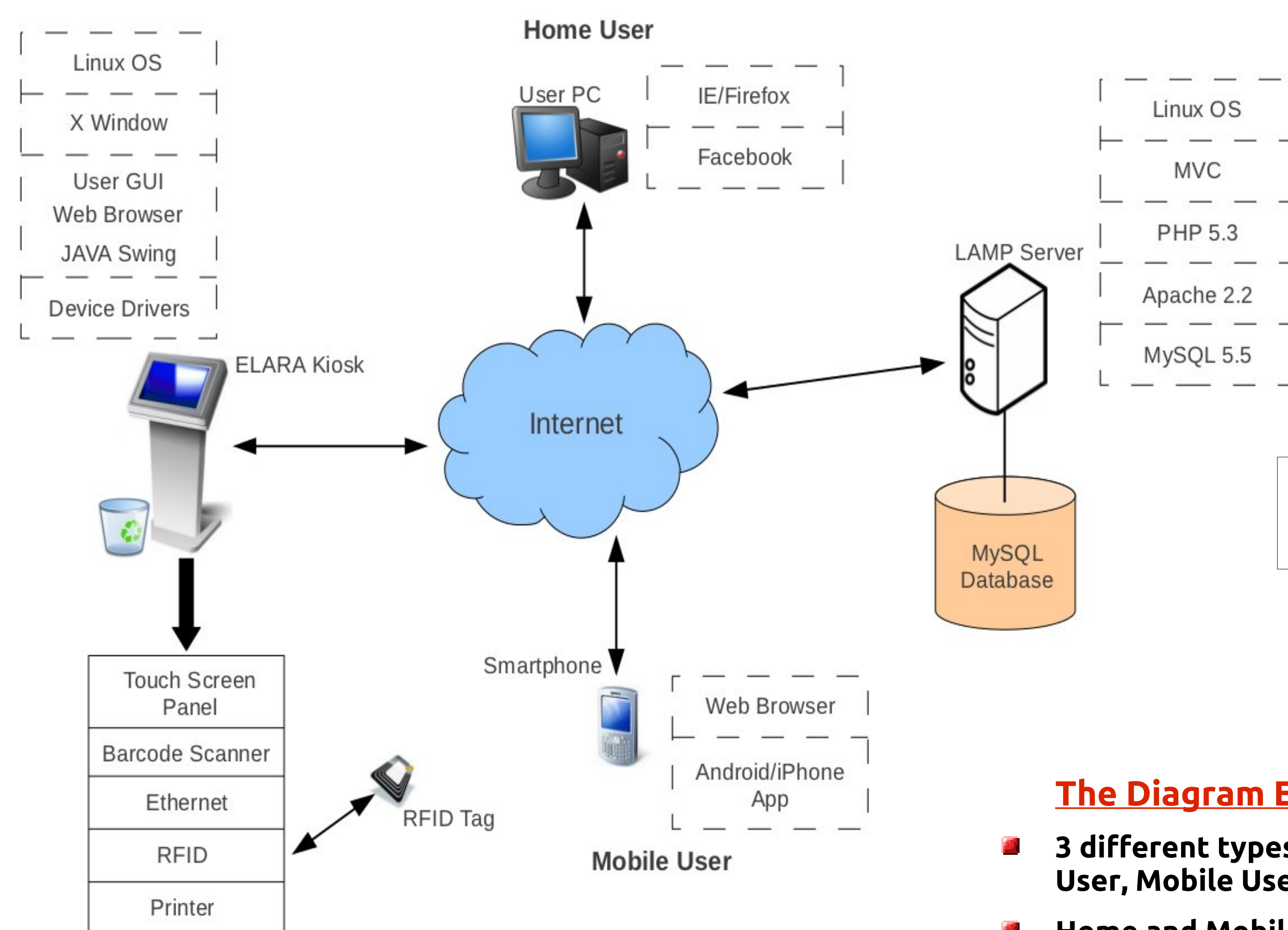image source: http://www.ecodaddyo.com/public-composting-bin

## The complete System



Legend:
- - -  Software used in components
——  Hardware used in components

Fig. 2 ELARA System Architecture Diagram

### The Diagram Explained:

- **3 different types of client nodes in the network: Home User, Mobile User, and Kiosk**
- **Home and Mobile Users, and Kiosk connect to system server via the Internet**
- **Each client type has its own protocol to communicate and exchange data with the server**
- **Home Users can only connect to the system through the system website, and the Kiosk acts as the ELARA**
- **Mobile Users are the fusion of Home User and Kiosk because they can act as both client types**

image sources (from left to right):
http://catholictechtips.stblogs.com/files/2009/01/recycling_bin.jpg
http://icons.iconarchive.com/icons/visualpharm/office-space/128/touch-screen-kiosk-icon.png
http://l.thumbs.canstockphoto.com/canstock2227097.jpg
http://tut5.com/tutorials/desktop/2c/mp33.jpg
http://www.flickr.com/photos/49974794@N04/5725673644/sizes/sq/in/photostream/
http://wwwcdn.net/ev/assets/images/vectors/afbig/server-outline-clip-art.jpg

## The ELARA Software

- **Two parts to the ELARA software:**
  - ⇨ **server scripts: written in PHP**
  - ⇨ **client application: written in JAVA**
- **The ELARA software enables and handles a user transaction at a Kiosk**
- **User transaction protocol:**
  - ⇨ **user indicates her type Guest or enters username if registered**
  - ⇨ **user scans their item**
  - ⇨ **user guesses which bin their item belongs in**
  - ⇨ **user starts next transaction or is finished**



Fig. 3 ELARA User Transaction Protocol
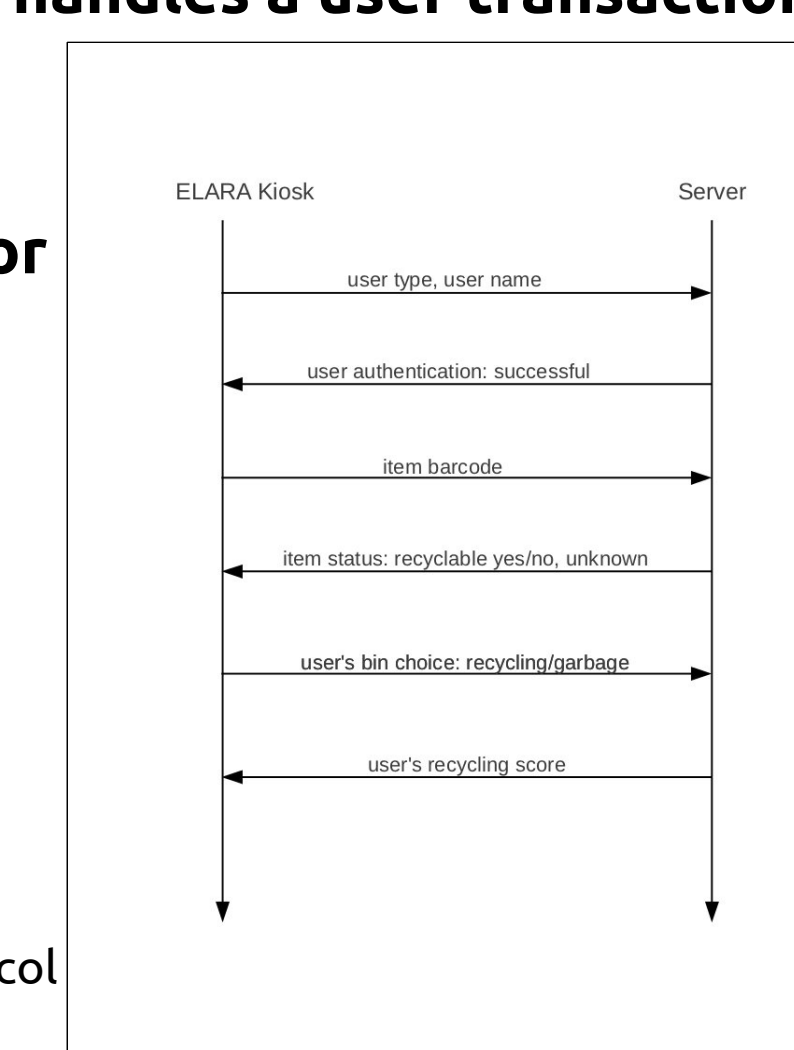
- **In order to prevent many security threats to both the client and the server, there is an underlying security mechanism to protect the system:**
  - ⇨ **Each ELARA Kiosk has a unique ID number and unique digital signature only known by itself and the server**
  - ⇨ **A cryptographic hashing algorithm is used on each message that is sent by one side along with the plain message**
- **The server records certain data for each transaction to keep track of the recycling profile of a specific user/city/state etc**

## The System Website

- **The website can be accessed from any device with a browser**
- **Built following the MVC architectural pattern used in software engineering: the application data and behavior (model) are managed separately from the user interface (view) and the controller which interfaces the model and the view.**



Fig. 4 Screenshot of ELARA Project Website

- **Any person can view the following pages on the site: registration, log in, about, contacts, view items in database, recycling profile of specific city/state/etc**
- **Each registered user has her own profile page on the site and a rank according to how much she has recycled**

### What can registered users do on the website?

- **Average Recyclers:**
  - • suggest new items for database
  - • register and manage their own ELARA Kiosk(s)
- **Trusted Heavy Recyclers:**
  - • rank other users' database entries
  - • add suggested items to database
- **All users have access to the public pages and can compare their recycling profile to that of any specific category**
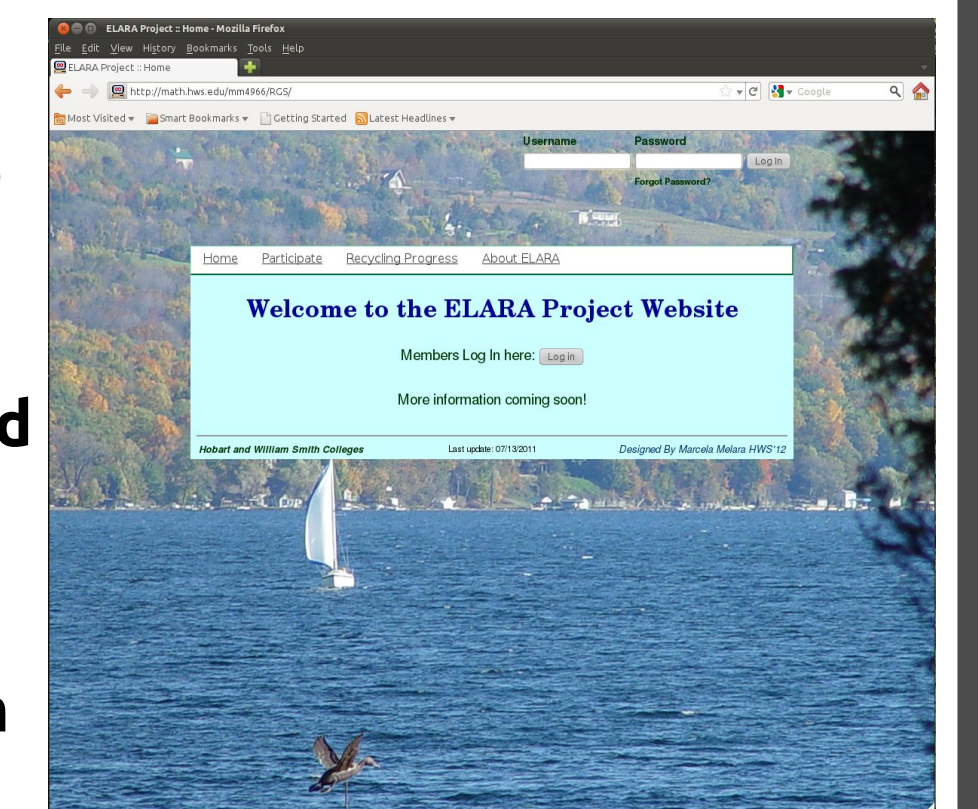
### References

1. Doan A., Ramakrishnan R. and Halevy A. Y. Crowdsourcing Systems on the World-Wide Web. In *Communications of the ACM* 54.4 (2011): 86-96.
2. Leimeister J. M., Huber M., Bretschneider U. and Krcmar H. Leveraging Crowdsourcing: Activation-Supporting Components for IT-Based Ideas Competition. In *Journal of Management Information Systems* 26.1 (2009): 197-224.