Freedge: Fighting Food Insecurity With Connected Infrastructure

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Abstract

We created the "freedge" smartfridge network to level the playing field for the 1 in 10 Americans that live with "food insecurity", the condition of not knowing where a next meal will come from at least once per week. To understand more about how to alleviate hunger, we spoke with food assistance organizations and conducted a cultural probe with the general public. Our research suggested our design must (1) focus on both the short- and long-term problems (2) be close to people's homes (3) support ad-hoc use (4) enable low-obligation volunteering. Our prototype "freedge" is a device for neighborhoods to collect and distribute food donations. It has built-in cameras and locking compartments, with a companion app that allows users to browse and reserve food remotely as well as to crowdsource quality assurance.

Author Keywords

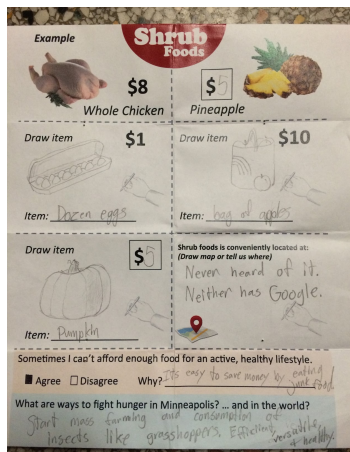food insecurity; smartfridge; crowdsourcing

ACM Classification Keywords

H.4.m [Information Systems Applications]: Miscellaneous; J.4 [Social and Behavioural Sciences]; K.4.m [Computers and Society]: Miscellaneous

Figure 1: Our cultural probe was a mock grocery store coupon booklet with fill-in-the-blank items, prices and map.

Figure 2: A completed cultural probe showing mix of items, and map with convenient placement.

Introduction

Currently, we struggle to feed every person on earth, and hunger is projected to increase over the next 40 years. The goal of "access by all people at all times to enough and appropriate food to provide the energy and nutrients needed to maintain an active and healthy life" is known as global food security [1]. According to the United States Department of Agriculture Economic Research Service fully 11.1% of U.S. households in 2005 were food insecure [10]. Living with food insecurity increases youth susceptibility to mood, anxiety, and behavior disorders [8]. These effects place food insecure individuals at a significant disadvantage.

Related Work

Perhaps because food insecurity is such a large problem, many attempts have been made to address it both from the supply side (food production) and the demand side (food consumption). Food Assistance Programs (FAPs), typically government or charitable organizations, are traditional ways of providing food. They have proven effective; the Supplemental Nutrition Assistance Program reduced the rate of food insecurity by 30% in the U.S. [11]. Considering food insecurity more broadly than just an access problem, there is also the problem of malnutrition. One inventive solution used a wearable camera paired with an app to allow users to share "stories" of fruit and vegetable preparation [9].

Although food can be "pushed" out to those with food insecurity, recipients may also want to "pull" resources. This reduces the stigma of "being a charity case". GroceryMate focused on this stigma by allowing grocery desires to be registered and then shown to food secure shoppers while they were purchasing for themselves[12]. Once acquired, food can also be used more carefully and wasted less. The Technicolor Fridge aims to do so with a camera that monitors inventory with every opening of the door [3].

Beyond the classic supply/demand thinking there are new initiatives to reimagine food insecurity as a symptom of global poverty - a livelihood issue. This "post-modern" perspective implores us not to think in terms of objective indicators but the subjective perception of humans' conditions, and empowering people with choice, self-determination and autonomy [7]. Post-modern HCI addressing food insecurity might ask how people can better grow food for themselves. Designers in Australia have proposed a wiki-style urban agriculture as a solution [5].

A user-centered line of inquiry asks how exactly people view the role of technology in food. When shown videos of hypothetical utopian and dystopian global scenarios, participants were generally positive about technology in food [2]. Qualifying that positivity though, recipients of FAPs in Karnataka, India only welcomed technology in assistance if it eased their access to benefits [6]. Such assistance programs available with technology are "farm-to-fork" distribution chains that reduce inefficiency and improve quality [4].

Formative Work

To inform designs for food insecurity, we executed two study protocols. In the first we conducted interviews with two organizations that provide help to people with food insecurity. In the second we collected information about the needs of people with food insecurity through a cultural probe.

Interviews with Organizations
We conducted interviews with Interfaith Outreach (IO) and Minnesota Students Association (MSA). These associations provide emergency, short-term, and long-term solutions for people with limited income via food, clothing, housing, transportation, and advocacy.

IO offers a mix of short-term solutions to hunger via food shelves and long-term solutions via job skills training. To

	Food in-secure	Food secure
# partici-pants	7	10
Vegetable item rate	38%	15%
Processed item rate	33%	15%
Custom item avg.	$4.07	$4.59
Most com-mon map location	no idea (x3)	near work (x7)

Table 1: In our cultural probe, 7 of 17 participants were food insecure. Variations of foods drawn and item prices were minor, compared to differences in mapping. While non food insecure participants frequently wanted a grocery store close to work, those who were more often said they had "no idea".

Figure 3: A free fridge in Saudi Arabia.

balance the supply and demand of their food shelves, they only allow members to use their services every 2 weeks, except for perishable goods. But they cannot always connect with all of the families that need assistance because some families have limited access to transportation. "If you want to pick-up from the food shelf you have to drive here, which is hard for some people. We would love to be able to deliver to people's houses, but obviously that is not a possibility." IO also mentioned that dependence on volunteers is difficult. "We really prefer people that can devote a lot of time, because you know it's a large investment to train them and organize schedules."

Our interview with MSA centered more on the economics that create food insecurity. The MSA president mentioned that the 1100% increase in college costs over the last few decades has forced some students to become food insecure. Furthermore, the significant increase in housing costs could also contribute to the problem. In the 1970s the University of Minnesota ran a food shelf for students which no longer exists. But the MSA claims that "food pantries won't solve the problem." From their point of view, a more effective route is political and collective action. "We're centralizing visceral anger at the gentrification which plays an integral role in food insecurity."

Cultural Probe
Since we thought asking people directly about food insecurity would be stigmatizing, we decided to conduct a cultural probe. We made a coupon booklet for "Shrub Foods" (a joke on the local chain "Cub Foods") in which the participants fill in blank coupons and a map (Figure 1). This protocol's main goal is to get a sense of what kinds of foods people desire, and what role geography plays in food insecurity.

We distributed 200 cultural probes into public spaces in Minneapolis and received 17 responses (Figure 2 for example), and then used content analysis to inspect differences in the responses (Table 1). 7 out of 17 participants agreed with the statement "sometimes I can't afford enough food for an active, healthy lifestyle," making for a 41% food insecure sample population. This might be high because our cultural probe attracted participants with a financial offer (a $10 Amazon gift card). Food insecure participants drew only marginally more vegetables (38% vs.15%) and processed foods (33% vs. 15%) than non-food insecure participants. Likewise when the participant was allowed to draw and price their own item, participants priced them almost identically (means: $4.07 vs. $4.59).

We found a large distinction between what food-insecure and food-secure participants drew on the map. Three food insecure participants wrote that they had "no idea" where Shrub Foods might be located, and the others drew it close to home. Food-secure participants drew Shrub Foods near their workplace or on their commute . Perhaps less secure participants have less routine around shopping, which would explain that more hunger-driven shopping would require locations closer to their house.

Implications for Design
Reviewing the interviews and the cultural probes, we wanted our design to embody 4 concepts.

1. *Short- and long-term*: Our interviews made it clear that both the symptoms and root cause must be treated to effectively fight food insecurity. Perhaps even the two modes could be connected.
2. *Distance to home*: Services being far from home are a main barrier to use, according to IO. The cultural probe confirmed homes as being a main locus of desire. Design should be sensitive to the home-radius.

Figure 4: Example of a "Little Free Library" book donation station.
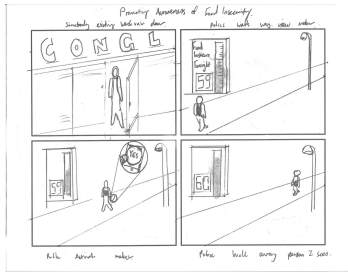
Figure 5: Sketch of food insecurity public awareness display, addressing the problem in the long-term.
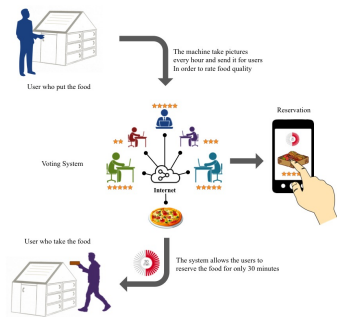
Figure 6: A sketch of our final design's user flow.

3. *Ad-hoc use*: Our cultural probe revealed that living with food insecurity decenters the notion of routine, and planned use of a service much harder. We should design for the "spur of the moment".

4. *Low-obligation volunteering*: High obligations often prevent long-term sustainability of volunteer-driven solutions. A successful design should give interested volunteers quick, easy ways to contribute.

Idea Generation
To encourage divergent thinking, we generated 120 ideas using IDEO-Style brainstorming without evaluating the ideas at this stage. Using affinity diagramming we merged our ideas into 13 clusters, and used our design implications to find our top-5 clusters.

Perhaps our most outlandish ideas were to not deal directly with food, but rather to raise awareness about the problem of food insecurity. We envisioned large public displays that would show statistics of the number of people facing food insecurity that day (Figure 5). On the opposite end of the spectrum, we conceived of a drone-racing league whose goal was to scavenge and deliver food to people. To lower cost we considered taking inspiration from Saudi Arabian free-food fridges often found at Mosques, which allow donations to locations instead of individual homes (Figure 3). This could put food close to those who needed it without the expenses of reaching the "last mile". Wanting to escape the idea of an organization being the sole provider for such a locker, we flirted with the notion of bartering and gifting via "leftover sharing," similar to book sharing that happens at "Little Free Libraries" (Figure 4). In this idea we would create a network so that rather than throwing away leftovers, people could drop off their meal for anyone who might want it. The idea of mixing formal and informal donations was

conceptually sound, but lacked the vision of an infrastructure that could make it possible.

Prototyping
After refining our top ideas, we settled on a design that met most of our design implications: the "freedge", a public network of decentralized smart-fridges. We built a medium-fidelity prototype of the freedge system which consisted of a custom smart-fridge and a companion app. The prototype allows, (A) In-neighborhood donations of food, (B) remote browsing, (C) remote reservation of donations, and (D) crowdsourced quality control of donations. Figures 6 and 7 show overviews of the user flow and physical form of the system.

(A) In-neighborhood donations
We wanted to make donation as intuitive as possible and so borrowed the "Little Free Library" existing design language. That is, we bricolaged a custom-wooden container, a fridge and it's accessories into a "house-on-stilts" shape (Figure 7). These self-contained systems can be located in public and spread throughout a neighborhood. The fridge is separated into compartments with independent doors, by sealing the main door shut, and cutting out small transparent acrylic doors with cold-proof sealing. To donate an item, one simply places it directly in a compartment, optionally vacuum-sealing it beforehand on a table located to the freedge's rear. After the user places the donation in the fridge, we sense when the compartment door is closed via magnetic contact switches. This sends a signal to a built-in Raspberry Pi which is controlling compartment-specific webcams (Figure 10) and uploads a snapshot to our web-app in real time. At that point the donor is done, but if the user wishes to specify more information, like a description, they can do so at any time as a crowdsourcer would (section D).

Figure 7: Exterior views of Freedge. With a human using toaster oven (top), tablet interface in-view (bottom).
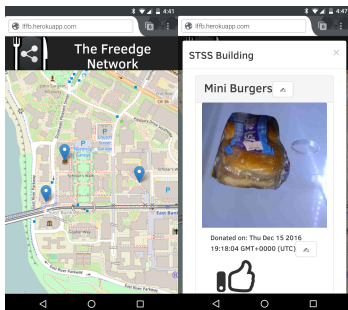
Figure 8: Screenshot of the Freedge web-app. Browse freedges (left), Detail view (right)

(B) Remote Browsing
We developed a web application that integrates with freedges to display their contents on the web[1] (Figure 8). For those who do not have access to a smartphone or laptop we mounted a tablet on the left side of the enclosure roof which is constantly displaying the web-app in "Kiosk Mode". The web-app displays a map with pins representing each freedge. When clicked, the pins show the latest images of that freedge's compartments, along with descriptions, a rating, the time at which the item was donated, and a reservation button. In this way users can check the status of the freedge network from the palm of their hand, or by walking to the closest freedge for those without a device.

(C) Remote Reservation
If a user wants any of the items they may reserve them through the app, or take them directly from the freedge. When the "reserve" button is clicked, the user is prompted to create a secret unlock code for later use. A signal is then sent to the freedge to lock the compartment door via "Particle Photons" (Figure 9). The donation is reserved for 30 minutes giving the user time to travel to the freedge. When the user arrives at the freedge, they enter their secret code on their phone, or the freedge's tablet in the case that the user does not have a smartphone and reserved on a different device. The compartment door is then unlocked and the user can heat their donation with the freedge's built-in toaster oven.

(D) Crowdsourcing Quality
The app also utilizes crowdsourcing to protect against potentially unsafe donations – a Wizard of Oz solution in place of advanced biochemical sensors. Each donated item has a thumbs up and down next to it, which anyone can click to give their rating on whether the food is safe. The picture of

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[1] http://lffb.herokuapp.com

the compartment is updated hourly, and if a downvote is received then the compartment is locked and the contact for that freedge is notified to remove the health-hazard item.

Evaluation and Future Work
We conducted a preliminary feasibility evaluation with 9 volunteers. The evaluation consisted of 3 tasks with follow-up surveys: to donate an item, to browse and edit data of an item, and to reserve and collect an item. Our participants were most positive about easy access to free food, being able to see what is inside the freedge from afar, and the reservation functionality. In terms of improvements, they said that it would be better if they could easily understand the status of the compartments (reserved, available, voting information) without checking on the app or tablet.

Will people actually use the freedge? We must conduct more user evaulations to understand perceptions of hygiene, and the importance of location. What are factors that lead people to trust food in public (cleanliness, packaging, donor reputation, etc.)? Additionally, what role does location play (in/outdoors, near grocery stores, bus stops, etc.)?

Conclusions
We designed and built the "freedge" system of smartfridges to fight food insecurity based on interviews with food-shelf organizations and cultural probes with the public. Our freedge prototype and app addressed four major design goals. Firstly we targeted short-term hunger by making a fridge which literally offers free food. In addition because of its digital nature using the freedge generates data which can be used to capture and display the scope of food insecurity. Secondly, we brought food donation closer to homes by making a device that could be walked to in a neighborhood rather than having to go to a central food shelf. Thirdly, we supported ad-hoc usage of the system through a web-
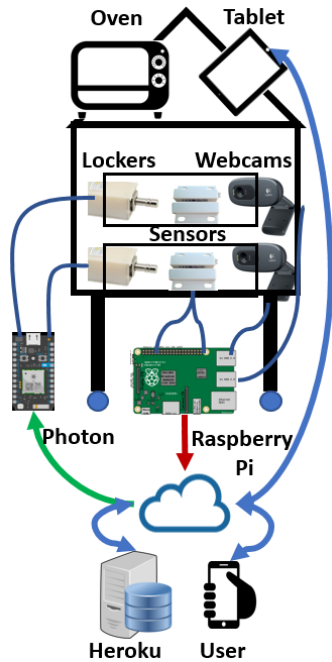
Figure 9: Technical overview of the Freedge.
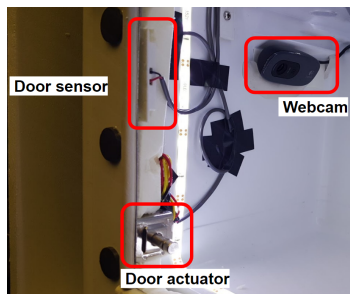
Figure 10: Close-up of one compartment's built-in door sensor, lock-actuator, and webcam.

app which is connected to cameras and locks inside the freedge, allowing users to view and reserve food from anywhere at any time. Finally, we created new ways to donate to the food insecurity cause, by crowdsourcing the state and safety of food in the freedges, as well as their maintenance tasks. In sum the freedge levels the playing field by providing public infrastructure to reduce food insecurity.

Acknowledgements

References

[1] Christopher B. Barrett. 2002. Chapter 40 Food security and food assistance programs. Agricultural and Food Policy, Vol. 2, Part B. Elsevier, 2103–2190. http://www.sciencedirect.com/science/article/pii/S1574007202100272

[2] Amel Bennaceur, Ciaran McCormick, Jesús García Galán, Charith Perera, Andrew Smith, Andrea Zisman, and Bashar Nuseibeh. Feed Me, Feed Me: An Exemplar for Engineering Adaptive Software *(SEAMS '16)*. DOI:http://dx.doi.org/10.1145/2897053.2897071

[3] Geremy Farr-Wharton, Jaz Hee-Jeong Choi, and Marcus Foth. Technicolouring the Fridge: Reducing Food Waste Through Uses of Colour-coding and Cameras *(MUM '14)*. DOI:http://dx.doi.org/10.1145/2677972.2677990

[4] Rachita Gupta. 2016. Food Security and Safety Using Advanced Information and Communication Technologies (ICTs) *(ICTCS '16)*. DOI:http://dx.doi.org/10.1145/2905055.2905264

[5] Peter Lyle, Jaz Hee-jeong Choi, and Marcus Foth. Growing Food in the City: Design Ideations for Urban Residential Gardeners *(C&T '15)*. DOI:http:

//dx.doi.org/10.1145/2768545.2768549

[6] Silvia Masiero and Amit Prakash. The Politics of Antipoverty Artefacts: Lessons from the Computerization of the Food Security System in Karnataka *(ICTD '15)*. DOI:http://dx.doi.org/10.1145/2737856.2738011

[7] Simon Maxwell. 1996. Food security: a post-modern perspective. *Food Policy* 21, 2 (May 1996), 155–170. DOI:http://dx.doi.org/10.1016/0306-9192(95)00074-7

[8] Katie A. McLaughlin, Jennifer Greif Green, Margarita Alegría, E. Jane Costello, Michael J. Gruber, Nancy A. Sampson, and Ronald C. Kessler. 2012. Food Insecurity and Mental Disorders in a National Sample of U.S. Adolescents. *Journal of the American Academy of Child & Adolescent Psychiatry* 12 (Dec. 2012). DOI:http://dx.doi.org/10.1016/j.jaac.2012.09.009

[9] Kher Hui Ng, Victoria Shipp, Anya Skatova, and Benjamin Bedwell. What's Cooking: A Digital Intervention to Encourage Sustainable Food Behaviour Using Mobile and Wearable Technologies *(MobileHCI '15)*. DOI:http://dx.doi.org/10.1145/2786567.2794330

[10] Mark Nord, Margaret Andrews, and Steven Carlson. 2005. Household food security in the United States. *USDA-ERS Economic Research Report* 11 (2005). http://papers.ssrn.com/sol3/Papers.cfm?abstract_id=878333

[11] Caroline Ratcliffe, Signe-mary McKernan, and Sisi Zhang. 2011. How Much Does the Supplemental Nutrition Assistance Program Reduce Food Insecurity? *American Journal of Agricultural Economics* (July 2011). DOI:http://dx.doi.org/10.1093/ajae/aar026

[12] Rajasee S. Rege, Jennifer L. Allen, Eric P. Drewski, and Robert S. Molnar. The GroceryMate: Eliciting Community Empathy and Transforming It into Purposeful Action *(CHI EA '08)*. ACM. DOI:http://dx.doi.org/10.1145/1358628.1358948