Community Systems, Sensor Monitoring, and the Internet of Things: A Case Study about Feed Denton Community Compost

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Abstract
This case study provides on the Feed Denton Community Compost Project. This ethnographic research will review how the collecting of social data and implementation of information communication technologies can provide a smart city infrastructure for this sustainable community of practice through sensor monitoring and the Internet of Things.
Keywords: social media; community of practice; Internet of Things; social data; sustainability

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1 Introduction Requirements

A growing number of cities claim to be 'smart;' however they rarely define and identify what a smart city is (Hollands, 2008). Through the use of social data, smart cities and communities have evolved to support growth and innovation. Smart cities claim to be smart based on how it uses information and communication technologies (Hollands, 2008), utilizes the collection of data to measure and influence operations (IBM, 2010), and allows for the potential for networked communities and organizations to develop ecological integrity and renewal (Halpern, 2005).

Communities of practice (CoPs) have evolved around topics and issues where individuals engage in social practices that are spontaneous, self-organizing, and fluid (Lave & Wenger, 1991; Wenger 1998). Participation in CoP results in exposing and sharing diverse information and knowledge among group members. Wenger (1998) views CoP as a place of negotiation, learning, meaning making, and identity. With the increase of smarter cities we see "the possibilities of using 'communities of practice' (CoPs) as a means of drawing upon the industrial knowledgebase, such organizations offer in developing integrated models" (Allwinkle & Cruickshank, 2011, 9). A growing number of CoP in smart cities use social data and emerging technologies to share information and collaborate. By using data and social technologies, communities are able to share information, collaborate with one another, cause behavioral changes based on informed decisions, and impact local environment or ecology systems.

2 Using Social Data and the Internet of Things

This proposal is situated at the intersection of social data, sensor monitoring, sustainability, and the Internet of things. Social data abounds in our present world. Social media platforms such as Facebook, Twitter, and Instagram facilitate connections between users, institutions, and organizations on a massive scale. Auger (2013) discusses the ways that ideologically opposed non-profits utilize Facebook, Twitter, and YouTube. According to Statistic Brain (2013), there are 554,750,000 active registered Twitter users as of May 2013. Not only are these connections massive in their sheer amount, but also they are also massive in terms of the number of tweets sent from mobile devices. Statistic Brain cites the percentage of Twitter users who use their phone to tweet as 43%. Whether mobile or desktop, the volume of data produced by users of social media platforms continues to grow exponentially.

With the development of affordable open-source hardware components like Arduino open up new possibilities for developers to move beyond software-only development into integrating hardware and software into an "Internet of Things." Essentially, the Internet of Things is a "network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment" (Gartner, 2013). Dignan (2013) believes The Internet of Things will create economic value for all organizations and sectors that significantly impact our economy by 2020.

Al-Haiija, Al-Qadeeb, and Al-Lwaimi (2013) demonstrate the potential for creating a wireless sensor network using Arduino microcontrollers and gas sensors to build an air quality sensor network at King Faisal University. Arduino is an open-source, physical computing platform that is based on micro controller board which allows computers to sense and control the physical world using writable software and programmable language (Arduino, n.d.). Currently there are Arduino-based projects involving different aspects of gardening, including GardenBot (http://gardenbot.org/about/), growerbot (http://www.growerbot.com), and Growduino (http://forum.arduino.cc/index.php/topic,8226.0.html). None of these projects focuses on monitoring compost, which is what Feed Denton Community Compost proposes.

The combination of Internet of Things and social data provides exciting opportunities for sensor monitoring and community behavioral changes. As objects can both sense the environment and communicate, they become tools and resources for information, analysis, automation and control (Chui, Löffler & Roberts, 2010). The process of implementing sensors in thoughtful places, monitoring their data, and publishing it to the web for the community to view is well within the reach of even low budget projects. One large problem, however, is determining if the Internet connectivity infrastructure is in place to do so reliably. Between short range (Bluetooth), medium range (Wi-Fi), and long-range connectivity (cellular networks), filling in the gaps of connectivity infrastructure may also be within the reach of a low budget project.

3 Purpose of the Study

To review and identify how the Feed Denton Community Compost program can implement smart technologies via web-connected sensor monitoring to stimulate data-driven social change increased sustainability and community health.

4 Research Methodology

Researchers will base this case study analysis after the Feed Denton Compost Exchange pilot (n=29), and current project development of the Feed Denton Compost pilot initiated in Fall 2013 to consider how to best integrate social data and the Internet of things. The case study is to review the current pilot project (n=15) to understand the process and potential implementation to the current Feed Denton Community Compost (FDCC) project (Stake, 1995; Creswell, 2009). The FDCC pilot program was developed from June-August 2013, which best informed the current pilot program running from September-December 2013.

For future studies, the researchers will utilize a concurrent mixed-methods approach to integrate the information collected to effectively interpreting the findings (Creswell, 2009). This investigation will produce a detailed description of how the existing Feed Denton Compost program operates and members of the Denton community participate in the shared system, specifically to identify how social and smart city entities can enhance infrastructure and development for this program.

4.1 Case Study

Feed Denton (http://feeddenton.org/), a directory and blog focused on the local food system of Denton, Texas, has been observing and stimulating community activity since December 2012. In June 2013, a founding member, Andrew Miller, developed and published a web application called Feed Denton Compost Exchange (http://feeddenton.org/compost/) to allow users to list themselves in a local composting directory as either accepting or offering compost. Users were prompted to describe the amount and type of compost they were either offering or accepting, as well as their general location and weekly availability. The purpose for this online posting area was to create a dynamic, user-generated directory to fuel inter-community discovery and facilitate initial steps towards a self-organized, sustainable community who contribute to a composting cycle similar to Figure 1.

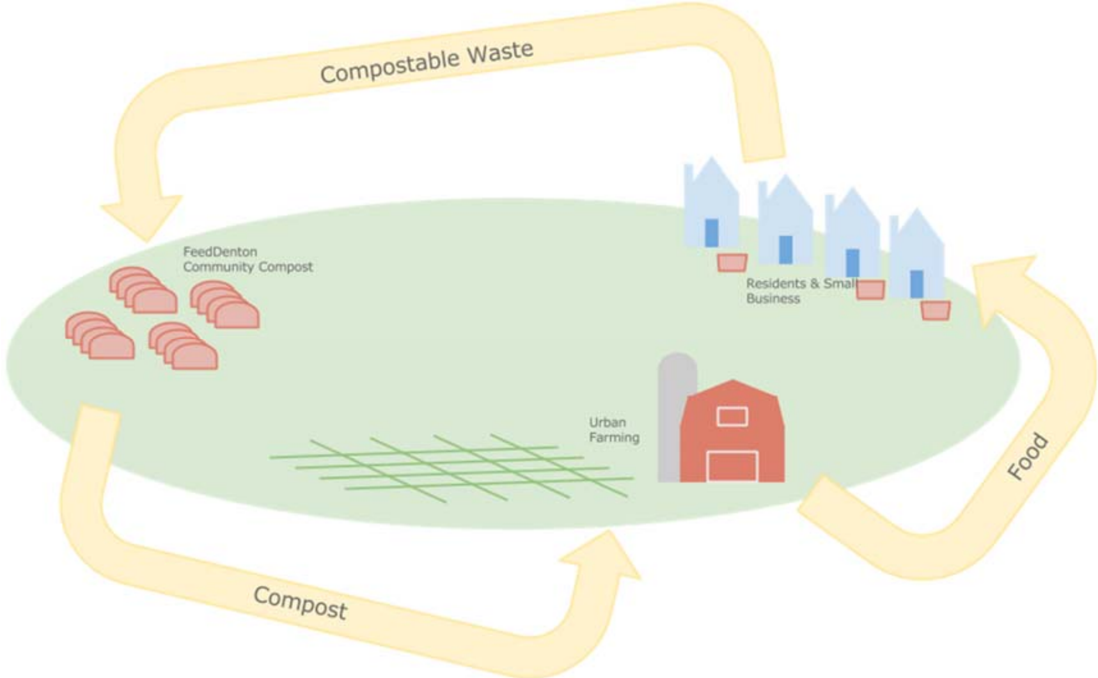

Figure 1. Current Feed Denton Community Compost cycle

Adoption of the online application was modest. Within one week 15 users had signed up, and currently there are 29 members. By August 2013 it was observed, through online user feedback and semi-structured interviews, that many users of the compost forum were not making real life connections and self-organizing. In short, online users were signing up online and then forgetting about the application. Functionally, the web application did everything it needed to do to facilitate discovery and self-organization; however, it was clear the web platform did not motivate users to take any further steps towards self-organizing.

Miller, the developer for Feed Denton Compost web application, considered how to redesign the online application, and take the organizational structure of the project to a centralized composting design. In August 2013, Miller collaborated with Nathan Penning and Thomas Wild, of the Community Composting Company, to initiate a pilot project. The pilot consists of a shuttle service for picking up compost bins directly from homes and small businesses weekly. The bins are delivered to a central community compost location. The interest on the community's behalf to form a CoP around composting, combined with the lack of self-organization, resulted in this pilot being formed to fill that need.

The FDCC team attended a composting workshop in September 2013, and announced the Feed Denton Community Compost Pilot Program to community of Denton, TX through the FeedDenton.org and other social media networks. The purpose of the FDCC pilot program was to organize logistics, test equipment, gauge capacity, develop a business model, identify unknown variables, and, most importantly, seek local interest from the city of Denton, TX. For the FDCC pilot, the program included a select population (n=15) from the interested 35 participants who signed up. Limiting the program capacity allowed the FDCC team to organize pickup dates, times, and routes for compost collection. After approximately three months of collection, the FDCC pilot program has diverted over 3.5 tons of waste from landfills, and attracted the interest of other members of the Denton community, including residents, small business owners, higher education institutions, potential investors, and the local municipal government.

5 Technology Components and Organizational Concerns

A growing number of communities of practice have been increasing to support composting for both business and other projects to model the Feed Denton Compost program (see Table 1).

Name	Compost Program Type	Location	URL
Feed Denton Compost Exchange	Online community swap discussion board for scraps and compost	Denton, TX, USA	http://feeddenton.org/compost/
Compost Now – Community Compost Shuttle	Compost pickup service for household and small business food scraps.	Raleigh, NC, USA	http://compostnow.org/
East Side Compost Pedallers	100% Bike-powered compost pickup system for homes and businesses	Austin, TX, USA	https://www.compostpedallers.com/
Living Earth	Largest recycler of green material in Texas.	Fort Worth, TX, USA	http://livingearth.net/

Table 1. Comparable compost programs reviewed

To improve upon the Feed Denton Community Compost cycle, sensor monitoring and the Internet of things could provide social data and information to effectively collect and compost in Denton. It would be useful to utilize Arduino sensors to gather social data, which may ultimately keep nutrient and mineral assets in the local soil for the city of Denton. Besides reducing waste for the city of Denton, The FDCC will improve sustainability and improve nutrient rich compost for the soil. To change the waste (a liability) into compost (an asset) increases the community health overall. By monitoring the compost cycle (see Figure 2), the enhanced FDCC will provide publishable information to share with the community to stimulate behavior change. The next section will outline the automation and creation of a smart community compost cycle detailed in Figure 2.

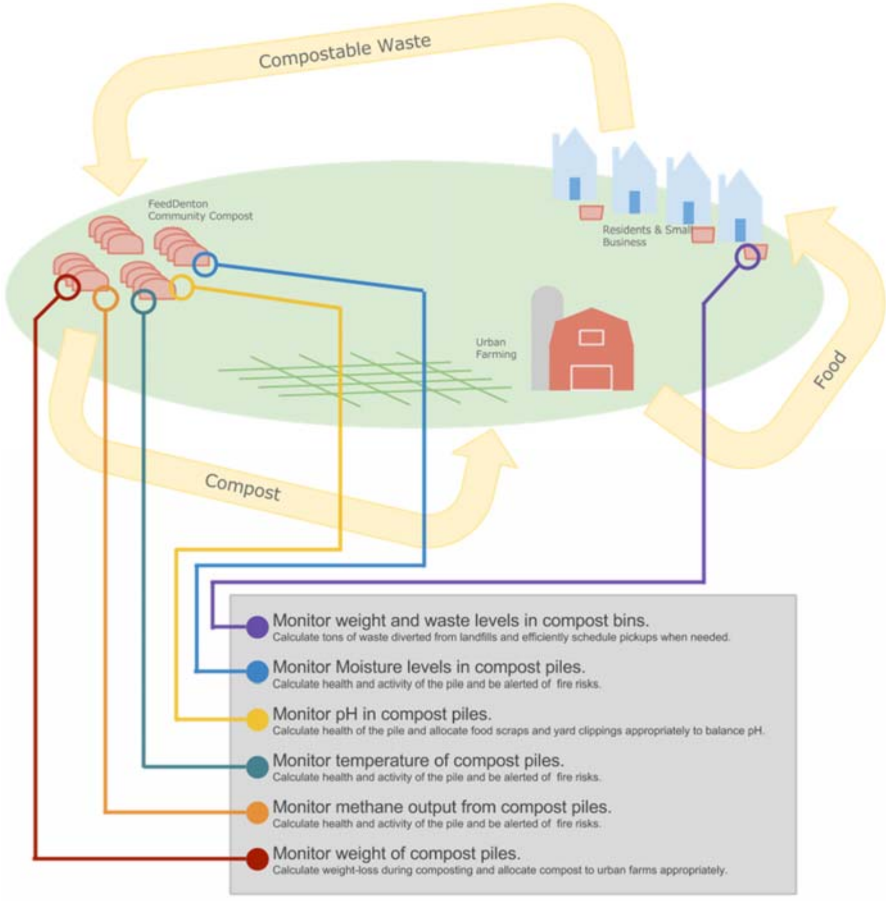

Figure 2: Sensor monitoring technologies for a smart Feed Denton Community Compost

By sharing the data, social and behavioral changes will increase as the community has access to the shared data and has the ability to review the composting progress throughout the cycle. During the smart composting cycle, there are a number of items monitored as shown in Figure 2. The compost waste can be monitored with Arduinos and weight sensors (Drobny, Weiss & Borchers, 2009; Bildr, 2012) within the compost bins, and then feed this information online to alert the community and the organizers to identify a date and location for a compost pick up. This sensor monitoring and Internet of Things technologies support efficiencies with use of resources, such as the vehicle, fuel, time, and labor. Monitoring compost bin weight can inform the FDCC of the amount and location of waste by geographic region (e.g. city, zip code, street, or address). This is an environmentally green and inexpensive system to sort and organize compost matter (Elfasakhany, Arrieta, Ramírez & Rodríguez, 2001).

Gamification elements are possible by publishing amount of waste diverted from landfills by city, zip code, or street. Residents would be able to compete for the status of 'most waste diverted from landfills' and rewards of badges or discounted service fees may be offered to encourage participation.

Besides organizing the collection and management of the community compost, social data and smart technologies will help to monitor the composting cycle, specifically the pH ratio and the temperature within the compost pile. Through the use of Arduino and pH sensors (https://www.sparkfun.com/products/10972) it will be easier to maintain proper pH levels in the compost pile to ensure that the finished product will be healthy and suitable compost. Different plants prefer different levels of pH (Cornell Waste Management Institute, 1996) to find balance in the compost pile. The compost site will require Wi-Fi to in order to send data over the web and through social streams to the community, and also as a type of monitoring system for the compost.

Arduinos can also be attached to temperature sensors (http://www.raywenderlich.com/38841/) within the compost pile (Boonsawat, Ekchamanonta, Bumrungkhet & Kittipiyakul, 2010). The U.S. Environmental Protection Agency (2012) indicates "composting facilities may need approval from the state before operating." As fire is a legitimate concern with compost piles, there are state legislations that require local governments to examine the composting (U.S. Composting Council, 2010). Compost piles can become so hot that they combust into flames if they are not turned regularly. Monitoring the temperature of the compost pile through social technologies and Arduinos provides a view into the health and activity of the pile, as well as its safety.

6 Conclusion

The Feed Denton Community Compost (FDCC) has the potential to expand beyond its current pilot study with the implementation of smart technologies. Through the use of data-driven social applications, community members in FDCC have the ability to inform, track, and monitor contributions to the composting system, while incentivizing others in the municipality to get involved with the program.

Through the use of sensor monitoring and social data, FDCC has the ability to develop a unique communication and outreach program to facilitate community growth and environmental impact to the city of Denton, TX. Social data and community involvement will instigate further impact towards a sustainable and renewable municipality.

Further research should consider the impact to the local community, to provide feedback for composting design, collection, and information sharing. Both organizing the data will provide the FDCC with continued funding resources, and provide the community members who participate with data that informs their continued involvement in the composting program.

Based on our case study, we would encourage the municipality to increase participation and social engagement of the Feed Denton Community Compost by utilizing sensor monitors to record and share data that informs the community of their environmental and sustainable impact.

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6.2 Table of Figures

6.3 Table of Tables