

Assistant for Recycling and Waste Management in Consumer Areas to Reduce Recyclables in Landfills (2018)

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***Abstract*—A solution to the problem of recyclable items being dumped in landfills, and an assistant to everyday Consumers in reeducation of recycling habits. A two-parter, when manufactured, all materials will have an embedded, small, inexpensive, and recyclable, passive RFID chip. The RFID chip will then be scanned by The Recycle Assistant in order for proper categorization of that recyclable material. To better educate the Consumer on proper recycling techniques, The Recycle Assistant will also display the statistics of recycled materials by that particular device, the overall recycling statistics of all Recycle Assistants in the world, and will even have a clear window to see into the physical bin to observe the recyclable item being added to its respective pile, as it awaits its future as a renewed material.**

I. INTRODUCTION

“Recycling is defined as the recovery of materials, such as paper, glass, plastic, metals, construction and demolition (C&D) material and organics from the waste stream (e.g., municipal solid waste), along with the transformation of materials, to make new products and reduce the amount of virgin raw materials needed to meet consumer demands.” [1]

When you’re done with it, the journey of your waste starts with collection at the street by county trucks called waste haulers. The hauler then trucks your waste to either a transfer station or a landfill. Your waste’s final resting place at the landfill is an “open cell” where compactors are used to flatten and remove as much air as possible and empty the contents of the haulers into the open cell. When that cell is full, it is permanently covered and a new cell is dug and filled. [2] So, what’s keeping recyclable items from being dumped into the landfill from the waste haulers?

Absolutely nothing. ... Well, that’s not entirely true. It can be prevented by Consumers before the materials are even picked up by the waste haulers!

If you’ve properly recycled, the items in your recycling bin are picked up and transported to a transfer station or collection station. It is then unloaded into a hopper that feeds the items onto a conveyor belt while being separated *manually* into paper, recyclable cardboard, glass, plastic, as well as manually removing any unrecyclable trash/waste. After the sorting occurs, each recyclable material gets grouped with like-items to be properly recycled into new versions of itself. [3]

In popular locations such as movie theaters, malls, airports, theme parks, etc., waste bins are littered all over the premises, and occasionally there are recycling bins with images to encourage Consumers to properly dispose of their waste and recyclables.

The current method of sorting recyclable materials at recycle sorting facilities is doing some really great work. An estimated 1.6 million consumers actively participate in recycling. [4] According to a study conducted by the EPA, in a single year, recycling and reuse in the United States accounted for: 757,000 jobs; \$36.6 billion in wages; and \$6.7 billion in tax revenues. [5]

But we can do better. We need to do better.

II. PROBLEM

There is a failure to properly recycle recyclables. There is a growing awareness of the *need* for recycling, but still a significant lack of *action* being taken to reduce the amount of recyclable materials still being dumped.

Since our trash isn't sorted for recyclables, there is a need for more clear recycling standards and easier-to-follow protocols. The EPA estimates that about 75% of waste generated by American Consumers is recyclable. However, only about 30% of that waste is actually being recycled. [8] 91% of plastic isn't being recycled. [9] The way it's trending, by 2050, there will be 12 billion metric tons of plastic in landfills. [9]

Whether out of apathy, negligence, or ignorance, much of that waste – which is actually recyclable – is ending up in our landfills. Unlike plastic and paper which have limits to the number of times it can be recycled, glass can be recycled an infinite number of times, yet studies show only 80% of all glass is actually recycled. [10]

User Story:

Joe Schmoe goes to Whole Foods because he feels like he's being healthy and he's helping the environment because Whole Foods is a healthful, environmentally-friendly company. He makes himself a \$15 salad – measured by weight ... he's pretty hungry – at the salad bar and eats it in the convenient seating area near the front door after paying.

Once he's finished gorging himself on red beets and collard greens topped with globs of fatty ranch dressing to drown the freshly-cut-grass taste, he brings his empty container, fork, used napkin, and still-fresh napkin up to the disposal bin.

But what's this?

There's a hole for food – compost. That's easy enough. ****scrape scrape****

There's a hole for plastic, but only plastic with certain numbers on it. Okay, confusing...

There's a hole for glass, but only green glass.

There's a hole for clear glass.

There's a hole for cardboard and paper, but there can't be food on it.

"So in which hole goes my dirty napkin?" he exclaims.

Hmm... Mr. Schmoe is thoroughly overwhelmed and no longer seems to care about the environment. He's already taken all his lunch break feeling good about his eating habits; there's no time to worry about separating his dirty napkin from the plastic container that housed his salad. He's gotta get back to work.

****blindly tosses it all in the same hole****

In consumers' homes, in schools, at public workplaces, in the city parks, all over the place, the understanding of "in which hole" to put each used item is lacking. It is a real problem that too many Consumers don't know how to properly recycle and are trashing items that could help extend our limited resources' lifecycles.

There are several programs – local and national – to help educate and reeducate Consumers regarding the proper placement of recyclable items. In some cases, there are even pictures and diagrams located on the recycling bins showing which items go where. Yet there is still too much of an unwillingness to acquiesce to these conformities, for whatever reason.

It seems that most populations are gaining more exposure to recycling lifestyles, however there is still a significant lack of education on the matter. A device like The Recycle Assistant would not only perform the act of recycling for the Consumer, but while doing so will teach the Consumer about that particular recyclable item and show its continuation in the recycling cycle.

Many similar bin structures have already been in use for several years in high populated areas. An upgrade to The Recycle Assistant software and structure wouldn't be that far of a leap for many institutions.

Use Cases for a Plastic Bottle

Actor: Recyclable Material (Plastic Bottle)

Flow of Events:

- Manufacturer X designs and produces a plastic bottle with passive RFID chip;
- Plastic bottle is taken to bottling plant/facility to be filled;
- Plastic bottle is packed with other like items and shipped to vendor;
- Vendor displays and sells product to Consumer;
- Consumer empties plastic bottle;
- Consumer approaches Recycle Assistant;
- Consumer places plastic bottle inside deposit port;
- see-through window shows the item being scanned;
- MCU scans passive RFID chip to determine recycle category

- If
 - plastic, sort
 - glass, sort
 - metal, sort
 - paper, sort
 - none of above, sort;
- See-through windows show plastic bottle being sorted into proper category bin inside device;
- LCD screen displays results of plastic bottle being sorted as plastic bottle, statistics of other plastic bottles sorted by this device, statistics of other plastic bottles sorted at other Recycle Assistant devices.

III. SOLUTION

The Recycle Assistant is an Internet of Things device made up of internal bins, an LCD screen, materials deposit port, and display windows utilizing proper recycling techniques in order to reeducate the public about proper recycling habits in the hopes of preventing recyclable materials from entering landfills.

The objective of The Recycle Assistant is to implement an alternative way of diverting recyclables from waste to reduce the amount of recyclables being added to landfills and aid the manual process of sorting recyclables at the Consumer level.

The Recycle Assistant will take a similar approach with recyclables and all waste before it makes its way into the landfill, but using the Recycle Assistant as the first line of defense before Waste Management Plant sorters or human sorters are involved.

Using a very small, inexpensive, yet sophisticated microcontroller (or MCU) [6], a passive RFID chip [7] can be manufactured and integrated into the manufacturing process used in container and materials manufacturing. This MCU will be read-only since there is no need for the material's recyclable type to change at any point during its lifetime. Eventually when the product is scanned and recycled accordingly, the MCU will be recycled with the product and make it's way back through the cycle.

This embedded system can be located on any part of the recyclable product and will be scanned by a product containing interpretive firmware, called The Recycle Assistant - the

more pressing purpose of this vision statement, although the microcontroller will also be an important and necessary aspect of how The Recycle Assistant performs.

The actual Recycling Assistant bin will be an Internet of Things device [11], connected to the Internet via a self-forming mesh network, containing separate bins within the greater structure, an LCD screen to show recycling results and statistics, and a clear window in the physical structure in order for Consumers to observe the actual act of recycling in effect.

All active Recycle Assistant devices will be connected via the Internet, but if there are any such devices with limited or no Internet connection, the mesh network will allow any such excluded device to participate in sending and receiving data from the primary database holding all relevant statistics.

The necessary recycle categories will have their own bin within the larger structure of the device.

If the recyclable material was not mass-manufactured (and therefore not compliant with a passive RFID chip embedded in its material during manufacturing of the product), the Recycle Assistant's scanner will categorize the material as *non-compliant*. It will then be added to its respective bin within the greater device to be manually sorted at the Waste Management / Recycle Sorting Facility. At the Recycle Sorting Facility, the current form of sorting will take place in case the item simply did not have an RFID chip embedded in its material. Whatever is left over will only be waste products that can then be compacted and placed in the open cell of the landfill.

Should there be false positives – namely, a recyclable of one category making it's way into a different category – the administrator who maintains and services the device (since there will need to be someone who checks the status of the device, ensures it is calibrated and working properly, ensures the statistics are being received and sent via the mesh network, and ensuring the bins are emptied in a timely manner), that administrator will recalibrate and service the device with the necessary testing.

The idea is that The Recycle Assistant is the first line of defense at the Consumer level,

facility sorting the second, manual sorting the third, and there should be no need for a fourth line of defense. Rather than the current order of operations which is no sorting if the item is in the waste bin, and manual – not infallible – sorting for recyclable materials.

The software making up the Recycle Assistant will be fairly straight-forward and should be programmable by any entry-level software developer, with occasional special skills in mesh networking, and database management (for the statistics hosting).

IV. METRICS FOR SUCCESS

By incorporating an integrated passive RFID chip using a microcontroller in all newly manufactured and recycled materials, and employing The Recycling Assistant's interpretive firmware to scan those chips prior to transfer from Consumer locations to the recycling and waste management facilities, the percentage of recyclable materials being dumped in landfills will greatly decrease, if not disappear completely.

The Recycle Assistant need only be able to scan a single item at a time, although multiple items would greatly increase its validity and Consumer participation. The item would be placed in the Recycle Assistant deposit slot, be scanned inside the device, and sorted as necessary.

In order to scan the passive RFID chips, The Recycle Assistant will need to have some way to remotely battery operate the RFID chip to enable it to emit the necessary material's signal (the nature of "passive" RFID).

In order to successfully divert the maximum amount of recyclables being "dumped", The Recycle Assistant will need to be used *in conjunction* with the current process of filling our landfills and *in addition* to the process that is undergone in recycling facilities.

Instead of blindly dumping our full waste haulers into the landfill, the haulers will also employ a similar Recycle Assistant within the internal structure of the hauler vehicle. The Recycle Assistant Vehicle, while quite similar to the Recycle Assistant bin that will be placed in high populated areas, will make use of similar – if not mostly identical – software and hardware, however it is out of the scope of

this Vision Statement and may be addressed in a follow-up Vision Statement.

The three most important features of The Recycle Assistant are:

1. MCU scanner;
2. See-through glass to show the bin fill levels
 - a. Gets Consumers excited about doing their part when they can really *see* the results pile up, literally;
3. LCD display for category results of the scanned item, explanation, and statistics.

Another important feature of The Recycle Assistant is the self-forming mesh network connecting all Recycle Assistant devices. Without Internet connection, this mesh network will allow even the most remote device to send and receive important statistic data.

Since there is no national law that mandates recycling, the state and local governments who adopt The Recycling Assistant will not need to decide for themselves how best to proceed on the matter of comingling due to the fact that non-recyclable materials will also be handled by The Recycle Assistant and categorized as non-compliant and subsequently transported to the corresponding Waste Management and Recycle Sorting Facilities to be sorted as usual.

The Recycle Assistant will also take care of the current need for more clear and accessible guidelines in reeducating Consumers as to the new system due to the fact that it is a self-sustained device and will be developed in such a way that reeducation will happen as a direct result of Consumers' participation and interaction with the device.

For materials manufacturers that do not wish to comply with The Recycle Assistant RFID chip integrations, their product materials cannot be successfully scanned by The Recycle Assistant and will therefore be categorized as non-compliant and transferred to Waste Management and Recycle Sorting Facilities for manually sorting after all other recyclable items have been identified (the "third line of defense"). It may be the wish of the state and local governments who adopt The Recycle Assistant to enact a series of

grace periods for adopting the RFID chip integration into their manufacturing processes until such time as all manufacturers will be required to comply or be subject to fine.

In the meantime, largely populated areas – whether privately owned or city/county/state run – can utilize The Recycle Assistant in their facilities and buildings to do their part in reducing the amount of recyclables being added to our already over-full landfills.

Successful application of The Recycle Assistant will be determined by the amount of usage of the device, the statistics showing amount of recyclable materials being kept out of the landfill (by being recycled) as compared with previous years statistics, and the popularity of the device in the given culture.

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