[Section 5][Intelligent Waste Management][Wasted]

Vision

The rapid development and urbanization of cities across the world has prompted a need for waste management issues to be addressed. Moreover, the development in technology has improved the efficiency of smart devices, enabling the incorporation of smart technology in our daily lives. Even basic furniture and appliances, such as refrigerators, laundry machines, and beds that we consider do not consider "smart" have some sort of computing device built in, why not our garbage? For a city to sustain growth and have a healthy populous, the resources involved in waste management (people, equipment, and energy) must be reduced. A possible way to improve waste management could be the introduction of IoT (Internet of Things) and other "smart" technologies to garbage disposal equipment such as trash cans, garbage trucks, etc.
One way to improve the efficiency in trash collection could be to implement IoT devices in trash cans and garbage trucks to optimize the trash routes. These devices will be connected to the internet and monitored constantly to deliver system information such as when a trash can is full or a garbage truck is available. With such automatic systems, garbage management will require less time and manpower, thus improving the efficiency of garbage disposal and the overall quality of life.
Additionally, the public should be better informed with regards to how to manage their trash as advances in the collection and separation process between different types of trash and recyclables. It is also important to realize the environmental impact of the boom of technology we are proposing, as increasing the amount of IoT devices in circulation will ultimately lead to more waste. Promoting the development of a circular economy is key, where products never really leave the economy but are always recycled or reused.

Background and Literature Review

As big data market grows with cloud development in recent five years, data management and security become the focus for the future smart city development. Without proper handling of data, civilians would be commodities whose data can be accessed, traded and supervised by both legal and illegal parties; While the US is only 4% of the world's population, it produces 30% of the planet's total waste. Among all the waste generated, more than 30% of them are from individual households and businesses. Therefore, to reduce the amount of waste produced and enhance the rate of recycling, governments and companies are currently looking into ways to use and analyze data collected from houses and businesses for decision making regarding recycling and waste management.

Ethics and Law in the Internet of Things World
- Internet of Things (IoT) involves a large number of objects and humans that are connected via the Internet 'anytime' and 'anywhere' to provide homogenous communication and contextual services
- Creates a new social, economic, political, and ethical landscape that needs new legal and ethical measures for privacy protection, data security, ownership protection, trust improvement, and development of proper standards
- "Security must be built into the foundation of the IoT solution"
- Device management standards include device: registration, authentication/authorization, configuration, monitoring, fault diagnosis, troubleshooting
- Barriers to IoT adoption include: privacy and security, lack of sound business structures, governance structures, lack of interoperability

Internet of Things: Some Ethical Issues
- Minimum requirements for ethical IoT: enforcement of property rights of information, assurance to access of information, assurance of integrity of information, enforcement of the right to private life
- Every individual needs to be assured that they are protected by effective technological solutions (encryption techniques, ID management, privacy enhancing techniques)

The Internet of Things: European Regulation
- Governments have two roles in shaping the future of IoT: user role and infrastructure provider role
- User role: Government should set how IoT should be employed, specify sound requirements for assuring highly secure, reliable, and robust IoT products and solutions
- Infrastructure provider role: Governments should issue regulations for devices not originally intended for connection to the IoT – release license regulations, IoT products and solutions are used exclusively for their specified goal
- i2010: A European Information Society for Growth and Employment - defined policies for development of "European Information Space"

European Internet of Things Cybersecurity Recommendations
- EU Directive-2013/40: Deals with "Cybercrime" (attacks against information systems), providing definitions of criminal offenses, sets proper sanctions for attacks against information systems
- EU GDPR-2016: Concerns privacy, ownership, and data protection

Internet of Things Cybersecurity Improvement Act of 2017
- Bill intended to improve the security of Internet-connected devices
- Directs government agencies to include clauses in their contracts that require security features for any Internet-connected devices that will be acquired by the US government

Optimizing Sustainable Waste Management
- Waste-to-Energy (WTE) plants treat 38% of the overall collected MSW (municipal solid waste)
- Material Recovery Facilities (MRF) and Mechanical Biological Treatment (MBT) plants are used to magnify treatment capacity and gain recovered materials at lower capital costs than building additional WTE plants
- Development of a circular economy (using disposed material as raw material) requires material recovery and separating different disposed materials at source
- "Wet" vs. "Dry" bin collection policies
- WTE Combustion Technology -

1. Grate combustion (full combustion)
2. Refuse derived fuel (RDF)
3. Circulating Fluidized Bed (CFB)

Smart Waste Management Systems - Pastscapes
- Compology - battery powered sensors with a camera, transmitted over a cellular network where a machine learning algorithm detects how full each waste container is
- Allows for dynamic, optimized routes and schedules for collection - reduces the number of trucks needed by 40%

Improved Smart Waste Management for Smart City
- State of the art uses sensors that measure how full the trash bins are, allowing for more efficient collection routes
- Still has issues when it comes to practicality, e.g sensors don't perform as well in the real world and it doesn't help with trash sorting
- Many systems utilize ultrasonic distance sensors
- Has some issues when trash isn't evenly distributed in the container, leading to false fill measurements
- Can be alleviated by using multiple ultrasonic sensors, but this increases costs
- Such solutions only optimize the trash collection portion of waste management, ignoring what happens after the waste is collected. The ideal solution would be end-to-end.
- Proposed fix: Integrate weight sensors to improve fill measurement and RFID tags to help with sorting waste

Smart Cities Dive
- Improving efficiency in waste collection in Pittsburgh ($128,000 per month)
- Sensors that track how full trash cans are and help determine the most efficient routes for collection
- Relocate public workers to other positions
- Support climate change initiatives, (target 50% reduction in transportation emissions)

Research Questions and Division of Labor

How do restaurants/businesses implement systems to manage waste (food, commercial, etc.), and are these sustainable - and do they differ based on scale (local vs. chain restaurants vs global)? **(Liam)**

How has the rise of consumer electronics changed the way we produce waste and recycle? **(Erik)**

How can IoT devices aid in the collection and analysis of waste management systems, in order to make development more sustainable, and what are the ethics involved? **(Karan)**

How can governments utilize, manage, and secure big data generated by and related to household waste to reduce waste generation, increase rates of recycling, and propagate sustainability ideas? **(Josie)**

What systems are in place to support reusing scrap waste for new and unique applications? Examples include: integrating scrap metal into public art and making sleeping bags out of spare textile. **(Chris)**

What are the effects of smart technology on waste output? **(Josh)**

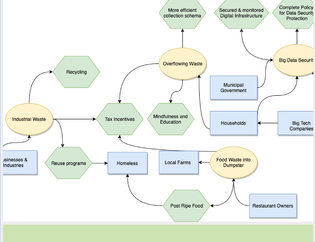
Stakeholder Design & Analysis

Because our vision is to develop a comprehensive smart waste system for sustainable ecosystem development, the three key stakeholders are businesses, people and cities. Decomposing each group into more specific stakeholders, we can see how different stakeholders interacting with each other and relating to main problems.

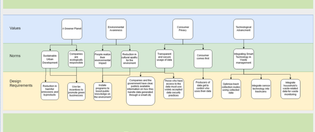
People:
- Restaurants owners: Restaurants are the main source for food waste, either from residuals or surplus dishes made. For most restaurants, these wastes are simply disposed into the dumpster. However, the surplus food can be distributed to local homeless people and the residuals can be sold to farms as fertilizer or animal food.
- Homeless: As a social edge group, homeless people should be considered in the future smart city waste management system because the recycling and reuse values can largely benefit them. By bringing them into our system design, we ensure that the future system can be inclusive and aims towards a more equal environment.
- Households: As the basis for future smart cities, households generate excessive wastes daily. The uneven distribution of waste generation can cause the city to have overflowing trash bins. Therefore, we can introduce more efficient waste collection schema using IOT or have tax incentive policies to reduce household wastes. However, the excessive use of IOT and data might cause data security issues in which illegal parties may use data related to waste to speculate household activities.

Businesses:
- Local farms: Local farms can be consumers for restaurant wastes because the excessive food can be used to fertilize crops or feed animals after proper food processing.
- Local businesses & industries: businesses and industries produce waste during their production cycle. For example, the clothing company can have leftover material when making a jacket. These materials can be donated to reuse or recycling programs to be distributed to homeless or non-profit organizations.
- Big technological companies: technological companies should ensure data security by building robust digital infrastructure.

Cities:
- Governments: governments are responsible for issuing tax incentive policies and data protection policies. It also functions as a lead for the whole smart waste system implementation.



Value Mapping and Hierarchies



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