COHOUSING IOT: DESIGNING EDGE CASES IN THE INTERNET OF THINGS

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COHOUSING IOT: DESIGNING EDGE CASES IN THE INTERNET OF THINGS

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LIST OF ABBREVIATIONS

IoT – The Internet of Things

RtD – Research through Design

HCI – Human-Computer Interaction

M2M – Machine to Machine

Coho – Cohousing

TS – Touchstone Cohousing

ELC – East Lake Commons

LCC – Lake Claire Cohousing

PC – Pacifica Cohousing

EC – Eno Commons

SUMMARY

Cohousing IoT: designing edge cases for the Internet of Things is a research through design project that considers emerging domestic technologies and their relationship to alternative living arrangements, particularly cohousing communities. Cohousing is a form of semi-communal living where private homes lie around shared space. Each residence is self-sufficient, but together the community can offer social support that would otherwise be absent. Cohousing communities typically feature a common house, which may include an industrial kitchen and large dining area for common meals, large-scale laundry facilities, recreational spaces, or even a wood shop. This domestic arrangement of things makes it clear that traditional assumptions around the smart home fall flat. What would an Internet of Things look like when spread across multiple houses but only one home? Cohousing communities offer a perspective to critique existing IoT practice as well as a site for producing design work that generates site-specific alternatives.

The term "object ecology" describes how objects hold membership inside multiple networks—information, electronic, legal, cultural, material, and more. An ecological understanding of objects means that objects cannot and should not be treated discretely. Instead, they must be considered as component members of social and material assemblages, each having their own variety of agency. In a domestic context, what makes a home is an object ecology comprised of all sorts of things: plates, furniture, heating vents, entertainment devices, family members, rugs and more. Cohousing extends this notion to neighbors, shared responsibilities, and so on. This project provides a

theoretical foundation for ecological design in order to create community-based domestic objects in novel ways. It describes and classifies the contemporary Internet of Things to provide as a springboard for design prototyping. Finally, it uses this ecological approach to develop speculative Internet of Things devices for cohousing communities.

CHAPTER 1: INTRODUCTION

The "Internet of Things" describes a trend advocating that all sorts of physical artifacts become connected to and controllable from the Internet. In this vision, a coffeepot might be controlled along with a thermostat to have a home already warmed and the coffee on when a person wakes up in the morning; or sensors in the basement might email you if your basement is flooding. While this all seems sanguine, if possibly prosaic, contemporary IoT technologies rely on centralized servers, well-defined APIs, and black-boxed electronics for the end-user, and are designed and built only to be used in specific, condoned ways.

The IoT exists simultaneously as a rhetorical practice, an organization of actors, and as an implementation of networked technology. As commonly used, the term refers primarily to a marketing agenda that describes how the physical world will become smarter, more convenient, and more responsive to human needs. Explicitly, the Internet of Things exists as a site for industrial opportunity and is a means of selling individually Internet-addressable objects to homes around the world. The vision of everyday objects that are connected to and addressable from the Internet provides an opportunity to produce new devices that replace almost everything currently in a home. The utopian vision from the consumer's perspective is one where the world is a seamless collection of devices that together "just work"—networked devices that operate in concert with algorithms and data to predict your needs before you know you have them. From the corporate perspective, the story of IoT is just as rosy: access to fine-grained information about habits in the home, household purchases and their frequency, social graph

information, and more are all baked into hardware that needs occasional upgrades and replacement while being locked into proprietary implementations.

The present availability and claimed future ubiquity of smart devices and systems like these—platforms to sense the world and report their findings to a central location to effect further changes in the world—has shifted the nature of designing technologies in domestic contexts. In such intimate environments as the home, the interconnectedness of IoT devices coupled with the black box of most domestic IoT systems reveals an opportunity for design to account for many different kinds of actors. This thesis introduces the term "object ecology" to describe how objects hold membership in multiple networks—information, electronic, legal, cultural, material, and more. An ecological understanding in design means that objects cannot and should not be treated discretely. Instead, they must be considered as component members of social and material assemblages, that each have their own kind of agency. This ecological approach to interaction design articulates the complexity of designing things in relation to one another to inform designs that push on the boundaries of what “home” can mean. As interaction design is being used to propose and articulate possible futures, it assumes the role of ideological speculator, investing the rhetoric, capabilities, and objects of to create artifacts that assert specific ideological visions. Presently, we have moved from a condition where design cannot and should no longer be concerned with the object itself or even interaction with a particular object. Instead, interaction design must concern itself with *ecologies* of objects, values, practices, contexts, social configurations, and any number of other things. To design in this relational space, new models for understanding a design space need to be constructed.

From this perspective, the Internet of Things becomes an assemblage of people, technology companies, concerns around privacy, corporatism, upgradeability, cost, material objects, utopianism, and so on. Each of these actors together play a part in the IoT in practice and understanding both what these are and how they operate at a low level is important to understand what kinds of values and practices are being built into the Internet of Things—and what might be left out. The usual understanding of domestic IoT assumes particular standards of size, space, and income, taking as a given a large, free-standing single-family home with garage and in many representations, a pool:

Figure 1: Texas Instruments' "IoT-enabled home."

Cohousing communities don't easily fit this vision of the independent smart home. Cohousing is a form of shared living where private homes reside around common space. Each home is self-sufficient, but together the community offers rich social support. Shared spaces typically feature a common house, which may include a large kitchen and dining area, laundry facilities, recreational spaces, or even a wood shop. What would an Internet of Things look like when spread across multiple houses but only one home?

Cohousing communities offer a perspective to critique contemporary IoT practice as well as a site for producing ecologically-oriented design work. Cohousing operates like a standard residential neighborhood at one level but also is connected into a rich and complex social structure at another level. It emerges from individual family homes that each operate as members of a connected social life, distributed across multiple residences. Cohousing is a system of people and things that operate in relation to one another, where any proposed smart home must operate across a number of buildings.

This thesis describes a design research project that operates in three parts to explore how a design approach based in object ecology operates in practice. First, it provides a theoretical foundation for ecological design based in design studies. Second, that theoretical frame is used to develop and describe a particular object ecology called "cohousing IoT." This object ecology is constructed from research into the lives and practices of cohousing residents, as well as research into the contemporary Internet of Things. This includes classification of the contemporary Internet of Things that provides a springboard for design prototyping that leverages the material language and values the IoT *already* supports, as well as involving alternative values the IoT *could* support in the future. Finally, this research becomes the foundation for designing speculative prototypes of cohousing-based Internet of Things objects. The prototypes are designed to support and sustain cohousing values and were evaluated using codesign workshops at communities in the American Southeast. This dissertation concludes with recommendations and heuristics for doing ecological design work, and how an ecological perspective necessitates speculation for interaction design. Its contributions are also threefold. First, it introduces the object ecology as a framework for approaching novel

design spaces. Second, it present a case of exploring and designing in an object ecology called “cohousing IoT” and using it as a venue for a design research project. Finally, it offers reflections on a design process in an object ecology.

1.1 Design

Most often, design is fundamentally invested in producing things that represent, set, or solve problems. An alternative role for design in to produce devices that illuminate arrangements of things in order to reveal new understandings of particular social contexts. This is a different means of understanding design that is constructed from three different theoretical traditions. The first is through historical understandings of the design process as creating solutions to problems, the second is through the lens of things as active agents in the world, and finally, through ecological perspectives on design.

1.1.1 Designing speculative placements

While design is often represented as a method of solving particular problems (Simon 1996), Buchanan understands the nature of the design process as something that is both situated and contingent (Buchanan 1995). Design is not a scientific exercise, but instead a process that offers a broad, humanistic way to gain insight into issues and their problems. To Buchanan, design is a recognizable process of discovery and invention that can operate across many different domains. The behavior that a designer exhibits while producing graphic layouts or sneakers or bridges is similar. “The subject matter of design studies is not products, as such, but the art of conceiving and planning products. In other words, the *poetics* of products—the study of products as they arc—is different from the *rhetoric* of products—the study of how products come to be as vehicles of argument and

persuasion about the desirable qualities of private and public life" (Buchanan 1995). Design is a process that produces a product, while design studies emphasizes and reveals the poetics of products as they operate in social contexts.

This process of producing products is rooted in making objects. While that might at first seem tautological, it's essential to remember that design is innately a process of producing things, and not theorizing them. As elaborated in Buchanan's "Wicked Problems in Design Thinking," instead of creating a system of categorizations, design produces *placements*. "Placements have boundaries to shape and constrain meaning but are not rigidly fixed and determinate. The boundary of a placement gives a context or orientation to thinking, but the application to a specific situation can generate a new perception of that situation and, hence, a new possibility to be tested. Therefore, placements are sources of new ideas and possibilities" (Buchanan 1992). This perspective of situated, flexible design is rooted in traditions from both craft practices such as (Ingold 2013) or (Sennett 2009) as well as an analytic process to evaluate appropriateness: what Buchanan has called *placements* and *categories* are similar to what Nelson and Stolterman have called *action* and *inquiry* (Buchanan and Margolin 1995; Nelson and Stolterman 2012). Here, design can be understood as a generalizable practice of gaining knowledge of a condition through a process of inquiry and attending to those conditions via action. In this way design action creates a situated, material response to a particular context.

This is a "third way" of producing knowledge that is wholly distinct from the arts or sciences. In *The Design Way*, they outline what design is and more importantly, the kinds of practices that operate to produce good design work (Nelson and Stolterman

2012). This third way of design is characterized by a recognizable combination of thought and action that distinguishes it from both craft and art, as well as the sciences and the humanities. Rather than creating objects for aesthetic value, as is the case in the arts, or systems that seek to gather information about the world at large to generalize, as is the case with the sciences, design objects exhibit intentionality about how the future *should* be. "Design is the ability to imagine that-which-does-not-yet-exist, to make it appear in concrete form as a new, purposeful addition to the real world" (Nelson and Stolterman 2012). Nelson and Stolterman situate design activity as taking place in multiple contexts and through multiple roles. Through the nature of design as integrating multiple perspectives on a particular situation, design can be used to challenge dominant viewpoints, where experiences are quantized and categorized to fit pervasive understandings of how the world operates, with other perspectives on problems. "Design wisdom has the ability to shift from an analog experience of life, to a digital or analytical perspective on the world *and back again*" (Nelson and Stolterman 2012). This takes place through a design problem that moves from a complex, undifferentiated mass of issues becoming refined into a specific context for a design intervention—producing a design object returns a theoretical inquiry to a material experience.

Unlike scientists, who are obligated to what is true, designers have an obligation to what is real, in addition to what is true. This truth is embodied in what Nelson and Stolterman call the *ultimate particular*. Instead of an abstract concept, or a category of things, or even a model of a thing, which can all be true while not being real, this "ultimate particular" is the result of the design process. Design, through seeking to create change, is invested in the ideal, grounded in the true, and expressed through the real. One

way to unpack this is by considering the ideal, true, and real as being linked to different forms of inquiry. Nelson and Stolterman describe each of these modes of design inquiry as having different outcomes. The outcome of design inquiry into the real produces *ultimate particulars.* Inquiry into what is true produces *facts* about a certain design problem. Inquiring as to the ideal solution produces what they call *desiderata*. Desiderata can be something that describes "what ought to be," and relates to how design can affect norms and values. This conception of the ideal is, of course, impossible to be built into a particular object. However, it is possible to approximate this ideal in the material world through a process of reflective practice and production. Nelson and Stolterman offer a way to enact a fluidity through multiple perspectives with their conception of design wisdom, looking both inside and outside of the systematized black box of a design problem to see what might end up satisficing multiple goals. Here, the idea of desiderata—or speculative placements—as approximated by a designed "ultimate particular" offers a way to do design that offers new perspectives on design spaces like the home.

1.2 Design and an emphasis on the thing

The "thing" is one way that designers and theorists have contemplated the role of objects in sociotechnical systems like the home. Etymologically, the "thing" comes from the term *ding*, a Germanic word for a specific kind of gathering. As described by Heidegger:

> *…the Old High German word thing means a gathering, and specifically a gathering to deliberate on a matter under discussion, a*

> *contested matter. In consequence, the Old German words 'thing' and 'ding' become the names for an affair or matter of pertinence. They denote anything that in any way hears upon men, concerns them, and that accordingly is a matter for discourse. (Heidegger 2009)*

This understanding of things as a shift from an object in space to a site for contestation is expanded by Bruno Latour in *From Realpolitik to Dingpolitik* (Latour 2005). This is Latour's proposal of thing-centered or "object-oriented" politics. He understands political actions as they are, and examines the messy nature of alliances and allegiances based around particular situated values. "We might be more connected to each other by our worries, our matters of concern, the issues we care for, than by any other set of values, opinions, attitudes, or principles." To Latour, objects become battlegrounds for differing perspectives on matters of concern: "*every one of these objects, you see spewing out of them a different set of passions, indignations, opinions, as well as a different set of interested parties and different ways of carrying out their partial resolution*" (Weibel and Latour 2005). From this perspective, the concept of an issue and an object get mixed together in a productive way: objects are issues that have enlisted actants that care about them. Beyond simple, objective statements that can be demonstrably true or demonstrably false, political decision-making is dependent on contested realities, as multiple perspectives on objects can be debated, discussed, and brought to closure. These contested objects are things in themselves, in that they are materialized issues that simultaneously embody multiple political perspectives; but are also the locus of another kind of assembly for those who have a vested interest in that thing. The thing becomes a site for contestation as well as a representation of a

perspective on the issue. Design produces objects that make claims about the how things engage with particular issues and values: they become a primary way to argue that objects can take a place in contested dialogues. These objects become the "things" that do work—in some ways implicitly: they operate through organizing and assembling actants into dialogues around contested issues.

1.2.1 Designing in relation

Actor-Network Theory (ANT) was developed in the field of Science and Technology Studies through the work of multiple scholars, including Bruno Latour, John Law, and Michel Callon (Latour 2007; Law 1992). ANT is a perspective on how actors—people—and objects—called actants—interrelate inside the network, the system of relations (Latour 1993). Actors are anything that might influence something else. Objects, people, things, and ideas, all have weight in this system, because only an actor's effect on other actors matters. In the network, the relations take priority: if a thing can be in a relation with another thing, it becomes meaningful. ANT considers the details of human and nonhuman networks to examine and understand specific ways a technology relates to other actors within those networks. One of the central tenets of ANT is that to build an accurate understanding of a given technology, it is necessary to identify and follow the capacities of all the actors within the network, both human and nonhuman.

On implication of putting all actors onto an even playing field is that they have the same agency. Rather than considering agency as a quality that comes from materiality as such, ANT understands agency as an effect of the configuration of a network. In it, capacities, responsibilities, and authorities are distributed—or delegated—across all human actors and actants that create the network (Latour 2007). Specifically, ANT and

design share a commitment to the object as having an intrinsic capacity for action. Whole other theories of agency privilege human action—in some cases exclusively—ANT and design each acknowledge the necessary role of the object in constructing society: things exert as much influence across the network as do the effects of people. One shortcoming of ANT as it applies to design, however, is that it is not intrinsically generative. ANT is useful for analyzing networks or assemblages that already exist or for considering arrangements of things that existed at a particular time, but does not offer a perspective that is useful for conceptualizing and generating new networks or the products, or services as actants within them. Being able to imagine the political implications of an assemblage in the making is beyond the scope of a vibrancy that interprets the political effects of things after they have happened. This mismatch for speculating about possible futures limits the utility of ANT for generating design (Lindström and Ståhl 2014), while at the same time offering rich theoretical perspectives on how to interpret a designed things' role in the world.

1.2.2 Design things

Studio Atelier have taken this framing of thing as an assemblage of ideas, issues, and objects to flesh out the idea of a *design thing*, a designed object that enacts multiple roles in the context of the process of design (Binder et al. 2011). Unlike design projects which have well defined boundaries, design things are messy, supporting many different values and viewpoints. The design thing "aligns humans and nonhuman resources into to move the object of design forward, to support the emergence, translation, and performance" of the design object through "participation, intervention, and performance in this sociotechnical thing" (ibid). Studio Atelier recognizes the ability of the object to

align various interests. To them, the object of design becomes a point of contention and contestation between many different factions. On the one hand, the design object is part of a lasting record of process: the designers build into the object a history of decisions and compromises. At the same time, the designed object is still an active space for current controversy and consequently, future decision-making. These design things are similar to Buchanan's idea of the placement, where a design "gives a context or orientation to thinking, but the application to a specific situation can generate a new perception of that situation and, hence, a new possibility to be tested. Therefore, placements are sources of new ideas and possibilities when applied to problems in concrete circumstances" (Buchanan 1992).

From this perspective, the Internet of Things changes from suites of consumer products or objects that exist for people to be used exclusively in the here and now into speculative social configurations: they postulate systems that create possible encounters between people, objects, and values. As the role of interaction design has expanded, the work of interaction design seems more allied with the idea of the design thing, of understanding design as producing context for things to contest issues that matter to people within computational environments, rather than as simply producing prototypes and wireframes (Vallgårda 2014).

1.3 Designing in an Ecosystem

As mentioned above, one shortcoming of ANT as it applies to design is that it does not easily enable generative design practices. ANT is useful for analyzing networks that already exist, but it is not a perspective that is helpful for conceptualizing and generating new networks or the products and services that operate as actants within them.

This mismatch for speculating about possible futures limits the utility of ANT for design practice. While the idea of attachments is useful in extending through past the actor-network and into a sense of relation between objects and how they manifest issues, there is still a generative spark missing. Here, the notion of an ecosystem offers a metaphor that works to guide design decisions to create speculative placements that are able to provide attachments to issues without human direction.

In the design context, the ecological perspective has previously been deployed to emphasize a particular product as a category of specific kind of thing—as a niche. In ecology, a niche is the set of conditions that a species is evolved to fit with precision (Kearney Michael and Porter Warren P. 2004). By trying to understand how products are bought and used as part of a social context, Forlizzi offers a framework for performing research into interaction design that tries to make sense not only how products come to be, how they fit their niche, but also how they come to be used and cared for.

> *The functional, aesthetic, symbolic, emotional and social dimensions of a product, combined with other units of analysis, or factors, in the ecology, help to describe how people make social relationships with products. These include the product; the surrounding products and other systems of products; the people who use it, and their attitudes, disposition, roles, and relationships; the physical structure, norms and routines of the place the product is used; and the social and cultural contexts of the people who use the product and possibly even the people who make the product. (Forlizzi 2008)*

At its core, the product ecology concerns itself with three goals. First, it describes social product use—how products evoke social behavior. Second, it provides a roadmap for choosing appropriate qualitative research methods to discover social product use. Finally, it extends design culture in interaction design by allowing for flexible, design-centered research planning and opportunity seeking (Forlizzi 2008).

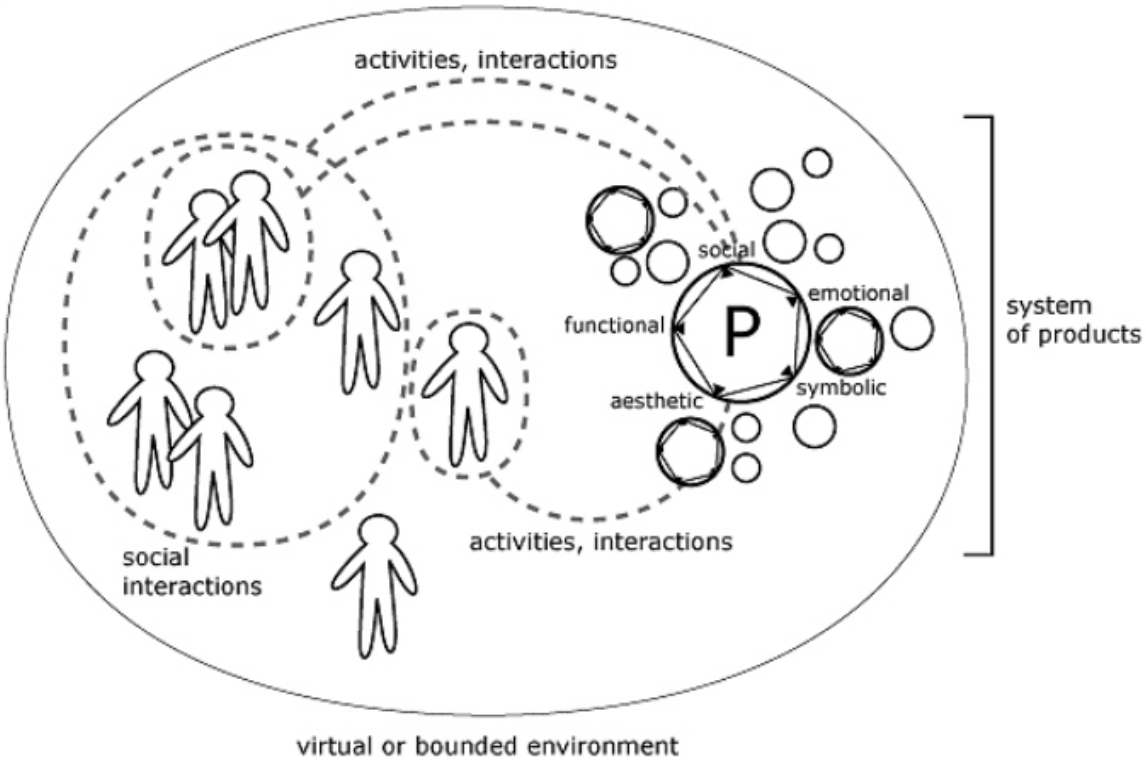

Figure 2: Forlizzi's Product Ecology

As a research framework, the Product Ecology provides both a way of understanding the complex physical and social context of use around a product as well as a way to consider and create change in the world. The Product Ecology framework is useful for broadening the view of what a product might be by defining the roles that it takes on as a member of a system of products. For example, many products are more than simply functional objects of use—they serve important emotional and social functions in

people's lives. These complex, emergent uses and meanings of products evolve over time, and may change during the course of research (Forlizzi 2008).

This complexity is a defining trait of how objects act as members of a broader ecosystem. In the *Product Milieu* (Margolin 2002), Victor Margolin describes objects—like Forlizzi, framed as "products"— that operate as part of a larger social sphere:

> *"To pursue the question of how products contribute to human experience, it is necessary to consider the large social sphere in which they exist. I have coined the term product milieu to characterize the aggregate of material and immaterial products, including objects, images, systems, and services, that fill the lifeworld. This milieu is vast and diffuse, fluid rather than fixed. It is always physically and psychically present and consists of all the resources that individuals make use of to live their lives…We therefore engage simultaneously with products developed at different historical moments. They embody different degrees of operational simplicity or complexity as well as the potential for different kinds of satisfaction" (45).*

By emphasizing the role of social structures in understanding how products operate, Margolin situates products as a part of culture, but may go too far in removing object agency as a component of that culture. Further, there is something dystopic in taking interactions with products exclusively as being paramount to human experience: "…questions of how products enter the milieu, how they find their ways to users, and what users do with them are much more closely linked to psychology, sociology, and anthropology—disciplines that study human development—than we have previously

recognized" (45). Margolin claims that this structure is not constructed by objects but is instead the result of social interaction with people: "The product milieu does not itself constitute a structured set of conditions to which individuals adapt. Instead, products within the milieu are drawn together in situations through human action" (45). This is a point that seems contestable. As described above, Latour (Latour 1993; Weibel and Latour 2005), among others, including Bennett (Bennett 2010) and Harman (Harman 2002; Latour, Harman, and Erdélyi 2011) have taken a more bi-directional understanding of meaning construction through interaction. In taking the things that surround us as having an active role in understanding the world, we need to move away from the idea of product, a term that casts things as being both primarily transactional and, as Forlizzi makes clear, being representative of a class or category of thing instead of a specific thing. What is needed, in this case, is an ecology of objects in concert with human values and goals, rather than products as a unit that act in response to them.

The product ecology and milieu are excellent first steps towards understanding the role of designed objects in use and as a location of social values found in products, but also have some shortcomings. Most obviously, they fail to account for any agentic property of the product as such—the designed object may help to create an emotional response on the part of the user or might have some symbolic value that is not intended, but this clearly comes back to the designer in the first case or to broader social construction in the second. In addition, the framework concerns itself only with *products,* and particularly how users interact with a single product at a time. This is understandable, considering the role of design historically—it has usually been a practice of creating a stand-alone product—but is beginning to feel inadequate and too limited in a time of

ever-more networked products. Contemporary rhetoric around "smart materials" means that the category of "product" is broadening even further than Forlizzi admits. Complexity emerges from social understanding of objects, to be sure, but contemporary objects also have their own sociability, one that these frameworks lack entirely.

Ecological metaphors have also been taken up in HCI to consider the relationships between different kinds of technologies. Beyond the product ecology and milieu described above, Jung et al describe as an *ecology of artifacts* the personal ecosystem of devices that mediate experience and exposure to other personal technological ecosystems of devices kept on the body (Jung et al. 2008). Similarly, Bødker and Klokmose describe as an *artifact ecology* the way networks of artifacts shape and influence conceptions and potentials for use (Blevis et al. 2015; Bødker and Klokmose 2012). Each of these ecological perspectives, however, place the focus on the interpretive power of the human user and do not account for any agentic property of the object as such. One problem that these interpretive frames do not address is the unknown aspects of the relations between devices: while they offer a means of understanding how devices work together, there's no way to consider or reveal effects that remain hidden or unseen. Being able to reveal the hidden parts of ecologies would constitute a rich vein for design. How can we use design in an ecological frame to articulate what's missing?

1.3.1 Object ecology

The object ecology takes the everyday built environment as an assembly of things. The role of design in producing new design things from an ecological standpoint is to consider the interrelatedness of these things and to prototype novel, interesting and—most importantly—worthwhile social interactions between and among them.

Likewise, the Internet of Things is an assemblage of people, technology companies, concerns around privacy, corporatism, upgradeability, cost, material objects, utopianism, and so on. These actors play a part in the IoT in practice and understanding both what these are and how they operate at a low level is important to understand what kinds of values and practices are being built into them as well as what might be left out. Part of the goal of considering the built environment as an assembly of specific contextual things is to be responsible to the specifics of a social situation. This is why the Internet of Things—and particularly, edge cases of the Internet of Things—are such a vibrant opportunity to deploy an ecological perspective on design. In the context of this project, the object ecology offers three main concepts that are relevant to analyzing domestic HCI design:

The first is that there is an ecology of objects that is populated by things. Design provides a means to create things in both senses of the word, as both giving form to devices, objects, and systems, of course, but also in creating assemblages that let different members of the ecology participate. This synthesizes the analytical approach towards materials characterized by ANT with the generative design strategies rooted in speculation that obligates a designer or scholar to speculate as to the inner workings of a complex system. Second, the Internet of Things is a rich context to explore things as sociotechnical assemblages: the IoT is already a complicated mixture of actants that taken together may not always be well-understood. Current IoT technologies rely on centralized servers, APIs, and black-boxed electronics for the end-user, and are built only to be used in specific, condoned ways. This IoT is a assemblage unto itself, a technological ecosystem that is already executing political agendas. It provides an exciting opportunity

to design speculative alternatives that are deeply situated in real domestic practices. Finally, outliers of conventional domestic life are a means to gain rich design insights into the object ecology unique to cohousing life. Creating technology for these practices lets us consider and design critical alternatives, throwing into relief strange and sometimes overlooked ecological components for further analysis. An object ecology has us examine those relations and how they are structured to produce (or thwart) a cooperative endeavor, a working together of humans and nonhumans in the context of an issue.

1.3.2 Design as ecological speculation

The Internet of Things offers a means to examine in domestic settings how cumulative computational relationships between things operate to produce social effects: between humans and their environment; objects and their surroundings; objects and the Internet; and objects among themselves, their histories, their materiality, and so on. This set of nested relationships comprises an *object ecology*, a site of near-infinite regress that offers fertile ground for designing elements of a larger interaction. The complexity of the ecology of objects means that it is impossible to know the design space in its entirety:

> *"Designers demonstrate this very understanding when claiming that their design can play particular roles relative to other artifacts. But the "human terms" that people bring to how they connect artifacts pertains to a highly localized understanding. This understanding does not embrace the whole ecology, and it is not generalizable to it. It is distributed, not shared. Whereas ecologies of biological species result*

from the multiplicity of local interactions between the organisms of different species, ecologies of artifacts result from enacting the multiplicity of local ecological understandings.

Thus, ecologies of artifacts, even of only moderate complexity, escape any one individual's understanding. To cope with this complexity, we may have to be satisfied with partial theories of how artifacts interact." (Krippendorff 2005, 195)

Because of this lack of access to a complete knowledge of the design space, speculation becomes an essential component of any design work done in an ecological context. Speculation provides a means to consider what is happening across various objects in different ecosystems, as well as a way to create boundaries—to claim for a particular case that these things matter while other things don't. In this way, the concept of the object ecology is useful in revealing the edges of the Internet of Things: through understanding the component parts in a broader material way, it's possible to draw together how objects and the relationship between them create and sustain novel social arrangements.

This project moves away from the unsatisfying definition of the Internet of Things as a Silicon Valley term of art for home automation, a rhetoric of 'smarter' technology, and instead understand it as a complex site for understanding how humans, objects and environments participate in sociotechnical *things*. In the end, the "Internet of Things" is just an ecology of objects. In order to engage in either analysis or generation of object ecologies *requires* speculation—the object ecology in both its analytical and generative form is too expansive to wholly comprehend. Speculation—and correspondingly

speculative design—within object ecologies provides a means to both understand existing technological interactions within an ecosystem as well as helps to produce new designed artifacts for these contexts.

The object ecology is a way of theorizing design that decenters human needs while taking the effects of artifacts into account. It comes from the idea of taking things and their relationships seriously—extending from design things through actor-network theory and building from Latour and conception of the black box. Here, the ecology itself is black boxed as a design space, and particular design concepts come from speculating as to specific locations in the ecology—designing placements as niches that operate inside of it. These ecologies as relational understandings of a design space per Buchanan, where the design complexity that the ecology bounds requires speculation as a mode of revealing desiderata that exists inside of it.

This ecological approach is useful because it offers a way to theorize a complex design space and turns an analytical perspective on theory into a generative one via speculation. Creating prototypes in an object ecology is essential to understand it—design produces placements that speculate as to the contents of that ecosystem and draw attention to issues that operate inside of the relational space. The prototypes that come from this perspective are placements that articulate a possible niche for design work in the object ecology: these material placements are agentic, social *things*. Krippendorff writes:

> *Technological cooperatives are held together by collective human actions, often coordinated by social institutions. They have histories and develop over generations in time. They have no parallel in ecologies of*

> *biological species. They do not merely aid social life; they can also shift what it means to be human. Thus, the interaction patterns that sustain or drive technological cooperatives easily escape traditional design considerations. The ecological meanings of artifacts that designers have the option to encourage or omit can make a difference in how large technological cooperatives develop. (Krippendorff 2005, 203)*

Cooperatives like these, including cohousing, are constructed from things, practices, and people, and provides an ecology to explore via speculation in interaction design. This approach offers ways of thinking about a design space in ways that will be discussed in the final chapter of this thesis. Cohousing offers a site for speculation at the margins in the ecology of IoT, domestic life, and social arrangements of people and things. How does an ecology of objects operate here to produce social effects?

1.4 Domesticity as a site for ecological speculation

By providing computational capabilities to materials in the home, the Internet of Things has entered this domain, and begun to change how it operates. At the most fundamental level, what people mean when they say "smart home" is a domestic residence that is instrumented with sensing and reporting technology that works to support residents' needs. From this perspective, of course, a smart home is nothing new. Smart homes have always existed as a matter of degree, not kind. In the 1950s, a smart home would look very different from a smart home of 1900. Washing machines replaced swathes of manual labor, refrigerators (when coupled with roads and automobiles) mean that buying groceries need only happen once a week without fear of spoilage, and so on

(Cowan 1976; Strasser 2000). Contemporary computing practices, however, are placing residences at a similar inflection point that might revolutionize the home in new and different ways. What makes a smart home in the late 2010s is the combination of already-existing domestic live with the burgeoning Internet of Things.

This section builds background for cohousing research that speculates into alternatives for smart homes. The first of these are HCI research into domesticity in general. The second is the epistemological framings of these projects. Together, these describe how domestic design research provides an opportunity to produce work that defamiliarizes domestic life by creating speculative design prototypes that operate at the intersection of the IoT and the home.

1.4.1 How HCI interprets the homes

The home and domestic life has long been a topic of interest to HCI. Understanding how domestic contexts might shape technology design is a theme common in CHI literature. Recently, Desjardins et al. have published a literature review and analysis of approximately the last twenty-five years of domestic-oriented design research in HCI (Desjardins, Wakkary, and Odom 2015). They classify this research into genres, e.g. (DiSalvo, Sengers, and Brynjarsdóttir 2010), that describe how research into domestic technology has operated. These genres provide categories of HCI research into domestic life that can be expanded by taking cohousing into account. With cohousing in mind, the most relevant genres are *social routines in the home*, *ongoing domestic practices*, *the home as a site for interpretation*, and *contested values of a home.*

Social routines in the home describe how routines affect everyday home life and social structures. This genre is influenced by ethnomethodology (Garfinkel 1991), and

asks questions about how social life is created and organized in the home. Inside of an individual family home, much of this social organization remains unchanged in cohousing, while a large set of community social routines become grafted on. Research into cohousing from this genre's perspective could reveal how domestic routines are reconstituted as being broader than a house and, indeed, become spread across a community at large.

Ongoing domestic practices emphasize the personal experience of living in the domestic sphere as linked to particular practices (Desjardins, Wakkary, and Odom 2015). Questions from this genre include: how do practices configure the home experience? How do people describe and reflect on the various domestic practices they perform? What is the role of artifacts and technologies in the practice of domestic experience? "Domestic practices" here includes gardening (Goodman and Rosner 2011; Jenkins 2013) pottering (Swan, Taylor, and Harper 2008; Susan P. Wyche, Taylor, and Kaye 2007), religious practice (Woodruff, Augustin, and Foucault 2007; S.P. Wyche et al. 2008; Susan P. Wyche and Grinter 2009), health monitoring (Aarhus and Ballegaard 2010; Grönvall and Verdezoto 2013), interpersonal communication (Ames et al. 2010; Anderson et al. 1999; Elliot, Neustaedter, and Greenberg 2005), domestic network management (Grinter et al. 2009), resource consumption (Strengers 2011) and simple living (Håkansson and Sengers 2013). At the very least, cohousing is a practice like these that carries with it its own set of material- and object-borne obligations. But as a style and arrangement of living, cohousing also inflects the practices and experiences that take place within its borders.

The home as a site for interpretation seeks to understand the "unique, nuanced, private, messy, and creative" nature of domestic life (Desjardins, Wakkary, and Odom 2015). This work concerns itself with ideas like playfulness (W. Gaver 2006; Bill Gaver 2009), exploration (W. W. Gaver et al. 2013), discovery (Lim et al. 2013), reflection (W. T. Odom et al. 2014), interpretation (William Gaver et al. 2007), speculation (Helmes et al. 2011), and provocation (Dunne and Raby 2001). This genre asks, how can we include reflection and interpretation in the home? Can we create technology that reflects the intimate, complex, and nuanced character of domestic experience? How do people react to, use, and explore with new technologies designed to support interpretation in the home? These questions are especially interesting in a cohousing context, as they mesh well with how cohousing life operates already. As intentional communities that are governed using consensus, cohousing is reflective in its practice to begin with, and respectfully engaging among and between cohousing residents is a core part of understanding its brand of domesticity.

One genre that seems particularly relevant to an expanded definition of domestic life is *Contested values of a home*. This genre brings attention to different constructions of what comprises "home." What have we overlooked when we've talked about the home? How can we go beyond common assumptions about what the home is in a way that can tell us more about how to design interactive domestic technologies? Research in this category examines alternative family structures (W. Odom, Zimmerman, and Forlizzi 2010), non-Western perspectives (Bell, Blythe, and Sengers 2005; Bell and Kaye 2002), mobile ways of living (Desjardins and Wakkary 2016; Zafiroglu and Chang 2007),

temporal understandings of home (Dong, Ackerman, and Newman 2014), and gender-based understandings of domestic spaces (Bell and Dourish 2007; Cowan 1976).

1.4.2 The epistemic commitments of domestic HCI research

In addition to establishing a set of genres that describe the categories of domestic research in HCI, Desjardins et al also sorted these genres by the epistemological commitments that each of them are subscribed to. These are reflected in the questions being asked as well as how results are uncovered and interpreted:

The *objective observer* commitment takes an overhead perspective on research. It is removed from the context and situation of a study and instead and relies on concrete, visible accounts to discuss domestic life. The *third person observer* commitment means that the researcher observes, asks questions, and sometimes participates in home life, allowing a deep dive into the routines and practices of the everyday. The *relayed informant* commitment is characterized by a participant's quotes (from interviews or photo/text/video diaries) and are relayed and selected by the researcher. In the *author interpreter* commitment, an author builds a reasoned argument about the domestic experience by asking questions. Finally, the *experimenter* commitment can be characterized by the issues a designer of research artifacts might concern themselves with while developing prototypes that are deployed to observe the effects of new technologies in the home (Desjardins, Wakkary, and Odom 2015).

Desjardins et al conclude that these commitments result in two dominant perspectives that the HCI community uses to do interaction design research in domestic spaces. The *anthropocentric perspective* understands the home as something uniquely human. The focus of the work, as well as the driving motivation for it, is to understand

the home and human life from the human perspective. Human experiences, routines, activities, challenges, and motivations provide the center of the work. The second dominant perspective is *observer/interpreter*. In this perspective, the author is the ultimate arbiter of what is discussed. He or she describes participants' perspectives, his or her own observations, and sets the scene for the research as part of a curated, mediated effort to tell a research story, choosing what to present with words or images to best support it. Three of the epistemic commitments (*objective observer*, *third person observer*, and *relayed informant*) are innately rooted in this perspective, while two (*author interpreter*, and *experimenter*) begin to offer a different perspective, utilizing either a more personal, experiential voice or the designer's perspective on a subject.

Desjardins et al have taken the dominance of these perspectives to propose alternative, complementary perspectives that may serve to elucidate missing or underexplored avenues in domestic HCI research. These are *a material perspective on the* home and *a first person view on the home* (Desjardins, Wakkary, and Odom 2015). While both are worthwhile moves towards design-based inquiry into domestic technology practices, the material perspective aligns itself well with the goals and theoretical grounding of this project: to better understand the relationships among and between objects in the home.

Table 1: Epistemic commitments of domestic HCI research (from Desjardins 2015)

Commitments	Genres
Objective observer	Social routines, testing grounds, smart home, interpretation
Third person observer	Ongoing practices, testing grounds, smart homes, interpretation

Relayed informant	Ongoing practices, testing grounds, interpretation
Author interpreter	Contested values, speculative visions
Experimenter	Testing grounds, interpretation

This dissertation uses the theoretical framework of the object ecology to interrogate smart home imaginaries by designing Internet of Things devices that explore what kinds of needs and desires residents of cohousing—as a distributed smart home—might have. The prototypes are built based on domestic values common to cohousing as well as the kinds of values that the IoT support or could support. The object ecology provides a theoretical framework that lets speculate as to the contents of unusual or novel conditions. After Desjardins et al, this project intends to do design work rooted in material production, while considering the capacity of things to participate in the social life of a distributed smart home.

Interaction design in HCI has sometimes been used to propose and articulate possible futures, or even preferable ones (Dunne and Raby 2014). In this context, design assumes the role of speculator, investing rhetoric into objects to create artifacts that take a stand, and play an active part in stretching the boundaries of what is possible while asserting ideological visions. As everyday devices become imbued with more automatic and agentic qualities, design cannot and should not be concerned with a solitary object or interactions with that object alone. Instead, we must consider how an object becomes contextualized within collectives of people, other objects, values, contexts, and social configurations. Speculation in design provides a means to create things in both senses of

the word: as giving form to devices, objects, and systems, of course, but also in creating assemblages that let different members of an ecosystem participate and act in the world.

Cohousing provides a venue to help understand how particular values operate in domestic life. Proponents and residents of cohousing take pains to emphasize that living in cohousing is not so very different than a standard condominium or neighborhood. There are clearly some differences, though, and these call attention to values and practices that are currently not a part of the usual domestic technology design in HCI. Taking the theoretical moves and domestic HCI themes from above, there are certainly ways to understand cohousing domesticity as being substantially different from existing domestic practices in ways that can generate inspiration for technology design. Cohousing is one way to think about how more usual understandings of technology in the home might become *defamiliarized*, a technique of inversion that takes standard, unexamined practices around everyday life that are culturally dominant and casts them in an unfamiliar light to reveal what kinds of assumptions exist therein. As a part of that process, defamiliarization can generate alternative stories of use that technology trends might otherwise elide (Bell, Blythe, and Sengers 2005). Bell et al. "suggest that identifying and resisting these trends cans suggest new portions of the design space to explore, resulting in a range of products that will more fully address the range of possible lifestyles in the home" (Bell, Blythe, and Sengers 2005).

Defamiliarization offers a means of understanding well-known contexts in a different way. Cohousing provides an opportunity to defamiliarize domestic practices by upending existing assumptions about what homes must be. In cohousing, the role of the community is expanded, more and different kinds of shared space exists, and who counts

as a member might be broader than usual. To speculate on what the future of smart homes might be requires a venue that can operate as a vantage point. Cohousing communities complicate the idea of home while keeping many of core structures similar—and provide a location for producing new varieties of design object. The material with which speculation takes place is the Internet of Things, connected technologies that use computational capacities to produce autonomous, agentic devices. The IoT offers an opportunity to investigate the interrelation of Internet access, materials, and everyday experience, emphasizing specific values through their design and use. Building a new hardware system that devises different connections to social and material qualities critically examines the role of objects in everyday life.

1.5 Dissertation Structure

This dissertation consists of 6 chapters. The first chapter described the research problem at stake in this project—how to design for complex social lives networked technologies that have their own kind of agency—and introduced the theoretical underpinnings and related work that articulates the role of HCI and design in producing speculative technologies. Specifically, it introduces the object ecology as the main theoretical framework for this project. The object ecology is the complex relationship of things in context that becomes a design space for developing prototype IoT devices for cohousing. In turn, these prototypes offer insight as to what designing for cohousing is like, as well as how an ecological design process operates.

1.5.1 Chapter 2: Methods

The second chapter discusses the methods that are used in this work. This is a design research project that uses research through design as its primary method to explore what designing speculative Internet of Things devices for cohousing communities. To get insight into these communities, a number of data-gathering methods have been used and are described here, including website analyses, site visits, device landscapes, and categorizing and interpreting existing IoT systems. The design process itself comes from methods used to create alternative interaction design artifacts. This chapter includes some discussion of speculative and critical design perspectives on design research, as well as the prototyping process native to a research through design project. Finally, the chapter ends with a discussion of how design work should be evaluated and understood as successful, with an overview of some workshop methods and the documentary practices of design workbooks and annotated portfolios.

1.5.2 Chapter 3: Cohousing

Chapter three describes cohousing in greater detail. It introduces cohousing as an alternative living style and provides a brief overview of the history and political context of cohousing. It shows that cohousing is growing in the United States and describes the relationship between cohousing communities design and the capacity for social lives that are built into them. It then describes six cohousing locations that were visited as part of this research project: Touchstone Cohousing in Ann Arbor, Michigan; East Lake Commons and Lake Claire Cohousing in Atlanta, GA; Pacifica Cohousing and Eno Commons in the Research Triangle area of North Carolina, and Sjöjunfrun, a cohousing-like community in Umeå, Sweden. It follows these descriptions of cohousing communities with the results of a series of interviews with residents of Lake Claire

Cohousing that consider issues that are important to residents of cohousing as it is lived and not just designed. Themes that emerge from these interviews include cohousing life, sharing space and place, keeping up with upkeep, consensus, conflict, and decision-making, coordination, and what it takes to maintain community. Finally, an analysis of cohousing community websites produces a list of the values that motivate cohousing life. These values drive how cohousing as a practice and offer means of thinking about contexts for technology design, including how cohousing makes the idea of "smart homes" and the Internet of Things more complicated.

1.5.3 Chapter 4: Design research into Cohousing IoT

Chapter four articulates the ecological design space of Cohousing IoT. This design space is constructed from three ideas that together define object ecology of cohousing IoT. The first of these is the form, rhetoric and values of the Internet of Things. It steps through an analysis of 25 contemporary Internet of Things devices and articulates their material qualities—what they look like, what they are made from, and how they fit into a domestic frame. The second part of this section interprets the Internet of Things from an information processing perspective, and labels these devices as hubs, inputs, outputs, or both inputs and outputs. To build on this, 11 IoT whitepapers were analyzed to reveal the kinds of values that IoT devices support—or are imagined supporting—by its manufacturers. Together, these frames offer a means of describing what an Internet of Things device looks like, what it does with respect to sensing and reporting, and what kinds of goals it might be materializing in the home.

The second section lays out a vision for an alternative IoT that is built in response to the values from the first section. The goal is to establish a list of values and goals that

describe an alternative perspective on the IoT that leads towards it becoming more agentic and active in the social life of the home and away from being a passive object in service of human needs. In order to design technologies like these for cohousing, the values that drive cohousing from chapter 3 are placed in relation to the values of the Internet of Things and the values of the alternative IoT developed in this chapter.

Finally, in order ot create design concepts that are based in the object ecology, two automated generators are used to produce concepts for prototype technologies. These generators use procedural techniques to cast elements of the design research project together, creating a flat ontology for design concepts to emerge from. Of fourteen design concepts, three were selected to be refined into prototypes.

1.5.4 Chapter 5: Speculative prototyping for community life

This chapter describes the design and evaluation process for three cohousing IoT prototypes: the Cohousing Radio, Physical RSVP, and Participation Scales. Each of these come from a triad of the values of the Internet of Things, the alternative IoT values, and cohousing values, and were informed by a series of interviews and site visits during the development of the prototypes. Briefly, the cohousing radio offers a way to produce podcast-like announcements for a community, the Physical RSVP centralizes participant response to aid in planning community events, and the Participation Scales offer a way to reflect on the level of participation in community life. These three prototypes were evaluated using a series of co-design workshops based on a device landscape game that worked in two ways. First, the workshops developed stories about the things in cohousing and how they relate to one another at various times and under certain pressures in the community. Second, the workshops offered a means of understanding how these

prototypes could fit in these scenarios. Overall, the workshops assessed how the prototype devices for the community fit in with cohousing experiences and expectations.

1.5.5 Chapter 6: Designing in an ecology of people and things

This chapter discusses the limitations of human centered design for evaluating projects like these and describes the Cohousing IoT prototypes as instantiating multiple modes of design, including public design, as examples of object-oriented publics, and ecological design. Finally, it describes the benefits and nature of an ecological approach to design, including inspiration though speculation, expanded perspectives on design, and agentic systems of people and things. It closes with the idea of searching for desiderata in design ecologies.

CHAPTER 2: METHODS

This project uses design research—specifically research through design—to explore the concept of an object ecology. It does this using a mixture of approaches to develop a particular object ecology called "cohousing IoT" as part of a research through design process that develops Internet of Things devices for cohousing communities. This object ecology is developed from three component parts. First, multiple means of learning about cohousing including site visits, interviews, photo-documentation, and participating in common meals to gain a broad understanding of how cohousing operates as a model of domestic lifestyle in practice. Second, this understanding of cohousing was augmented with research into current IoT technologies in order to inform a broader design process. To those ends, this project uses multiple ways of engaging with both the Internet of Things and cohousing using a mixed-methods approach (van Turnhout et al. 2014). These methods include evaluation of primary texts extracted from cohousing web sites as well as on-site ethnographic methods that are described in detail below. Third and finally, these research avenues were combined to inform the design and development of speculative cohousing IoT. As a design research project, this combination of methods is intended to inform the development of new prototype systems based on insights from cohousing communities using the framework of object ecology.

This work is not motivated by a goal to discover concrete facts regarding how cohousing communities operate, but instead is meant to extract broader themes and ideas to inform a design process that constitutes a research activity in itself, a process of speculative design that is oriented towards articulating and designing for the specific object ecology of cohousing IoT. Because an object ecology involves a diversity of things

and their relations, what is needed to approach that complexity is a diversity of methods that are each attuned to different things. Together, these research methods comprise a process of "diverse engagement" that builds the breadth of understanding that is necessary for researching something as complex as an object ecology. This chapter describes the techniques used to tease apart an object ecology as well as the motivation behind choosing each method for this project.

2.1 Design research

The first way to approach an object ecology is through design research, a method focused on understanding how research operates and what kinds of capacities it has. The roots of design research come from a historical context focused on evaluating design methods in order to figure out what makes them work. Design research has since expanded to include research practices that are embedded within the process of design, including work concerned with the context of designing as well as research-based design practice. The nature of design research remains quite general within design, as it is concerned with understanding and improving design processes and practices broadly, instead of developing domain-specific knowledge within any particular professional field of design. This sense of generality can lead to quite expansive definitions of design research, given that to many practitioners any activity of making a state into a more preferable one is an act of design (Simon 1996). To Archer, "design research is systematic inquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value, and meaning in man-made things and systems" (Archer 1981). While this might seem to be so broad as to be meaningless, the agenda it sets is clear. Design research is a mode of inquiry not into design as such, but into the

process and outcomes of design in general—its practices, its outcomes, and it implications. Bayazit further articulates Archer's definition and roots it in a humanistic tradition. To her, "design research tries to answer the obligations of design to the humanities:

A. Design research is concerned with the physical embodiment of man-made things, how these things perform their jobs, and how they work.
B. Design research is concerned with construction as a human activity, how designers work, how they think, and how they carry out design activity.
C. Design research is concerned with what is achieved at the end of a purposeful design activity, how an artificial thing appears, and what it means.
D. Design research is concerned with the embodiment of configurations.
E. Design research is a systematic search and acquisition of knowledge related to design and design activity." (Bayazit 2004)

Design research is research that attends itself to the nature of design in one of three ways. In 1994, Christopher Frayling at the Royal College of Art wrote *Research in Art and Design*, where in an attempt to conjoin practices that were wary of adopting the label "research," he posited three modes of research that can happen in what are typically regarded as creative disciplines. These are research *into* art and design, research *through* art and design, and research *for* art and design (Frayling 1994). Broadly speaking, this breaks the space of design-based research into three categories. The first is a classical humanities-style approach to design, that could be characterized by historical, aesthetic, or theoretical analyses of design. The second, research *through* design, produces knowledge by creating some sort of design outcome and understanding the contributions

that this design process has produced. This includes concepts like materials innovation, novel technology applications or customization, or complex documentation of process. Finally, research *for* design is characterized by the idea that "thinking is, so to speak, embodied in the artifact" (Frayling 1994). Here, the research contribution is somewhat more abstract, but relates to the thing itself as materializing a particular kind of knowledge that words do not have access to. Put a different way, these three categories broadly map to ideas of studies about design, to experimentation in design process and outcomes, and to the objects of design themselves.

Design research does not usually create some sort of abstract knowledge of how to do design better or more efficiently. This distinguishes it from many fields, like biological research, where a researcher could be contributing to the field of biology or electrical engineering research projects that advance our understanding of the processes and products of electrical engineering. Instead, design research uses design methods and practices to create research about design research itself: a growing body of literature that pushes at the boundaries of what design is and can be (Cross 1999). Design research provides ways to frame a research project as it is beginning, as well as means to draw conclusions from a project, and make the results of a specific design process become generalizable and extensible—in short, to become research.

2.1.1 Gathering information

This project takes the theoretical framework of object ecology and uses it as a perspective on speculative design to produce research through design artifacts rooted in a specific context. In this case, that context is cohousing IoT—combining cohousing with smart homes and domestic IoT practices. In order to know what should be brought into

being through design, it becomes necessary to know in greater detail how both cohousing and the Internet of Things operate. This aspect of the project takes as inspiration the work of John Law, a British sociologist and co-founder of actor-network theory, or ANT (Law 1992). In *Aircraft Stories*, Law tries to both unpack and understand a sociotechnical artifact—the ill-fated British TSR2 fighter-bomber—through multiple methods presented as vignettes of material inquiry. The linkages between blueprints, interviews, requisitioning documents, personal memories of the plane, and so on cumulatively serve to "decenter the object in techno-science" (Law 2002). In its place, he builds a new understanding of the object from multiple contingent contexts. Together, these fractional, partial understandings of the TSR2 offer a way to know the specific aircraft and its multiple contexts and roles somewhat differently than other sociological or ethnographic methods. To Law, the TSR2 is an airplane, but also an agenda; it is a plan for construction, but also a manifestation of a waning power's geopolitical anxiety; it is born of military requisitioning, but also of advertising; it is the archive, but also the anecdotes. To understand the multivalent nature of the TSR2, Law draws all these aspects together and interprets them in ways that are simultaneously independent and intertwined. This rich multiplicity of perspectives is what Law calls *the mess*.

This style of research foregrounds material things like blueprints, patents, sketches, schematics, stories, and models in ways that other kinds of inquiry do not specifically attend to, meaning it can become especially relevant to a research through design project. These objects are the substance of the design process, and as such can serve to inform design in ways that interviews alone cannot. In keeping with Law's mess, this mix of approaches provided a way to systematically approach multiple spaces. First,

multiple kinds of methods including site visits, interviews, photo-documentation, and participating in common meals to gain a broad understanding of how co-housing operates as a model of domestic lifestyle in practice. Second, using design research techniques to build an archive of IoT technologies that can become part of a broader design process. To that end, this project uses multiple ways of engaging with both the Internet of Things and cohousing using a mixed-methods approach (van Turnhout et al. 2014). These methods include evaluation of primary texts extracted from cohousing web sites as well as on-site ethnographic methods that are described in detail below. As a design research project, this combination of methods is intended inform the development of new prototype systems based on insights from cohousing communities. This work is not motivated by a goal to discover concrete facts regarding how cohousing communities operate generally, but instead is meant to extract broader themes and ideas to inform a design process that itself constitutes a research activity.

The methods used to get this general sense of cohousing could be together considered as a kind of "lightweight ethnography" that has a long history of use—and critique—in HCI contexts (Dourish 2006). In this case, a mixture of methods is used to get a sense of how residents in unusual living situations use various technologies in their own lives and how they might interpret the potential for Internet of Things systems in their homes. Interviews will focus on unusual users of the IoT for three reasons. The first is that as a designer, unusual characteristics of a design space frequently provide the most interesting prompts to do design work. "Extreme characters" offer a way to consider a design problem in a more highly-scoped and provocative way (Djajadiningrat, Gaver, and Fres 2000). Second, unusual users can be used to find richer knowledge about a topic

more quickly than users more central to a practice (Millen 2000). Finally, these users can inspire *transfer scenarios*. Here, developing innovative and novel technologies for already-existing domains is driven by practices at the margin rather than the center, as these marginal practices offer insight into specific features or aspects that might be worthwhile at larger scales in unexpected ways (Ljungblad and Holmquist 2007).

2.1.2 Web analysis

The first way to approach cohousing is by analyzing USA-based cohousing community web pages. These sites were approached systematically to learn how communities across the country describe themselves, and contained descriptions, mission statements, and sometimes lists of values for each community. Simple content analysis performed on the contents of these pages generated a list of the values of cohousing via grounded theory (Potter, Wetherell, and Wetherell 1987; A Strauss and Corbin 1994). This categorization of web pages is similar to what Noortje Marres has called *web analysis* in her study of sustainable living blogs (Marres 2012). Web analysis of these blogs helped her to answer the question "what is sustainable living made up of?" as a way of drawing out the practices of what she called "experiments-in-living" (ibid). The goal of this analysis is to study "ontologies in the making" that offer a way that residents think about their own kind of intentional living. For cohousing, the codes that emerged from this analysis describe an ontology of values that are important to cohousing communities. These cohousing values became a starting point to understand how these communities see themselves and what they are doing, as well as what kinds of goals their practices support. It is a way to map intentions across intentional communities in general.

2.1.3 Site visits

For more specific and personal engagement with cohousing, six visits to cohousing communities across three U.S. states and 2 countries supported a strategy of "diverse engagement" inspired by Law's *mess*. This combination of different approaches over a period of two years provided a unique perspective on what cohousing is and how it operates. Over that time, the author conducted interviews with residents, took tours of the communities, and was a guest at common meals. Each of these engagements provided a different way to gain insight into the practices of cohousing. Semi-structured interviews, for example, provided a way to get cohousing residents' experiences in their own words, while still retaining flexibility to respond to unexpected aspects of conversations with residents (Bernard 2011).

Attending common meals and going on tours of cohousing sites each add something unique to the research process. While cohousing communities are at first glance not very different from other kinds of housing developments, being able to visit them and get a guided tour of the community draws out differences that may not be so apparent when alone. Similarly, common meals are one of the hallmark aspects of how cohousing communities live together. Attending them makes it clear that this is a group that is intimately familiar with one another—it is a family dinner in a home that is shared that the neighborhood attends. Together, these different methods offer a means of doing what Wright and McCarthy describe as *knowing the user*: "knowing the user in their lived and felt life involves understanding what it feels like to be that person, what their situation is like from their own perspective" (Wright and McCarthy 2008).

2.1.4 Device landscapes

One way to understand current technology use in cohousing homes (and begin to see what kinds of technological adoption is common to cohousing residents) is through the idea of a *home inventory*. The semi-structured interviews at residents' homes were followed with a "home inventory" (Grivas and Zerefos 2015) to reveal what kinds of information and computing technologies were used in the home. Interacting with and discussing these home technologies helped to generate more questions about their use and role in domestic life. All of the interviews were audio recorded in addition to field notes written contemporaneously. During the visits, photographs were taken of objects or quirks that arose during interviews. Each interview was transcribed and open-coded to identify common concepts and recurring themes in the data, while the photos served as visual aids for later analysis.

The concept of the home inventory meshes nicely with other theoretical models of understanding how personal technologies operate in the lives of their users. Stolterman et. al. call this perspective on the multiple roles of different artifacts in a person's everyday life a *device landscape* (Stolterman et al. 2013). The device landscape perspective is useful to both articulate how technologies are used together, as well as what technologies matter to what person in which ways. One classic example of a device landscape is an individual's laptop, mobile phone, MP3 player, desktop computer, and so on, and together can be used to understand the different layers of what these researchers call an *artifact ecology* (Jung et al. 2008). How a user chooses to use which device for what task and the relationships between these devices describes both in an ontological way the devices at hand, as well as a more goal-oriented perspective on what kinds of objects

matter when. Understanding personal and domestic technologies as members of a landscape of devices provides designers with a more robust understanding of what devices could do in a future landscape. To go even further, taking the technologies at home as members of a domestic device landscape—an object ecology of the home—provides a way to do design work that seeks out niches to fill in these future conditions.

Together, these methods offer a means of approaching cohousing and considering two questions about it: what is common to cohousing communities? What is distinctive to cohousing? This messy, contingent process of engaging with communities in multiple ways offers advantages in terms of thinking through cohousing as a space for ICT design. Alongside this process of investigating cohousing, some more traditional humanities methods were used to build knowledge around the state-of-the-art in Internet of Things systems.

2.1.5 Categorizing and interpreting IoT systems

In order to get a sense of what the Internet of Things is like as well as the kinds of things that manufacturers felt that this burgeoning field could eventually become, it was necessary to survey and review existing IoT platforms and services. In order to do this, a list of 25 then-current systems (Appendix A: IoT Systems) were analyzed to begin to understand what the Internet of Things offered at the present. Taking the devices themselves and the attributes of them directly from device specifications and product descriptions on sales pages provided information that could be used to compare them to one another. This information included price, manufacturer, year of product introduction, intended purpose, data protocols, sensor capabilities, actuators, and so on, and offered a means of comparing fundamental technical qualities across a broad range of artifacts and

devices. The IoT objects themselves were then placed into five categories that describe their use in the most broad terms, as *hubs*, *input/outputs*, *inputs*, *outputs*, and *other*. On top of that broad characterization, though, it's clear that the uses of the systems and devices on offer fit generally into three categories: devices for security, monitoring, and control; systems that promote efficiency; and those built primarily for entertainment and consumption.

The first and largest category of devices are for security, monitoring, and control. One system in this category includes the Samsung SmartThings hub and it's various SmartSense modules that provide different kinds of sensors to deploy in a home. These include motion sensors, moisture sensors, temperature and humidity sensors, smart power outlets, an open/closed sensor, and so on. Together, these sensors are meant to instrument the home and provide total knowledge of its condition. On the other hand, the Philips Hue is a "smart bulb" that lets a resident set exactly the color and brightness that they want for a space from their phone, or even to program different settings based on particular conditions. The Hue offers their owners fine-grained control over the feel of the home and can offer an endpoint to visualize a host of different information sources. Products like these illustrate one of the major promises of the Internet of Things. The IoT offers a way to make individual objects addressable and controllable, while simultaneously reporting that information to a resident via the Internet.

The second category of contemporary IoT devices are designed to make everyday life more efficient. Google's Nest Thermostat, for example, promises to help homeowners reduce their energy use over time, saving both the planet as well as on their energy bills. It does this by learning resident's daily patterns and schedules over time in

order to build a model of their lifestyle and operates more efficiently by coupling heating and cooling changes to these patterns more closely than a person could do (or, perhaps, would want to). The "smartness" of the Nest and other IoT devices like it comes from sets of algorithms that operate in concert to develop rules to describe larger events in the world. As it "learns" the behavior of a home's residents, the Nest and other IoT devices in this category exemplify the promise of ever smarter algorithmic ways to make everyday life easier. This perspective, building on a similar rhetoric of more perfect knowledge of many conditions through "big data" is another way that the Internet of Things is being positioned as a way to participate in this information revolution.

Finally, the third class of devices emphasize entertainment and consumption. The Amazon Echo is, at its core, a computerized Bluetooth speaker coupled with a conversation-based interface that lets it both respond to and answer short verbal commands or queries. Its conversational agent, called Alexa, uses the internet to provide weather updates, news, music, and so on, while providing hands-free kitchen timers, grocery lists, to-dos, and more. The real appeal and value to the Echo, however, is its access to the massive product and service infrastructure that Amazon operates. Amazon Prime members have access to a colossal library of music that can be played directly from the speaker and can order products from Amazon directly using voice commands. The Amazon Dash goes even further to make ordering products easier. These are small buttons that connect to a home Wi-Fi system and have product names and logos emblazoned on them. They are placed where the product is used, and by pressing the button, replacements can be ordered directly from Amazon. The Echo functions admirably as an entertainment device, but as an endpoint for Amazon's shipping

Table 2: Whitepapers used to generate a list of values to describe the IoT.

ORGANIZATION	YEAR	TITLE
ARM/The Economist	2013	The Internet of Things Business Index: A Quiet Revolution Gathers Pace
Cisco	2011	The Internet of Things: how the Next Evolution of the Internet is Changing Everything
CTIA	2014	Mobile Cybersecurity and the Internet of Things: Empowering M2M Communication
ARM/Freescale	2013	What the Internet of Things (IoT) Needs to Become a Reality
HP	2012	Managing the Internet of Things
Intel Corporation	2014	Developing Solutions for the Internet of Things
IEEE	2015	IoT Ecosystem Study
BCS	2013	The Societal Impact of the Internet of Things
Texas Instruments	2013	The Evolution of the Internet of Things
McKinsey & Co.	2015	The Internet of Things: Mapping Value Beyond the Hype
Wind River	2014	Smarter Ways to Use the Internet of Things

infrastructure, it makes it clear that much of the promise of the Internet of Things, at least for now, rely on creating new opportunities for traditional commerce.

Because the rhetoric of the IoT is so pervasive and all-encompassing, being able to articulate the values that it supports—and alongside that those which it does not acknowledge or rejects—offers a starting point to design for different kinds of users. In order to understand how the IoT was being positioned by companies manufacturing and marketing these devices, a review of 11 industrial and corporate whitepapers became the source for a list of values of contemporary (and perhaps imagined future) IoT. As with the cohousing web pages above, this set of papers was interpreted using grounded theory (Potter, Wetherell, and Wetherell 1987; A Strauss and Corbin 1994) to draw out as codes

these values. The whitepapers range from consultant-led speculation about how to position a business to take advantage of a looming market opportunity, to offering better understanding of what the potential of machine to machine (or M2M) communication could be, to issues that the Internet of Things might compound or exacerbate. What they had in common was an orientation toward the future that spoke directly to the promise of what the IoT had to offer, as well as the certainty that it would be coming, for better or for worse.Overall, this set of messy techniques across cohousing, living in cohousing, homes and devices, as well as the contemporary and imagined future of the Internet of Things, taken together describe what Marres has called a "multifarious instrument," an experimental and exploratory set of methods that enact a range of different kinds of research at different levels of fidelity and at times, and embodying differing and contradictory agendas (Marres 2012). Ideas of what constitute a "smart home," assumptions around what smart homes look like, how personal experiences of living in housing that does not conform to these assumptions, various traces and records of intentions and values from web sites, motivations behind existing technologies and designing and constructing IoT devices and systems each operate at a different register and do not easily fit together. These piles of information become the material for the next phase of the project.

2.2 Research through design

This project uses *research through design* as means of doing constructive design research. RtD has become a well-accepted form of research in Human-Computer Interaction (Fallman 2003; William Gaver 2012; Zimmerman, Stolterman, and Forlizzi 2010) characterized by structured activities of making coupled with rigorous

documentation, reflection, and analysis. Combining making and reflection on the made as well as the process of making produces forward-looking research that can be used to articulate a possible design space. Here, designing becomes a way to do research that explores possible futures through creating prototypes that operate inside of speculative scenarios. Unlike other kinds of research in HCI, where the thing proceeds the theory, research through design provides a way for theory to proceed the thing (Zimmerman and Forlizzi 2014). This means that the design process, reflection on a design process, the design materials, and how these design materials are understood by both researchers and communities offer a way to produce knowledge about the role of design and designed prototypes in addressing issues in practice. Design research provides empirical insights into the practices of designing, the qualities of the designed system, use and the context of use, and is often articulated through academic papers, workbooks and annotated portfolios, and other kinds of process documentation that generates design theory and inspiration for other design practitioners to build upon. (Bowers 2012; Fallman and Stolterman 2010; William Gaver 2012).

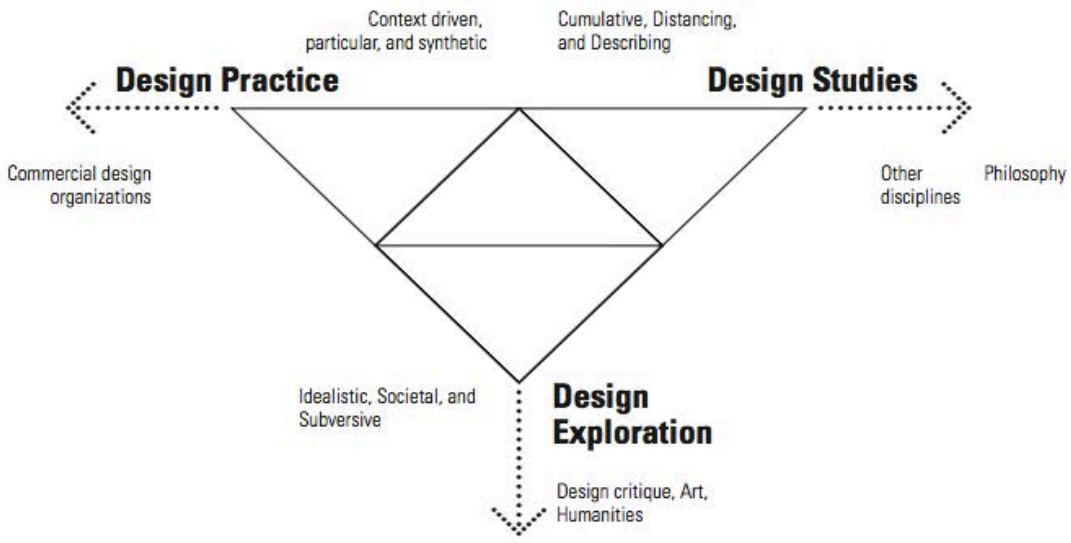

Figure 3: The design research triangle (from Fallman 2008)

One way to understand how research through design operates to produce knowledge is to consider design research as a triangle composed from three closely-related practices (Fallman 2008). This triangle places different disciplinary approaches—including industrially or commercially-oriented design practice, scholarly design studies, and arts- or socially-motivated design exploration—as the vertices of a triangle. The discipline of design research in general is the area of the triangle (see Figure 3). The three disciplines are components of interaction design research—together they define the discipline. They frequently have smilar practices, but come from traditions and perspectives that are distinct from one another. This means that productive research takes place while moving in between the different kinds of activity areas. Fallman describes three ways to move through this triangle that produce research through design (Figure 4).

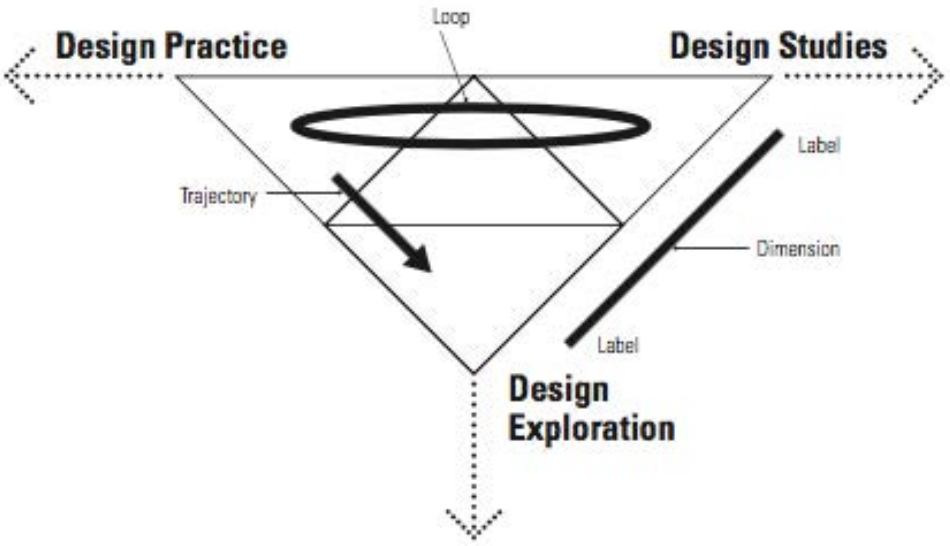

Figure 4: Research in the Design research triangle (Fallman 2008)

The first of these moves is a *trajectory*. Trajectories are travels within the triangle that are either intentional moves from one vertex to another or accidental drift during a design process. Trajectories become a means of reflecting on the perspectives that a

project might embody at different times during its lifespan. *Loops* are trajectories that move between perspectives freely—what Fallman describes as the hallmark of design research (Fallman 2008). This mixture of practice and reflection offers insight to both practical design production as well as the theoretical grounding that is driving the project. Loops shift roles repeatedly through a project, making a researcher consciously consider how the previous or current perspective might affect future iterations. This iterative process of making and reflection is similar to Agre's critical technical practice (Agre 1997), where technical production is informed by reflection—here, design practice might be influenced by design exploration, which might seek to inform design studies. Finally, the last way to use the design research triangle to consider how research through design operates is through the idea of *dimensions*. Dimensions are tensions that exist between two of the perspectives on the triangle, articulating the "side" of the design research triangle. In Fallman's studio, for example, the tension between design practice and design exploration could be "money versus vision" or the tension between design practice and design studies might be "the real versus the true." Taking this tension into account helps to situate research through design as a process that creates provocative prototypes to explore this multivalency.

In this project, prototypes are being designed that articulate attributes of a particular object ecology. These prototypes combine aspects and perspectives from this design research triangle to explore a design space that is comprised of many different interests and goals. The object ecology itself is an concept that is rooted in *design studies*, for example, while the design process that results in a prototype is a part of *design practice*. Fundamentally, the prototypes themselves are making claims about how design

operates and what it is that design can do in novel contexts—instances of *design exploration*. The prototypes produce knowledge and claims in their material, performing theoretical perspectives via their dissemination and use. In that way, the prototypes adapt Bogost's concept of 'carpentry' as a mode of philosophical inquiry (Bogost 2012). Rather than producing monographs, treatises, books, articles or any of the other kinds of written work that has come to define academic scholarship, he offers an alternative producing theoretical constructs *as they are practiced*. Constructing artifacts creates systems and interactions that embody philosophical claims. While philosophy and design research are not the same things, by opening the door to producing artifacts as exemplars or actors or even producers of theoretical work, Bogost does a service to those who produce functioning systems with the goal of articulating and advancing theoretical agendas. In addition to provoking existing scholars to create more than just papers that describe their work as their research material, it also empowers those who create different kinds of material work—fine artists, dancers, engineers, hobbyists—to produce artifacts in their 'native' perspective and advance it as scholarship.

Producing design objects that articulate the edges and boundaries of the Internet of Things provides an opportunity to perform carpentry of this kind. This project's intention is to understand how objects and systems work together to create social arrangements, and to create designed work that makes material claims about what the Internet of Things might become in the future (Jenkins and Bogost 2014). Design research, and particularly research through design is a strong way to do this kind of research, as it tends to operate in two ways: first, research through design as a reflective practice reframes an underlying situation and goals during the process of design and

shifts the subject of research into investigating design futures as a way of understanding the world that should be brought into being (Zimmerman and Forlizzi 2014).

In this way, design is fundamentally a process of creation that is in response to a particular condition. It finds a problem, articulates the issues therein, and devises a way to address that problem. As mentioned above, the messy and multiple way that data have been collected for this project is compelling to design research as it foregrounds material things like maps, practices, technologies, images, lived experiences, and so on, in ways that other kinds of inquiry do not usually attend to. The goal of the information gathering using the "multifarious" perspective is to get enough information to articulate what kinds of conditions might be preferable to what was already taking place in both cohousing and IoT that can be constructed through research through design.

2.2.1 Critical design and designing for alternatives

The research through design process of designing and building IoT objects for cohousing operates in a vein of critical design. Here, the goal of this critical perspective on design is to produce physical, prototype IoT objects that stand on their own and perform critique on contemporary technology culture through the production of what might be considered as a pseudo-product (Dunne 2006). Often, critical design work can be understood as designing objects that subvert existing expectations around the effectiveness or efficiency of technological systems. Human-centered design practices emphasize intelligibility and usefulness at each stage of development, and in the process, can effectively remove alternative perspectives from finished work. A number of positions in contemporary HCI operate to emphasize moments of difference and multi-stability in the design process Reflective design, for example, builds on critical technical

practice (Agre 1997) to produce technical artifacts that are open-ended, interpretable in multiple ways (W. W. Gaver, Beaver, and Benford 2003; Sengers et al. 2005; Sengers and Gaver 2006). In addition to fabricating design artifacts as functioning proofs of concept, many research through design projects deploy these artifacts with users to document their experiences interacting with and interpreting the projects in reflexive ways (Boehner et al. 2005; Sengers and Gaver 2006; Sengers et al. 2005). In the domestic context, novel systems in particular have been used to probe unexpected wants and needs within families (Hutchinson et al. 2003; W. T. Odom et al. 2014).

Some of the primary goals of design in this frame are to subvert and push against dominant tropes in technology. These perspectives help to build artifacts that advance ideological perspectives, offer space for deliberative reflection, or upend how we understand technology as usual, but in some senses, may not go far enough. The goal of this project is to understand how objects interrelate at an ecological level and might need to produce a new kind of object. Object-centered design in the IoT context moves beyond the understanding that technologies are for humans exclusively, and casts homeowners or residents as extras in a new narrative that focuses on things. In cohousing, community is more present than in traditional homes, more and different kinds of shared space exists, and who counts as part of "home" is broader than usual. In this project, the design process operates critically not just as a way of responding to contemporary market trends for Internet of Things devices and platforms, but also as a means of describing and putting forward an alternative Internet of Things that comes from a completely different perspective: an IoT for cohousing.

2.2.2 Speculative design

Speculation is the core activity of designing. The reflective practice that characterizes design involves entering into a dialogue with material, seeing where the object is, and imagining where it might end up (Schon 1984). This act is foundational to design, imagining what should or could be. Speculation is essential in this project as both a means to try to attend to what is not-yet-imagined, but also in the paring down of possibility through selecting particular aspects that matter to a certain condition. In this sense, speculation is both prosaic as well as critical: it chooses what matters and what kinds of perspectives are important to both the Internet of Things and the domestic lives of cohousing.

Table 3: *A/B* from Dunne and Raby's *Speculative Everything* (2013)

A	B
Affirmative	Critical
Problem solving	Problem finding
Provides answers	Asks questions
Design for production	Design for debate
Design as solution	Design as medium
In the service of industry	In the service of society
Fictional functions	Functional fictions
For how the world is	For how the world could be
Change the world to suit us	Change us to suit the world
Science Fiction	Social fiction
Futures	Parallel worlds
The "real" real	The "unreal" real
Narratives of production	Narratives of consumption
Applications	Implications
Fun	Humor
Innovation	Provocation
Concept design	Conceptual design
Consumer	Citizen
Makes us buy	Makes us think
Ergonomics	Rhetoric
User-friendliness	Ethics
Process	Authorship

In *Speculative everything: design, fiction, and social dreaming,* Dunne and Raby provide a chart that distinguishes between two contrasting modes of design. Marked as *A* and *B* (Table 3), they distinguish between design as it is usually understood, and the kind of design that they find themselves practicing. Here we see a broad range of values or rationales for design, that cumulatively place it as inquiry into futures. What *A/B* offers design research is a perspective on the intentions or outcomes of design that can be

understood as a model for future kinds and goals of design. Most traditional design work can be understood as being rooted firmly in *A*, or normative design practices that seek to solve a problem in a market context. Dunne and Raby's own style of highly-finished gallery-based design work can be considered as being wholly *B*, and operating if not quite in response to A, then staking a territory that is clearly not A (Dunne and Raby 2013). Considering these lists of design capabilities as they are, however offers a way to reflect on design as it is being practiced, as well as a way to understand currently-extant artifacts. If we take each of these oppositional terms as poles on a continuum of ways of thinking about the role of design in constructing artifacts and social interaction, they serve as a framing for design practice. These lists offer a starting point to think critically about the role of not just design, but also to help generate alternative modes for any number of technical practices.

One of the major goals of speculative design as practiced by Dunne and Raby is to articulate *preferable futures*. They are not invested predicting the future in some accurate way to help understand market trends, but instead to use the rhetoric of "the future" to help understand what futures are desirable and why.

> *As all design to some extent is future oriented, we are very interested in positioning design speculation in relation to futurology, speculative culture including literature and cinema, fine art, and radical social science concerned with changing reality rather than simply describing it or maintaining it. This space lies somewhere between reality and the impossible and in order to operate in it effectively, as a designer, requires new design roles, contexts, and methods. It relates to ideas about*

progress—change for the better but, of course, better means different things to different people. (Dunne and Raby 2013)

The diagram *PPPP* (Figure 5, on the next page) offers cones of projected probable futures, a broader cone of futures that could be considered plausible, and finally the broadest cone of all possible futures. These are the different futures that might exist, depending on choices made in the present. They add their own cone that bridges the plausible and the plausible, calling it the *preferable.* This 'preferable' cone makes it clear that these futures are intended to do something distinct—that design decisions made now should try to make a stand about what kinds of worlds we are building. Through articulating visions of possible preferable futures, Dunne and Raby force us to encounter the present from a new frame of reference. Rather than producing artifacts that can be used as exemplars for future development, these future scenarios turn the present on its head, and forcing their audiences to ask themselves "what might it take to get there from here?"

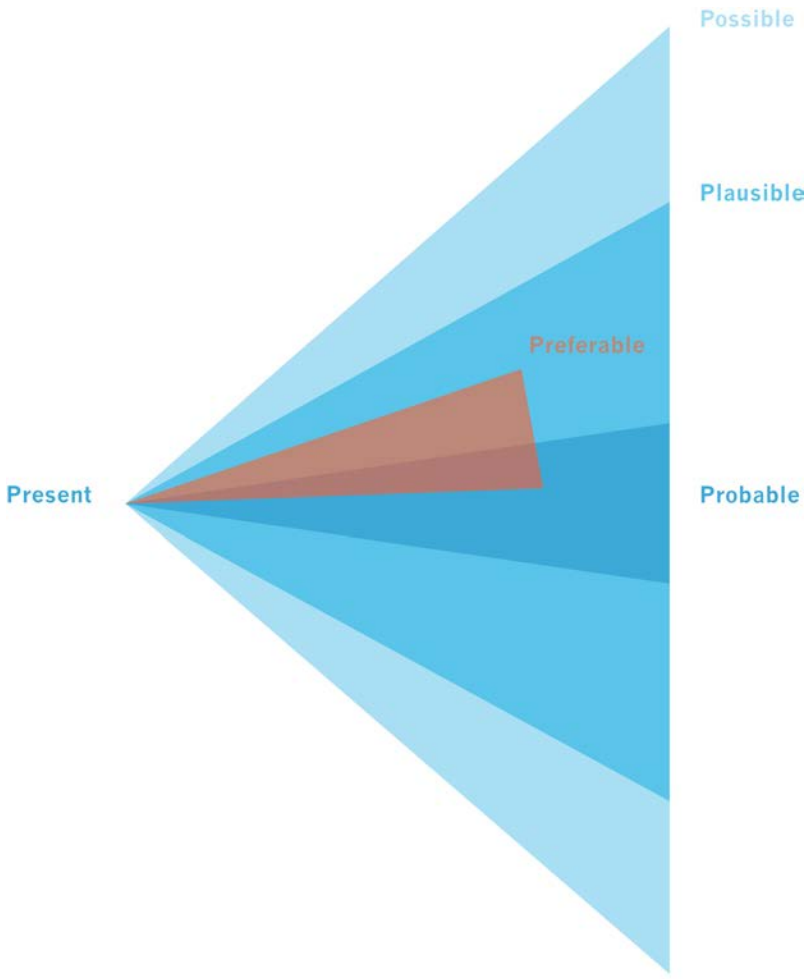

Figure 5: *PPPP* from Dunne and Raby's *Speculative Everything* (2013)

2.2.3 Prototyping

In order to move towards these more preferable situations, things need to be designed. Design is a process that produces material outcomes. At its core, design is a prototyping process where a context or problem presents itself and materials are produced iteratively to create an artifact that solves or otherwise operates in conversation with a situation (Schön 1984). This conversation with materials, context, and a practitioner's skills is called a number of things. Donald Schön calls it "reflection-in-action," meaning

that production and assessment get closely linked with one another in the mind of the expert. This is not so far from Phil Agre's idea of "Critical Technical Practice" above (Agre 1997). The nature of the conversation with design materials is based on the practitioner forging connections across wealth of different kinds of inputs. Here, design concepts and insights can be generated via a process of "abductive sensemaking" (Kolko 2010). In this process, design research materials can be synthesized into concrete design ideas through multiple iterations of prioritization, judging, and forging connections based on the materials gathered through design research coupled with a researcher's own experience and insights.

The result of this sensemaking process are prototypes that give form to what Chapter 1 has called *speculative placements*. These prototypes become examples of theoretical agendas, but also serve to instantiate and reveal a particular manifestation of the broader object ecology. Design prototypes are essential to making design intention manifest. From drawings, sketches, and plans to more formal models and higher-fidelity prototypes, being able to put a concept into the world is necessary. At its core, a prototype is just a representative model or simulation of a final system that lets various stakeholders discuss that system (Warfel 2009). Prototyping is often used as a necessary component of an iterative design process where prototypes can be used as a means of getting feedback on earlier versions of a design to help to refine the later iterations (Saffer 2009). In this project, the process of prototyping is used in two ways. First, prototyping is used to reflect on a design process itself as a way to work through a design concept until it seems right. Secondly, prototyping produces objects that can be used to articulate the research through design process and concepts back to the community that

they are designed for. Instead of a series of interviews about technology use in cohousing, for example, a speculative prototype that pushes on the idea of what technologies might do in a cohousing context can be placed in the middle of a table and be discussed as a technology probe in itself (Hutchinson et al. 2003). In this way, a prototype speculates to what the contents of an object ecology might be, fixing in place a particular set of relations and values from that ecosystem in material form. This freezing of relations lets the prototype become a site to discuss what the role of technology design might be in a particular context.

Often, speculative and critical design (SCD) objects try to provoke and reveal potentialities rather than fulfill well-understood roles or provide functional objects that fit into existing technological niches. These systems are built to raise awareness, provide room for alternate values, or create fundamentally new value propositions. In Fallman's triangle, design exploration matches very well with critical design in practice. Bogost's Carpentry mentioned above also shines as a way to consider the theoretical contributions from SCD. Good critical design work engages with particular issues to promote particular understandings of how things should or could be. Unlike design research taken broadly, SCD objects are rhetorical, and have the ontological reflexivity to close the feedback loop: good critical design makes strong claims both contextually and in particular with that object. The downside to most SCD work is in the distribution and in the means by which the design work is passed from community to community: critical design work is almost exclusively rhetorical, living not as a device that can be held, used, or experienced, but instead as stories, perhaps illustrated with photographs, or video. While developing a strong story is an important part of building things that do philosophy, when

it comes down to it, most critical design doesn't actually do much of anything. These prototypes primarily exist to be read about, and not to be used or interacted with.

2.3 Evaluating and understanding research through design

As a means of understanding the relevance of the prototypes and to avoid the feedback loop from above, the prototypes that result from this work need to be evaluated. This happens in two ways. The first is through a series of workshops with cohousing communities that determine what the prototypes mean to them—whether they fit or don't fit with the practices of cohousing that already exist. Pushing further into the speculative design nature of the prototypes under discussion, the workshops provide a venue for speculation into how they might imagine cohousing in the future and what kinds of role technology should or shouldn't play in it. The second mode of evaluating the project is by building on an overall process of documentation through workbooks in order to create an annotated portfolio that synthesizes insights and research outcome into an overall document.

2.3.1 Workshops

Design workshops taking place at cohousing communities is the primary way that this dissertation work will be evaluated. Because the cohousing IoT object ecology itself is a speculation, a possible relationship between people and things, it is especially necessary to locate the provisional objects of that ecosystem in real-world practices As the object ecology relates to the lived experiences of people as well as things, it is important to hold these workshops at cohousing communities to get a sense of how these prototypes might operate in real-world contexts, even imaginary ones. Rosner et al

describe how the workshop acts as simultaneously a site, instrument, and account of a research topic (Rosner et. al. 2016). As a *site*, the workshop provides a means of placing objects and people into relation. As an *instrument*, the workshop invites participation among attendees to consider issues with one another via the workshop's materials—the workshop consists of a set of practices that orients participants towards the matters of concern with respect to the materials at hand. Finally, as an *account*, the workshop becomes part of a broader research narrative that can be brought back into a field as part of a coherent research strategy.

In *Rehearsing the Future*, Halse et al write about strategies for participatory design workshops, claiming that one key to understand how future technologies might operate is to act them out beforehand. While this might at first seem outlandish, one way of building knowledge about future applications in their contexts is to gather members of those settings and together perform future scenarios to reveal what might work (Halse et al 2010). In this way, performance can become an integral part of design research via workshops that using participatory design strategies. In the book, they offer two (and many more) ways of understanding possible futures—and gaining insight into what future practices might be like—through *design games*, well-constrained activities that are oriented towards revealing and understanding how domain experts operate. Fort this project, a workshop emphasizes two of these design games, the *landscape game* and *situational enactments*. The first is a way of understanding how issues, objects, and prototypes relate to each other in a spatial way, while the second is a way to understand how people perform interaction with novel systems or prototypes in specific scenarios.

Cohousing communities feature a perfect venue for playing design games. The common house provides a space that is simultaneously shared and home for residents of the community and produces a comfortable space for codesign workshops that are rooted in cohousing practices. Because "the challenge [of enactments] is to evoke the sense of 'everyday life with a reflective twist'" (Halse et al. 2010), using the common house as a site for performative enactments of possible cohousing futures makes a lot of sense, as it provides a unique flexibility for design research. If needed, residents can use the common house to stand in as a part of their own home as well as a stand-in for broader community life.

In *Participatory Sensing in Public Space: Activating Urban Surfaces with Sensor Probes* (Kuznetsov and Paulos 2010a), Kuznetsov & Paulos describe a research project that seeks to understand how different groups might imagine sensors that detect toxic substances. They gave non-functioning sensor objects that "measure" various kinds of toxic substances to different groups that included the homeless, new parents, students, and bicyclists, and asked them to place them where they wanted to measure different kinds of environmental factors, such as exhaust, smog, pathogens, noise, chemicals, and dust. These participants used these sensors to assert what kinds of issues were most important to them in particular places, what Kuznetsov and Paulos call "authoring" public space. With this workshop in mind, including false sensors offers a way to open up a discussion about contemporary sensing practices as well as providing a way to further articulate what kind of issues are most important to cohousing residents at specific locations inside their common house.

Part of the goal of using these design game-based codesign workshops is to understand the interrelationship of novel design research prototypes with everyday cohousing life. This everyday life includes the daily routines of cohousing residents, what kinds of already-existing devices and objects might be implicated by speculative prototypes, and finally, what kinds of new routines or practices might be required for these prototypes to make sense in context. Finally, using participatory design workshops to evaluate appropriateness of technology for cohousing makes a lot of sense: because much of the work of cohousing is face to face negotiation and conversation around issues that matter to the community, performative, dialogic engagement with technological issues and practices seem like a native evaluation technique, one that residents are familiar with, comfortable doing, and skilled at already.

2.3.2 Design workbooks and annotated portfolio

The design work that results from this process will be part of an annotated portfolio (Bowers 2012; B. Gaver and Bowers 2012; William Gaver 2012) that serves to synthesize the outcomes of the designed work into a research object that can be disseminated as a finished object of research on its own. The annotated portfolio provides both analysis of the designed objects from the workshops, as well as a metanarrative around the design process and outcomes that are have been built into design notebooks (Bowers 2012; William Gaver 2011) over the course of this project. The annotated portfolio moves away from the designed object in itself as being an instantiation of an ultimate particular (Nelson and Stolterman 2012) towards general insights about the design process, intermediate-level knowledge that might contribute towards future projects and applications (Löwgren 2013). Reflection on these provocative hardware

prototypes using techniques like annotated portfolios are a fundamental way that design research produces knowledge (Boehner et al. 2005; B. Gaver and Martin 2000; William Gaver and Dunne 1999). The annotated portfolio is a design artifact that works as an archive of the results of this project: it contains the design workbooks and prototypes as well as the implications and insights that result from interview and analysis. This document works alongside the dissertation document as a standalone artifact of documentation.

2.4 Conclusion

Design research is a broad method that encompasses a range of activities. The design process itself is interpretive and analytical as well as synthetic and generative. The goal of this design project is to create prototypes that make specific claims about the potential of the Internet of Things, particularly in contexts that existing understandings of the IoT fall short. The above approaches and perspectives together begin to outline a way to make sense of the Internet of Things as a sociotechnical practice, from a theoretical standpoint as well as a practical, generative perspective. The web analysis, site visits, and device landscape techniques provide a concrete way to get a sense of the lived experience of cohousing and inform what speculative IoT devices in the home might be or how they should be used. The goal of these methods together is to obtain some insight to an existing object ecology—in this case cohousing—that through this research process becomes a venue for design—cohousing IoT. The mixture of methods here are aimed at finding general insights about life in cohousing, the nature of contemporary trends in IoT and technology cultures, and design theory that can be combined in productive ways. Critical or speculative design practices offer a way to select what matters, letting a

designer create objects that support ideology in practice while not pushing too far into science fiction. The result of good design speculation needs to be on the edge of plausibility. The resulting future objects and scenarios are ways of considering the present via conjecture and speculation. Rooting these rhetorical moves in modern practice—especially among outliers like cohousing—can provide a means of producing new imaginaries, working metaphors that influence what we consider the purpose and nature of domestic technology to be.

CHAPTER 3: COHOUSING

Cohousing is a mode of living that exemplifies how a particular object ecology operates in domestic life. This object ecology is quite distinct from the networks of things, people, and so on that is found in more usual single-family homes. Cohousing is composed of community practices and material obligations that together operate in a way that resonates with both domesticity as well as the Internet of Things: in living together, people are connected to one another though networks of obligation and functions that work together to satisfy community needs. Because the fundamental goals of cohousing are driven by social goals and values that are supported through a social compact, planning, and designed landscapes, the object ecology of cohousing emerges as a contingent and situated manifestation of these attributes. By understanding the history, roles, and goals of this residential network as a design research project, new insights towards designing IoT for this ecosystem are revealed.

The components of intentional communities such as cohousing offer a unique space for doing design research that explores the interrelationships between things, practices and the goals and values that they support—the meaning of artifacts in context. While HCI has always had an interest in domestic spaces as a site for developing information and communication technologies, it has so far had a relatively constrained understanding of what counts as domestic life and experience. Designing for home life tends to privilege single-family houses, and leaves alternative spatial arrangements and configurations out of the frame. Shifting patterns of contemporary life—whether economic, geographic, and demographic—have led to new modes and new models of habitation becoming prevalent. Cohousing is one of these new ways of living, offering a

different understanding of what "home" means. A richer understanding of what cohousing is as a site and a practice as well as how residents of cohousing understand themselves can provide a fresh perspective on the boundaries of where and how domesticity takes place as well as new perspectives on role of technology design in the home.

This chapter describes cohousing as a means of both broadening a definition of "home" as well as offering a space to do design research that explores how this object ecology operates in practice. In terms of a broadened understanding of domestic life, cohousing offers an expanded sense of a home—one that includes the neighborhood—while keeping much of the structure of home life the same. Materially, there are differences between a cohousing community and a more standard subdivision or neighborhood development, and these will be described below. In general, the commitment to a social life in the community offers a means of considering a broader design space than just a single-family home. Cohousing is simultaneously both unusual and mundane—it is a way of living that helps to build strong social and community bonds within its borders, while leaving room for private homes and personal lives to coexist.

3.1 Introduction to cohousing

Cohousing is a style of living that is meant to provide a functional alternative to social disconnectedness that has made contemporary living untenable for many (McCamant and Durrett 2011). Cohousing builds strong community among its residents through design and is a response to contemporary single-family houses that lack vibrant social connection between and among neighbors. In *Creating Cohousing: Building*

Sustainable Communities, McCamant and Durrett describe their own journey that led them to plan, build, and eventually become residents in cohousing (McCamant and Durrett 2011):

> *Over two decades ago, as a young married couple, we began to think about where we were going to raise our children. What kind of setting would allow us to best combine our professional careers with child rearing? Already our lives were hectic. Often, we would come home from work exhausted and hungry, only to find the refrigerator empty. Between working and housekeeping, where would we find time to spend with our kids? Relatives lived in distant cities, and even our friends lived across town…. Most young parents seemed to spend most of their time shuttling their children to and from childcare and playmate's homes, leaving little opportunity for anything else.*
>
> *So many of us seemed to be living in places that did not accommodate our most basic needs…We dreamed of a better solution—an affordable neighborhood where children would have playmates and we would have friends nearby, a place with people of all ages, young and old, where neighbors knew and helped one another (McCamant and Durrett 2011).*

For them, and many others, the solution to issues like these has been cohousing. Cohousing is a kind of collaborative community that aims to replicate a village-like atmosphere. Cohousing comes in all kinds of shapes and sizes. In the most traditional

form, residents each own their own self-contained house and share ownership of common spaces, like open outside areas, storage facilities and a large "common house" for events, entertaining, and occasional meals. Most cohousing communities have common meals a couple of times a week. Many cohousing communities are committed to social values like resource sharing, involvement, sustainable living, and diversity. Residents are responsible for maintenance and upkeep and are expected to provide a small amount of their time monthly to keep up with the work that helps the community function. This labor can be landscaping, cooking, cleaning, and so on—the functions of a traditional home, scaled up. Cohousing communities are governed by consensus, meaning that any decision-making needs to be approved by the entire group. Depending in the size of the community, there may be a number of committees that focus more deeply on particular aspects, such as the common house, landscaping/exteriors, planning and executive committees, and others like these. These groups make higher-level decisions that they bring to the larger group during community-wide meetings, where a final decision can be made.

One resident of cohousing has described his home like this on Facebook: "It's like a village. You know all your neighbors, have shared meals a few times a week, and share the labor of maintaining and growing the community. There are lots of shared resources including a common house with a big commercial-style kitchen, laundry, meeting rooms, TV room, kids play room, and a guest room that any resident can use. Legally it's a condo, so you own your own self-contained townhouse unit, but the design is a little different. The parking is off to one side, so the interior of the community is pedestrian only which really reinforces the 'village' feel!"

3.2 History of cohousing

Cohousing originated as a specifically ideological practice in Denmark in the late 1960s. In particular, McCamant and Durant offer two articles that helped to inspire and form the foundation of the nascent cohousing movement: journalist Bodil Graae's *Children Should Have One Hundred Parents* (1967); and architect Jan Gudmand-Hoyer's *The Missing Link between Utopia and the Dated Single-Family House* (1968) (McCamant and Durrett 2011). The architectural firm, Vandkunsten, which designed the first cohousing community in Denmark, still operates under the premise that cohousing and similar works can precipitate fundamental changes in society: "At the risk of sounding extravagant, we reserve the right to think and believe that good architecture has the capacity to make society more liveable[1]."

Lucy Sargisson describes the tones of this Danish approach to cohousing as being "firmly utopian," offering an intrinsically feminist, communitarian critique of then-contemporary institutions and practices. The work of Graae and Gudmand-Hoyer claim that the design of the city has created ever-more extreme isolation and alienation, and even further, that urban housing has played a causal role in that shift (Sargisson 2010). This critical perspective provided an ideological foundation for what became cohousing, or in the original Danish, *bofællesskaber* ("living together"). There, multiple independent households coalesced into new developments combining the advantages of community with the autonomy of private housing. They sought to restore what they saw as

[1] http://vandkunsten.com/en/approach

disintegrating community values, to build stronger families, and to (as above) create 'villages' in an urban context (Sargisson 2010).

In *Collaborative Communities,* Dorit Fromm writes of the Danish history of families and individuals choosing to live together (Fromm 1991).

> *The idea for collaborative housing began in the 1960s when a group of friends began talking about their living situation and realized they shared similar problems. Most were too busy working to have much time to spend with their friends, and when they came home from work, their time was taken up with cooking, cleaning, and washing. Their children spent too much time watching TV, often because no other children their age lived in the neighborhood. The kind of housing these people could afford was either isolated in suburbia or too dense and urban. They felt there had to be a better way. When they talked about the kind of place they would like to live in—good housing, lots of trees, a big playground, and many amenities all in a safe neighborhood—they realized the benefits they could gain by building housing together. (Fromm 1991)*

In Northern Europe, these ideas took off through a combination of tax incentives for developing lower- and middle-income housing and local architectural styles. Whether the Danish *bofællesskaber*, that most often look like townhomes in a neighborhood, the Dutch *centraal wonen* ("central living") defined by clusters of residential buildings, or the Swedish *kollektivhus* ("collective housing") that is most often built into a single apartment tower, these models of cohousing via collaborative communities provide a

means of living alongside one another in order to create a better and more fulfilling lifestyle together (McCamant and Durrett 2011).

Sargisson notes a possible distinction between cohousing communities in Europe and North America. From her perspective, European cohousing communities are historically based more on an ideological critique of late capitalism, while North American communities cast cohousing as a pragmatic response to fundamental everyday problems. This is exemplified by the *Creating Cohousing* quote above that positions cohousing as a way of helping solve problems around caring for children, interacting deeply and meaningfully with neighbors, and offering intergenerational living in a safe context for children to play with one another.

3.3 Cohousing's growth in the USA

Understanding cohousing as a pragmatic means of better distributing domestic labor across a group of residents in a community has led to its growing adoption in the United States. As of 2016, there are 223 cohousing communities planned in the US, at varying stages of completion. This number accounts for active cohousing sites that have been operating for many years, sites that have broken ground building new communities, those that are in the design and planning stages, and prospective communities that are seeking like-minded people to begin a common project of living together. Figure 6 plots both real and projected completion dates for these projects:

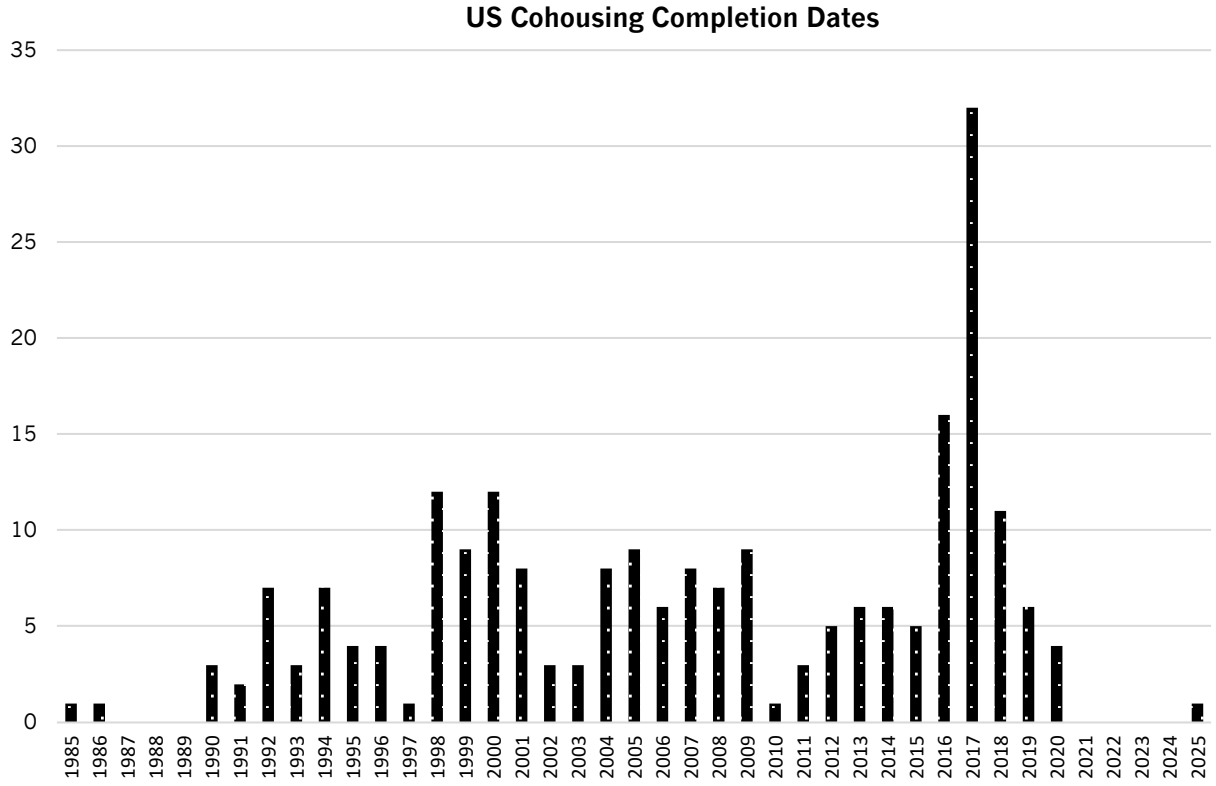

Figure 6: Cohousing community completion dates, as of 2016. ***Data from cohousing.org***

In general, interest in cohousing has been growing steadily since the publication of *Creating Cohousing* in the middle 1990s, with a spike of completed communities being moved into in the late 1990s and strong sustained development of new cohousing communities throughout the 2000s. Some of this activity may correspond to economic bubbles both in being able to find funding for housing projects as well as cohousing itself becoming more appealing in response to increased home prices. The spike of cohousing completion dates in 2017 might also reflect aspirations of groups that are in the planning process. Because this data is from 2016, and includes groups that are forming and

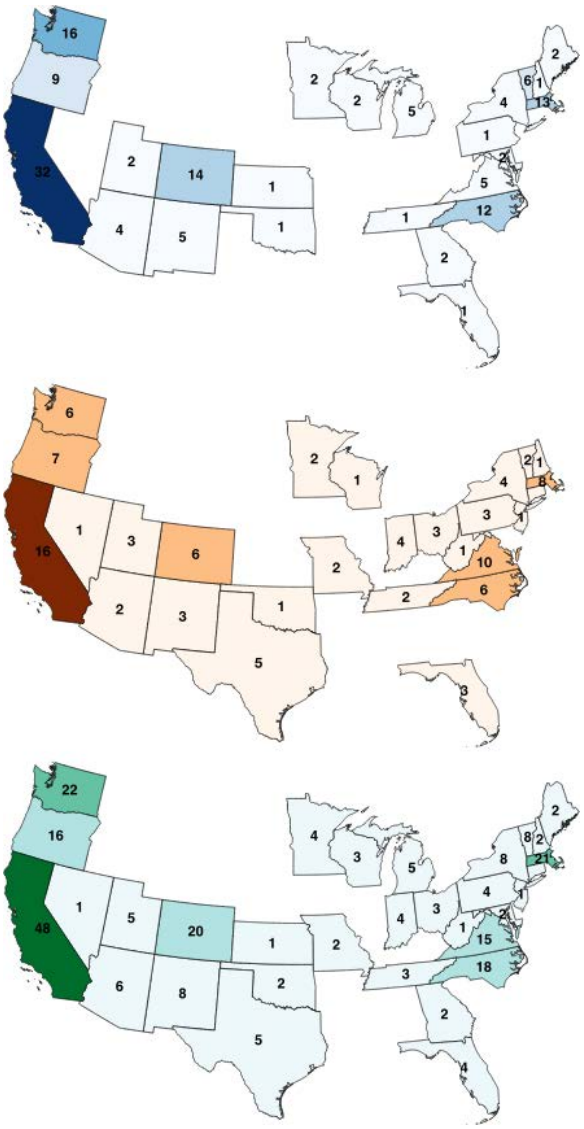

Figure 7: A geographic representation of existing cohousing communities as of 2016 at the top, with planned communities in the middle. At the bottom, the combination of planned and existing communities. Data from cohousing.org.

planning cohousing communities of their own, the dates after 2016 are projections of when a community might be expected to be through all the stages of planning, construction, and completion. Rather than being representative of a particular development timeline, these groups are gauging local interest in cohousing, and the date may simply refer to a general "in the future" for possible community members.

Regardless, in the USA, this spike indicates a real interest in cohousing that is growing over time.

Coupled with this growth of interest in cohousing, the locations of cohousing communities in the United States is becoming more geographically diverse (Figure 8). The first United States-based cohousing communities were located in parts of the US that might be expected to be sympathetic to the goals of cohousing—primarily in stereotypically "liberal" strongholds in the Northeast, like Massachusetts and New York; the Mountain West, specifically Colorado; The Pacific Northwest, namely Oregon and Washington, and Northern California, where McCamant and Durrett designed and built their own cohousing neighborhood outside of Nevada City.

Recently, though, cohousing communities are being planned for regions that might have been thought to be inhospitable to them. While there are of course still many sites being constructed and planned in the strongholds of cohousing like Massachusetts, Colorado, North Carolina, and California, the Midwest is showing increased interest in cohousing communities being planned in Missouri, Indiana, Ohio, Pennsylvania; in plains states with a doubling of sites in Oklahoma, and Nebraska; central southern states getting their first communities, as is the case with West Virginia, or doubling the existing numbers like Virginia and Tennessee. Cohousing is making inroads in many parts of the US as well as becoming more established in states that it already has a strong presence in. Figure 8 shows these trends in clearer detail. As of 2016, Connecticut, Indiana, Iowa, Missouri, Nevada, New Jersey, Ohio, Texas, and West Virginia all have their first communities being planned. This is not to say that there is some essential difference in the politics of these areas, but rather that interest in cohousing is growing, and the

locations of cohousing communities are becoming more diverse. To emphasize that point, Figure 9: In 2016, Planned and in-progress cohousing communities equal the already-existing number. Data from cohousing.org compares the numbers of cohousing communities that have been built already to those that are being constructed and planned. The numbers of communities in progress is about the same as those that are complete. Clearly, cohousing is a style of living that has been gaining momentum in the USA.

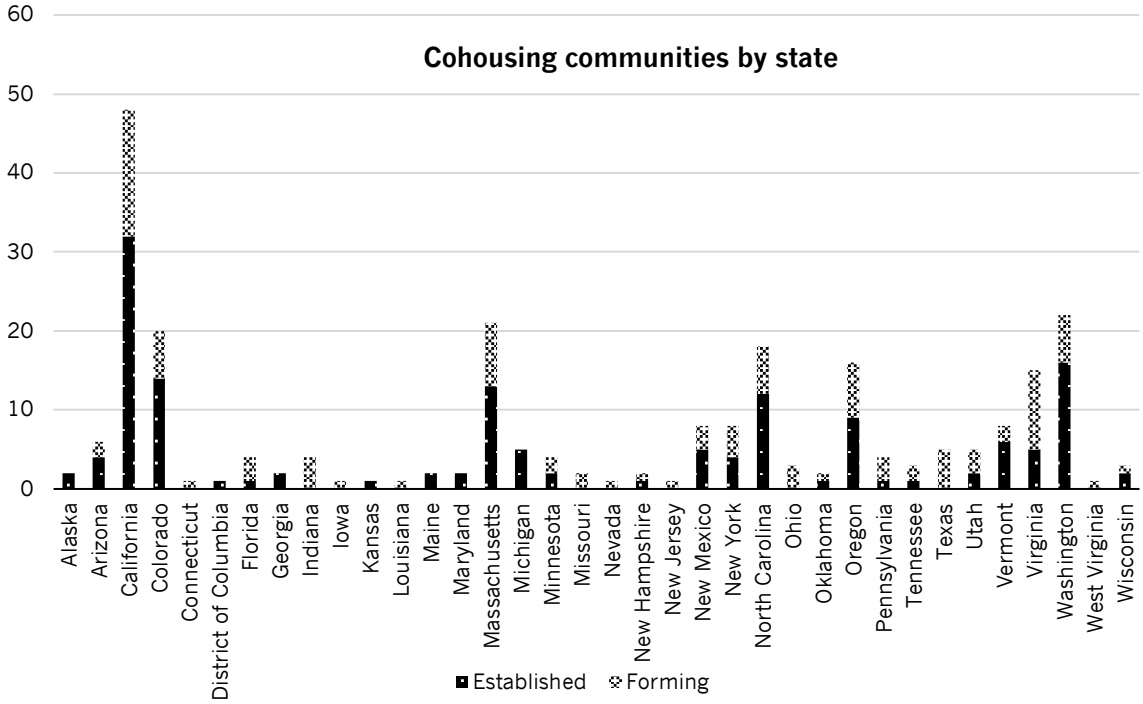

Figure 8: Cohousing communities in various states as of 2016. Many states have their first communities being planned. Note that this chart only has data for 36 states. Those not on this list have no cohousing. ***Data from cohousing.org***

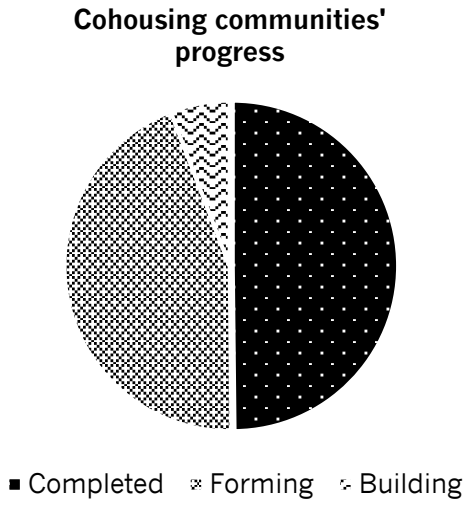

Figure 9: In 2016, Planned and in-progress cohousing communities equal the already-existing number. Data from cohousing.org

Figure 10: Cohousing in Ann Arbor, Michigan, USA.

3.4 Cohousing and design

One of the things that makes cohousing unique is how it is overtly designed to promote social interaction among residents. In much the same way that interaction design prototypes alternative technological futures, cohousing might be considered a prototype

for alternative residential futures. As an intentional project that involves architectural, legal, and planning consideration, cohousing communities reflect a particular design ethos. While communities certainly vary in terms of size and physical structure, there are some common design features that are shared among communities. For example, many design decisions serve to facilitate a sense of safety, as well as fellowship. Cars stay on the periphery of the property, leaving space between the homes to become play spaces for children. Common houses are in the center or near commonly-accessed parts of the property. Homes are oriented towards pathways and front windows in residences are large enough to let passers-by see inside. These architectural traits underscore the role of design in cohousing. While particular implementations vary somewhat from community to community, the role of design in these residences is to support and extend community life wherever possible. This is how cohousing comprises a particular kind of object ecology for domestic life. The architectural design, layout and planning of the community becomes integral to its operation while being interpreted by residents and supported by the values and practices of the people that live inside of it.

In *The Cohousing Handbook*, Hanson describes these particular relationships as specific goals of cohousing design: *purposeful separation of the car*, *pedestrian pathways*, *kitchens facing pedestrian pathways*, *a centrally located common house*, and *affordability* (Hanson 1996). Each of these are efforts to create in cohousing a particular orientation towards space and the ways that that living in cohousing can take place. There is a distinct intention in these design goals to build upon one another to create a particular kind of social space: *separating the car* works in two ways. It increases opportunities in everyday life to encounter and interact with neighbors while walking to and from a more

remote parking area, but it also serves to deemphasize what Hanson calls "the single biggest environmental impact we have in North America" and prevents paving over large chunks of a property's land area that could be used for other purposes. One of those purposes is to create *pedestrian pathways* that become the circulatory system for cohousing communities. These paths provide a place for children to play or for adults to have spontaneous interactions with their neighbors. These pathways that are so central to cohousing often become important in orienting homes. Orienting the *kitchens to face pathways* is a way to connect one of the busiest rooms in the house to the broader world of cohousing. Resulting effects of this choice include both being able to see the pathways better while children are playing, but also to be able to be seen by other community members whether a family is home and available for visiting. The *common house* offers a shared space expressly for community life—while it is possible to reserve them in many cases, it is a co-owned resource that represents a significant investment of resources and trust and is used as a multi-purpose area for events like common meals, parties, and meetings. Finally, keeping individual units affordable ensures that a broad range of experiences and perspectives are a part of life in the community. Together, these design goals articulate a set of relations that describe fundamental qualities of life in community. They have not remained static over time and across communities, though, reflecting local differences and emerging customs around how cohousing is best built and practiced.

Since the first cohousing projects were built in the early 1970s, certain planning, spatial and building size patterns have emerged. These have changed over time in response to what works and what doesn't work. Jan Gudmand-Høyer, considered the father of the cohousing movement in Denmark, has observed that the design of cohousing

designs has evolved considerably as the idea has grown and spread among groups around the world. These material changes over time reflect different kinds of social effects and tend to lead to communities that are more and more committed to living together. Gudmand-Høyer identifies four distinct generations of cohousing communities:

3.4.1 First-generation cohousing

The earliest cohousing projects were designed to include private units averaging about 1,500 square feet with a common house of a similar size at also 1,500 square feet. The families and planners designing and building the space didn't know for sure how well the idea of common space would be taken up, or how often residents might benefit from use of the common house. In this model, private units remained large in case the community idea didn't work out the way the planners hoped, so that the community might still operate as a more traditional neighborhood. The early community of Skråplanet where Jan Gudmand-Høyer lived until his death in 2017 is an example of a first-generation *bofællesskaber*.

3.4.2 Second-generation cohousing

As confidence grew among planners and cohousing designers, the following generation of cohousing evolved towards smaller individual private units and larger common facilities. Individual residences floor sizes came down to an average of about 1,000 square feet, while the common house increased to about 5,000 square feet. In second-generation cohousing the pedestrian street became more well defined, and more fully removed from automobile use. As well as becoming larger, the centralized location of the common house and its relationship to the private units became very important in

order to afford equitable access to community space. This is the most common kind of cohousing in the United States, and in the next section, Lake Claire Cohousing, East Lake Commons, Pacifica Cohousing, and Eno Commons are examples of this model.

3.4.3 Third-generation cohousing

In third-generation cohousing the common house continues to get larger and the private units continue to get smaller. More and more resources are dedicated to the expansion and enhancement of the common facilities, with the common house size increasing to nearly 10,000 square feet. The average size of private units shrinks to as little as 750 or 800 square feet, just enough to accommodate the necessary areas for personal privacy, retreat away from other community members and sleep.

More significantly, the common house and the private units are brought together into a single building, often connected with a glass-covered street. Access to the common house is easier and more and more specific uses are included in the common house, such as darkroom facilities, or a music room. Although the private units are somewhat larger, the WindSong community in Vancouver, B.C. is an example of third-generation cohousing. A variation on this model, Sjöjungfrun in Umeå, Northern Sweden, builds a community out of two large apartment buildings connected through a common atrium.

3.4.4 Fourth-generation cohousing

In fourth-generation cohousing, clusters of second- and third-generation cohousing are brought together into a larger neighborhood or village. Jan Gudmand-Høyer designed a new neighborhood of 48 cohousing communities, including shops and other commercial services. Located in the village of Ballerup, a suburb of Copenhagen,

much of it is now complete. A number of groups are planning fourth generation cohousing communities in North America, including the Ecovillage at Ithaca in New York State and the Ann Arbor Cohousing group in Michigan, discussed below.

Trends in cohousing over time have tended to embrace community life more deeply, making contemporary cohousing communities more and more distinct from the subdivision-style developments that the earliest communities resemble. Cohousing is designed to support residents creating and living in community with one another, and it does this through a combination of architectural features that privilege common space alongside the commitments and bylaws that build into cohousing the management structures that are distributed across residents. Together, this interrelationship of design qualities, systems, and process comprise an ecological context for domestic design research that is oriented towards living together.

3.5 Cohousing communities

While the shape and structure of cohousing varies from location to location, the goals and practices of cohousing are often the same—residents seek to build community with their neighbors. The section follows consists an overview of six different cohousing sites visited as part of this research project. Each of these communities are somewhat different in form, while remaining similar in structure. All of these cohousing projects are driven by a sense of values and goals that motivate residents' participation in community life. The breadth of communities described here are meant to provide a way to get a better sense of how cohousing communities "feel" on the ground and are intended to draw out the similarities as well as articulate differences among them. These differences come from the varying sizes of the communities, how their development was funded,

what kinds of values are particularly important to a community, and how their commitment to living intentionally with one another manifests in everyday life.

3.5.1 Touchstone Cohousing

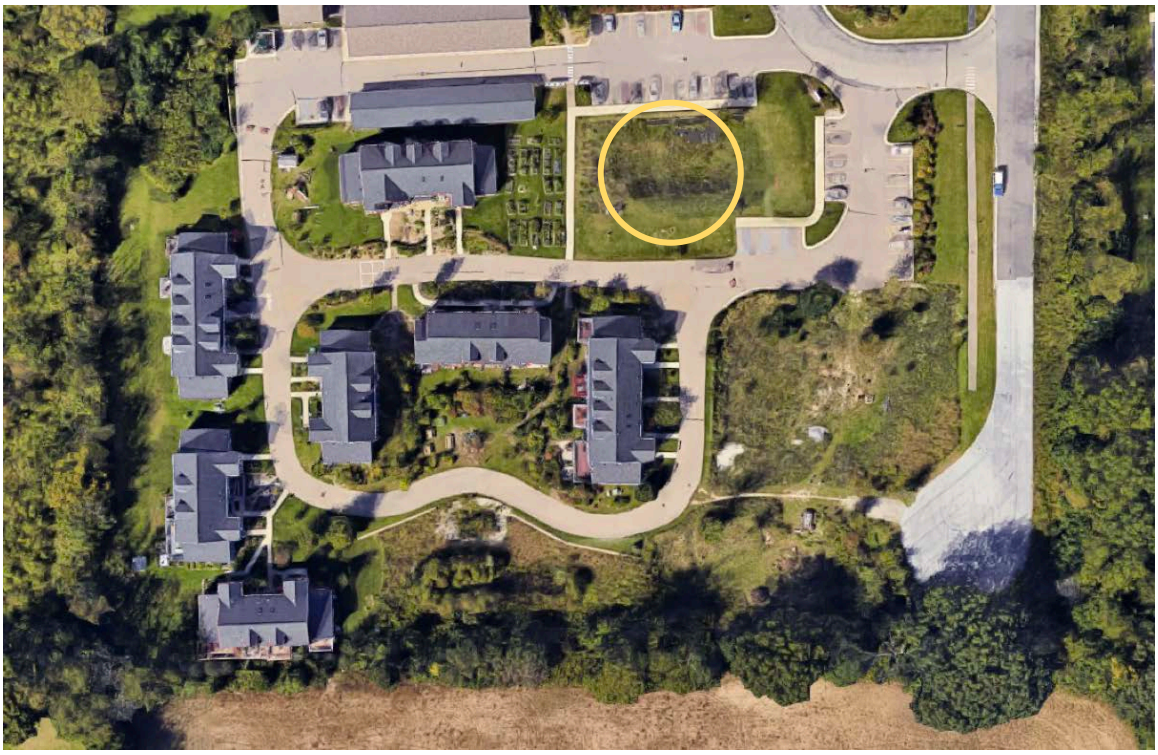

Figure 11: An aerial view of Touchstone. The upper right (circled) is the site of the new common house, not included in this image. Additional residential buildings were originally intended to be constructed at the bottom and right sides of the community as well.

Touchtone Cohousing[2] is located just East of Ann Arbor, Michigan, and is one of three adjacent communities there. Together with Great Oak Cohousing immediately next door, and Sunward Cohousing across a small ravine, they call themselves Ann Arbor Cohousing. Each of these communities are independent and self-sufficient, but there is quite a lot of knowledge that transfers among them regarding management and

[2] http://touchstonecohousing.org

technological infrastructure. This proximity between communities offers what Ann Arbor Cohousing calls on their website "an enhanced opportunity for networking and resource sharing among neighbors.[3]"

Touchstone itself is the youngest of these three cohousing sites. 24 homes are built into 7 buildings, sharing walls to improve energy efficiency and decrease costs during Ann Arbor's winters. Approximately 60 residents live at Touchstone of all ages and family sizes.

Figure 12: A residential building at Touchstone behind both private as well as community planters.

When visited, Touchstone was in the middle of building its common house. The community's construction process was truncated by the economic crisis in 2008, meaning that another 2 or 3 residence buildings as well as the common house wasn't completed in

[3] http://aacoho.org

the first building phase. From its inception to 2016, Touchstone had been sharing the common house of Great Oak next door, meaning that in many ways, there were two cohousing communities overlapping in a novel arrangement.

One side effect of this developer-driven model of cohousing was that when the money ran tight, the lower cost of cohousing residences meant that people bought into the community with little intent to participate in the social lives of the community. Especially without a common house of their own, Touchstone was in many ways more similar to a condo community that properly living in intentional community. Over time, though, turnover among residents less committed to the aspects of cohousing has created a tight-knit community.

3.5.2 East Lake Commons

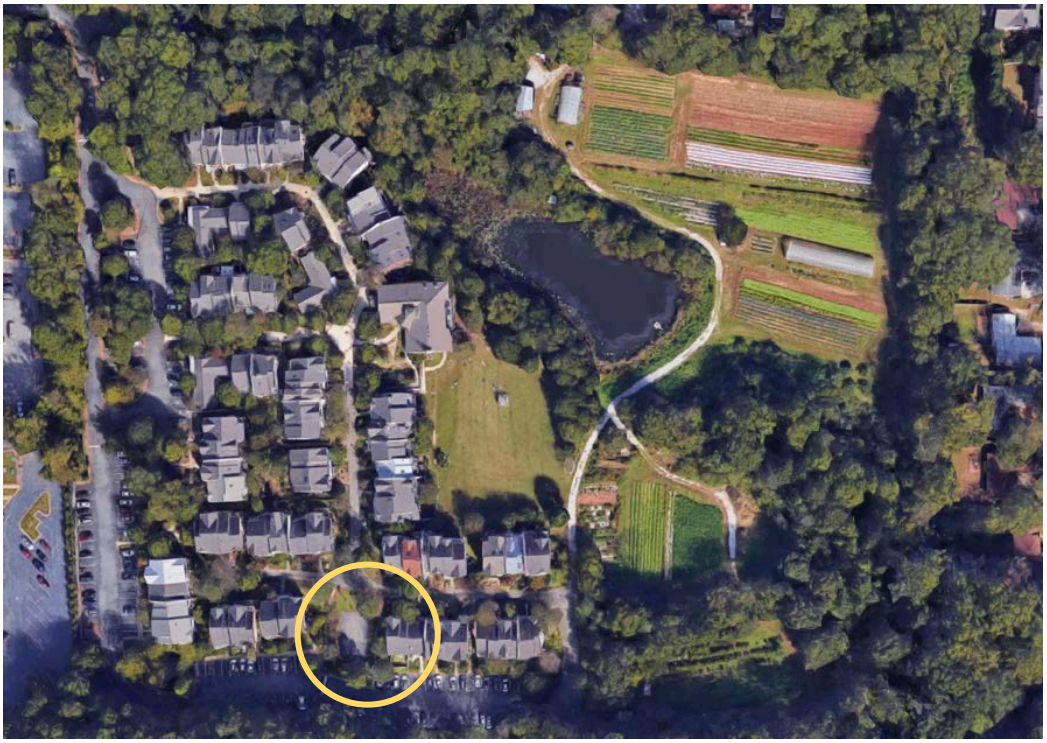

Figure 13: East Lake Commons. The basketball court at the bottom of the community (circled) was orginially inteded to be a common house for a second community on this site.

East Lake Commons[4] (ELC) is the largest cohousing community in the USA. It is built on 20 partially-wooded acres located 4 miles east of downtown Atlanta (Figure 3, left). There are 67 townhouses in that space, a large common house, and "Gaia Gardens," a 3-acre organic garden and orchard, greenhouse, apiary, blueberry patch and pond. The garden and orchard together supply a CSA, or community-supported agriculture, and provide fruit and vegetables to the surrounding neighborhoods.

What became ELC was originally intended to be Section 8 housing (government-sponsored housing for low-income residents), but a community of Quakers looking for a site to create a faith-based intentional community entered a discussion with the property developer and established a cohousing community. The community no longer has any formal religious affiliation. Now, it is a burgeoning cohousing community of approximately two hundred residents. This is many more than it was originally designed to accommodate. Originally, ELC was intended to be two separate cohousing communities, but development costs meant that the second common house was never built.

In practice, this community can be a bit unwieldy: the large number of residents make it too difficult to operate by what might be considered as "true" cohousing principles. Consensus, for example, is extremely difficult to achieve with over two-hundred residents. Instead, residents use a super-majority of 80% of the community to make resolutions that cannot be blocked by dissent. ELC makes it clear that cohousing can be too large to work well. The "village in a city" atmosphere that lends itself to

[4] http://www.eastlakecommons.org

values like community or cooperation evaporates when the scale gets too large. As with other neighborhoods, there are tensions, but with twists that reflect a community containing common interests and intentional deliberative structures.

Like many cohousing communities, there is a limit to how many of the units can be rented. Design constraints on limited resources like the number of available parking spaces make it difficult to have many independent roommates in a single unit. During a common meal at ELC, my host mentioned that there was some concern that the new owner of a unit sold due to its relatively low cost for the area wanted to create a live-in/incubator space for founders of technology companies. This was a possible problem in two ways. First was a concern that any large group of renters might not be very interested in playing an active role in the community at large, making the community less functional as cohousing. Second, and building from the first, these residents would use community resources in a way that was disproportionate. If you divide the number of residential units on the property by the number of parking spaces available, each unit is allotted effectively only one parking space (with a bit of cumulative wiggle room, as the average is actually ~1.2 spaces). These are in a small parking lot just past the gated entrance to the property. If a home has four or five residents that each intend to park their own car, these residents would occupy parking spaces that could otherwise be used by three or four households. The issue of parking as a resource that was being consumed disproportionately was one way that this very large community has recently had troubles regarding commitment to cohousing principles.

3.5.3 Lake Claire Cohousing

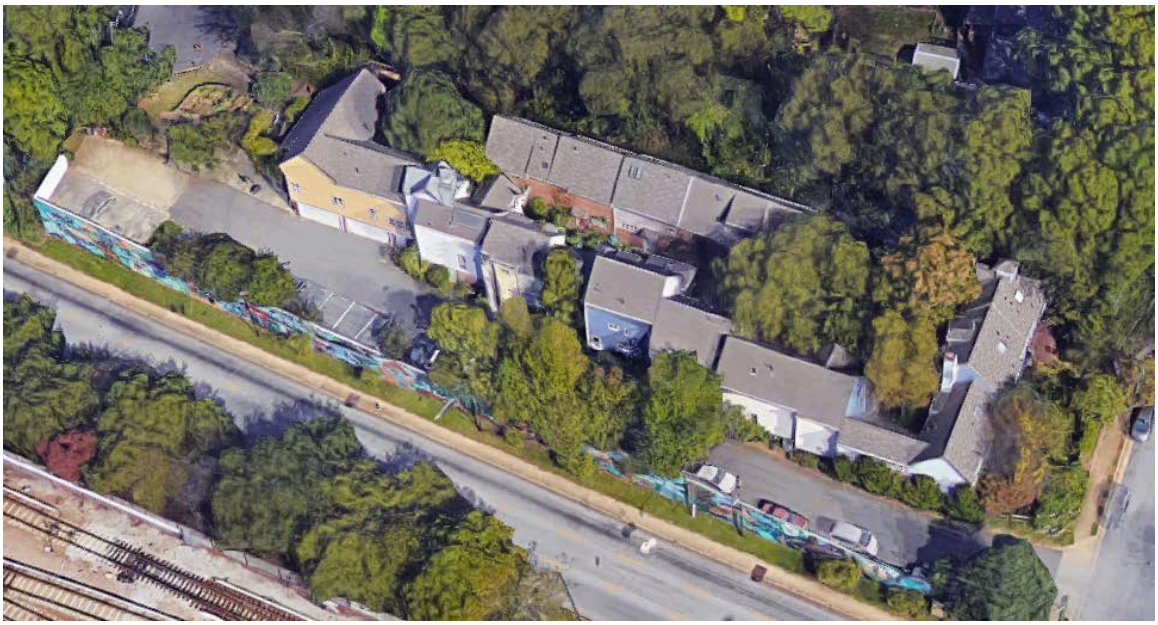

Figure 14: Lake Claire Cohousing.

Lake Claire Cohousing (LCC) is among the smallest cohousing communities in the USA. In contrast to ELC, it sits on a half-acre plot in a densely-populated residential part of East Atlanta. Surrounded in the area by detached, craftsman-style homes, the 12 townhouses at LCC are clustered tightly around open, common space in the center, with a common house and garden plot at the west end of the property (Figure 14).

Figure 15: Lake Claire Cohousing's structure provides an inner play space for children and families.

LCC was built in 1997, and the first residents moved in the following year. Unlike ELC, LCC was self-funded by a group of people inspired by McCamant and Durrett to create a cohousing space. These residents followed the guide of books like *Creating Cohousing* (McCamant and Durrett 2011) and *The Cohousing Handbook* (Hanson 1996) in finding land, architects, planners, and so on to build a community that fit their needs and resources. One way it's possible to understand the difference between ELC and LCC is through their approaches to development. While developer-driven cohousing might mean that larger-scale funding is possible at the outset, it may also mean making certain kinds of concessions in the design and construction that make cohousing values harder to maintain over the long term. The inability to build a second common house for ELC and the resultant need to create one large community from what was intended to be two neighboring ones has made it difficult to forge a single cohousing community that works together well. While the genesis of cohousing plays a large part in establishing common values, it's also important to see how the community functions after it has been built.

3.5.4 Pacifica Cohousing

Figure 16: Pacifica Cohousing

The Research Triangle in North Carolina is home to a number of cohousing communities. Pacifica Cohousing[5], in Carrboro, NC, consists of 46 residences that are a mix of townhomes, detached dwellings and stacked houses on eight acres about a mile from Chapel Hill. The first residents moved in to Pacifica in 2006, but the community's history stretches back to about 2001. At that time, architect Giles Blunden, who lives in one of Carrboro's other cohousing communities, Arcadia, and a group of interested people sought to create a cohousing community close to downtown Carrboro. After many meetings and an expanding group of people interested in creating the community, construction began in 2005. The community celebrates its anniversary on May 1, 2006, when the first homeowner moved in.

Figure 17: Row of houses at Pacifica Cohousing

[5] http://pacificaonline.org

As with many cohousing communities, environmental sustainability is a major factor for residents, Pacifica includes two large rainwater cisterns (5k & 15k gallons), organic community gardens, passive solar design with respect to the houses' orientations, and solar hot water and radiant floor heat in many buildings. Notably, Pacifica's common house has the largest residential photovoltaic solar array in the Research Triangle area of North Carolina.

3.5.5 Eno Commons

Figure 18: Eno Commons.

Another community in North Carolina's Research Triangle area is Eno Commons[6]. Eno Commons is a 22 household, cohousing neighborhood in Durham. The 11.2-acre site is a stone's throw from the Eno River Park and just six miles from the

[6] https://www.enocommons.org

center of downtown Durham. Twenty-two households create a community size that they consider near optimum for balancing privacy and participation. Eno Commons offers the opportunity to have both the privacy of your own home and yard, and the option of gathering with neighbors in the common house, community gardens or orchard.

From the Eno Commons mission statement: “We believe that a neighborhood with a diversity of residents is a more vibrant place. We are accessible to people of all physical abilities: with the site plan, Commons House, and home designs all planned with accessibility and wheelchairs in mind. People of all ages, races, religious beliefs, and affectional preferences are invited to make Eno Commons their home.”

Figure 19: Houses in Eno Commons are spread along two pedestrian paths.

Eno Commons is built to support ecological sustainability. To compliment the passive solar design, each home at Eno Commons is heated and cooled by a geothermal heat pump, the most efficient, low maintenance heating and cooling systems available. Power bills are for residents are quite low, meaning that efficiency works for residents in

two ways. As with other cohousing communities, Eno Commons is built using a design which focuses on people, not cars. By limiting the road, they feel that they create a neighborhood that is safer and more pleasant for children and adults and that preserves large portions of their land undisturbed for both wildlife and recreational uses.

3.5.6 Sjöjungfrun

Figure 20: The exterior of Sjöjungfrun.

In contrast to the American cohousing communities, Sjöjungfrun[7] ("Mermaid House") in Umeå, Sweden is a single building. The Mermaid House association formed in 2005, with construction beginning not long after. Mermaid House itself is built from wood and other environmentally friendly building materials, and consists of 32 apartments that have 2, 3, or 4 rooms each. The apartments all share a large, open

[7] https://www.sjojungfrun.net

conservatory space in the center of the building. They apartments are spread over four floors in two parallel buildings and are connected by the inner garden and conservatory. Each of these apartments has a large balcony space that faces the conservatory's interior garden. These are often decorated like an extension of the private apartment, like a living room that looks out into the garden. The other areas in the central conservatory are common and are used for parties and other social activities.

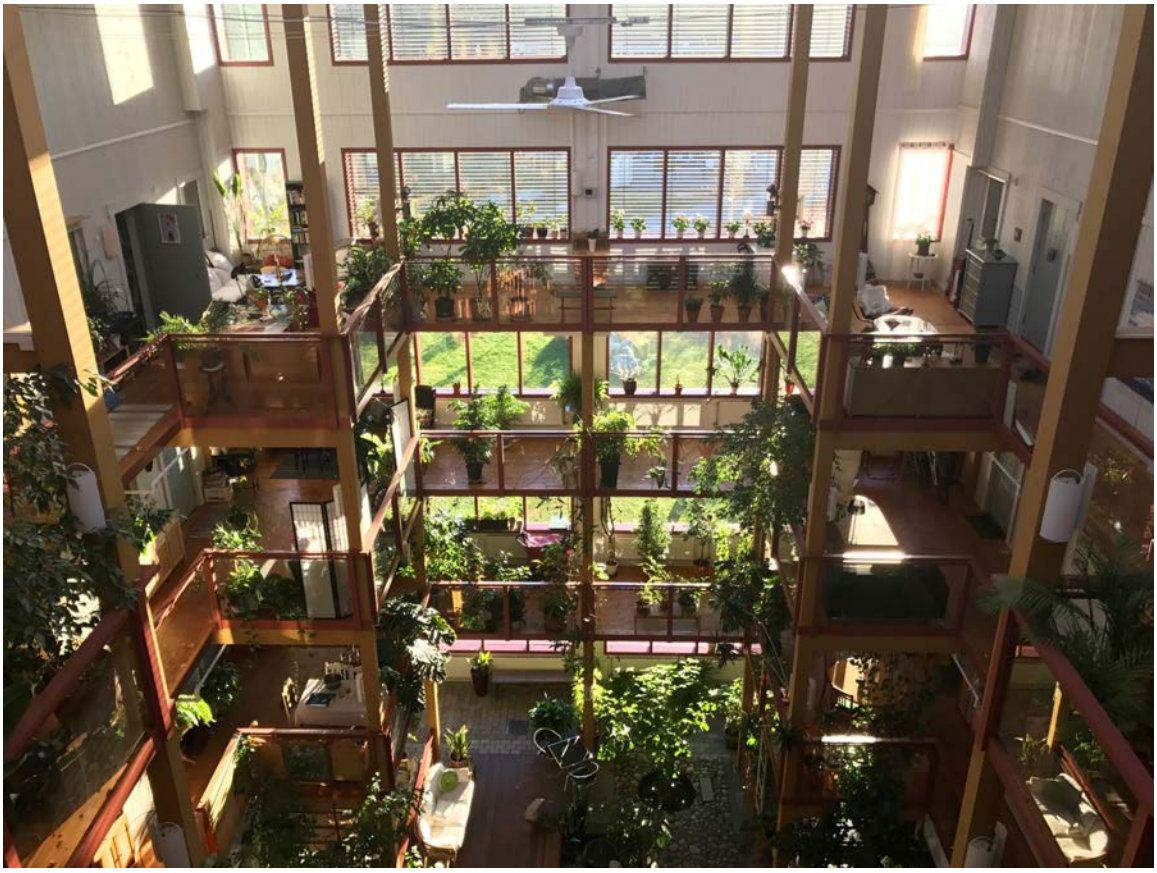

Figure 21: Inside the Conservatory at Mermaid House.

A primary goal at Mermaid House is ecological sustainability. The garden and apartments are heated with renewable energy using pellet-burning stoves. The residents sort their waste and compost all organic household waste in their on-site compost machine. The design itself—a multi-family house with a large conservatory in the middle—was proposed by architect Anders Nyquist, who wanted to realize a vision that

helped to better connect residents to one another in Northern Sweden. Some of Anders Nyquist's visions were not able to be realized, however. An energy-saving glass roof designed to be placed over the conservatory became plastic smoke shutters, as the glass roof proved to be too expensive to realize. Other concepts, like a water purification plant and fecal composting system were also planned, but never implemented. Instead, the house has a common drainage system where all sewage is sent to the municipal system. There is also no heat recovery from the treatment plant, which would increase the overall efficiency. Mermaid House contains residents of all ages, ranging from the elderly to newborns. As with other cohousing communities, residents share responsibility for common tasks. Residents of the Mermaid community feel that the social concept is very successful. The house's inner garden helps to foster a sense of community, and the private and common areas of the inner garden offer many opportunities for chatting, informal contact and social interaction for anyone who wants it.

With the exception of Mermaid House, each of these cohousing communities looks quite similar to more traditional neighborhoods and subdivisions. The difference is in the details of each community: how and whether cars have been excluded to create pedestrian paths, or in tradeoffs that have been made as part of the development process. Individual homes are smaller than average, or whether particular ecological features have been implemented. In this way, the role of site planning and design is essential in considering how and why cohousing communities look and act the way that they do. Cohousing communities are neighborhoods that are expressly designed for social interaction (J. Williams 2005). At their core, cohousing communities become homes that extend beyond a single house—the common house, for example, is both common space

as well as a continuation of an individual residents' home. So far, though, all of these design considerations are architectural and relate to planning social interaction through manipulating space and arrangements of residences and buildings in different, intentional ways. As smart technologies become more common in the home, devices and systems might serve to construct social interactions as much as the site plan does.

Designing devices like these for cohousing requires an ecological perspective on how cohousing is constituted and constructed. Cohousing is a lived practice, more than just a design space that stretches the definition of "home" across many buildings and multiple families. This ecological perspective on design means that cohousing is made of more than just plans, architecture, and sites. These aspects are important parts of the object ecology, to be sure, but the perspectives and values of residents of cohousing is also necessary to understand what living in cohousing is like. As noted above, in addition to a design artifact, cohousing is also a social practice that is driven by the commitment of its residents to live intentionally and in community with one another.

3.6 Living in cohousing

To obtain a richer understanding of the lived experience of cohousing, as well as the opportunities for ICT to play a role in that setting, 5 residents of Lake Claire Cohousing (LCC) were interviewed in the Fall of 2015, and followed up with in the Fall of 2016. While this may seem like a small number of participants, in a smaller group like LCC it represents half of the households in the community. These residents varied as to their age, gender, occupations, and how long they have been living in cohousing. Three of the interviewees had been involved with the community since its inception, either as a founding member during the development process (R2, R3), or as an interested party

during that time who moved in a year after the project was completed (R4). Two of the participants were men (R2 and R3) and three were women (R1, R4, R5). All interviewees had families, although at different life stages. Some residents' children were adult and out of the home (R2, R3, R4). Other residents had small children currently in the home (R1, R5). This "next generation" of cohousing was often mentioned in interviews.

Each home visit lasted for about an hour. The visits consisted of a semi-structured interview asking about alternative styles of living, how and why participants chose to live in cohousing, and the role of ICTs in their living arrangement. This semi-structured interview was followed with a "home inventory" (Grivas and Zerefos 2015) to discover what ICTs were used in the home. Interacting with and discussing these home technologies helped to generate more questions. All interviews were audio recorded in addition to taking written field notes. During the visits, photographs were taken of objects or quirks that arose during interviews. Each interview was transcribed and open-coded to identify common concepts and recurring themes in the data, while the photos served as visual aids for analysis.

As described in the introduction to this chapter, one goal of these interviews was to understand how residents of cohousing already use technology in their homes, with an aim towards getting a finer-grained sense of how their domestic practice features or utilizes technical infrastructures that are shared or personal. Each of these families owns at least one computer, and all use them for both work through Internet and e-mail, as well as entertainment via streaming media services like Netflix or Hulu. Each participant interviewed owned and used a smartphone. Indeed, conversations around technology design that could benefit cohousing frequently revolved around potential smartphone

apps. Despite smartphones being common, other kinds of domestic technologies were conspicuous in their absence, at least at the individual household level. Only one participant had cable TV in their own home (R3), although there is cable TV in the common house, as well as shared Wi-Fi. Especially for this project, it was interesting to see that no cohousing resident interviewed had or used any sort of "smart home" technology themselves. Indeed, conceptions of what kinds of devices might be considered smart or might use sensors were nebulous. Residents understood sensors to be present in devices like microwaves, ovens, and thermostats, but not necessarily what possibilities sensing technologies might have in their own home.

From the perspective of investigating object ecology in cohousing, these interviews offered the opportunity to discuss and consider the domestic relations of cohousing life starting from a blank slate: how does cohousing work? Where does labor take place in maintaining the community? What kinds of issues arise? Are there things that take on particular roles in everyday life? Answers to questions like these offer a means of considering opportunities for designing ecological objects in context.

3.6.1 Cohousing life

For the residents of LCC, community is at the core of cohousing. Like McCamish and Durrett's example earlier, cohousing is appealing as a means of making community and living in a way that connects to others: *"I describe [cohousing] as being an intentional community. We are living together and we want to make community with each other, we want to interact with each other, so we do things purposefully to do that. Now, after this many years, it's kind of like automatic. We don't even think about it." – R4*

"Intentional community, consensus, some commitment to sustainability. I've often described when people ask me, 'What is co-housing?' I say it's like a college dorm where everyone has a mortgage, with less sex (laughter). It's extended family without the baggage. It's a cross between a commune and a condo." – R3

This nearly-familial connection is important to residents of cohousing. The village feel that comes from the spatial arrangement and practices of cohousing—what together could be described as designed intentionality—is very much the goal. Here R3 talks about why cohousing is so appealing to them: *"It's not infrequent that I just stop and go, 'I can just walk over to John and Sara's house and walk in the house and say this and ask that.' That ability to know that the boundaries are a lot more porous and that I can get the help when I need it. We get the help with the kids. We get someone picked up or dropped off. Can we borrow ... That's that extended family, the familiarity, the ease." – R3*

At its most basic level, cohousing is about this kind of ease, a comfort with others and a joyfulness in having a community around to share experiences with. Designed and built as antidote to urban neighborhoods where residents are anonymous—and homes are independent—cohousing creates a community through both intention and practice.

3.6.2 Sharing space and place

Sharing is something that takes place inside of cohousing without much concern. Other than time, probably no part of cohousing is shared as much as the common house. The common house is the heart of the community, a social hub for entertaining as well as a venue for events that are open to the broader community at large, outside of cohousing residents: *[Partner] has private students, occasionally. I host lots of meetings at the*

common house. A lot of the people I work with, whether it's the theater I work with, or the non-profit I work with, I say, 'Should we do the meeting at the common house?' A lot of people know the common house. It really is a great resource in that way." – R3

As the largest enclosed space in LCC, the common house is the main site of social activity in the community. Because individual homes are relatively small compared to contemporary houses, the common house takes care of the overflow. The common house, for example has an industrial kitchen, laundry facilities, deep freezer, cable TV, and Wi-Fi that is used and shared by residents. It offers a way for residents who do not have devices and systems like these—whether for personal or practical reasons—to use them as they please: *"There were times before we got our own Wi-Fi signal, because there was a time when we were feeding off others and trying to share…We would more regularly go down there to tap the signal. There are other people who do that…Recently, I've seen two sets of our neighbors spend a lot of time down there. I think it tends to be when your signal goes out." – R3*

"We share the common house, which I see people have these big houses and they have theaters where they watch movies and stuff, and it's like, 'Well, we have a space that's big that we all take turns. We're not going to have a big dinner every night, but when we do have a big dinner two times a year, three times a year, we can go over there and use it and share it.'" – R4

That said, the common home is still shared. For at least one resident, shared space and the home are not exactly one and the same: *"It feels like a shared space. I can't say it's an extension of my home. We say that to people, 'That's an extension of my home, so don't I don't want you to do that there' We'll use that line, but yeah I don't ... I don't*

know. It's hard to say that. I feel very comfortable when I'm there. I'm very relaxed. I don't feel like I'm not ... I'm in somebody else's house" – R4

This tension—between shared and private space—might be the defining character of the work of maintaining cohousing. Shared space is never quite as comfortable for this resident as their own home is. However, they are clearly willing and able to participate in events that take place there and use the common house when they want or need to without discomfort.

3.6.3 Keeping up with upkeep

Shared infrastructure means that there are shared obligations to maintain and repair it. The design of LCC involves a parking lot that has security lights over it that are not very accessible, and repairing even something so simple involves more than might otherwise be expected: *"What was the latest thing? We had to get all the outside lights fixed. They're so high, it's three stories over the cement; the parking lot there, and you know, you don't want to get a ladder up there. You have to hire somebody. It's expensive, but just getting that all worked out… There's always something going on." – R4*

During these interviews, various residents were installing solar panels, taking advantage of tax incentives from the state. Shared residential infrastructure is not always very simple for licensing or permitting agencies to understand. *"We want to do one for the common house, but we... They're having a hard time because we want to do third party payer, and they're having a hard time giving us a quote on that, which I don't know why. I think it has to do with the ownership of that common house, they're having a hard time." – R4*

Because the construction of LCC was completed in 1998, the roof was nearing the end of its natural lifespan. Different approaches between different residents become clear when facing looming financial obligations, especially when the issue may affect multiple people at the same time: *"Here's where you learn living with other people how different people term ... or, feel about their maintenance. My husband is always proactive with like a roof, replace it after fifteen years if it's a fifteen-year roof because the leakage then, oh, my gosh, by the time you notice, there's a lot of damage and it's a pain in the butt. When we went and it was time to change the roofs, we got a guy out here and he gave us quotes. I think eight out of the twelve did it, but not everybody was convinced. Some people said, 'No, we're going to wait for it to break.' I was like, 'That's fine. That's your choice. We're getting a great deal now.'*

Twice a year we get the guy to come out and clean our gutters. Same thing, not everybody participates in that. Thank goodness for emails, it's much easier than going down and writing things up and having people ..." – R4

Here maintenance activity that is normal and mundane in individual housing contexts becomes much more complicated. Just clearing the gutters requires coordination and organizing residents and makes it clear how decision-making processes might sometimes become contentious.

3.6.4 Consensus, conflict, and decision-making

Consensus is a way to be sure that everybody is happy with the outcome of a group decision. By making sure that all participants agree before an issue is considered as resolved, everybody can buy into the process while feeling respected. This does not mean that it is an efficient process, though: *"I like co-housing, [but] the blessings are also the*

curse. The house is small; the house is small. You live next to your neighbors; you live next to your neighbors. You have to make decisions together; you make decisions together. Almost every single thing that's a good thing about co-housing is a bad thing about co-housing. I'd say the main thing is it takes longer to make decisions. Even though we have it down to a science, [and even though] it's very seldom we get into a cankerous debate about things. Especially early on, once you realize that you're making decisions together, it's just amazing how many things you have opinions about." – R2

The frustration that can come from this kind of work is immense. Every person interviewed had a story of how the process can be annoying. Questions as trivial as "what colors should we paint the exterior of our houses?" become protracted conversations that can be resolved in ad hoc ways: *"[One] contentious situation we had was painting… Before, I think we had a lot of terracotta color, that was our original color. Then we went through this whole thing of 'multi-color, but then if we do too many everything is a little different color of the same palette then it starts to look like these things over there, and we don't want it to just look like something that a developer put up. We don't want it monochromatic.' We came up with, 'These three would be this tone. There'd be a tone of blue, and a tone of green, and a tone of off white.*

Then it turns out that we came home and looked at our house and went, "It's not quite what we thought." It turns out, the person who went to get the paint had forgotten, had lost one of the chips. She just called it on the spot (laughs)." – R3

One of the values common to many cohousing communities is a desire for outreach, to either serve as an example for other kinds of intentional communities or simply to provide space for cultural events from broader Atlanta. With shared resources

like the common house, this is not always smooth sailing: *"Then there's been a little tension in terms of community life in people who bring in outside things. For example, I make myself available to host, to sponsor things. At this point, there is someone who comes in and does a yoga class once a week. There's someone else who comes in. There's a group the comes in and does drumming there and I'm their sponsor. There have been times when it's come up, 'Someone wants to do this on a weekly basis.' In the community, there's a discussion about, 'It starts to feel like it's not our common house anymore.'" – R3*

3.6.5 Coordination

As one might expect, coordinating among cohousing residents sometimes proves a challenge. Here is the most obvious use of existing information and communication technologies, providing a means of connecting residents to each other. In LCC, at least, this changeover is partial and ongoing: *"We have a Google Doc for our phone numbers; our contacts. We haven't done the meals that way yet. There's still a sign up down there, though we have, and this is just recently, like the last eight months, we start sending an email out like two days before the meal just to remind everybody." – R5*

Organizing events among the community is an ongoing challenge. While in such a small group the work of making sure that every resident knows what is happening might seem simple, the task is still difficult—especially in a group where there is intentionally no leader that can make some sort of *de facto* decision. The move to internet or electronic mail systems coexist awkwardly with existing organizing tools like whiteboards or paper: *"We need something, even if it's a dry erase board with a big calendar spread. I just think, when it started, it seems like scheduling the common house*

meals; it was, you walk down to the house and you wrote it up on the wall, and you wrote what day you can clean or what day you can cook, and then people would write down whether they could come that day. They would RSVP on the paper. Some people ... [another family] are still using that kind of paper thing and they always forget to send an email but, most of us seem to be operating on emails these days. I won't even know that you're cooking unless you send out an email saying, 'Hey I'm cooking. Email me if you're coming.' ...Sometimes I miss things because there's a few people that don't operate on email exclusively they just use paper but nobody does paper anymore." – R5

While email has advantages in terms of immediacy, convenience, and fit into existing technological workflow, it can sometimes become overwhelming on its own: *"We have these email chains going about several different things. Right now, we have emails chains that we're going to do a Saturday clean-out of the garage and not only have that and, 'Oh the business meeting is coming up. What are we going to bring to have a potluck for the clean-out?' All these different things are going at the same time and sometimes the chains get too long. Sometimes depending on what email platform people are using, how the emails are showing up, they miss out on something that said before, and Tom's like, 'I thought I was bringing cookies, I thought I was ...' I'm like, 'No, Tom, you're bringing the cornbread.' It's just silly things like that that there's too much. I wish it was simpler..." – R5*

Among residents, ICTs revolve around coordinating meals, costs, bills, upkeep, work, and so on. Better legibility and simplicity would be helpful, especially for subjects like these. These examples show how asynchronous, text-based communication can lead to misunderstandings or confusion.

3.6.6 Community, by design

One worry that original residents had in creating LCC was whether the goals and practices of cohousing would die off as the founding generation moved out, that the effort spent designing and constructing the community might be lost: *"Everyone thought one of the big concerns with co-housing [was] that it was the camaraderie or the hassle of building it together that drew people together and you get a founder's syndrome. As soon as the first generation moved away, it would just become any old townhouse community. That has definitely not happened." – R3*

The values and practices unique to cohousing are maintained over time because it is committed to by residents and reinforced by design. It is performed as a practice and supported by the design of physical surroundings and social covenants that underlies it: *"I think there is something about the fact that the place is place, there's a certain amount of forced interaction legally and voluntarily does create this. For me it has actually created a lot of friendships. I have two or three really strong friendships here now. Whereas I didn't for most of the time I lived here. I don't know what that is." – R2*

These interviews depict cohousing life as consisting of a balancing act between public life and private life, as well as an interplay of individual goals and shared interests. The object ecology of cohousing emerges from these competing values, as well as the venues and context that make cohousing work. The arrangement of people and practices in this form of intentional living are sustained by the design of the communities and the roles that objects and technologies take on in domestic life. These are not the only members of it, though—fundamentally the design and practices of the object ecology of cohousing are in support of particular values. The goals of cohousing are related strongly

to living in a particular way, and living life in service of values that matter to residents. To design for cohousing as an ecosystem of people and things that reflect issues that matter to residents, the values of cohousing need to be considered.

3.6.7 Values of Cohousing

In the United States, the primary web presence of cohousing on the internet is the Cohousing Association of America (http://cohousing.org). The association coordinates information between residents of various cohousing communities via a wiki-style master list of sites at various degrees of planning and execution, from long-term, well-established communities, to those in the building process, to those in the very early stages of designing or interest-gathering for prospective communities.

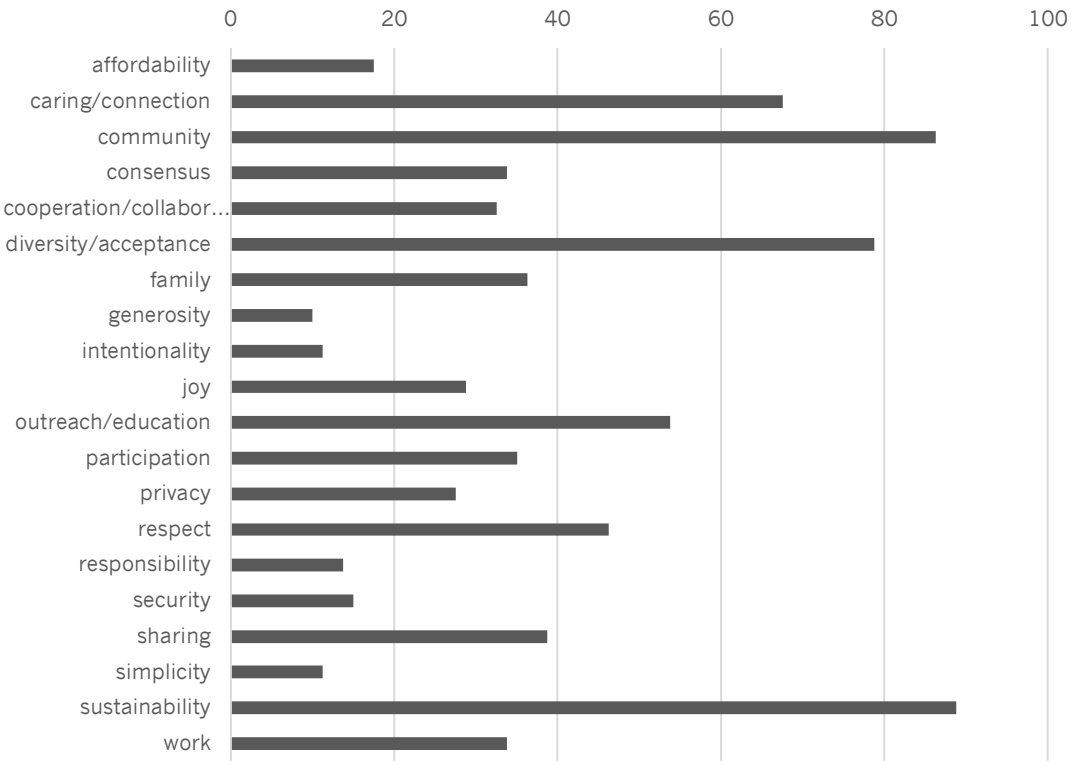

Figure 22: Percentage of cohousing community websites using these terms in vision or mission statements.

Cohousing websites frequently include a "Vision and Values" section that emphasizes what a community believes is important in a general sense, as well as the ways that these beliefs are materialized as practices in the community. Often, these pages include how the communities intend to achieve these goals as residents via a mission statement. A survey of 80 established cohousing community web sites provide a way to reveal the goals and intentions of US-based cohousing communities. Using grounded theory to generate a list of codes, 20 distinct values emerged. Some of these values are described here, but a full list of these values can be found in Appendix B.

The first of these is *affordability*. Cohousing communities control costs through smaller-sized floor plans for homes or even direct subsidy for residents that would not otherwise be able to afford to live in the community. *Community* is perhaps the value that most represents cohousing as a practice and can be understood as a sense of general fellowship among residents. *Consensus* refers to the method of managing the community that cohousing uses and refers to making decisions in a group through deliberation and unanimous consent. *Cooperation* or *collaboration* is a common sense of working with one another towards shared goals. Intentionality is a style of living thoughtfully and deliberately, especially with respect to cohousing values. *Outreach* or *education* refers to the goal of serving as an example of lifestyle for the greater community outside of the walls of cohousing. This also can mean that resources like the common house can become the venue for third-party groups or associations who need space. *Participation* is taking an active role as a resident in shaping the community that you want to reside in and be a part of. Participating in the community is essential to keep it functioning through *work*, meaning helping to maintain the community by doing labor that makes it run.

Finally, two values are almost always found in these descriptions, meaning that they are key interests in cohousing more broadly. *Diversity* is an open-mindedness towards and acceptance of differences in race, age, gender, sexuality, ability and other aspects of identity and experience. residents. The second of these is *sustainability*, meaning that these communities are committed to ecologically sensitivity and energy-efficiency. Often, this is phrased as "living lightly on the Earth."

Cohousing produces a community that is both sensitive to and driven by values. These values offer a way of considering how technology design can support or extend existing cohousing practices in ways that feel normal or natural to residents. It's especially interesting to see the most common values across cohousing groups. Caring, community, diversity, and sustainability, for example, each appear in over 70% of the community descriptions. The ubiquity of these values emphasize what intentionality means in practice for cohousing communities. They are designed and constructed from the ground up to support mutualism among their members. These values are important for designing artifacts that serve to support and sustain cohousing: they need to be in line with these values, or at least not subvert them. Considering the values of cohousing life offers a final component to describing an object ecology for cohousing: perhaps unsurprisingly, the cohousing object ecology emerges from the combination of designed things, people, and the values that are present in shared life. Taking cohousing as a site for interaction design from an ecological perspective needs to take all of these components into account simultaneously.

3.7 Why Cohousing?

Cohousing is a social structure that bonds a standard condominium association or homeowner's group into a community that lives in an intentional way by design. Social compacts are agreed to that play out—to varying degrees—every day of the resident's time living in that community. From a research through design perspective, cohousing offers a site for doing interaction design research that takes a broader ecology of people and things into account than traditional homes allow—it becomes a smart home bounded by a community rather than the walls of a single-family home. It is a neighborhood as distributed home that operates together in service of values, and is designed from the bottom up to support a social life invested in those goals.

HCI has long had an interest in using alternative practices to produce novel technology designs that question the status quo. Designing for cohousing is a means of beginning to push on expected artifacts for domestic HCI. In *Making by Making Strange*, Bell et al. offer heuristics for defamiliarizing domestic life that dovetail neatly with cohousing (Bell, Blythe, and Sengers 2005). The first of these heuristics is *no home is an island.* Contemporary domestic technology design usually portrays the home as a sanctuary from a hostile outside world and provides residents with security-minded features that monitor or surveil the home. Rather than as a site to be defended, actual home relationships are complex, and require one to negotiate privacy and personal relationships within the home. Cohousing exemplifies how homes operate across multiple sites and multiple families, and to varying degrees serves to broaden what domestic technology design might be.

The second heuristic is *homes are in communities/homes resist communities*. The relationship between homes and communities is portrayed in two competing ways. At one end of the spectrum, a home is implicitly seen as decontextualized, ignoring the conditions in which the home is embedded. At the other, communities and connectivity are understood as intrinsically good. Both framings are too simplistic for designing meaningful technologies. Communities can support households, but they can also interfere with them. Design must take communities into account, but it cannot assume that greater integration is necessarily a good thing. Cohousing again makes this case concrete: for better or for worse, residents of cohousing are embedded in a community with their neighbors, and even simple decisions need to take many voices into account. homes in this frame cannot simply stand alone.

Finally, cohousing exemplifies how *the user is plural*. The unit of design should not always be an individual but can also include other members of the household or even larger, extended family units. One clear limitation of existing smart home technologies, for example, is accessing multiple users' calendars or Spotify accounts through a single voice-activated agent. Whose information is needed when? Households do not always or even often contain just a single resident. In cohousing, locations like the common house extend how sharing takes place. While it is meant to be an extension of an individual's home, it is shared space that needs to be understood in subtle ways. Taking these three considerations into account offers a direction for cohousing-inspired interaction design research.

3.7.1 Cohousing Smart homes and the Internet of Things

One way to consider the impact of cohousing in domestic interaction design is how it might problematize the idea of the "smart" home. Most visions of the domestic IoT extend from Weiser's vision of the computer for the 21st Century (Weiser 1999) or Tolmie's notion of "unremarkable computing" (Tolmie et al. 2002). To this point, descriptions of what future life might be like in Internet of Things-enabled smart homes frequently portray standalone residences with garages and pools as being representative of typical domestic life. Cohousing offers a different understanding of what a smart home might be. Here, there are three different kinds of life in the community: public life in a broader city, public/private life within the cohousing community, and the private life of the individual family home. Cohousing features like the common house exemplify this variety of contested space. Considering how these three layers interact could serve as a model for how alternative IoT might support different styles of communities (Djajadiningrat, Gaver, and Fres 2000; Ljungblad and Holmquist 2007).

Pushing on the concept of the object ecology, designing Internet of Things technologies for cohousing means considering the role that the things themselves are taking on. Here, the intention of designing orients towards creating objects that actively participate in constructing and perpetuating intentional community. Because cohousing consists of a public that is driven by certain values, and is invested in particular issues and matters of concern (Weibel and Latour 2005; DiSalvo et al. 2014). Designing for and supporting these matters of concern could mean that the objects themselves participate in new ways (Jenkins et al. 2016). Cohousing perspectives also serve to complicate smart

homes is by thinking of the connection among and between residences, rather than simply taking houses as simply having an “inside” and an “outside.” What kinds of services and platforms operate through the fringes of the home? What devices make the home permeable? Contemporary smart home technologies like Amazon’s Alexa or Dash buttons provide access to massive industrial infrastructures for purchasing and shipping. Cohousing provides a venue for alternative social models for this infrastructure-based approach (Jenkins 2015b). The home’s relationship to water, electricity, internet, gas, mail, and so on might be productively reframed by considering social infrastructure and how services could be designed to support broader community life. Here, designers might think of “smart homes" not as providing access to product or service infrastructure, but instead social or civic infrastructure.

3.8 Conclusion

This chapter set out to develop a broader understanding of cohousing with a aim towards getting a sense of cohousing across multiple perspectives: first, through its historical context and contemporary aims; second, as a style of living that is growing in the USA; third, by describing multiple communities and their goals; fourth, through interviews with residents of one cohousing community in Atlanta, GA; and fourth, through an analysis of cohousing communities’ websites as a means of drawing out common visions and values.

What these different ways of approaching cohousing reveal, is that cohousing is a designed space that operates to align people towards living together with certain kinds of goals and practices in mind. These aspects combined describe an object ecology for cohousing. It is characterized by a specific commitment to living with one another that is

values-based. This is articulated through intentionality, enacted by consensus-driven decision-making, and supported through the architecture and material design of the communities themselves. This network of materiality, people, and intention provides a rich context for interaction design. As a way of living together that is both akin to and distinct from more standard single-family housing, cohousing is both familiar and unfamiliar in ways that are productive for considering how people might or could live in the future. From a distance it looks much like a more traditional housing arrangement—and is often built on a traditional condo association or HOA agreement. When you get closer, however, it becomes clear that a different set of goals and values are being enacted.

In designing technology to support cohousing life and experiences, it is necessary to consider the networks of human intention and material practices that currently work together in the cohousing object ecology. How might novel technological devices work to support and sustain cohousing values while remaining legible and relevant to residents? This question describes a design space called Cohousing IoT.

CHAPTER 4: DESIGN RESEARCH INTO COHOUSING IOT

"Cohousing IoT" represents a propositional object ecology that can be explored using design research. Conceptually, cohousing IoT is built from three interlinking parts. These are the current Internet of Things, speculation as to what an alternative IoT might be like, and cohousing as a venue for this speculative IoT to be sited in. This chapter defines the cohousing IoT design space through a research through design process as described in Chapter 2. This process operates in two parts. First, the object ecology of cohousing IoT is constructed through the relation of the current IoT, speculation about an alternative IoT, and the existing values, practices, and goals of cohousing. Second, software-based generators are used to procedurally explore the cohousing IoT object ecology. These generators serve to flatten the component parts of cohousing IoT and creating concepts in relation to elements inside that design space.

To that end, this chapter examines the Internet of Things in order to gain insight toward of what kinds of characteristics IoT devices have as a category, including form, color, and materials. After that, the IoT is discussed as operating in particular roles in relation to the overall network of devices. Then, the existing IoT is interpreted as sustaining a set of values through the design and implementation of the systems that comprise it. After that, the motivation and choices for an alternative Internet of Things is discussed, and a set of alternative IoT values are proposed and explained. This is followed by returning to the set of cohousing values first described in Chapter 3 to establish an alternative IoT ecosystem that is based in a specific kind of social and domestic context—this is the object ecology of "cohousing IoT."

Finally, this chapter describes the motivation behind two software-based "generators"—procedural tools for generating design ideas. These generators offer a means of exploring the object ecology of cohousing IoT from a machine perspective and serve as the sources for design concepts that have been refined into prototypes. These prototypes will be described more fully in the following chapter.

4.1 Approaching the Internet of Things

Like cohousing, The Internet of Things is another example of an ecosystem consisting of devices, values, and practices. It is a promising site to consider the interrelationship of interaction design, the roles that objects take on in domestic contexts, and how cumulative computational relationships might change or accentuate these roles in the future. In more and more homes, the Internet of Things is producing autonomous devices that take on responsibility for certain tasks. Designing artifacts that explore how these kinds of devices might both take part in and support domestic practices in broader kinds of homes is one way to better understand the capacity of these augmented things.

In order to design new devices that take part in a domestic Internet of Things, a survey of what the domestic IoT currently is like was performed in two ways. The first of these takes a sample of current IoT devices (as of 2015 and updated where applicable) and categorizes them by the role that they play in the home. Further, these devices are taken together as a group to identify design trends among them in order to help create new IoT systems and platforms that operate within the look and feel of the Internet of Things. The second survey was of industry whitepapers that describe both the marketing of and possible future visions for the Internet of Things (Table 2), discussed in more detail later.

Taken together, these surveys approach the Internet of Things as a phenomenon operating across three dimensions: What does an IoT object look like? What do the devices in it do? What values do the IoT support at present? Providing answers to these questions gives insight into what kinds of things are counted as members of the Internet of Things, what they can or could do, and how manufacturers of these systems articulate the present applications and future visions of what the IoT might become in the future.

These comparisons of physical attributes are based on a list of 25 IoT systems (Appendix A). These systems were analyzed to begin to understand what the Internet of Things offers. Aspects of these systems like their material qualities, price, manufacturer, year of production, their intended purpose, what data protocols they use to connect to one another, their sensor capabilities, what kinds of actuators they have onboard, and so on provided a means of comparing fundamental qualities across a broad spectrum of IoT systems. The goal of this comparison was primarily to categorize and describe the kinds of technologies that make up the current Internet of Things, as well as to articulate the intended uses that link these different systems together into a broader set of objects and associated practices.

4.1.1 Material qualities of the IoT

The first way we can examine the Internet of Things is through the material qualities of the devices themselves. While whether a device is a member or not of the IoT is dependent on the networking and connectivity aspects rather than the design qualities of the object, there are distinct trends in systems that can be found. The material form of IoT objects project a specific mode of being technological through their shape, color and

materials. For example, below is the Samsung SmartThings Hub and several of the sensor packages that work with it to monitor a home:

Figure 23: Samsung SmartThings hub and various SmartThings sensors.

All of these devices are rounded rectangles made of white plastic that look like a bar of soap. This style might be paradigmatic in the Internet of Things and is not limited to Samsung's offerings. The EcoBee Smart Thermostat's remote, the Wink Hub, Nest's Protect, and Link Bulb are all similar in look and feel to the SmartThings.

Figure 24: From top left, the EcoBee remote, Wink Hub, Nest Protect, and Link Bulb.

Figure 25: Nest Thermostats. Top row, generation 1; middle row, generation 2; bottom row, generation 3.

It's clear from these examples that things on the Internet are expected to be white. This trend extends even to quite well-established IoT offerings, like the Google-owned Nest Thermostat. Over the course of its product iterations, it has moved from more traditional indicators of being "technology"—originally as a chrome-ringed black LCD display—to becoming available in more home décor-friendly styles, including more color options for the rings (white, silver, copper, and black in the second generation) and finally to offering a white LCD display in the most recent third version (2017).

As these technologies become more at home in the home, they have tended to become softer as well. Alongside the shape and color trends, there are certain materials that are becoming more and more prevalent in IoT design. While the Amazon Echo initially came in white and black, leaving no room to get paler, the shorter, squatter redesign in 2017 included new fabric and wood components that made the device more

appropriate for a living room or bedroom, rather than the harder, easier-to-clean plastic that made the Echo seem most at home in the kitchen or bathroom.

Figure 26: Original Amazon Echo, left, and 2017 redesign, right.

Part of this shift in material may be to keep up with other entries in the smart speaker category. Google Home, that company's entrant into the voice assistant category was on release available with fabric components and came in many different colors.

Figure 27: Google Home. In addition to gray, the fabric could also be red, teal, indigo, black, copper, and white.

This section has described the contemporary Internet of Things as with respect to its material qualities. For a system to be interpreted as being part of the Internet of things, the style of the object matters. In order for devices to fit into a home, and be legible as

part of a larger system of objects and practices, they need to follow certain styles that reflect both contemporary trends in the Internet of Things, as well as emulate the kinds of things that are already present. As the IoT has become domesticated, discrete trends have emerged that together establish a certain IoT "look." These are rounded corners, white plastics, softer, warmer materials like woods and fabrics, with electronic components hidden inside of casings. These trends create contemporary home technologies that are comfortable inside the home, replacing the boxes and wires that had been grafted onto it before.

4.1.2 Information processing

The second way we can understand the contemporary Internet of Things is by relating each system to what it is that they do with information. From this perspective, the systems become less monolithic in their applications and more interconnected as members of a home network. Approaching the Internet of Things as a way that information is collected, reported, and consumed emphasizes the material content that the IoT consists of—if things are on the internet and controlling bits of everyday life, then the substance that is being sensed and reacted to makes sense as a way of approaching what it does. This is important for designing new IoT objects as how they participate in the networks of other devices and objects is core to how an object ecology works in context.

What we see from this angle is that the Internet of Things is comprised of a hub-and-spoke system that takes information from far flung devices, processes them, and produces effects in other objects based on that data:

Table 4: Categories of the Internet of Things.

Hub	Input	Output	Input/Output	Other
SmartThings Hub	ecoBee Remote Sensor	Sonos speaker	Nest Thermostat	Cat Genie
Vera Edge	Nest Dropcam	Hue bulb	Nest Protect	Roomba
Harmony Hub Remote	SmartSense Motion Sensor	Link bulb	ecoBee Thermostat	
Revolv Hub	SmartSense moisture sensor			
Wink	SmartSense temperature/ humidity sensor			
Amazon Echo	SmartSense open/closed sensor			
Google Home	SmartPower outlet			
Apple Homepod	SmartSense presence sensor			
	SmartPower outlet			

Hubs connect various components together as part of a broader system of devices in a home, operating as a control point for them. Frequently, hubs also provide residents with services in their own right. An example of the first kind of hub is the Samsung SmartThings Hub. It serves as a kind of data clearinghouse and routing system for the sensors that its SmartThings offer. It provides web-based tools so that a homeowner can monitor the state of their home from their phone or desktop computer remotely. More recently, though, a new kind of hub has subsumed this inert, appliance style of IoT control system. Voice-activated assistants like Amazon's Echo, featuring its virtual

assistant “Alexa,” and Google Home, with its own voice-based assistant, offer features like timers, music, simple data lookups, and so on, while also providing residents ways to control items like smart lights and thermostats using their voice.

Another category of home device is *Inputs*. These are simple sensor modules that are deployed to measure a particular situation. The SmartThings mentioned above are a good example of an input. These include motion sensors, moisture sensors, temperature and humidity sensors, smart power outlets, an open/closed sensor, and so on. Together, these sensors are meant to instrument the home and provide total knowledge of its condition. This does not mean they are simply sensors—a SmartPower outlet provides electricity to whatever is plugged into it as well as reporting energy use to its hub. Inputs provide data to the system about the state of the environment. The ecoBee smart Thermostat uses inputs called Remotes to get a sense of different climate zones in a house. A different kind of input is Amazon’s dash button. These are placed in a home to offer quick ordering of products through Amazon where they are being consumed and eventually, replaced. Near a washing machine, for example, a Dash Button might be placed that orders a refill of laundry detergent when the current bottle empties. This is an example of a “hubless input,” where the hub equivalent is the remote server that Amazon controls. The Dash Button is interesting as it operates more as an instantiation of corporate infrastructure of shipping and logistics, rather than a domestic input technology that is designed to be legible and controlled by the user to effect some actuation in the home.

Outputs are ways that data or information can be expressed in a system. Examples of IoT outputs are the Philips Hue system of smart bulbs, that lets a resident set exactly

the color and brightness that they want for a space from their phone, or even to program different settings based on particular conditions. The Sonos smart speaker, similarly, can be controlled from the internet to play sounds from multiple sources. As the physical means of expressing system data, outputs act as translational objects between the information streams that, to the IoT, describe the home and the home itself.

A broad category of devices, *inputs/outputs* combine aspects of both inputs and outputs in a single device. Two of these are the Nest Thermostat or Nest protect, a smart smoke and carbon monoxide detector each mentioned above. The Thermostat is accessible from the internet and promises to help homeowners reduce their energy use over time, saving both the planet as well as on their energy bills. It does this by learning resident's daily patterns and schedules over time in order to build a model of their lifestyle and operates more efficiently by coupling heating and cooling changes to these patterns more closely than a person could do. The "smartness" of the Nest and other IoT devices like it comes from sets of algorithms that operate in concert to develop rules to describe larger events in the world. As it "learns" the behavior of a home's residents, the Nest and other IoT devices in this category exemplify the promise of ever smarter algorithmic ways to make everyday life easier, and more automated while being more responsive.

Finally, while this is not necessarily a category of device, the software that operates these systems, their standards and interoperability can be taken as an integral part of each platform. Here, the protocols that connect Hue Bulbs to their base station, or SmartThings to the Smart Hub mean that each of these systems operate inside of a walled garden, fiefdoms inside the home. Larger technology players in the IoT space, including

Apple's HomeKit, Amazon's Alexa SmartSkills, and Google's Actions offer APIs that access aspects of each of their software frameworks.

This perspective offers a way to categorize IoT objects based on the role they take on as members of a smart home network. It helps to make clear the relationship of the device to other members of the network, and it means that newer or emerging members of the Internet of Things can be interpreted quickly as one of these, establishing how they take part in a local object ecology. Hubs, inputs, outputs, I/O objects and the software that runs them are simple, but frame a relationship between objects and devcies in the home that might demystify some of how the IoT is represented. This perspective also makes clear when devices may not make much sense, at least so far. An Internet-connected coffeepot, often rendered as part of the prophesied smart home, from this perspective is just a simple output—not very different from a Hue bulb—that produces coffee based on a signal from the Internet. What distinguishes the Internet-connected coffeepot from the more standard programmable version is that the IoT offers the opportunity to control the coffeepot based on an arbitrary input.

4.1.3 Interpreting the IoT's values

The final way to approach how the IoT operates is to articulate what kinds of values the Internet of Things promises to support. Because the rhetoric of the IoT is so pervasive and all-encompassing, being able to articulate the values that it supports—alongside that those that it does not acknowledge or rejects outright—offers a starting point to do design work that supports new and different kinds of users. In order to understand how the IoT was being positioned by companies manufacturing devices, 11 whitepapers were reviewed and analyzed, as described in Chapter 2: and listed in Table 2.

These whitepapers were interpreted using grounded theory (A Strauss and Corbin 1994) to generate a list of values that the contemporary (and perhaps imagined future) IoT supports from the perspective of the companies actually designing and building technologies. The whitepapers range from consultant-led speculation about how to position a business to take advantage of a looming market opportunity, to offering better understanding of what the potential of machine to machine (or M2M) communication could be, to issues that the Internet of Things might compound or exacerbate. What they had in common was an orientation toward the future that spoke directly to the promise of what the IoT had to offer, as well as the certainty that it would be coming, for better or for worse. Reviewing the whitepapers and extracting themes led to particular ideas appearing often across the documents. These themes were clustered and organized to produce codes that correspond to 22 values built into the contemporary IoT:

Table 5: The values of the contemporary Internet of Things.

Analytics
Connectivity
Convenience
Control
Data-driven decision-making
Decentralized intelligence
Digitizing the physical
Efficiency
Makes the internet sensory
Managing
Measuring
Monitoring
Operationalizing
Computers in your home
Productivity
Profitability through ubiquity
Safety
Security
Time-saving
Transformational
Tracking
User autonomy

22 codes, corresponding to the values of the Internet of Things emerged using this method. A full description of all these values can be found in Appendix B: IoT A Values. These are a varied set of terms and run the gamut from straightforward and legible goals for technology use in the here and now (such as convenience, control, and efficiency) to more ambiguous ideas about the overall intentions that operate through these technologies (operationalizing, data-driven decision-making, making the Internet sensory) to more abstract ideals that might come in the future from broad application, acceptance, and uptake (transformational, profitability through ubiquity, digitizing the physical). At their core, though, these values reflect some of the basic assumptions of

what the Internet of Things does at the most fundamental level. Connectivity, for example, is the basic premise of the IoT. Various devices and objects are connected together using networking and sensor technologies, with side effects that track and measure what happens in the home. This can also be interpreted through the hub-and-spoke framing from before. On the input side, IoT devices *monitor* what is happening in the home, *tracking* and *measuring* what takes place inside of it. Hubs (or more properly, the Internet servers that run the software that powers them) *manages* these devices with goals towards producing *convenience* or *efficiency*. To enact these goals, Outputs *make the internet sensory* by changing heating systems, say, or playing a requested song.

Together, these values describe the Internet of Things as a constellation of devices that impose a specific vision of the future on the home. There are downsides to this vision, to be sure: the IoT's value to device-makers derives from consumption and the concomitant ecological impact; coupled with an extractive mentality around data practices and monetizing everyday life. But there are also some upsides as well. Whether they outweigh the cost of inviting these objects into the home is a personal decision, but the uptake of home IoT products reveals that many people find this tradeoff acceptable. In 2018, Smart home product sales are expected to total $4.5 billion this year, a figure that is up 34% from 2017, according to the Consumer Technology Association[8]. The growth of this sector means that it's all the more important to examine and understand what is going on in this space.

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[8] https://www.usatoday.com/story/money/2018/02/28/alexa-need-everything-voice-shopping-becomes-common-sales-through-amazons-alexa-others-could-reach-4/367426002/

These values provide another way to interpret the list of Internet of Things technologies from before. It stands to reason that each of these devices, to varying degrees, enact these values through their design and use. In order to compare the IoT systems, their compliance these values were rated by the author on a scale of 1 to 10 (Appendix B: IoT A Values). This rating became the genesis of a series of design exercises aimed at building a richer understanding of the IoT to gain inspiration as to how IoT devices are designed and operate to support these values. The ratings reveal some insights as to the design qualities and roles for IoT in practice. This table shows the degree to which these devices manifest these values. However, this mode of representation does not always make it clear what devices are particularly strong in which areas.

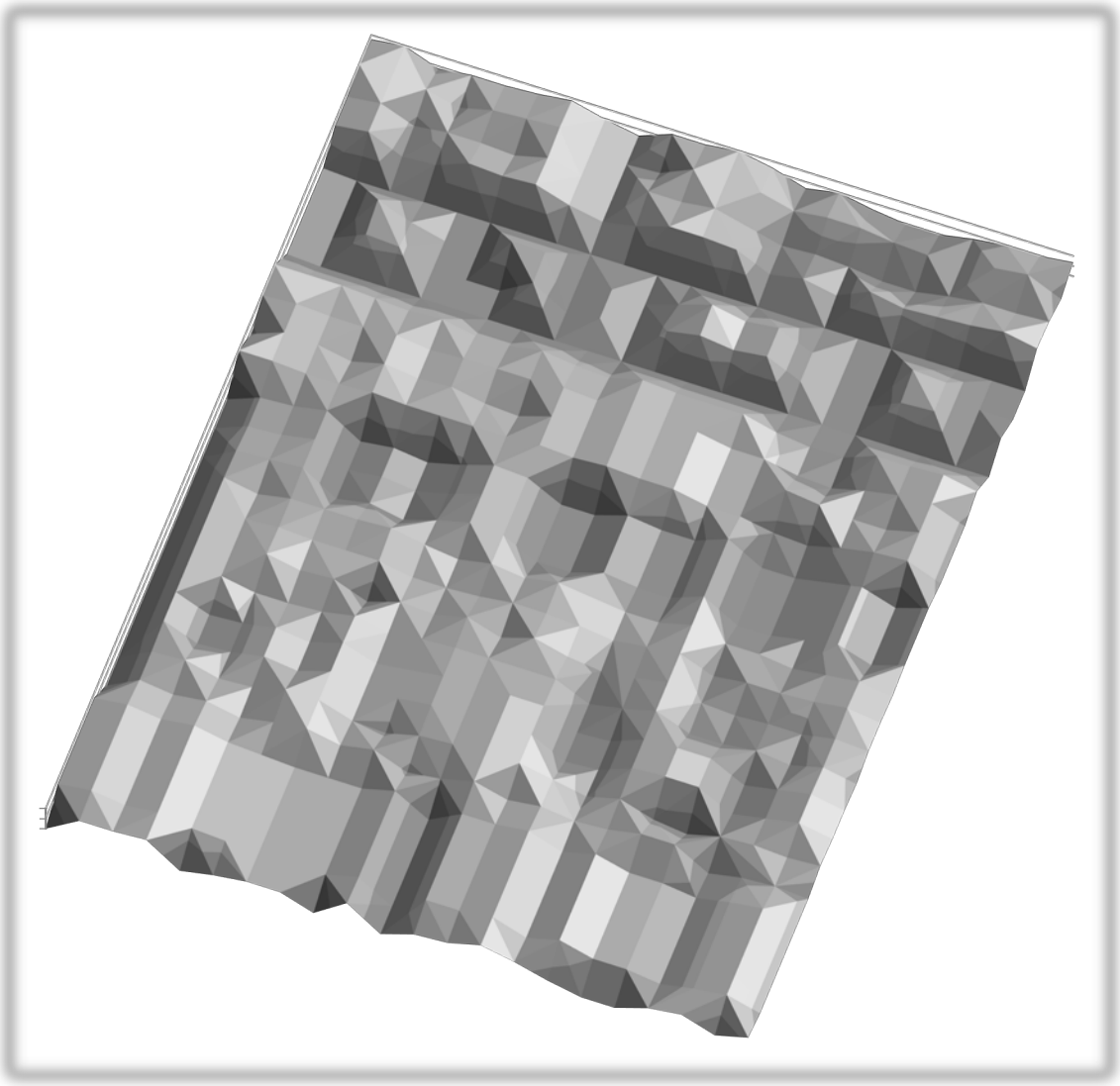

Figure 28: IoT Values represented as a surface

Figure 28, above, plots these numerical values as a surface, revealing highlands and lowlands that correspond to devices that very much exemplify the contemporary Internet of Things, like the "hub plateau" at the bottom, or the mountainous smart thermostat range at the top of the image. Likewise, we see valleys of devices that in some ways are "less IoT." The outputs create a trench in near the upper third of the surface, for example, as do the Cat Genie and Roomba above those, both devices with little connectivity.

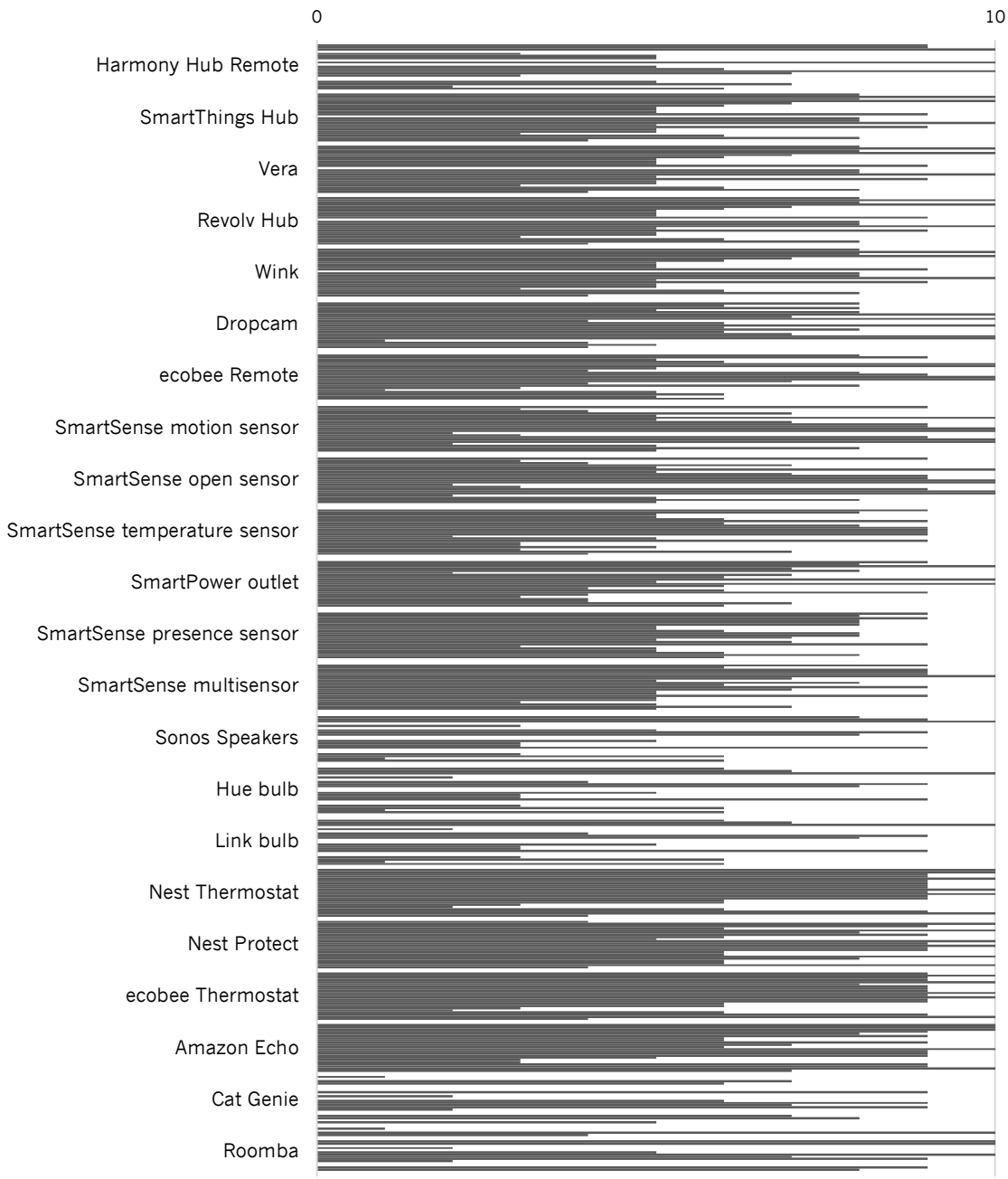

Figure 29: "Density" of IoT Values on a device basis.

Another way to chart these values is as a line graph whose density reveals the relative degree to which various Internet of Things devices are enacting them. In Figure 29, it's especially clear that the Nest Thermostat, Nest Protect, ecobee Thermostat, and the Amazon Echo are, broadly speaking, are the "most IoT" objects in this list. On a

surface level, they have the highest scores most frequently and embody most clearly the rhetoric and promises of the Internet of Things. This result isn't surprising, but it does make it clearer that some of the systems that are taken as exemplars of the Internet of Things, notably the Sonos speakers, and smart light bulbs like the Hue and the Link are not producing these IoT values so resoundingly. These devices work as pure outputs, from the framing above, and reveals that the set of values gleaned from the whitepapers privilege inputs over outputs—the sensing capacity is more easily related to other ideas like security, measuring, and monitoring, for example.

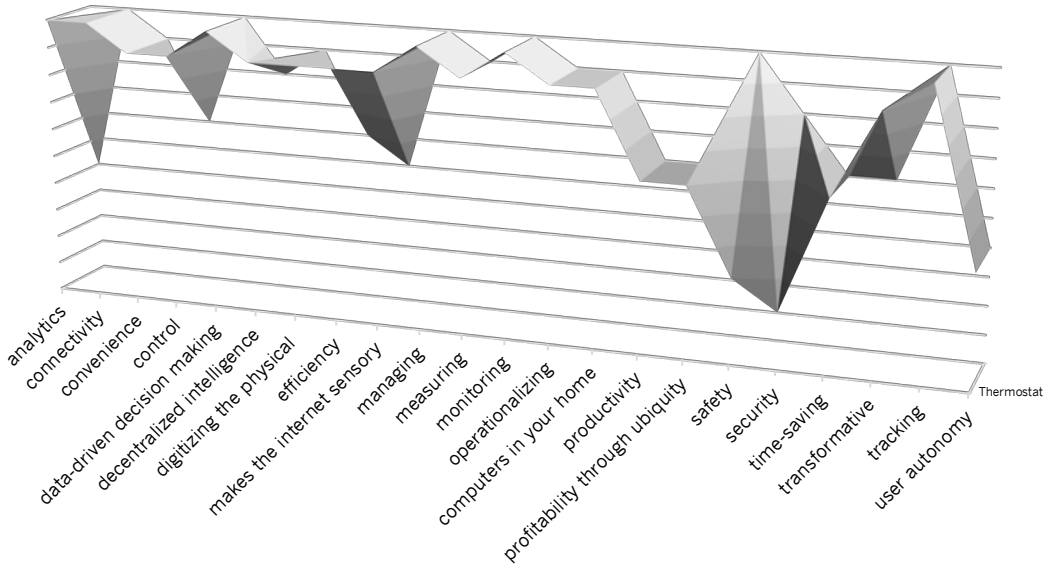

Figure 30: Comparison of Nest Thermostat to Nest Protect.

This promise of the IoT can also be compared across systems using these metrics. In Figure 30, the Nest Thermostat, a learning thermostat, is compared to the Nest Protect, a combination smoke and carbon monoxide sensor. While these two devices are quite

similar across many of the values, they differ substantially in *analytics*, *efficiency*, *making the internet sensory*, *safety* and *security*. This difference reflects the disparate applications for each of these devices. Both are part of a single vision of a smart home. The Nest Thermostat is designed to build an HVAC model of the home and find efficient ways to meet resident needs, while the Nest Protect is built purely to monitor smoke and carbon monoxide in the home, reporting their presence audibly as well as via emails or SMS. This process of exploring how the IoT values work across and among existing IoT systems has been useful to this research project in helping to conceptualize how IoT products operate. Combining the information-based analysis of the IoT from above with a values-driven approach offers insight towards designing now IoT devices. IoT systems emphasize certain values that motivate their use—-one of the major implications of this is that things are purpose driven, and that different applications are distributed into different specific objects. These devices are also contextualized in the relation between and among them, meaning that their vision, values, application, and how they are interpreted and represented become linked together as members of a domestic object ecology.

4.1.4 Designing in the IoT

This section has used three perspectives to consider the Internet of Things, focusing on the material qualities of objects and devices, how they relate to one another in terms of information processing, and finally the values that devices like these support in use. The rhetoric of the IoT comes from a combination of its physical characteristics and promises made by manufacturers in marketing materials—schematized here as the values of IoT. This imaginary of the Internet of Things is not the only one that can exist, though. There is an opportunity for design to create gaps in this vision of what the IoT

can be and offer something different that might fit in its place. So far, the Internet of Things looks a certain way and does certain kinds of things in service of specific goals. These goals are not the only one that they might serve, though. Speculating about what might exist alongside or in opposition to established schemas for the IoT is a core part of this project. The next section describes a set of goals in conversation with the IoT values from before that establishes an alternative agenda for the Internet of Things.

4.2 Towards a Speculative IoT

4.2.1 Modes of speculation

In imagining a different kind of Internet of Things, two diagrams illustrate the thinking that informs this project. In Chapter 1.5.5, Dunne and Raby's *PPPP* showed a way to think about the future as consisting of the possible, the plausible, the probable, and the preferable. These lie in narrower and narrower bands inside one another with the range of preferable futures jutting out as something to be curated through thoughtful design. That there are many possible Internets of Things—across various futures—that are in conversation with and responsive to many different issues and perspectives is implicit in this idea. Choosing what is "preferable" among this set is the role of the designer, as what "the future" looks like is distinct and specific to individuals. The orientation that they bring towards what kind of future is desirable, or what kinds of technologies that a designer believes is preferable means that an idea of "futures" is always rooted in a particular perspective.

Figure 31 is another rendering of the futures cone from *PPPP* but illustrated as the light that is thrown from a flashlight: the hand that holds the flashlight chooses what kinds of futures to illuminate and selects what kinds of futures should be examined:

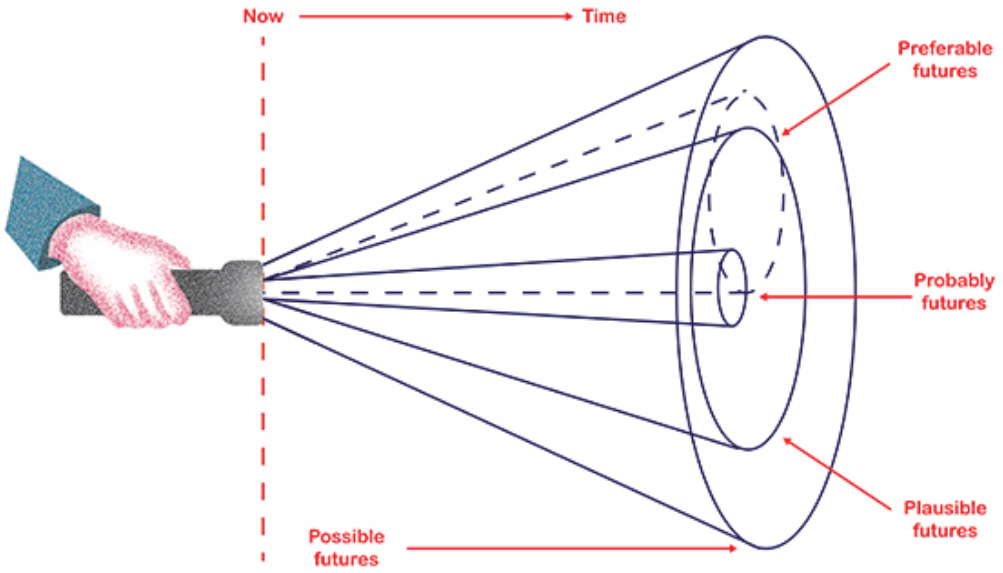

Figure 31: Futures cone as coming from a specific perspective (image via http://www.nesta.org.uk/).

The other way to think about this mode of speculation is as articulating alternative *presents* rather than alternative *futures*. In his paper *Speculative Design: Crafting the Speculation*, James Auger offers methods and strategies for both thinking about and doing speculative design work. One of the issues that he has with the term "speculative design" is the implicit orientation of the word "speculative" as being invested with futures—in most cases, speculating as to the condition of something is inherently invested in what it might be like in the future. For Auger, speculative futures extend contemporary trends to imagine what they could be like in the future, in some ways similar to *reductio ad absurdium* for design. Alternative presents, however, "are design proposals that utilise contemporary technology but apply different ideologies or configurations to those currently directing product development" (Auger 2013). In Figure

32, Auger's chart of how alternative futures are generated illustrates the process for imagining these alternative presents by re-narrativizing a process of domestication for technologies in the past that get us to a different "now."

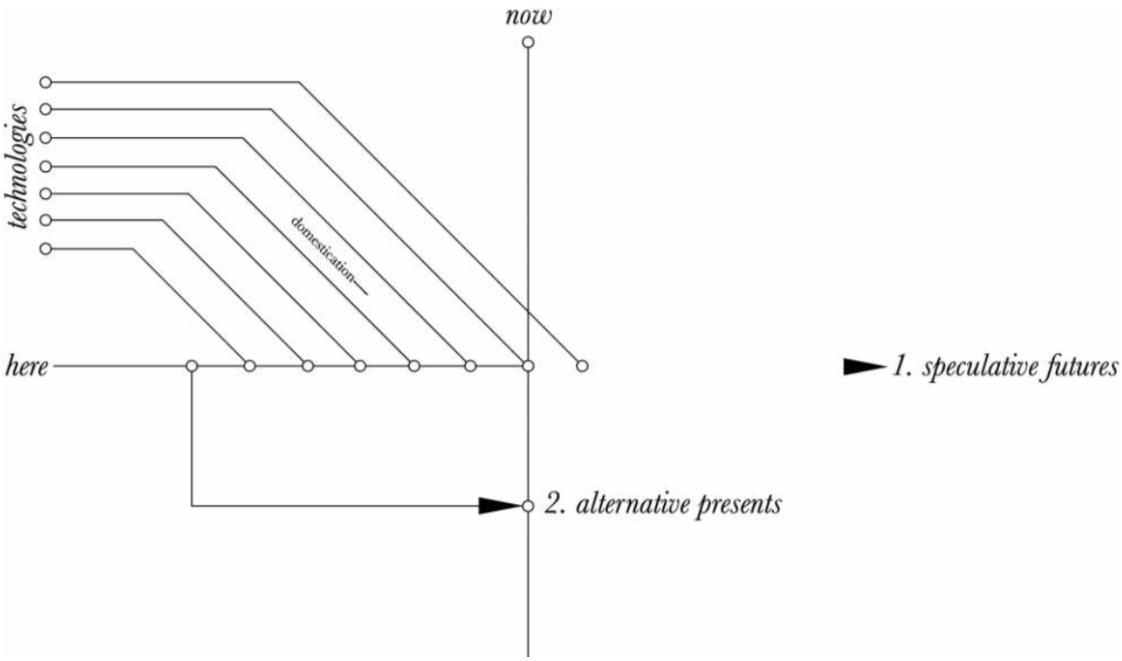

Figure 32: Building alternative presents (from Auger 2013)

This approach to speculation as a technique for design fits the goal of the project better than imagining the implications of current technology drawn through to various conclusions but is of course still rooted in a particular perspective. The Internet of Things as it is used currently is only one of a number of instantiations of networked objects that is possible, across any number of configurations. Rather than working inside the definition of IoT that is well known, an alternative IoT is a new present that takes a point of view to build a different agenda into a reimaging of today's technology.

As described in Chapter 1:, the complexity of object ecology means that it is impossible to know the design space in its entirety. For this reason, speculation becomes

an essential component of any design work done in this project. Speculation provides a means to consider what is happening across various objects in an ecosystem, as well as a way to create boundaries—to claim for a particular case that these things matter while other things don't. Selecting what matters while designing in an ecological frame means pruning possibilities to choose futures that resonate with a particular context and perspective. In this project this perspective is based on an individual designer's point of view that is invested in articulating alternative technical practices while remaining within established system of people and things—namely cohousing and the Internet of Things. The concept of the object ecology is useful in revealing the edges of the Internet of Things: through understanding the component parts in this broader material way, it's possible to draw together how objects and the relationship between them create and sustain novel social arrangements. Likewise, cohousing is itself a structured social arrangement that offers a context for designing objects that play a role in this social world. The role of the designer in this project, then, is selecting issues that matter to both cohousing and the Internet of Things and producing designed artifacts that articulate a different way of thinking about these relations.

4.2.2 Alternative IoT Values

Imagining an alternative present comes from internal responses on the part of the designer, invested in thinking about different orientations, ideologies, and configurations for the Internet of Things. In this case, the author reflected on the 22 values of the contemporary become to produce a new set of ideals that try to set a different agenda for what the Internet of things *might be* in an alternative present. Inspired by Dunne and Raby's *A/B* described in the previous chapter, where the goals and outcomes of normative

design objects and practices became countered by practices rooted in a more critical perspective, each of these values became inspiration for another set of values from a more critical point of view that describes an alternative IoT that is intriguing and appealing from a design perspective.

Here, the goal is not to counter the more normative values of IoT outright, but instead try to articulate a realignment towards this technology that might help to create a different kind of Internet of Things, one that puts people and things on a more equal footing. This IoT is invested in device collaboration with people, not subservience to their needs. Could different aims or perspectives create things that are more agentic? How might people learn to live with devices as partners in their everyday lives? What kinds of values could be supported that the Internet of Things might be currently eliding?

Table 6: Alternative values for the Internet of Things

Intuition
Distinctiveness
Willfulness
Abdication
Emergent consensus
Cumulative wisdom
Supporting the ineffable
Leisureliness
Making sociality physical
Delegating
Reflecting
Participating
Interpreting
Collaboration across space
Playfulness
Site-specific utility
Freedom
Semi-permeability
Time-sensitiveness
Being supportive
Forgetting
Object autonomy

As above, a full description of these values can be found in Appendix C: Values. Taken together, these values describe a different relationship between the various objects in the IoT. Rather than acting in service of human goals such as efficiency or convenience, this IoT is composed from devices that are meant to actively *participate* in the home: it imagines devices that are *willful* and may collaborate only on their own terms, exhibiting agentic behavior or *object autonomy*. In addition to a different perspective on the devices' social role in the home, the goals of this IoT are different as well. *Distinctiveness* and *site-specific* utility portray technological relationships that are

local and rooted in particular domestic practices that might not make sense in other households of different types; rather than making information from the Internet physical, this IoT looks to create *physical representations of social worlds and social life* in order to provide residents with opportunities for *reflection* and *interpretation* rather than being simply more convenient.

Table 7: Table 7: "A" and "B" Values for the Internet of Things

A	B
Analytics	Intuition
Connectivity	Distinctiveness
Convenience	Willfulness
Control	Abdication
Data-driven decision-making	Emergent consensus
Decentralized intelligence	Cumulative wisdom
Digitizing the physical	Supporting the ineffable
Efficiency	Leisureliness
Makes the internet sensory	Making sociality physical
Managing	Delegating
Measuring	Reflecting
Monitoring	Participating
Operationalizing	Interpreting
Computers in your home	Collaboration across space
Productivity	Playfulness
Profitability through ubiquity	Site-specific utility
Safety	Freedom
Security	Semi-permeability
Time-saving	Time-sensitiveness
Transformational	Being supportive
Tracking	Forgetting
User autonomy	Object autonomy

4.2.3 Designing alternative IoT

These values, both A and B begin to define a design space for what the Internet of Things currently is as well as what the promise of the Internet of Things might become.

However, as a design project, these values are operating in a vacuum: These ideas need to be located in a particular site in order to produce design work that is compelling and contextual.

4.3 Cohousing as a venue for IoT

Cohousing provides a venue for this speculative IoT, offering a real-world location to consider the implications of a new imaginary for the Internet of Things. As a realization of speculation-in-living, cohousing offers a unique venue to consider what this kind of alternative, speculative IoT might be like in practice. A collaborative living space that operates both as a community and a home, with organizational concerns, strong value-laden practices, distributed political management, and semipermeable boundaries between private homes and public life offers a rich, multivalent site to think about what the role of smart technologies could be.

The networks that are created among and between things as a material is a design resource for understanding how the Internet of Things makes social and cultural values manifest. What kind of networks matter to the Internet of Things? Networks themselves can be considered as a kind of design resource that illustrates how there is more than one kind of connectivity possible. Cohousing is a different network that exists between people already, in an alternative configuration of domesticity. In the introduction, cohousing was discussed as a distributed community—it shares one home across multiple houses. As such, the opportunities it has to design IoT will be different than the ones that have been designed for single-family homes like the "IoT-enabled home" pictured below. An IoT designed for cohousing will take the community itself into account as a part of the material practices that are supported through technology. Further, it will account for the values of cohousing that drives the design and goals of living in community with one another.

Figure 33: Texas Instruments' "IoT-Enabled Home" (top) compared to a cohousing community (bottom)

4.3.1 Cohousing values in an alternative IoT

In Chapter 3:, cohousing websites' values and mission statements were analyzed to produce a list of values that drive cohousing. These are a set of ideals that cohousing is invested in. People choose to live together in order to foster these values among themselves and their neighbors. As described earlier, the design of the communities themselves differentiates cohousing from other kinds of residential developments. That these values can be supported through design is implicit in the architectural features of cohousing, like community-facing kitchen windows, or car-free internal paths that double as play areas. Just as these architectural features can support social practices in cohousing, interactive technology design can both articulate the values of cohousing and support cohousing practices.

Examples from Chapter 1: make it clear how interaction design can work to produce social effects in particular domestic contexts and among communities in a speculative way. The *Home Health Horoscope*, for example, was designed to re-imagine what processes and technologies might constitute environmental sensing and monitoring in a smart home (William Gaver et al. 2007, 2009). Instead of sensing residents and trying to predict their needs, the *Home Health Horoscope* kept a "fuzzy" understanding of what was happening around it. This work asks, "If we expand the data of environmental sensing and monitoring to include coarse, anecdotal, and abstract reporting, how might our desires for and expectations of future systems and processes change?" On a similar note, The *Presence Project*, modelled a design process where elderly residents become actively engaged in the conceptualization and specification of technologies to support their participation in community life (William Gaver and Beaver 2006). This prototyping of new social arrangements of things and technology was even more pronounced in Kuznetsov's projects authoring public spaces with sensors. These created new relationships between stakeholders that could lead to innovations in the use of data to support urban sensing and discussions around issues such as air quality (Kuznetsov et al. 2011; Kuznetsov and Paulos 2010b). Objects also take on some responsibility to support values in Pierce and Paulos' *local energy indicators*: they demonstrate a possible future—or alternate present—where energy concerns are so relevant in everyday life that local production is something that residents need to both attend to and materially participate in (Pierce and Paulos 2012b). The displays advance an argument that if energy issues were made more salient in everyday lives, how residents use and marshal a resource could be affected.

Cohousing can also use interaction design to help make more salient or visible the values of cohousing in things that participate in an object ecology. This set of 22 cohousing values—again, explanations are in Appendix C—drive cohousing as a practice, and provides a way to think about what the object ecology of "cohousing IoT" might be like:

Table 8: "A" and "B" Values for IoT, juxtaposed with cohousing values.

A	B	C
Analytics	Intuition	Affordability
Connectivity	Distinctiveness	Caring
Convenience	Willfulness	Community
Control	Abdication	Consensus
Data-driven decision-making	Emergent consensus	Cooperation
Decentralized intelligence	Cumulative wisdom	Diversity
Digitizing the physical	Supporting the ineffable	Education
Efficiency	Leisureliness	Family
Makes the internet sensory	Making sociality physical	Generosity
Managing	Delegating	Intentionality
Measuring	Reflecting	Joy
Monitoring	Participating	Outreach
Operationalizing	Interpreting	Participation
Computers in your home	Collaboration across space	Privacy
Productivity	Playfulness	Respect
Profitability through ubiquity	Site-specific utility	Responsibility
Safety	Freedom	Security
Security	Semi-permeability	Sharing
Time-saving	Time-sensitiveness	Simplicity
Transformational	Being supportive	Sustainability
Tracking	Forgetting	Efficiency
User autonomy	Object autonomy	Work

Juxtaposing these cohousing values with the values of both the Internet of Things and the values of a speculative Internet of Things produces a full design space to consider the nature of a speculative Internet of Things for cohousing that can be a site for interaction design. It combines a functional approach to *creating* IoT from the normative

values that currently defines the Internet of Things with an aspirational set of values that illustrate some of the *possibilities* of a more agentic and less operationalized Internet of Things. Finally, these sets of IoT values are sited in the values and goals of cohousing to define a design space in three dimensions: speculative IoT for cohousing. The three A, B, and C lists above are not meant to be exclusive, or the only kinds of values that might be relevant to an object ecology. As with Dunne and Raby's A/B "B was not intended to replace A but to simply add another dimension, something to compare it to and facilitate discussion. Ideally, C, D, E, and many others would follow" (Dunne and Raby 2014). While the A, B, and C, list above has grown slightly from representing modes of design, there could easily be a D list that examines in detail concepts and values derived from the perspective of device manufacturers, as these companies are certainly on the forefront of defining what the emerging IoT is. For the purposes of this project, though, the lists above, rooted in consumer products uses of these technologies (while incorporating interpretations of corporate practices) emphasize the end-user view of the cohousing IoT object ecology. Future work to include a corporate perspective would be very interesting.

4.4 Exploring this object ecology

Keeping the idea of design as a context to develop preferable futures in place, and coupling to it the concept of agentic IoT, one way to produce design concepts in this space was by using procedural techniques to generate concepts of what cohousing IoT might be like. This project has gathered information about what the IoT is materially, practically, and rhetorically, and has asked questions about what an alternative IoT might be like. This was coupled all of these with the of things, practices, and design attributes make cohousing work. The idea of using generators comes from the way that an object

ecology casts its contents as members of a flat ontology, systems of relations where no perspective is primary. Procedurally generating combinations of things puts items onto the same ground to consider possible relationships among them. This is important, because part of what defines an object ecology is lack of access to the entire contents of it. Instead, designers need to speculate about what might be there. However, this speculation poses a kind of paradox. How can a designer speculate to the contents of an object ecology without in some way taking on a perspective that privileges human input? For this project, generators allow us to partially sidestep that concern. While the concepts will always be a product of a human-based design process, the prompts and concepts come from random generation. From this perspective, the generators are necessary to take the materials generated during a design research process and flatten it to procedurally explore the object ecology.

One rationale to use procedural techniques to approach this design space was to help concepts remain defamiliarized (Bell, Blythe, and Sengers 2005): responding to combinations of things generated from scripts means that the designer's role is to place a set of concepts that may seem to be in opposition with one another into the domestic life of cohousing as a coherent idea. Using generators also help to fill in some of the gaps that Desjardins et al. identified as lacking in domestic HCI research. These, *a material perspective on the home* and *a first person view* on the home (Desjardins, Wakkary, and Odom 2015) are addressed directly in having computational systems provide fodder for design concepts. In designing agentic things that are inspired by generated concepts, this is a material perspective on design to be sure—a relational approach to the values of the IoT and cohousing through design. The concepts themselves come from the material that

is being designed around. Finally, this move is inspired by a very pragmatic aim: the idea of "cohousing IoT" is unusual enough that there is no clear move to begin to understand what it should be. Plumbing the depths of a design space is not always simple, and these generators offer a means of breaking that block and providing concepts immediately that can both inspire and refined into stronger work.

This project used two different kinds of software-based procedural "generators" to good effect during the course of the ideation phase of the project. The first generator produced catalogues of the things that comprise cohousing with an aim towards generating concepts through contrasting those things to one another. The second generator produced new sets of three values in relation from the list of IoT values, the alternative IoT values, and the values of cohousing. Each of these generators provided a way of gaining access to the broader cohousing IoT design space and offer a designerly way of obtaining inspiration about what cohousing IoT might be in practice.

4.4.1 Things of Cohousing

The first generator focuses on things that can be found in cohousing, and relates them to one another in novel and unexpected ways. Upon running, it constructs a set of devices that are common to cohousing. Understanding domestic life as comprised of objects, and as being built from everyday minutia that surrounds us means that one way to generate concepts for future designs is to reflect on those minutiae. Based on items seen in images of cohousing from fieldwork, domestic objects in general, and the A and B values for IoT, it assembles sets of things to describe what an ecosystem of cohousing technology might look like:

Cohousing is made of

Bills, mail slots, windows, WiFi, shirkers, couches, curtains, ovens

Peripheral cars, laundry, couches, carpet, bags, thermostats, public life, private life

Mail slots, developers, windows, legal frameworks, entertaining, trees, bylaws, collectives

The goal of these "litanies"—after Bogost's Latour Litanizer[9]—is to produce lists of things that are suddenly and inexplicably cast together to be considered in a cumulative way. These are things in the world that would not usually be considered in the same breadth, like mail slots and legal frameworks, or WiFi and windows, but somehow cohere to describe a thing through the confluence of them. This is one way to think about how devices and objects might play a role in the combined design space described by the value lists of A, B, and C. To push on this concept even further, all of the values from lists A, B, and C, as well as the list of Internet of Things systems were added to the list, which produces litanies of "connected cohousing[10]:"

[9] The Latour Litanizer can be found at http://bogost.com/writing/blog/latour_litanizer/

[10] The connected cohousing generator can be found online at http://cohousing.tech/value_ecology.php

Connected Cohousing is made of

Nest Thermostats, interpreting, Harmony Hub Remotes, telephones, emergent consensus, site-specific utility, SmartThings Hubs, and trust

Support, managing, earth movers, intuition, choices, safety, bags and SmartSense Moisture Sensor

Tags, measuring, collaboration across space, Dropcams, mortgages, Roombas, emergent consensus, and Amazon Echo

By producing lists of things in relation to one another in procedural ways, this generator served to attune the design process to some of the material participants of cohousing. In doing so, these generators began to describe the things that could be members of cohousing IoT, combining contexts, issues, and things in ways that were provocative and sensitizing to cohousing. The lists that this generator produced were interesting, and indeed seemed to describe some of the contents of a cohousing IoT object ecology, but did relatively little to inspire design concepts. To that end, a second generator was used to prompt design concepts based on the values of IoT, the alternative values of IoT, and cohousing values.

4.4.2 Values Generator

The first generator sought to present what constitutes cohousing in a flat way in order to inspire design concepts marked by things in relation to one another. The second procedurally presents variations across a design space that is defined by the relationship between the IoT values, the alternative IoT values and the values of cohousing. By

randomly selecting one value from each of the lists of A, B, and C, this generator phrases that describe IoT objects that might be native to cohousing IoT[11]:

IoT/Cohousing values generator

A	B	C
Connectivity	Freedom	Diversity
Digitizing the physical	Participating	Affordability
Convenience	Cumulative Wisdom	Sharing

Reading across the rows, these values prompt a designer to imagine systems that work to support these multiple values. These lead to concepts fairly directly. How does connectivity reflect issues like freedom or diversity? What kinds of systems could support participation in issues of affordability that digitizes physical things? How can sharing the wisdom of crowds make things more convenient? For this project, the values generators created 14 sets of terms that lead to design concepts:

[11] The values generator can be found at http://cohousing.tech/values/

Table 9: Cohousing IoT concepts from the values generator

01 Hyperlocal radio (connectivity/participating/collaboration)	**08 Emotional intercom** (analytics/semipermeability/responsibility)
02 Competitive energy use monitors (computers in your home/collaboration across space/sustainability)	**09 Coho.org** (connectivity/interpreting/choice)
03 Physical RSVP for common meals (convenience/makes sociability physical/ responsibility)	**10 Work monitor that doesn't hold a grudge** (tracking/reflective/work)
04 Committee process objects (productivity/makes sociability physical/responsibility)	**11 Github for bylaws** (connectivity/supportive/transparency)
05 Dashboard for resident statuses (monitoring/object autonomy/collaboration)	**12 Expert system for decision-making process** (data-driven decision-making/ abdication/intentionality)
06 Homemade sensor kits (computers in your home/supporting the ineffable/resident management)	**13 Organic farms/garden technology** (managing/site-specific utility/support)
07 Sharing economy within cohousing (tracking/collaboration across space/collectivity)	**14 Stranger detector** (safety/interpreting/trust)

Descriptions of these concepts and sketches of them can be found in Appendix C. Each of these ideas are built from a triptych of values terms that are imagined as an application of interactive technology designed specifically for cohousing. While some of these might be "more IoT" or "less IoT" than some of the devices discussed above, all of the concepts that come from this process are rooted in the rhetoric of IoT, alternative IoT, and cohousing. While the design ideas that come from the second generator inspire more fleshed out technology concepts directly, the first generator works in concert with them to sensitize the triptychs to cohousing. The three concepts with light gray backgrounds are

the ideas that were prototyped and implemented. The first of these is the *Hyperlocal Radio* concept. This concept was selected because it offered a different kind of participation in cohousing life. Cohousing offers a connectedness through proximity that leads to social outcomes distinct from other styles of living. Considering a technical implementation on top of this sociality means that other, less physical modes of participation could apply. This concept also offered a means of thinking about how this participation might foster collaboration around community issues. The *Energy Babble* project (William Gaver et al. 2015) used a similar audio-based domestic technology to prompt residents to reflect about energy consumption in the home, and build community around a common issue. One reason that a local radio concept was selected was to see what kinds of issues might be important enough to cohousing communities to utilize a new format of communication.

Figure 34: The Energy Babble.

The second concept chosen to be refined into a prototype is the *Physical RSVP*. This concept was produced by the generator but also resonated with interviews and site visits regarding the frustrations that organizing groups of people could be. In visits to communities, most of the means of organizing one-off events were decidedly analog and

relied on materials like physical tags or bulletin boards to establish participation (Figure 35). That figure shows ways that Lake Claire Cohousing uses physical objects to organize residents, incuding tags to mark property during a cleaning-out session of shared storage space (left), a way for the community to vote on spending for an upcoming budget (center), and a bulletin board that includes a "sound-off" area for residents to express themselves (right). Interaction design prototyping means that these kinds of physical traditions can be merged with digital technologies, and that speculative IoT objects could take on some of the responsibility for managing and keeping track of organizational needs like these around living and making decisions together.

Figure 35: Physical systems used for community organization at Lake Claire Cohousing.

Finally, the third concept chosen for refinement into a prototype was the *Work Monitor*. This concept came from the generator, to be sure, but was also inspired many interviews during the data gathering phase of this design research project. In most cohousing communities, members are expected to contribute to the labor of maintaining a community by participating in a set number of work hours every month. This work is varied, and can consist of working in community gardens, or preparing and washing up after common meals (Figure 36). These work hours are often a subject of anxiety or stress for residents, and this goes both ways—some residents are worried that they do not do enough work to be fair to other members of the community, and others worry that other

residents don't do enough work to be fair to other members of the community. In considering a system around this issue that could be used to help maintain the social goals of cohousing, the idea of not having it be doing overt record-keeping was necessary—here corresponding to the idea of "keeping a grudge". This prototype offers a way to think about how personal labor vs collective labor is managed in cohousing life.

Figure 36: Work assignments at Ann Arbor Cohousing and examples of work in cohousing.

4.5 Conclusion

This chapter outlined the relevance of a values-driven, ecological approach to design for this research project. It describes in some detail the values that are being built into the contemporary Internet of Things, it examines the material qualities of the Internet of Things, the roles that IoT devices take on in their domestic contexts, and illustrates through design materials and exercises the relative amplitude of these values as materialized by objects in the contemporary Internet of Things. It then proposes an alternative set of values for the Internet of Things that operate in response to the first set of current IoT values. This speculative Internet of Things has different sets of motivations and goals that speak to the "liveliness" of IoT objects—the IoT is autonomous and active but is rarely treated as such. Here, they are taken as agentic, motivated things that work in concert with residents to achieve goals together. Finally, this chapter takes cohousing values from Chapter 3: and situates them as a context for new Internet of Things

technologies in order to firmly root new design concepts in the lives and goals of cohousing. Joining cohousing values to Internet of Things values and alternative IoT values creates a specific object ecology for this design research project to explore using research through design. In order to generate concepts rooted in the flat ontology that is native to the object ecology, procedural generators were used to create design concepts that speculate as to the possible contents of the cohousing IoT object ecology.

In general, Internet of Things devices look a particular way, operate in relation to other devices in a certain way, and support particular values. In considering what Cohousing IoT might mean, the contemporary IoT design space has had other values and considerations grafted upon it, and fourteen ideas that explore this space were generated. Three concepts: a *hyperlocal radio system* for cohousing, a *physical RSVP system for community meals*, and a *work monitor that doesn't hold a grudge* were selected to be prototyped at a higher fidelity to bring to communities. These prototype concepts are useful to think through possible technical futures with because they use IoT concepts to push on the edges of what works in cohousing—and simultaneously explore the concept of a cohousing IoT. They are discussed in detail in the next chapter.

CHAPTER 5: SPECULATIVE DESIGN FOR COMMUNITY LIFE

Research through design, as described in Chapter 2:, is a mode of design research where knowledge is built from designing and constructing artifacts that can provoke or assert new visions of contemporary design spaces. The prototypes created as part of an RtD process become materials that instantiate theoretical concepts in themselves. In this case, a series of prototypes are designed to argue for alternative visions for the Internet of Things that moves away from currently-dominant domains for technology like security, management, or efficiency. In addition, this idea of an alternative IoT is the idea that these prototypes take on a role in the life of the community, operating not just as mediators for human agency, but also as agents in themselves that support, sustain, and create the values that cohousing communities are committed to. From this perspective, designing and building these prototypes is at the same time building community—the prototypes support certain community actions, and play an active part in the construction and sustaining of community life. The prototypes—a community-based radio system, a platform for RSVPing, and a way to reflect on community participation—serve to reframe the constraints and parameters that surround issues of cohousing, while simultaneously proposing new opportunities for community and device collaboration. These prototypes represent speculative investigations into the cohousing IoT object ecology. They are procedurally generated concepts that relate cohousing goals, alternative visions of what the Internet might become and the contemporary materials, practices and rhetoric of the Internet of Things to create propositional artifacts that take on some of the responsibilities and structure of life in cohousing.

5.1 Speculative IoT

Designing for the IoT provides a means to examine how the computational relationships between things operate to produce social effects in domestic settings—how devices take part in an object ecology. The IoT relies on and generates infrastructure, but in the nascent product space it occupies, it is *proto-infrastructure*. Among others, Star notes that "infrastructure" has characteristics of transparency, standardization, being built from an installed base, and that it only becomes visible on breakdown (Star 1999). In an environment where domestic IoT is currently contested and partial as multiple companies develop their own proprietary hub and spoke systems, the IoT is gesturing towards becoming infrastructure. It is assembling complex mixtures of standards (Wi-Fi, Bluetooth, electrical power), and practices (APIs, use cases, consumer demand, and investor responsibility). Presently, we can see multiple aspects that construct the contemporary IoT: it is simultaneously a site for contestation regarding what "home" can and should mean, a corporate battleground for future influence, and a *design thing* (Binder et al. 2011), that is being performed by residents, enthusiasts, and designers. More and more often, the Internet of things is creating the design thing as *proto-infrastructure* (Jenkins 2015b). From a design research perspective, prototyping speculative devices for the Internet of Things serves to reveal the unrefined "edges" of the present IoT. By articulating the IoT's component parts and their assumptions as representing assumptions about future infrastructure, it becomes possible to examine their implicit social relations and value propositions before they become invisible.

Prototyping speculative technological systems creates new configurations of infrastructures and materials. These prototypes generate new contexts for existing

products and services as well as new understandings of how they might operate in different social worlds (Anselm Strauss 1978). In this way, technology prototyping instantiates new arrangements of social forces, and not simply objects in themselves (DiSalvo et al. 2014; Jenkins 2014, 2015a). These prototypes are part of a long line of HCI technologies that are aimed at developing richer social connections in the home. These including using techniques like habituation and ritual to produce connection between geographically distant kettle users (Ambe et al. 2017), tablecloths that leave traces of domestic activity (William Gaver et al. 2006), fostering visibility for elderly residents of a housing project (William Gaver and Beaver 2006), and providing a venue for community narratives to be both recorded as well as travel through a deprived community (Crivellaro et al. 2016). In a similar vein, these three prototypes, described in detail below, instantiate a different cultural imaginary for the Internet of Things in order to explore cohousing's human, social relationships with proto-infrastructures as well as the community-driven domestic life that they are a part of through a process of speculation in materials (Wakkary et al. 2015).

5.2 Design prototypes

In order to see how cohousing communities might see smart home technologies as something that can be used to support the social life of their communities, three prototypes were designed to specifically support cohousing values and practices. After DiSalvo et al (DiSalvo et al. 2014), and building from Latour (Latour 2004), these prototype objects articulate "matters of concern" that are important to cohousing, and together, they help to define a public invested in those concerns (Jenkins et al. 2016). As described above, these three prototypes are the result of a design process with a public

orientation (DiSalvo et al. 2014). This means that the prototypes work to support a cohousing public—they provide material scaffolding to support the construction of this public around the issues that matter to cohousing residents. These scaffolds support knowing a condition by experiencing its qualities in a new way, in this case built from workshops that provide residents an opportunity to approach the material conditions of computation and sensing rooted in their own lives and personal experiences.

The three prototypes here operate at the edges of the currently-existing smart home and provide an opportunity to do design work that helps us to understand the social role of technology in spaces like these. This process articulates the components of this network of people and things in a broad, material way, and emphasizes how objects and the relationship between and among them might help to create and sustain community life. The three prototypes are a radio system, built to connect residents together in a subtle, private way; an RSVP platform that links physical and digital worlds together around issues of participation in cohousing events; and a set of scales that foster an opportunity to reflect on an individual's participation in the cohousing community at large.

5.2.1 Cohousing Radio

> *Robert has been a resident of cohousing for a few years now. At first, he didn't really know what to expect in his new community—for him, the biggest appeal was how inexpensive the homes were compared to other standalone houses in the neighborhood. They're smaller than average, but the social amenities more than make up for it, he's found.*

Ready to start his day, he heads downstairs, sets up the coffee pot, and taps his cohousing radio to listen while it brews. The radio is an interesting way to keep up with the community's musings and goings on, he finds. Residents send sound clips, music programs, or notices to an email address, and the files are queued for broadcast to devices like these in every home. Frequently funny, sometimes cute, often informative, Robert appreciates the link it provides to his community.

Figure 37: Cohousing Radio

In a way, this concept finds its genesis from the ideals of cohousing not quite panning out for one relatively new resident. The promise of living together was appealing, but in practice there was perhaps not as much social interaction as she had expected:

I wouldn't say I'm best friends with anyone here. It would be cool to be even closer with some people, like to hang out more often. There's

one person that I kind of hang out with regularly, we have wine, but it's hard. We're all so busy. I think that's the one thing. It's like you kind of imagine that we're all going to be hanging out every night, but we're so busy. Everyone's got a zillion other organizations that they're parts of, so there's not as much time for us to socialize together as ... It also just takes a little bit of legwork. Like, someone's got to have the idea and make it happen. It's easy to sit back and like, not make it happen.

The goal of this system is to help residents feel more connected to one another even when business gets in the way of intentionality. *Cohousing Radio* (Figure 37) is built to connect residents in cohousing in an informal and passive, asynchronous way using audio sent to devices placed in the everyday domestic life of cohousing. This prototype system imagines each cohousing residence has a small radio placed in the home. Residents can use this device to send audio files to all the other members of their community. Inside the radio housing is a Wi-Fi-enabled Raspberry Pi Zero driving an amplifier connected to an external speaker. Residents send audio files that they create to an email address, and a script on the server adds the music file attachment to an internet radio station's playlist. The radios are tuned to that station and play what they receive over the air. The prototype can then queue announcements, music, or shows that residents create into the homes of all the other residents in the community.

This radio prototype is designed to create an ambient understanding of the social life of cohousing through creating, sharing, and listening to short audio programs. These are meant to connect residents together in a new, subtle way that would not otherwise be available before the radio was in the home. The asynchronous nature of the system means

that it provides an opportunity for residents who can't always schedule time to meet face-to-face a way to feel more connected to one another outside of more traditional or sanctioned events. In this way, the radio offers residents a hyperlocal "backchannel" to share bits and pieces of their own lives that might using existing channels. This concept builds on top of other modes of communication that can be found in current cohousing communities. For example, at one cohousing community in Atlanta, Georgia, USA, residents have a monthly "stick-passing ceremony" to discuss issues and experiences, both good and bad, with the broader community. One resident describes this ceremony: "You can share joys, concerns, things going on in your life and anything that's bothering you, or things you're really happy about, and it's just connecting with one another and sharing what's really going on that you might not bring it up in conversation over dinner." The radio provides a community channel for things that are different than lighthearted dinner conversation or the more formal discussions that already have ongoing venues. *Cohousing Radio* offers a way for residents to share personal creative projects like songs or poems, or enthusiasm for old jazz LPs in a casual way that fits into other domestic activities such as preparing morning coffee or doing the dishes. This prototype explicitly seeks to support new relationships between residents of cohousing. Here, making content for or listening to *Cohousing Radio* produces a new social medium inside of the cohousing community. In this way, the prototype radio becomes a material participant in the social life of the community.

The cohousing radio is rooted in three values originally generated by the values generator, that taken together with anecdotes from interviews inspired the prototype.

Table 10: Values at play for the Cohousing Radio prototype.

A	B	C
Connectivity	Participation	Collaboration

5.2.2 Physical RSVP

After breakfast, Robert heads out towards his car to go to work. As he grabs his keys, he also picks up two clay balls lying nearby. One is maroon, his favorite color, and the other is turquoise, his son's favorite. Heading past the common house on his way to the parking area, Robert drops the balls in a bowl on the common house's porch to let his neighbors know that they will come to this week's common meal. He smiles when he hears them clatter among other balls in the bowl and keeps walking towards his car.

Later in the day, Ken is at the common house to get his mail. He sees the maroon ball in the bowl and remembers he needs to return the soldering iron he borrowed from Robert. He makes a mental note to bring it to this week's common meal.

Figure 38: Physical RSVP.

The second prototype builds from ideas around convenience, making social life physical, and the responsibility to the community that cohousing requires. *Physical RSVP* (Figure 38) provides residents of cohousing a way to materially respond to invitations to events within the community. In cohousing, all kinds of events need to be scheduled and coordinated, including common meals and committee meetings. One resident of cohousing described the confusion around planning these kinds of events over email as "all these different things are going at the same time and sometimes the chains get too long. Sometimes depending on what email platform people are using, how the emails are showing up, they miss out on something that was said before." As the currently-primary way of organizing social life in cohousing, operating in conjunction with the bulletin boards and sign-up sheets that are falling by the wayside, email is a necessary evil—it is broadly accessible and almost everyone has access to it, but messages being asynchronous makes it hard to know whether people are on the same page. This prototype is meant to coalesce this kind of intention into something that is simultaneously

physically tied to a site for both accountability and legibility purposes, while being viewable remotely in a calendar event.

By placing a clay ball in a bowl, a resident registers their intent to attend the event, and that event's organizer can plan for the correct number of people. These balls are embedded with NFC chips that are unique to each resident. By dropping their ball into a bowl, an Arduino-based reader on the underside of the prototype detects the user's string from the NFC card, sends the resident's ID to a webserver, where finally a script updates their attendance for an event on a shared community calendar. This prototype is intended to be placed in a common area of the cohousing community and be centrally available to all residents to use as they take advantage of shared space. The visibility of the balls in the bowl becomes a way of indicating intention in an unequivocal, public way. The physicality of clay balls unambiguously replaces murky and impenetrable email chains. By having specific NFC balls for each resident, their own intent to participate becomes tied to a totem that is able to store and report their own particular needs. Allergies, food preferences or other dietary requirements could be associated with an event to make planning the details of a common meal simpler.

Like Durrell Bishop's famous *Marble Answering Machine*[12], *Physical RSVP* makes information material. In this case, that materialized information is not waiting to be processed by a single user or family. Instead, the balls represent the intention to participate in the social life of the community. The balls are meant to be left by residents,

[12] http://dataphys.org/list/durrell-bishops-marble-answering-machine/

and be recognizable to other residents as well as event organizers, but the information that they concretize remains accessible through online calendars and phone applications. The relatively simple form of the *Physical RSVP*—a bowl and tray that the bowl sits on—becomes a springboard to reimagining and reconfiguring the device's role in the community. One cohousing resident during an interview immediately extended the idea of a single bowl to schedule community dinners to an entire row of bowls, each with their own placards that indicate a new, different tally. In his vision, these tallies could take multiple forms for different kinds of events: the bowls could become a means of polling questions to the community (and through that polling, enacting community governance), sign-up sheets for cohousing events, a way to commit to doing particular work in the community, in addition to a means of simply letting the community know that you'll be at the common meal on Sunday evening.

Table 11: Values at play in the physical RSVP prototype.

A	**B**	**C**
Convenience	Making Social Life Physical	Responsibility

5.2.3 Participation Scales

> *It's after 10pm, and Rachel is just getting home. She had had an emergency committee meeting at the common house on top of a community meal. It looks as though the roof might be beginning to leak, meaning the emergency fund that community dues have been going towards will be exhausted. On top of this, it's the busy time at work. Rachel is feeling like there's not enough of her to go around, but all of the things she's committed to feel essential. As she takes off her coat, she*

notices her participation scales in the corner. She doesn't think about them often—they've faded into the background for her over the past few months. Stepping closer, she notices that the scales seem wildly out of balance. The part that represents her own life is high up in the air, while the community life is all the way to the bottom. She realizes that she is a far outlier in terms of taking on community responsibility right now. Resolving to spend more time for herself, she places all the weights on the pan for her own life. It doesn't quite balance, but it's getting closer. Maybe she should try to hand off directing the community's fall play to someone else…

Figure 39: Participation Scales.

The final *Cohousing IoT* prototype is a set of scales that help a resident reflect on their level participation in the community. In many interviews, residents expressed

anxiety or frustration about their community activity, particularly around the monthly work hours that residents are expected to complete:

> *I wasn't excited about having to do seven hours of work, and I still don't really put in seven hours of work, but I guess I was like, a little bit more optimistic [that I would]. It does become a drag after a while—when you're like, 'Oh I forgot to do my hours' and you feel this guilt like, 'I should cook but I hate cooking, and we need somebody to cook, and I can't clean, because I have to put my kid to bed.' It's just feeling guilt, like I'm not putting in my dues sometimes, but then there's also some annoyances when I feel like I am putting in a lot of time to being on the common house committee, and like, trying to get the flooring for the kitchen, you know?*

These work hours can include cleaning the common house, landscaping and yard work, cooking for the group, or managing supplies. Often, the work hours requirement is not met, and residents (like the one above) feel as though they should be doing more, afraid of not doing their part.

In the *Participation Scales* prototype (Figure 39), the position of the scales' arms represents an individual household's level of participation in the community. This is measured by attendance at events, work hours, and so on. The arms' position is controlled by a servo motor connected to a Wi-Fi-enabled microcontroller that reads participation data from a server. The left pan is the average level of participation for the community as a whole, and the right pan corresponds to the participation level of a particular home or family. If a resident is not spending enough time for themselves or their household, the left pan will drop. A force sensor on the right pan detects weight

placed on it. Placing a weight to balance the scale becomes a symbolic gesture to take more time for yourself or your household, or, if no weight is needed, to realize that, despite your concerns, your own participation is actually close to the community average.

This scales prototype is not meant to be punitive. Instead, it is intended as a tool for self-care, and making sure that you are not overextending yourself within the larger community. In this context, the idea of "self-care" operates on two registers. The first is through the idea of managing the effects of a condition in everyday life. In HCI, this has often been understood as e.g. a patient's medical conditions and managing medicine or the symptoms as they affect everyday life (Nunes and Fitzpatrick 2018). The second register is as understanding care as part of a relational understanding of interdependence within a community, after Light and Akama (2014). Together, these double reading combines to produce an artifact that offers a means of reflecting on your participation and the effects that this participation might have on your own well-being. In this way, these scales shift current ideas of domestic IoT as monitoring the condition of your home to understanding the conditions of your participation in a community. Alongside this shift comes implications for the social relations in cohousing as being mediated through IoT technologies. The scales become a material representation of personal participation in the broader cohousing community, as well as representing and displaying overall participation levels within the community in real-time. The values that correspond to this concept is tracking, reflecting, and work.

Table 12: Values at play for the participation scales prototype.

A	B	C
Tracking	Reflective	Work

5.3 Co-design workshops

These prototypes are intended to plausibly take on a role in the life of the community, operating as agentic members of cohousing that support, sustain, and create the values that cohousing communities are invested in. In order to understand how this might play out in practice, the prototypes need to be evaluated in the context that they are designed for. The primary way that these prototypes have been evaluated is through a series of workshops with cohousing communities that determine what the prototypes mean to them. These workshops provide a venue for speculation into how they might imagine cohousing in the future and what kinds of role technology should or shouldn't play in it. They include sets of activities designed in various ways to understand how various technologies might fit cohousing community members' visions of their collective futures.

In *Rehearsing the Future*, Halse et al write about strategies for participatory design workshops, claiming that one key to understand how future technologies might operate is to act them out beforehand. While this might at first seem outlandish, one way of building knowledge about future applications in their contexts is to gather members of those settings and together perform future scenarios to reveal what might work (Halse et al 2010). In this way, performance can become an integral part of design research via workshops that using participatory design strategies. In the book, they offer two (and many more) ways of understanding possible futures—and gaining insight into what future practices might be like—through *design games*, well-constrained activities that are oriented towards revealing and understanding how domain experts operate. Fort this

project, a workshop emphasizes two of these design games, the *landscape game* and *situational enactments*. The first is a way of understanding how issues, objects, and prototypes relate to each other in a spatial way, while the second is a way to understand how people perform interaction with novel systems or prototypes in specific scenarios.

Cohousing communities feature a perfect venue for playing design games in the common house. The common house provides a space that is simultaneously shared and home for residents of the community and produces a comfortable space for codesign workshops that are rooted in cohousing practices. Because "the challenge [of enactments] is to evoke the sense of 'everyday life with a reflective twist'" (Halse et al. 2010), using the common house as a site for performative enactments of possible cohousing futures makes sense, as it provides a unique flexibility for design research. If needed, residents can use the common house to stand in as a part of their own home as well as a stand-in for broader community life.

Part of the goal of using these design game-based co-design workshops is to understand the interrelationship of novel design research prototypes with everyday cohousing life. This everyday life includes the daily routines of cohousing residents, what kinds of already-existing devices and objects might be implicated by speculative prototypes, and finally, what kinds of new routines or practices might be required for these prototypes to make sense in context. Finally, using participatory design workshops to evaluate appropriateness of technology for cohousing makes a lot of sense: because much of the work of cohousing is face to face negotiation and conversation around issues that matter to the community, performative, dialogic engagement with technological

issues and practices seem like a native evaluation technique, one that residents are familiar with, comfortable doing, and skilled at already.

Figure 40: Phase 1 of the device landscape game. Here, the residents have chosen a time of Sunday at 6:00pm.

5.3.1 Workshop Structure

This workshop includes a set of activities that discuss the prototypes that I've designed in various ways in order to understand how they might fit in with cohousing community members' visions of their futures. It uses a landscape game, part a set of co-design workshop tools from the Royal Danish College of Art's book *Rehearsing the Future*, to collaboratively construct a set of scenarios on a map using tokens that represent objects in everyday life in order to see the relationships and stories that emerge. It has been held five times in four different cohousing communities in both Atlanta,

Table 13: Times included in the cohousing device landscape game.

Tuesday 6:00pm	Sunday 6:00pm
Saturday 10:00am	Wednesday 8:00pm
Tuesday 8:00am	Thursday 12:00pm
Sunday 9:00am	Thursday 3:00am

Georgia and the Research Triangle in North Carolina. For each of these workshops, an overhead map of the community taken from Google Maps was printed in a large format and provided a "game board" for the activities. The overall workshop had three parts, described below.

First, residents chose a time to build a device landscape for. In cohousing communities, there are specific times that are commonly associated with events or activities. (a full list of possible times is in Table 13: Times included in the cohousing device landscape game.). Sunday at 6pm, for example, is often when common meals take place, and residents in Figure 40 are placing cooking and food-related tokens on their community's common house. Other times are less immediately loaded in terms of having a particular cohousing value or interpretation. A weekday morning at e8am means that households are preparing for a work schooldays, no matter the kind of community that they live in. Regardless of the time selected, residents select among tokens that represent common household and community objects and place them onto the map of their community. Residents explain how these things relate to one another and then annotate the map to describe that time completely, including what is going on in the community then as well as where these are taking place and what kinds of items are involved.

Table 14: Scenarios for the cohousing device landscape game.

1. A resident is out of town and his CSA shipment needs to be eaten before it goes bad. It is a large amount of food and will spoil quickly.
2a. An ice storm has struck the region overnight, leaving glassy roads and power outages in its wake. 2b. A severe storm has been active for the last day with strong winds and rain, and for the most part, residents are hunkering down.
3. A group of teenagers in the community have been busted for a large party via noise complaints.
4. Over the last couple of weeks, more and more rats have been seen on the property. It looks like there may be an infestation.
5. Usually, the community has a WiFi signal blanketing it. It is currently on the fritz, however, except in certain places.
6. New residents have moved in that don't seem to be so interested in actively participating in the social life of the community.
7. A household in the community has just had a new baby. They are tired and could use some support.
8. A neighbor's car is in the shop and will be for a while. They've been driving a carpool for children in the community to school each morning. What happens now?

After producing a map of devices in a landscape that corresponds to a particular time, cohousing residents next select a scenario from a set of cards (Table 14). These scenarios represent problems that cohousing communities can face, and are a mixture of ideas that have come from earlier interviews (2a, 5, 6, 7); fairly standard homeowner or family problems, adapted to cohousing (1, 3, 8); and local issues that affect the area in general (2b, 4). In the case of scenario 2, the remnants of Hurricane Irma, by then a tropical storm had recently passed through the area in the Fall of 2017, and the days-long rain and wind storm seemed like it would be a worthwhile scenario to consider among cohousing residents in Atlanta. For earlier workshops in North Carolina, ice storms came up as a topic of conversation, and were at those communities. The scenarios become the

Figure 41: The second phase of the device landscape game. Residents respond to a scenario and modify the device landscape to take the change into account.

basis of a reimagining of the earlier device landscape, responding to the shift in attention that the scenario demands (Figure 41). The representations that residents generate reveals connections between the lifestyles, values, and objects that comprise the overall device landscape. It's important to note here that there is not a distinct link to the specific values of cohousing from Chapters 3 and 4 to any of the scenarios specifically. Rather, through interacting with one another in the workshops, the intention was that cohousing values would emerge in conversations about the issues at hand.

Finally, in the third phase of the device landscape game (Figure 42: In the third and final stage of the device landscape game, cohousing residents imagine roles for the three prototypes as part of the device landscape.), residents are introduced to a new set of tokens that represent each of the prototypes. After some conversation about the devices

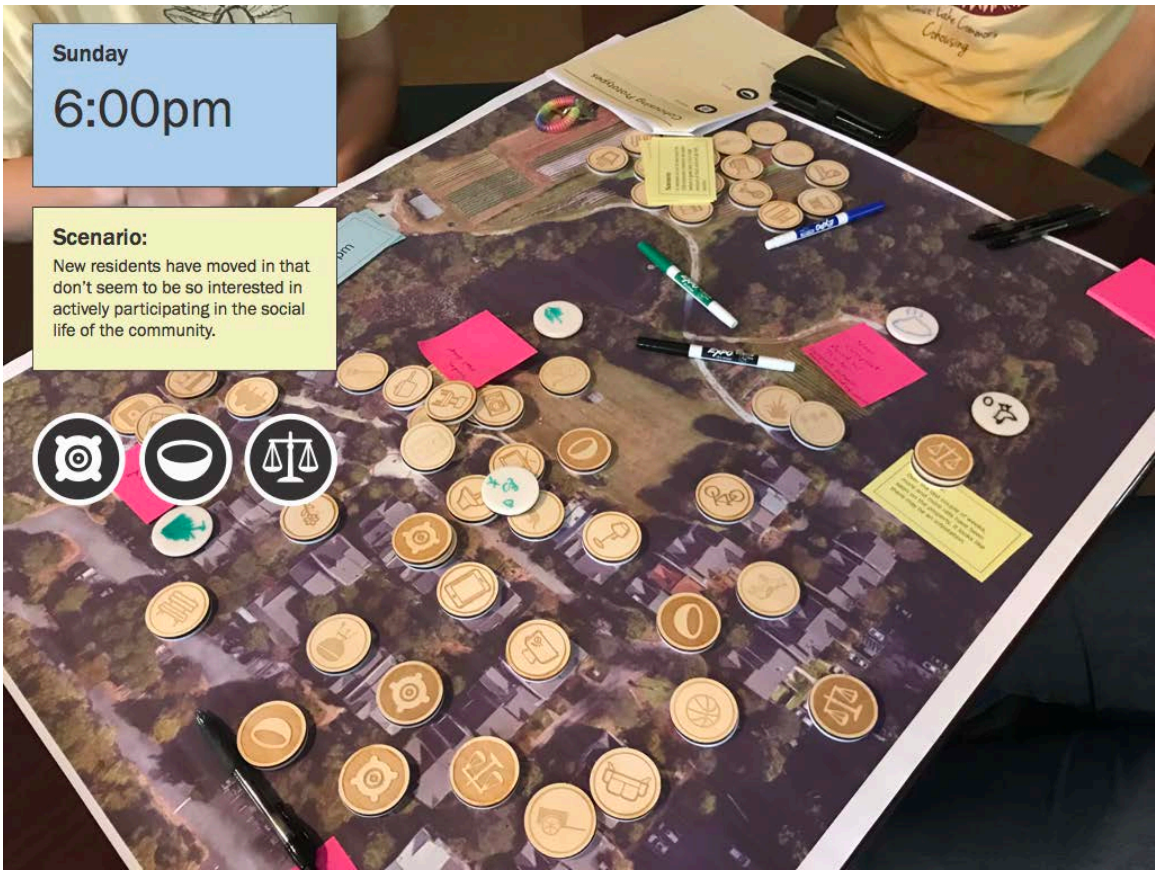

Figure 42: In the third and final stage of the device landscape game, cohousing residents imagine roles for the three prototypes as part of the device landscape.

and their possible uses, residents discuss how these prototypes might fit into the design landscapes that they created, and whether or not they might be useful or interesting in addressing the scenarios, or even just in general. The device landscape game provides an opportunity for residents to generate a physical mapping of things and their environments, to articulate the relationships between things and social infrastructure, and document the emergent properties of objects and devices in cohousing with an eye towards incorporating prototypes that are meant to mediate certain aspects of cohousing life.

The goal of this process is to produce stories that residents tell about the possible role of the prototypes in cohousing. In lieu of a longer-term deployment, the scenarios

concretize an issue for cohousing residents to make applications of the prototypes more legible or pressing. At the same time, the device landscape game provides a simple, conversationally-driven means to more deeply understand cohousing and its arrangements of things and people. Ideally, using methods like the landscape game can insert prototypes into a richer frame than a simple interview might, while attending to the issues of cohousing in a way that is congruent with a public design perspective.

5.4 Workshop results

This series of workshops was aimed primarily at gaining insights across two dimensions for the prototypes. The workshops themselves were captured with both photographs and audio recordings. These were coded using grounded theory to draw out and interpret the reactions and understandings that were generated by participants interacting with prototypes and maps. These codes had to do with two issues, primarily. First, what did the residents think of these prototypes? Second, could they imagine them as a part of their everyday lives?

Answers to these questions were gleaned from the segment of the workshop when the prototypes were introduced, and conversations around the goals, purposes, and acceptability of the prototypes came through. The second dimension operated at a higher level. Here, the interesting aspects of the workshop for evaluating these prototypes related to how the prototypes might or might not support cohousing values. Could they be understood as becoming "members" of cohousing, or be a part of the social praxis of the community? From the even higher level of a public design perspective, what mattered about these devices in the workshops was whether the prototypes were able to articulate issues that were of importance to cohousing and offer a site for residents of cohousing to

consider matters that matter to them during our conversations. This highest-level perspective on the prototypes may rely on the success of the first two in being able to script cohousing life into an object to begin with:

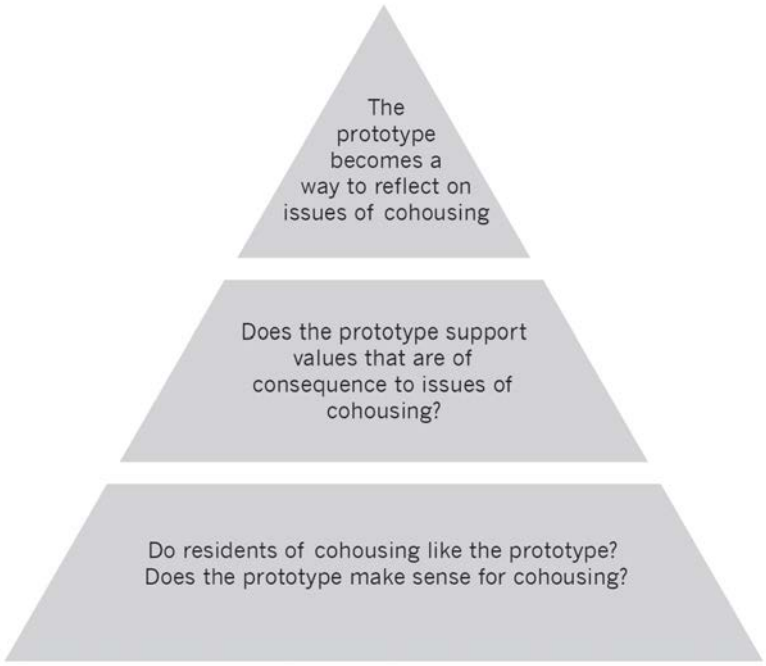

Figure 43: Three levels to consider the outcomes of the co-design workshops.

One way to consider the workshop is to consider the conversations that result from it as taking place on three levels that build on top of one another. The apex of the triangle has to do with whether the prototypes can become a location for residents to reflect on the conditions and issues of cohousing. This relies on the middle level of the triangle, whether the prototypes can engage with the values of cohousing. Likewise, the prototypes' fundamental fit with the community's vision of itself is needed to script residents into the device enough to engage with it as an object that can encounter cohousing meaningfully. If residents can engage with the prototypes and discover ways that the devices might support cohousing values, it becomes possible to use the workshops and prototypes to reflect on how issues of cohousing can be bounded into

materials—or when it might be better not to make these kinds of connections so formal. These three layers are used here to structure an analysis of the results of the workshop.

5.4.1 Level 1: Comfort and Application

5.4.1.1 Radio

In general, residents of cohousing found the radio system appealing, but perhaps not for its intended uses. While it was envisaged primarily in its design as providing a casual backchannel that could augment other kinds of social interaction within cohousing, residents first found themselves understanding the Cohousing Radio as a means of creating an emergency contact system for residents in case of an issue on the property:

> *When you first brought this up, I was like "Oh my god, Susanna". We have an emergency calling post that nobody knows about, nobody uses. It's a service that we're paying for that never gets used. And you can call it, record a message, hang up, but only on certain hours, and it will call everyone that's signed up for the emergency calling post. But I think it has to be a house phone or something, I don't know. And it'll play that message.*

> *So, I mean, right off, if this was a working thing, and was cheap, Susanna would be all over it. Like trying to flood people's houses with it because we have no way to communicate with one another in an emergency. We get people running through the community, breaking into houses ... Well the break-ins only recently happened. But yeah, stealing*

bikes, going into cars. I mean I've chased people off the property, several of us have chased people off the property. And to be able to go "Hey, 911, there's people here" or whatever. "Something's going down." That would be incredible.

In these examples, residents take the prototype and immediately link it to current issues in the community. They have been experiencing an uptick in crime locally, and the radio is seen as a device that can support connecting and mobilizing residents in service of protection and security. While this is not very closely related to the device's concept, ideas around security and monitoring are classic goals of IoT in general and reflect these prototypes as doing legible technological work in a domestic context.

As designed, however, the cohousing radio was meant to afford a different kind of participation within the community, and conversation around the device, the possibilities it could offer became somewhat clearer among residents. Beyond simple alerts or announcements, residents could also understand it as a way of connecting people together more subtly, and in a way that might supplant email for organizational purposes:

I think it'd be really great… we have a participation problem, so if there's a way to just have people feel more plugged in, even if it is just socially, or by something beautiful—like, we have a recording artist who lives here, Jim. We have other artists. We have really interesting news that not everyone's on the listserv necessarily, or just doesn't check their email. But yeah, I mean if it can help get people plugged in. A lot of times like what Dale just did, somebody's going around, if there's a thing, someone will go around and be like "Hey everybody, come out."

After some discussion of the intention behind the radio, residents found some appealing aspects to consider, as well as ways of incorporating it into their daily routine.

- *[First listening to global news] and then listening to local news, and then listening to very local news.*
- *We have a very hyper local news.*
- *You get to hear like Dancing Water's poetry, and ... Susanna's meeting pitch and reminders and stuff.*
- *Yeah it could just have tough, really clear guidelines.*
- *Like hey, these are the meetings coming up today.*
- *Yeah, 'cause someone even started that, and everyone really liked it on the listserv.*
- *Oh, yeah. And then Kat had to move.*
- *Yeah, Kat. That's right.*
- *I would see, like maybe if it was an emergency post, you could get it to go right through.*

Throughout these discussions, the possibility of abuse remains a concern. Above, "tough, really clear guidelines" underscore a fear of giving unfettered access to creating sounds for sending into people's homes. That this ability might be abused is very rational, and could fragment a community in innovative and ever-more-annoying ways.

While the above conversations captured a certain level of acceptance or enthusiasm around uptake of the cohousing radio and the possibilities that it might hold for community life, residents were at least as often initially nonplussed by it, or found it unappealing:

- *This would be interesting, I'm just not sure how [the Radio] would ... I'm just not sure how that would go ... How useful that would be.*
- *Yeah, I have a hard time thinking about this community, how that would be used.*

I don't actually like the radio idea. Just because I think as a shared ... I don't know that anybody wants to hear my music.

Sometimes, residents wondered what the point of the radio was. Part of the issue may be that, as a speaker system, the materials that are shared can only be audio-based, and messages or other kinds of content that could be aural seem particularly limited. Beyond this, though, the idea of distributing devices that builds a certain kind of connection in a narrow-band way actually subverted cohousing ideals. The primary goal of cohousing in general—one that is emphasized through its design and reified through its development—is to support a sense of community through in-person, face to face interaction. This is constructed both architecturally in the layout of communities, as well as through the bylaws and social structures and traditions that residents produce. Building connection between community members in a more ambient way emphasized the

difference to some residents between in-person sharing and a more faceless broadcast approach, especially one that requires active production or curation:

> *Even with the creative stuff though, if Alex is gonna put his music on, or Jim is or something, I love the visual. You know if somebody's gonna post a clip of streaming of their actual playing. I love to see them playing, so, I'd be giving up something.*
>
> _____
>
> - *It feels like work.*
> - *It's more inviting to say, "Jim is playing at the common house, Alex is playing the common house." Or "The kids are putting on a show at the common house." That's just more inviting.*

The most salient criticism of the radio is that while it distributes participation and perhaps in some ways might lower the bar to participate in community life, it works counter to the norms and structures of cohousing. For residents that are able to participate in a more analog sense, the radio prototype seems like something that needs to be added on to everyday life to work if it worked to build community at all. The best reception for the radio prototype was as an emergency broadcast mechanism, something already-understood that explicitly operates outside of day to day norms and where a technological solution is expected. Even in the most enthusiastic conversations, the radio became an extension of currently-existing applications of technology—email listservs, emergency alerts, updates on current events—rather than a space for thinking of something new or emergent that might be possible.

5.4.1.2 RSVP

In general, the RSVP device was the most well-received prototype. Perhaps because it was so closely linked to actual events in cohousing, what the RSVP device had to offer cohousing proved to be clearer to residents straight away—the prototype is meant to organize people together while relating their participation to a physical quality that it didn't have before.

- *Exactly. And so it would be like "Hey, are you coming to the movie night? Throw your ball in the popcorn bowl". So that's cool.*

- *I like the idea of having a token that's me that I can put some place. That's fun. Similar to this kind of stuff. Having one of these be me.*

This resident buys into the idea of an RSVP ball representing their participation in the event to the point of scripting themselves into the device directly—having that particular ball become them in the context of the event. As ever, though, the concern of whether the interaction is something that residents could be expected to do is a concern.

> *I like that idea. I would ... Let's just say, you know, in a fantasy world, we could have something at the mailbox that would display kind of your same concept. But it wouldn't be ... I just don't see people taking something to the mailbox and putting it in. But, if I'm at home, or even if I'm just on the [community] website, and if I RSVP, then I have a picture of that event and who's all RSVP-ed.*

Even if the idea of a physical front-end produces a barrier to entry for the device, the goal of representing the community's interest or level of commitment to an event is

appealing. Especially for this resident of cohousing whose community has a less-formal structure of common meals or social events, having a way to quickly and easily get a general sense of a guest list for an upcoming event seems worthwhile:

> *I do like the visual…Sort of knowing if I'm thinking of coming next Thursday, I wanna know that at least more than two people are coming. You know? Is there a critical mass coming? I don't know. It's kind of to your point of giving the community a big picture of who's coming. Without having to physically go drop something somewhere.*

Similarly, having this information in a central, highly-visible location in the community adds something useful to community, making information accessible to anyone who passes by:

> *I like the idea that oh, we're in community, it'd be nice to come and have it in some common spot…*

The concept of a highly customizable, personal representation of intent or responsibility seemed especially appropriate for cohousing residents. Customizing a ball to represent a particular resident's commitment resonated with community members, as it was similar to existing, ad-hoc examples of customization of other personal objects in shared space:

- *It's really visual. It's cute.*
- *I really like it. It's very tactile.*

- *I like to think about all the different balls, and all of the designs and the colors. Cause we keep all of our little laundry detergent in there. Those of us that don't have one at home. And so everyone kind of draws their own little laundry detergent and puts their house number. But people draw on it.*

- *People decorate it.*

- *Mm-hmm (affirmative). Some people. Artistic people. Not me, but ... I'm not very artistic. So yeah, people could make their own balls.*

Beyond a way to organize events, members of cohousing at these workshops extended the concept of relating a person's physical presence to an internet-based articulation of existing cohousing practices readily. At Pacifica Cohousing, for example, the RSVP system as such was not very appealing. However, they've been having issues with shared resources like tools being either misplaced and not available at times, and fear theft. This has led to discomfort around larger investment in the common space for more expensive community investments such as speaker systems or projectors. In the workshop, conversation around this NFC-based system morphed into a way to record how tools or common goods might be checked out to a particular person through a similarly personalized object as the clay balls—totems, but for registering responsibility or custodianship instead of intention:

It would be nice to be able to keep ... Let's say I need the sledgehammer or stake driver or whatever, and I'm gonna use it for a

whole week, to keep it at my house without having to worry about nobody knowing where it is.

Right. Things that facilitate community gatherings. We're just on the minimal side for that, because who wants to put money into something that's going to disappear? The projector, music. I think like nicer ways to clean the floor. We could get it cleaner faster if we had a nice cleaning machine, but I'm not going to propose that on any budget because who knows how long it'll be here.

As illustrated in the previous example, a key concern for many cohousing communities is the potential expense of these imaginary systems, especially when contrasted to the kinds of training or skill-building that would be necessary to have residents become fluent enough to use the prototypes in their intended role.

- *I think the bowl is a cool idea, but you're competing against a piece of paper, which is what we do now.*

- *And that works pretty well. Paper is so easy. The other thing that communities, I think, technology, if it was very easy, could facilitate in sharing our resources. We have things that work for us, like the wonderful mulch pile, I think a dump truck comes. I assume it works fine. We just write down how many loads we use. But there are other things that are more valuable. We might buy more food in bulk or who knows what, if we could distribute it in an easy way amongst the community. Nobody wants to do all the keeping track and the*

accountability of all that. If there was some way that it was more automated…

The concern of practicality, of having a proximate use that satisfies immediate issues in the lives of cohousing residents really underscores some of the issues that are at stake in cohousing. These residents share responsibility for their lives together, and that is a responsibility that they take quite seriously.

5.4.1.3 Scales

Overall, the scales garnered some of the most interesting comments from the workshops. They became perhaps the most provocative prototype: they manifest an anxiety that arose frequently in interviews with residents. The scales take internal concerns around freeloading and equality in participation and makes them legible visually. In conversation, the prototype forces residents to attend to an issue that can often be a problem the organization of a community. Beyond a fear of what might come from representing community work and participation, though, was an acknowledgement that there are residents who do more, and that there might be a possible use for this sort of system to help community members who take too much community labor onto their own shoulders:

I don't want them to get burnt out. I don't want them to feel like they have to do everything they're doing all the time, or the place will fall apart. I don't want them to do so much that they just kind of suddenly fizzle and go "I am done". Cause that's happened, we have people like that. And it's really sad."

In cohousing, participation is always a concern. Participation can be understood as the benchmark for community wellness—more people participating more often makes a community healthier and more vibrant. On the other hand, less participation overall, or participation that is primarily on the shoulders of one main "champion" of the community is in danger of becoming simply another housing development, one where the goals of intentional living have been abandoned. The scales' potential to prompt reflection on this issue was appealing to some members of cohousing in the workshops:

> *"There's something powerful about ... I mean, I wonder if that would change people's perceptions of community participation? I mean, at our house we would be short on ... We're tryin' to take care of ourselves, 'cause we give a lot to the community, and oftentimes too much in a lot of ways. Would that help us ... I don't know. But I like the visual. There's something happening that I like here."*

More than just comfort with the idea in broad strokes, though, some residents really latched on to the concept and made it their own. One resident—who was a software developer—immediately took to the idea, and both adapted it to become more feasible and workable for his community while thinking how to build a real-world implementation for it. The scales prototype resonated with him enough to really think through how these issues manifest in his everyday life:

> *"Let's just say we had our scale, let's just say we had a participation scale next to everybody's name in the directory. And let's just say it was all over the chart. But if on our home page there was a*

summary of that in a scale that says how are we doing with meeting it? Right? So, we have 75% of the people exceeding our goal. Then that individual scale wouldn't hurt as much."

The residents in the workshop were often skeptical of the scales' value in their communities, but often found some aspect of the prototype interesting. The idea of tracking participation was often regarded as possibly being disruptive to a community, but possibly worth it in terms of building accountability and mutual understanding. Putting numbers to an abstract concern might be too far for many, but the idea that there could be a more formal way to track participation and try to build it into a more formal accounting of what it means to live in community is not such a no-go as might be imagined.

"I like the idea of here's the four hours, here's what you've done this far. Now, we did have for a while a system of logging your participation hours. And I did it for years. But I actually only recently stopped. 'Cause I just have no idea what anybody else is doing, I don't think anybody's doing anything with the data."

In the workshops, residents of cohousing found the prototypes to be a mixture of interesting, provocative concepts on the one hand, but just as often rejected them. For the most part, residents didn't find utility or sensible application of them as presented, but in conversation derived situations or adapted uses for the concepts behind the prototypes that fit the way they live. This interpretation is based on how they interpreted the devices as supporting the values of cohousing that they choose to live by.

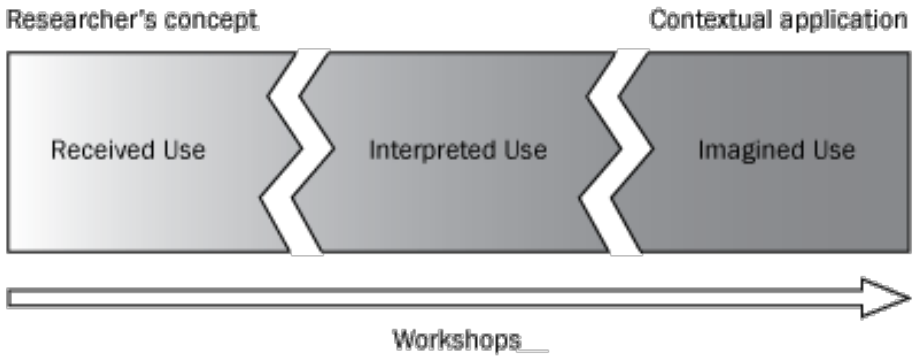

Figure 44: How prototypes move from being solely a researcher's concept towards imagining real-world application by communities via workshops.

5.4.2 Level 2: Connection to the values of cohousing

The patterns exhibited by cohousing residents in getting to know the prototypes through the landscape game operated through three phases, illustrated by Figure 44: How prototypes move from being solely a researcher's concept towards imagining real-world application by communities via workshops.. First, they are introduced to the prototype, and the intended use of the device is explained. This might be called the *received use* phase of understanding the prototype, as a designer's thinking about what the prototype is for is the subject of discussion. After that, the residents would try to fit the prototype's use to their own experiences and structures of real-world cohousing life. This could be called the *interpreted use* phase, as residents interpret the prototype based on their own knowledge. Finally, conversation about the prototype becomes more open-ended, and new applications or contexts for the prototypes emerge wholly different to any original design concepts. This is the *imagined use* phase of the workshop, as cohousing residents take up the concept and make it their own through imagining novel uses embedded in the real-world practices of cohousing. These distinctions are important in discussing how

these prototypes were received as it provides a way of considering how real issues of cohousing—and not the issues of cohousing as imagined by a designer—are related to the prototypes. Each step away from the design as something that is being imposed on a conceptual understanding of cohousing, even one that is informed by interviews and time spent with residents, gets closer to accessing how these prototypes could reflect the values of cohousing communities as they are actually lived and practiced.

In particular, these prototypes produced conversation that covered eight of the values from the A, B, and C design space from Chapter 4. From A, the traditional list of IoT values, comes *tracking, security*, and *connectivity*. From B, the list of speculative IoT values, comes *making sociability physical*, and *reflecting*. Finally, from C, the list of cohousing values comes *participation*, *collaboration*, *work*, and *site-specific utility*. In the workshop conversation, none of these values were discussed individually, of course. Rather, these ideas overlap in ways that reveal how these values are actually practiced. The Through interpreting these speculative IoT prototypes as instantiating, supporting, or subverting these values, how these values are being constructed into contemporary IoT becomes clearer. The rest of this section offers examples of how these values are imagined into the prototypes.

5.4.2.1 Tracking

The idea of tracking users as they interact with systems is one that is built into the contemporary Internet, and therefore is implicitly part of the cohousing IoT. This is especially clear in the RSVP prototype as well as the Participation Scales. The RSVP device is designed to explicitly take input from residents and place them in an event in both physical and virtual space. Accounting for participants in an event can then be

interpreted through two kinds of traces—as both a list for an event on an online calendar as well as by looking at the prototype and seeing different colored balls in the bowl. This idea of tracking becomes the material for imagining alternative use cases for the RSVP device. Understanding the NFC-augmented balls as corresponding to intention lets residents extend the concept to be a way to vote on community issues. The ability to track intent becomes part of an expanded space for the prototype to participate in.

The Participation Scales perform tracking in the opposite direction. Instead of recording intention to participate at the individual level to be aggregated and reported to the community-at-large, they are designed to understand a resident's participation as compared to the aggregate and report it to an individual resident. This tracking is more akin to self-monitoring and relates to ideas around the quantified self (K. Williams 2015). Rather than tightly monitoring facts about the body and its relationship to knowledge, devices and data, this design gives a broad assessment of participation that might be called the "qualified self" as it relates to broader patterns of participation and activity in community life.

5.4.2.2 Security

Issues of security arose frequently in conversation with cohousing residents. This may reflect how residents conceive what technology is for and how it can be imagined. The smart home has long been considered as a way to know more about the home, and to be able to monitor it for lapses in security. The Radio prototype, while intended to be primarily a social channel, was broadly interpreted by cohousing residents as a way to send emergency messages to the larger community.

Similarly, the shift from the RSVP system as a way to organize social events to an imagined system to be able to track and monitor tool use—or to facilitate investment in more expensive systems for cohousing use—reflects the paramount need in cohousing to not waste community investment. This imagined use of the RSVP prototype as an NFC based check-in and check-out platform is interesting in two ways. First, it flattens the system to something that is more overtly "technological" by falling in line with expectations for smart houses and smart platforms. Second, it reflects how essential issues of security come up in cohousing—theft from the common house has been a topic of conversation in both the workshops and preliminary interviews, and perhaps reflects the tragedy of the commons in action. The common house is simultaneously everyone's and nobody's. Automating "keeping an eye on it" is an appealing idea for many residents of cohousing.

5.4.2.3 Making sociability physical

A major concept that drove the design and manufacture of these prototypes was to make physical representations of issues and practices that matter to cohousing. As participants in the social world of cohousing, the prototypes are designed to take that social life and physicalize it. The Radio perhaps does this work the least, as it places devices in homes that are meant to carry some correspondence to the social networks that makes up cohousing while not really actively taking a role in it. The RSVP platform, on the other hand, creates an interaction with cohousing events that produces a physical gesture: by placing the ball in a bowl (or by choosing not to), a resident sends a particular signal that they will attend a community event. The Scales prototype does a similar kind

of gesturing, but instead acts as a proxy for social life in itself: it gestures to a resident who interprets that gesture as a representation of social participation.

5.4.2.4 Work

During the workshops, most residents immediately understood the issues that were being presented to them with the participation scales, and how it represents participation in the community, and more specifically the labor that comes with community membership. For some, fear of letting those who champion the community overexert themselves is paramount, while for others, it's more about a lack of information or clarity around existing accountability practices. The other two devices imply work in a very different way. Rather than being a way to consider community work in the abstract, they were interpreted as requiring a resident to do more work to participate. For the Radio, this meant that creating content for other residents with a radio was nonsensical, or simply unappealing. They figured that the device had no real application for them, and indeed would require substantial energy to take part in using it. The RSVP system was considered by some residents as offering a substantial overhead to already-existing organizational structures. Requiring residents to go to a place and drop a ball of seemed supremely impractical to residents using sign-up sheets or other systems to do this organization work already.

5.4.2.5 Site-specific Utility

Finally, where the prototypes were imagined to be located shifted the understanding of the devices substantially. The location revealed interesting differences between how the prototypes were received and conceptualized among workshop participants. In general, the three prototypes were designed to each operate at a different

level of privacy through their location. The Radio is meant to operate at the private level of an individual home, the RSVP system was meant to be fully public and to be placed at a central, common location like a common house; and the Scales were meant to be private, but in conversation with residents many though it could easily become public as well.

5.4.3 Level 3: Reflecting on conditions of cohousing

The discussion of values above was informed by the imagined uses of the prototypes by cohousing residents. Understanding the broader conditions that the devices operate inside of, however, might best be learned by considering the breakdowns in conversations about the prototypes. That these objects are hard to understand or frequently unacceptable for cohousing members reveals "ground truths" about a community and how it has to work in order to keep working. In a way, these are also values that cohousing adheres to, but they come with a deep pragmatism to them: they are the conditions that all of the values and goals of a cohousing community operates inside of.

This is one of the major goal of these workshops, to have richer conversations around issues that are common in the everyday lives of these residents but are not often explicitly taken under consideration. While the prototypes were not built to be deployed in any long-term installation, they do act as material representations of matters of concern for these communities and as such open conversations around issues that matter to them. Here, a resident in one of the workshops realizes that these conversations never happen, even as issues are constantly being negotiated implicitly:

"You know, it's interesting, is when you stop to talk about this stuff, because we get so busy sometimes, we don't stop to even talk about all the challenges of cohousing, because we're in the midst of it."

The conditions of cohousing that came through in the workshops are, broadly speaking, some of the fundamental tenets that are able to sustain community over time. This may not be a surprise, as maintenance might be a foundational goal of any organization. However, this is notable in considering designing for cohousing as there is a small disconnect between the "cohousing values" from Chapter 3 and how the needs of cohousing communities influenced the reception of the prototypes in the workshops.

The concern of practicality, of having a proximate use that satisfied immediate issues in the lives of cohousing residents really underscores some of the issues that are at stake in cohousing. These residents share responsibility for the community and its perpetuation, and the choices that they make can have strong effects on the viability of their community in the future. Rather than reflecting on cohousing values that might be manifested through technology in the future, residents focused on how technological values might serve cohousing in the present. One way to consider this split is as the *values* of cohousing operating in contrast to the *concerns* of cohousing. These concerns are much more foundational to cohousing than the values are, and reflect more fundamentally how the community is organized. Being beholden to these concerns is what makes it possible for the higher-level values of cohousing to exist. These are *communication, governance,* and *fiduciary responsibility.*

5.4.3.1 Communication

Communication is fundamental to the operation of cohousing in that it is necessary to interact with others to organize a community and live intentionally. This concern is reflected in the way that the prototypes help to foster interaction among residents. The Radio, for example, organizes people around content, and hopefully provides a new way for different content or more people to be able to have access to one another. The RSVP device offered a way of organizing people around events in a hopefully clearer way. The concerns with these devices reflect opportunities for this concern to be subverted. In the Radio, breakdowns might include residents not wanting to share things that others don't like, or the possibility of abuse. Each of these would serve to create discord among a community. More subtly, the radio lacks the personal touch of in-person communication. Not being able to see a resident perform, for example, might be understood in cohousing as widening a gulf between residents instead of building a richer social sphere.

5.4.3.2 Fiduciary Responsibility

The concern of fiduciary responsibility was a constant presence in discussing the prototypes at cohousing communities. By choosing to live together and pooling resources that are managed by the larger group, spending is and needs to be beholden to the common interest. This concern was an issue throughout the workshops—without an existing line item in a budget for technologies to support cohousing, it was hard to imagine these devices being possible. This often tempered any interest or appeal that the prototypes might have had: for some participants, they felt an inability to say whether something would be good or not if it seemed like a real-world installation would be

expensive. While in some cases, the prototypes could perhaps sometimes seem like they might be a "culture fit," to cohousing, residents were often interested in the bottom line.

5.4.3.3 Governance

In governance, all of the earlier concerns collide. The idea of governance builds on communication, managing, and fiduciary responsibility to describe the overall structure of making collective decisions in community. Because cohousing often uses a consensus model for decision-making, and can become both ponderous and personal, any technological intercessions in this process is especially fraught. The idea of governance was raised through the prototypes and concepts in interviews where the RSVP prototype became a kind of voting system that let residents use their totemic clay balls to make their choices. The responsibilities associated with a concern like governance is more than just how these tools might be used to organize residents to make decisions within broader community, though. That these prototypes have some barriers to entry, as with the Radio prototype requiring some knowledge of how to produce audio, or that lack a clearly defined role in cohousing, as the Scales prototype's possibility for misuse, means that they could upend a fundamental concern. Barriers to entry means that not everyone could have equal access to cohousing infrastructure, and the Scales seem just as likely to produce dissensus as harmony.

Overall, while there was often interest in the prototypes, the ability or willingness of cohousing residents to project themselves into the devices possible futures was at times lacking. The intentions of the prototypes to probe values in cohousing was subverted by a reluctance to push past foundational concerns. Being able to imagine what cohousing might be like with prototypes like these in the future, or what the current

experiences of cohousing might be like now if these prototypes were "real" was not always a conversation that was on the table. The practical concerns that make cohousing work in day to day life, was simply not congruent with the idea of speculation about futures.

5.4.4 User studies in an object ecology

The object ecology is a means of considering a specific research idea—cohousing IoT—that places all attributes of the design space into a flat relationship. In this design project, the concepts that came from that space have been articulated into prototypes that need to be assessed to understand how they fit into existing cohousing life. This assessment is a means of testing whether and how the prototypes make sense in the real world. Because the goal of the cohousing IoT object ecology was to support the design and development of speculative IoT objects that support cohousing practices, the prototypes need to be returned to the real world. The theoretical construct of cohousing IoT is not the same thing as the actual, lived social practice of cohousing.

One result of this user study is a more concrete understanding of what makes cohousing work. Despite representations of cohousing values as presented on websites and through interviews, what it takes to DO the work of cohousing is fairly provisional and constrained. Inherently a kind of conservative process that seeks to maintain the community first, and work towards particular social goals second. This makes total sense from a practical perspective: for social goals to be something that can happen at all, the community itself has to exist and keep existing.

The ecological space of cohousing IoT is of course broad, and the three axes describing it from Chapter 4 cannot and was not meant to be a complete, fully fledged

representation of all that cohousing IoT could be. The user study revealed the fundamental concerns of cohousing communities in ways that can help future design work in this space be not just acceptable or legible to residents, but more foundationally relevant, interesting, or integral to cohousing as it is actually practiced.

The object ecology is built from different aspects of design theory that are already established as epistemological tools. What the object ecology offers in particular is a means of approaching a broad range of things, flattening the relationship between them, dissolving existing understandings of what might be. In its place is an opportunity to produce design work that is unfamiliar, prototypes that have been defamiliarized (Bell, Blythe, and Sengers 2005) from already-existing expectations around how technology should work in cohousing life. The workshops led to conversations around the prototypes that emphasized what was appealing or unappealing to residents of cohousing. How the discussion of what worked and what didn't work in the prototypes played out at these workshops is helpful to think about the values of cohousing as they are practiced in the real world. That the cohousing radio might subvert face to face interaction and thereby break down cohousing itself is a fascinating result. As above, this breakdown seems to indicate a fundamental disconnect to what really matters to cohousing life. This disconnect itself is the second component—this insight can feed back into the cohousing IoT object ecology and help to inform future design concepts.

5.5 Conclusion

This chapter set out to understand how ideas from the Internet of Things might be enacted in cohousing communities under the concept of "prototyping community life." To do this, three prototypes were designed based on data from interviews with residents

of cohousing communities, constructed using rapid prototyping techniques, and evaluated through a series of co-design workshops with residents of cohousing across the American South. The workshops proved to be broadly successful in engaging with the ideas of cohousing through prototyping, and the prototypes as instantiating imaginaries for community life. However, these workshops also revealed a kind of flawed success in the prototypes' ability to engage cohousing and broaden the frame of what a smart home might be like for cohousing. In general, despite some enthusiasm about possible applications and uses for these devices (or imagined extensions of them), there was not often much passion or interest for the prototypes—they could often be seen as expensive or redundant, epitomized by a comment about the RSVP prototype that it was "competing with a piece of paper."

This accounting of the prototypes reflects a certain kind of pragmatic approach to the devices on the part of the community, where taking them as a design research system outside of certain endemic constraints limits the possible conversation to what already works, rather than what could work in the future or might work now, given an underlying shift in perspective. One way to articulate this issue is that the prototypes failed in their task of defamiliarization with respect to cohousing life—On the one hand, they seemed like they might be either too unfamiliar or different from what cohousing already is. On the other hand, they could also be too familiar, mapping so directly on cohousing life that space for considering the nature of cohousing is curtailed, leaving the possibilities for reflection too limited. In the first case of the prototypes being too unfamiliar, the cohousing radio is almost irrelevant for many residents of cohousing—it either subverts existing goals in ways that don't spark interest among residents, or the idea is simply

unappealing. In the second case, where the prototypes are too familiar, the scales have an obvious mapping to a cohousing issue in a way that is quite literal, and so the prototype forecloses avenues to speculate as to what other kinds of issues they may represent. Ultimately, the kind of overall pragmatism that is necessary to be responsible to and maintain a cohousing neighborhood—what residents might describe as "being in community"—means that the interpretive flexibility to reimagine the conditions of cohousing through the prototypes becomes attenuated.

One way to move forward in this space is to think of other ways to interpret objects and the systems and structures that they inhabit. The history of HCI has traditionally been built on an accounting of the user as the supreme arbiter of the success or failure of a system. Another perspective on HCI that could prove to be fruitful is to decenter the "user" in discussions of what it means for a design to be successful. User-centeredness as a supreme aim of HCI is excellent at optimizing for efficiency or simplicity in use but lacks a way to consider more arrangements of things and externalities in relation to one another. The next chapter discusses these prototypes as examples of ecological design.

CHAPTER 6: DESIGNING IN AN ECOLOGY OF PEOPLE AND THINGS

This dissertation project has operated in three parts in order to explore a particular design process that operated in an ecological frame. First, in Chapter 1, it described the theoretical underpinnings of this ecological frame. Building on definitions of design that move away from straightforward problem-solving, the roles that things play in social worlds, and networks of people and things, it constructed a framework called the *object ecology* that described the complex interrelationships of devices, things, and people that operate in various contexts.

The second part of this came in Chapter 2, where the design research methods that would be used to explore a particular design space—cohousing—to produce a research through design project to design IoT devices to support cohousing were discussed. Chapter 3 described in more detail how cohousing works, and what aspects make it different from other kinds of housing situations. This analysis became part of Chapter 4, which created a design space for the object ecology of cohousing IoT. This was built from three parts. A material analysis of IoT platforms and their meanings became one component of the design space. A second component was constructed through imagining alternative values that the Internet of Things might support. Finally, the last component of the design space came from the cohousing values from Chapter 3. In keeping with the flat ontology that the object ecology is based on, design concepts were procedurally generated based on thr three values components that describe the cohousing IoT object ecology.

In the third part of this project three design concepts were selected for prototyping. These and were described in detail in Chapter 5, and were evaluated among cohousing communities using a series of workshops featuring codesign activities as a way to understand how the devices were understood by residents, and how well they responded or reflected cohousing life.

This final chapter describes some discussion of ecological design based in the experiences of this project. First, it discusses the cohousing IoT prototypes as exemplifying aspects of contemporary design theory. Then, it reflects on how the ecological perspective on designing worked in this project, and describes some of the design implications that thinking ecologically affords a designer, Finally, it reframes some of the design theory from Chapter 1 to think about an expanded field for designing technologies that operate in an object ecology.

6.1 Limitations of human-centered design

The major limitation and risk of human-centered design is that it privileges the human perspective, to the detriment of any other. The classical HCI feedback loop of optimization towards task-oriented goals means that any kind of outcome not part of that loop becomes an externality—not necessarily taken as non-existent, but simply not a part of what matters to the design. From this perspective, a classical user-centered design process leads to local optimization at the expense of anything else. A relentless emphasis and focus on the user means that design processes are stuck not only to a particular problem, but also in a particular moment. The traditional evaluation mode of design, development, and deployment can't account for or imagine futures or future impacts of the technologies that are being created.

Of course, there are many design traditions that seek to expand the purview of a human-centered design process. Participatory design, for example, operates by bringing in plural perspectives in the design process. This breadthening of points of view that are considered strengthen a democratic purpose of design, and by bringing more people into the process serves to create technologies that are more strongly rooted in issues such as labor equality and justice. These are still rooted in commitments to the present and the perspectives of people, though. Especially in a field like HCI, where the fundamental conceit is one where the judicious application of computing technology has the potential to make lives better, there are situations where the overall best course of action may in fact to do nothing—energy use and carbon impact, data breaches, and other kinds of negative externalities of ubiquitous technology are usually not part of the discussion of what design choices matter in a human-centered context.

6.2 Prototypes as instantiating different aspects of design

One way to make it clear how design objects differently can offer new insights to researchers is to examine them as instantiations of different modes of design theory. Each of these different ways of understanding the role of designing things accentuate different aspects of this project. This section looks at the Cohousing IoT as an HCI project, as a design research project with a public design orientation, as an example of how material products can create object-oriented publics, and finally as an example of a design process rooted in an object ecology.

6.2.1 Cohousing IoT as public design

The second way to consider the prototypes is as instantiations of a design process that is oriented towards publics. Like an ecology, a public consists of both people and things that are organized around issues that matter to them (DiSalvo et al. 2014; Jenkins et al. 2016) The skepticism of cohousing residents towards the devices meant to ostensibly be for them emphasizes two aspects this mode of design that HCI design alone does not handle well. First, that the success or failure of a public design orientation is less about the uptake and use of devices or systems than in the power of a system to articulate an issue that a public takes seriously. The quality of a device or whether or not it "works" to mobilize a public in a "real" way is not of primary concern. Second, that this limitation is not a failure in itself—ultimately, though, the techniques and tactics that public design takes on might mean that a focus on publics and the issues that come with them obligate designer to consider different scales or methods that strictly human-centered ones.

Table 15: Public design strategies and tactics (from DiSalvo et al 2014).

Provide scaffolding or infrastructuring to support articulation and form-giving toward the production of publics
Artifacts, systems, and events function to expose and re-imagine constraints and parameters surrounding issues and problematic situations
Designers and participants engage in prototyping new social, economic, and political arrangements
Objects become arguments for alternate situations in which the problematic condition which give rise to publics have been reconfigured

This perspective is alluded to in Chapter 5:, but it is worth discussing how this perspective plays out specifically. From a public design perspective, this design process and the objects that resulted from it represent the matters of concern that are important to

cohousing, and together help to articulate a public that is invested in those concerns. These prototypes work in four ways to support cohousing publics, as illustrated in Table 15.

The first way the Cohousing IoT prototypes work is by providing scaffolding or infrastructure to support publics invested in cohousing issues. This scaffolding supports cohousing residents in cohousing to consider the qualities and factors of cohousing in a new way. Activities within a workshop, like the landscape games that sought to understand how things and existing technologies already work together in cohousing, give residents an opportunity to approach the material conditions of computing and how it could affect their own lives in cohousing. By extending this thinking to the prototypes and imagining how they may relate to existing practices in the community, cohousing residents are able to consider concretely how issues within the public are manifested in a spatial way. In the workshops, the prototypes drove freewheeling conversations about cohousing, including the goals and practices that motivate it, the roles (or lack of roles) that residents see for these devices to support and sustain cohousing, as well as the current issues and frustrations that were present in the particular community at the time of the workshops.

Second, these artifacts expose and re-imagine constraints and parameters surrounding issues and problematic situations. The participation scales are an example of re-imagining constraints and parameters inherent to cohousing. Many residents consider participation in the community or managing work hours that come with residence in cohousing communities to be of the utmost importance to maintaining a community, even as their community may not have many problems around participation or labor that they

could point to. The participation scales materialize this anxiety and seek to frame it as a means of producing common ground among residents, reassuring them that their own level of participation is not abnormal. Considering managing self-care with respect to social participation as the primary goal of an artifact changes the social role that devices can play in both smart homes as well as cohousing communities.

Third is that the design process for Cohousing IoT has resulted in prototyping new social arrangements of the people and things that constitute a public. This is made clear in the design of the cohousing radio. It explicitly aimed at fostering new relationships between residents by offering them a new context or means of building community with one another. In this concept, making content for or listening to the cohousing radio might produce a new medium for social participation inside of a cohousing community. Similarly, the RSVP prototype outlined a new arrangement for people to participate in the events of cohousing. It meant to orient residents to denote their participation in future cohousing events differently in two ways: first by materializing intention in a totemic form that could be read by all residents of cohousing, and second by forcing residents to visit the common space where the prototype was located to register their intent.

Finally, the prototype objects together become arguments for alternate situations within a public. These prototypes materialize and reconfigure the conditions that operate inside of the cohousing public. Cohousing IoT prototypes use the rhetoric of the Internet of things—the idea of radical connectivity to product or service infrastructure—to materially advance an argument for alternatives. Here, the prototypes connect residents to social and civic infrastructure. At the same time, the prototypes also make claims about

what kinds of values that Internet of Things devices should support in general. These prototypes seek to reconfigure existing conditions within both cohousing and the Internet of Things through speculation in materials and their social roles in alternative housing structures.

The workshops became a venue and the prototypes a site for considering impacts of technologies in cohousing. In this way, the prototypes were quite successful in providing a site for considering and respond to cohousing issues. This is the fundamental way that public design works via prototyping—the prototypes become a means of *articulation* for issues, representing them as a manifestations or representations of computational things.

6.2.2 Cohousing IoT as an example of an object-oriented public

The second way that we can understand this project is as an example of object-oriented publics. The idea of how a public is object-oriented publics accounts for how computation plays an active role in the creation and the sustaining of publics. We are moving into an era where we need to consider the social construction of meaning and action *with* computing through shared participation, accountability, and agency. This is especially important in a domain like the Internet of Things, as pervasive computational environments exemplify how computational things become agentic in the world. Fundamentally, the shift in perspective that considering publics as being object-oriented enables a move away from thinking about computing as augmentation to everyday life, where technological devices provide a grafted-on appendage to human-centered concerns, and instead allows us to examine the ways in which technical artifacts and systems participate as peers in publics.

These cohousing IoT prototypes are examples of *design things*. They are proposals that align the interests of cohousing with issues in the Internet of Things and end up as venues for residents to debate and reflect with one another the ideas and values that drive their participation in living together. The prototypes create a speculative future form of intentional living where some of the work of cohousing is being supported and sustained through internet-connected devices. From a perspective of how these prototypes represent an object-oriented public, the question becomes how cohousing issues are being reframed through the lens of computational things—creating a new kind of "connected cohousing" public.

This connected cohousing public lets us understand differently what is at stake in cohousing, at least in regard to how it might play out in practice. The Cohousing IoT prototypes do more than simply try to connect humans together in new ways—the prototypes instead are acting as a way of framing connections that already exist among people in cohousing differently via establishing new relations among people and technology. At the workshop, this kind of relation-building emerged as residents began to interpret the prototypes more deeply and imagine what kinds of roles the devices might play in cohousing as they know it. This shift is demonstrated as residents imagine that the RSVP prototype's balls and bowls might be used to take tallies as part of a decision-making process in the community, or to become the basis of a tool or materials check-out system. In both of these cases, the device's role expands to take on a more fundamental component of community life. The capabilities of a prospective system become a lens to take on other fundamental issues where that capability is understood to participate immediately. This kind of perspective is also clear where prototypes are not as appealing

for residents. The Radio's short-circuiting of physical interaction as a condition of participation in community life, or the Scales' new accounting and representation of levels of participation in communities mean that that the relation that the prototypes engender may not always be positive or welcome—in these cases, who participates with the prototypes and how become stumbling blocks for how the issues at hand align in the public.

The codesign workshops used to evaluate the prototypes particularly emphasize how the idea of object-oriented publics play out in the way they deal with computation as a material in the everyday lives of cohousing, but also as a means of thinking through social issues. The workshops take as a given that computing and computation has a role in cohousing life. While that idea certainly could be contested in particular cases, as it was, the residents at these workshops seemed take it as a given that computational artifacts can be designed and deployed as actors that effect change in even so humanistic a domain as cohousing.

The material things of the IoT actively participate in how publics can be supported and sustained. The IoT is a collective of both people and computational things that work together to produce effects in the world. In this case, "Connected cohousing" is a public that is being generated through these prototypes, enacted through speculation and discussion during workshops. As with all publics, it is rooted in issues, and the members of publics have voices in creating them. Here, we see that the idea of an object-oriented public is a way to understand differently the *composition* of a public. The addition of computation as a member of the public rather than a means of extending human influence means that the public itself becomes altered.

6.2.3 Cohousing IoT as ecological design

Finally, we can examine the prototypes from Cohousing IoT as examples of an ecological design process. The conceit of the object ecology is that it forces a designer to consider a broader design space—one that might serve to help unpack or account for complex interactions and interrelations that would otherwise be excluded or ignored. For this project, the guiding question was what might an alternative Internet of Things look like, guided by different values and concerns, and designed to be placed in a different context than what we usually expect a smart home to look like?

As an example of an alternative Internet of Things, Cohousing articulates a different vision of IoT devices and services that are beholden to a set of goals that are more social and distributed across people than located as monitoring and instrumenting a specific home or residence. From an ecological perspective, Cohousing IoT provides an opportunity to investigate the interrelation of Internet access, materials, and everyday experience, while emphasizing specific values through design activity. By building new hardware concepts that devise different types of social connectivity vis material prototypes, Cohousing IoT critically examines the role of objects in the everyday lives of cohousing members, as well as how the devices themselves can support and sustain the ideals and practices of cohousing.

From an ecological perspective, these prototypes provide an opportunity to investigate the interrelation of IoT devices, materials, and everyday experience, while emphasizing particular values through design activity. By building new hardware systems that devise different types of social and community connection through materials,

Cohousing IoT critically examines the potential role of objects in the everyday lives of cohousing communities.

For the Cohousing Radio, this means that being able to create a new kind of social sphere for cohousing needs to be sure that the existing practices of cohousing are not undercut. The intention and goals behind cohousing need to be aligned strategically and carefully with the political goals of cohousing, the personal rationales for participating in cohousing and forms of material participation that residents are comfortable with. As it stands, the cohousing radio takes a stand for a cohousing IoT object ecology that has its own internal logics. As these prototypes operate presently as a site for productive design and intervention, this object ecology spurs speculative claims both about how communications technologies in homes might impact the social conditions around participation in cohousing as well as how those new conditions might be maintained over time.

Second, the object ecology also becomes a useful way to consider how designed objects help mobilize a broader ecosystem as members of a public. Physical RSVP and the Participation scales both illustrate the ways in which the ecology of mobile apps, databases, modeling and analysis make webs of mutual dependence and responsibility in cohousing more visible. The RSVP takes intention and physicalizes it, while the Scales represent participation itself in ways that prompt reflection in the community. In addition to making values present for humans, though, both of these systems serve to offer a way for ideals to participate more actively as part of cohousing: for the RSVP, social obligations and community traditions like common meals become instantiated and present in a thing that cohousing life itself participates in. For the Participation Scales, the

idea of being present and available in the community itself, as well as the obligation to do work for the community becomes newly present as a participant in reckonings about how well cohousing is being enacted at a particular site.

Methodologically, this ecological perspective comes from the idea of concretely comparing issues and ideas across multiple categories to produce an *expanded design space* that considers the perspectives of the contemporary Internet of Things, what an alternative Internet of Things could be like, and the values and needs of cohousing.

6.2.4 How these prototypes work

One way to think about how the role that these prototypes took on consider both whether they work and what kind of work that they do. On the most straightforward level, these prototypes didn't work. They sometimes failed to be compelling to residents, so they didn't work as design solutions to real-world problems. Technically, too, these prototypes didn't work precisely as described. As speculative Internet of Things devices, each of the prototypes relied on imaginary networks to tell a story about how they would or might operate practice. This is different from the prototypes not working at all though. The RSVP prototype, for example, sent a real signal to the internet that updates a calendar event. The Radio prototype plays songs that are sent to an email address and queued on a server. The Scales prototype is the least "real" in this sense, as the position of the scales represents a number that changes every 10 minutes on a server rather than the actual participation levels of cohousing community residents.

If these prototypes were approached as though they were real product concepts that were intended to be used in the here and now, this project might be a failure, at least from the perspective of human-centered design. Residents were skeptical of how the

prototypes could be used in cohousing. The Radio, for example, subverted an in-person sociability that many residents thought was an essential part of living together. The RSVP device, while possibly serving a useful function, would be too expensive to implement in the real world, meaning that common resources would be spent unwisely. The Participation Scales could just as easily create discord in the community as they could help understand what might work better. The prototypes offered applications and ideas that did not relate that strongly with the concrete issues and to the lived experience of cohousing residents. The day-to-day issues of the cohousing public and the speculative issues that the prototypes were concerned with were simply at odds with one another. From that perspective, the proposed devices misunderstand the relationship that residents of cohousing have to one another.

A more productive reading of these prototypes and the workshops, though, is that these breakdowns reveal hidden aspects of the cohousing IoT object ecology that were not considered during the design process. The devices were successful in helping residents consider the issues of cohousing but missed the mark in terms of their lack of fealty to plausibility in implementation for some residents. Instead, the mismatch made it clear what is actually at stake for cohousing residents—as outlined in the last chapter, these matters of concern are communication, fiduciary responsibility, and commitment to governance and process. The prototypes reveal a disconnect between the residents of cohousing and the design goals of the process: as they have to remain in order to maintain their community, residents are pragmatic first, and perhaps speculative last.

The alternative proposed here is to consider design as operating in a relational space that is contingent on context, but also to broader issues and outcomes than those

that benefit people alone. Designing in this frame does three things to explore an expanded design space. First, prototypes that result from this process represent issues that matter to publics. Further, though, these prototypes actively participate in the publics that they articulate the issues of, reframing the venue for interaction design research. Finally, the ecological perspective means that the design space itself becomes broader, meaning that the how the work "works" is not contingent on whether or not a particular design is successful or appreciated in itself, but rather how it makes manifest issues that operate as part of a broader system of objects, relations, and concerns—and whether those manifestations represent productive avenues for future design inquiries.

6.3 Reflections on ecological design

In this project, the object ecology is useful in that it provides a technique to consider things together that we don't usually think of as being related. Because the object ecology is a flat relation, it makes the work of creating relation easier. In Chapter 4, the generators that produced design concepts used technique that were speculating as to the possible contents of an object ecology. This is a means of speculating about those contents, and imagining new members of an object ecology that is rooted in practices in the real world that haven't been related, cohousing and IoT devices. While this might be common to many kinds of speculation in design, it is distinct in that this flattening de-privileges human perspectives. While human opinions matter in understanding what is made, as it is not possible to interview other members of these ecosystems, one of the ways that this approach differs from human-centered design is that in this accounting, people matter, but also more-than-people matter.

The object ecology offers a way to speculate without feeling quite so beholden to the human members of a condition. Sea changes in contexts for design are affecting how things relate in ways that humans don't have access to. This project used different ways to try to produce a breadth of concepts and project ideas that describe the contents of an object ecology that is unknowable and indescribable. The contents of an object ecology like Cohousing IoT can only be accessed through prototyping novel devices that work in that context. To understand whether or not this approach was successful required human input, which was in some ways at odds with the spirit of the project. Earlier visions of this project promised new understandings of the interrelationships between people and things. While that may not have manifested, exactly, what has happened in this project is itself interesting, if more limited than that. It offers a framework for thinking about the relationship between people and things as a framework for design—object ecology. It has illustrated how speculation can work within the framework as a means of generating design concepts rooted in a particular context, in this case the object ecology of cohousing IoT. Finally, it has prototyped these concepts and taken them to members of the ecology where a discussion of them has served to articulate the contents of the object ecology more concretely—thereby offering the chance to develop more concretely applicable design concepts in future iterations. This project developed out of idea and issues in contemporary design theory, and has a point of view about what designing from an ecological perspective can offer that is is described in detail below.

6.4 Ecological approaches to design

Using this ecological metaphor to drive a design process is useful because it reorients the designer away from human-centered ideas of success and seeks to take into

account a broader variety of stakes and perspectives. Rather than straightforwardly hoping to satisfy the needs of a user, design in this context hopes to produce artifacts that articulate missing aspects of a broader ecology. This design process comes through three angles on what the object ecology provides and requires as part of a design process. The first of these is how speculation is required as means of gaining access to a complex design space that is impossible to know in its entirety. The second is the expanded perspective on a design issue that comes from ecological approach, and the third is how a flattened perspective on the broader ecological design space in this project helps to produce agentic systems of both people and things.

6.4.1 Inspiration through speculation

One of the first ways an ecological perspective affects the design process is through an oblique perspective being taken on a design space. One of the goals of approaching a design project through an ecological frame is to be able to take components of an ecology into account that are usually not under consideration—and correspondingly articulate ecologies that are not often accounted for through prototyping. Based on this oblique inspiration, ecological perspectives can account for a broader range of participants than humans and human needs.

In this project, for example, speculation is used as both a method for doing design work, but also as a means of articulating the unknown aspects of an object ecology comprised from the Internet of Things, visions of alternative technological presents, and domestic outliers such as cohousing. In Chapter 4:, these three concepts were combined using the idea of values from each. Because the contents of the object ecology aren't readily available, it's necessary to find means of accessing what sets of ideas in relation

correspond to design ideas in that space. For this project, the means of probing the edges of a design space was programmatic and relied on lists of values that together comprised three axes for a broad design space called “Cohousing IoT.” The generators that were described in Chapter 4 served both to generate collisions of values that described possible points in the design space, as well as served to attune the designer to what kinds of things might be possible in that system.

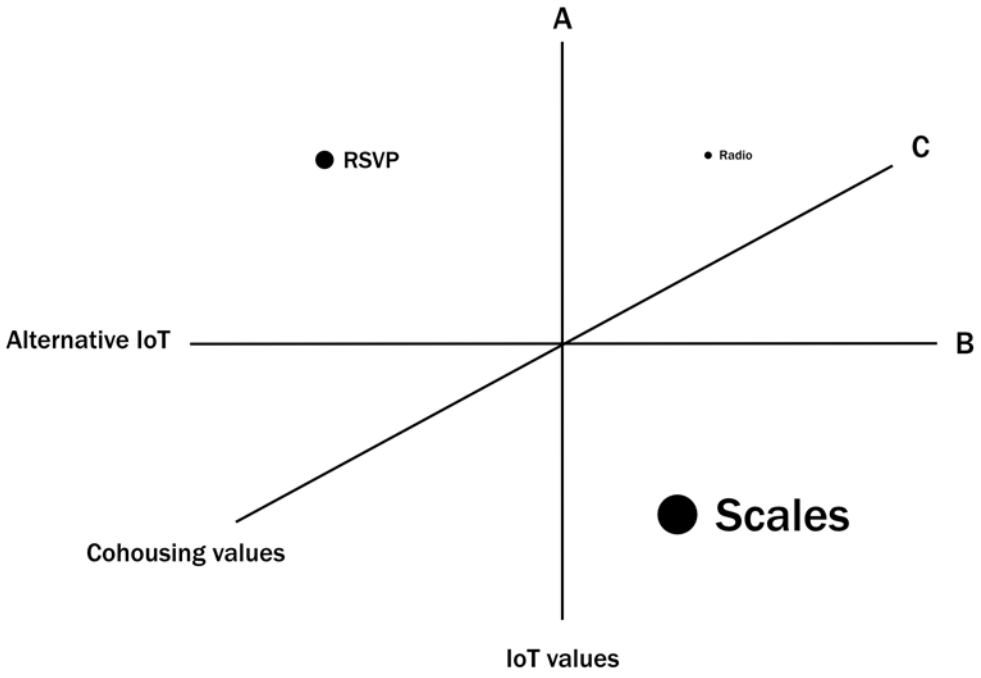

Figure 45: The Cohousing IoT design space

The second mode that speculation takes on in ecological design comes from how the generated values in collision with one another become interpreted as relevant design concepts. Here, speculation is necessary to interpret points in a design space as becoming something more than simply lists of values, in this case. In Chapter 1:, this project was described as “not so much an effort of producing devices that work in cohousing itself, but instead as a means of physicalizing a locus of different interests that together serve to cast a new light on existing trends in design as well as contemporary understandings of

technology" (3). This process of physicalizing means that speculating as to the contents of the Cohousing IoT object ecology is essential to produce real-world concepts that make these loci able to be prototyped, described in Chapter 4: as being a process of inductive sensemaking that relies on the experience of a designer—here, design research materials can be synthesized into concrete design ideas through multiple iterations of prioritization, judging, and forging connections based on the materials gathered through design research coupled with a researcher's own experience and insight (Kolko 2010). This meshes nicely with the concept of design wisdom to produce the right ultimate particular (Nelson and Stolterman 2012). Here, the goal is to produce a particular that exemplifies the nature of an object ecology through speculation as to its contents.

Theoretically, the result of this kind of speculation as to those contents of an ecology generates placements that do the work that Buchanan describes: "Placements… shape and constrain meaning, but are not fixed and determinate. The boundary of a placement gives context or orientation to thinking, but the application to a specific situation can generate a new perception of that situation and, hence, a new possibility to be tested. Therefore, placements are sources of new ideas and possibilities when applied to problems in concrete circumstances" (Buchanan 1992). This is how these placements reveal aspects of a broader object ecology that is itself black-boxed. Because the placements in the object ecology describe loci of interacting aspects of a design space, design objects serve to describe the object ecology in richer detail. These placements are both provisional, in that they speculate to aspects of a space that is unknown, as well as rigid, in that they are design concepts that instantiate an idea of an ultimate particular in a specific design prototype. Uncovering particular loci in an object ecology that offers the

"new possibilities to be tested" that Buchanan describes is how Cohousing IoT can produce the desiderata of the Internet of Things. The prototypes work to describe multiple visions for alternative approaches to IoTs, housing, and how they might interrelate.

6.4.2 Expanded perspectives on design

The broader perspective on a design space that these speculative placements represent reflect a broader theoretical engagement with how design works in different contexts. An ecological perspective on design means that existing design theory may need to be adapted to reflect new issues and different understandings of that design space. In Chapter 1:, ecological approaches to design are often framed as a "product," centering a human need as the core obligation to be designed for. In cohousing, though, this idea of product is not quite broad enough to account for the work that things do in social spheres. A distributed home affects the idea of product by breaking down some of the boundaries that contextualize the thing. For example, Forlizzi's product ecology seeks to address how functional, aesthetic, symbolic, emotional, and social dimensions of a product combine in an ecology to understand how people make social relationships with products (Forlizzi 2008).

Cohousing as a venue for this design process changes the product ecology, or at least broadens how it has to be understood and approached. The product ecology needs to account for more domains in a situation of the distributed homes of cohousing than it would in a single-family home. Distributed "homeness" and designing across shared the shared boundaries of cohousing means that design artifacts need to account for how values and practices are negotiated by people, but also materialized through things. In

this shared space, the product ecology becomes more complex. Further, without a specific product niche to be designing for, other questions arise. What does it mean to speculate towards future ecologies? What might it be like to design for multiple different futures? Figure 50 shows what a set of possible product ecologies might be like in a object ecology—a design space rooted in speculation:

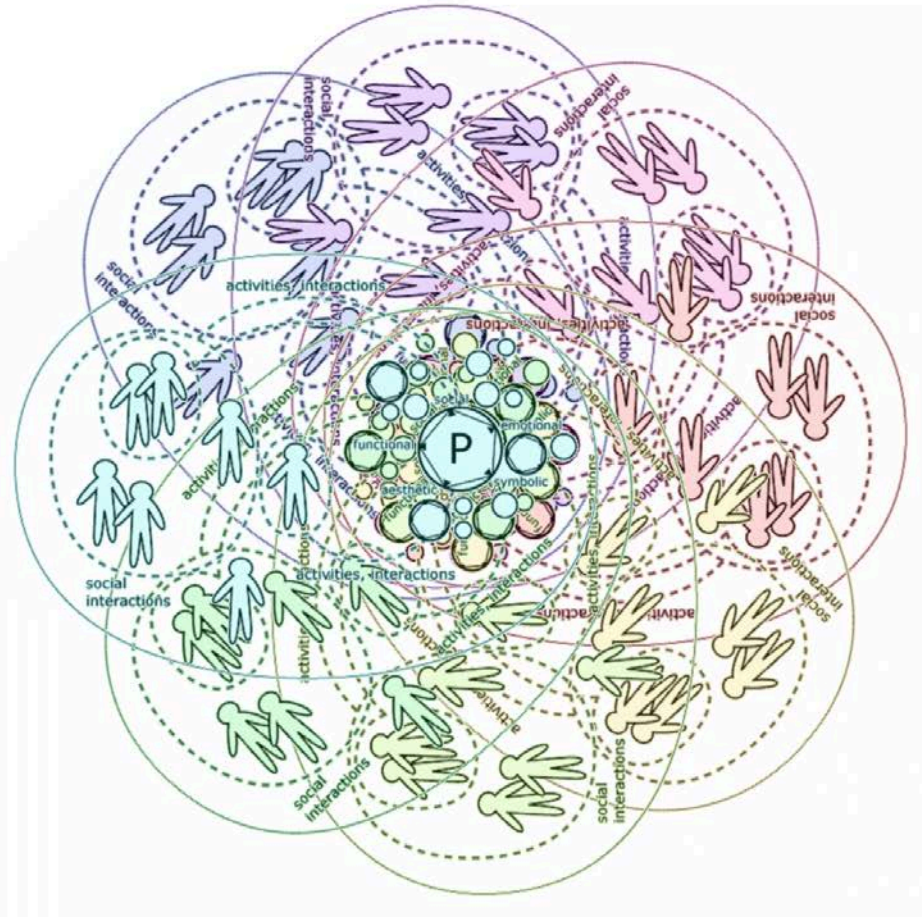

Figure 46: Possible product ecologies

Most problematically from the perspective of this research project, the product ecology centers around the idea of a product that is designed to be evaluated and understood by humans—designed for human use and fulfilling well-defined product roles. This project, though, tries to decenter the human from the process of design, considering the design object as sites for articulating futures and manifesting complex

design spaces. Instead of fully realized "products," as Forlizzi and Margolin might call them, the Cohousing IoT devices are provisional concepts that are closest to some sort of imaginary, speculative product. These speculative products make the role of the object ecology fundamentally quite different than the product ecology. In the product ecology, there are established niches for products that live in the home—say a vacuum cleaner—and then the idea of the ecosystem of products can be used to understand how iterations within that niche could be received. Rather than products that are meant to solve problems in cohousing, Cohousing IoT seeks to understand the matters of concern of cohousing and see how they can be represented in design artifacts.

6.4.3 Agentic systems of people and things

The Internet of Things is an ecosystem of devices that controls, adapts, and regulates informational aspect of the home towards particular ends. The devices in that ecosystem take on particular roles in the home that could be considered as niches. Connectivity to the Internet and automation based on sensor technologies make the devices of the Internet of Things more obviously an ecological analogue than many other sets of things. Domesticity too, though is also an ecosystem that deals with things and cumulative meanings to support the practices that make home what it is. If we think of objects and materials as collaborating in constructing social practices, then of course domestic life is shaped by things.

Domesticity is a site for participation of materials. Cohousing demonstrates how materials like these support novel kinds of participation through aligning residents in social routines, ongoing domestic practices. Bulletin boards organize events and structure discussions, and barriers keep cars from encroaching on pedestrian spaces, for example.

What the prototypes do to extend how domestic objects can participate in cohousing life is to offer a site for interpretation, or perhaps in this case contestation about what it means to live in cohousing, and what kinds of roles smart home technologies could play in this realm. Cohousing IoT is an example of how prototypes could be understood as authoring space for intentional living. Intentional communities like cohousing are driven by a set of goals and values that drive participation in the community, and the prototypes are designed to extend how these intentions are enacted in the community through devices. The object ecology simultaneously lets a prototype representing issues, construct novel object relations, and articulate design spaces in richer and more specific detail than they were before.

The epistemological framing of the object ecology relies on producing placements that speculate as to the edges of an ecosystem: it is rooted in the author/experimenter commitments towards HCI research in domestic contexts and emphasizes a material perspective on how homes are constituted. This means that "smart home" is an ecology of things that work together to produce certain effects. Looking at smart homes as an object ecology offers a perspective where we can critique and interpret IoT practice in new ways. Cohousing IoT provided a lens on the role of materials as producing and supporting values in home practices, distributed across the property of cohousing communities. Each of the prototypes sought to support the values of cohousing for residents, and through supporting those values, to assist in the practice of constructing a smart home that is specific to cohousing.

6.5 Conclusion: desiderata in design ecologies

Cohousing provides a means of approaching smart homes as a system of already-connected residences that work together for aims that are social and strongly oriented towards values and intentional living. This project produced three prototypes that articulate these values and provide a means of thinking about how smart home technologies might be acceptable, unacceptable, or intriguing in cohousing contexts. A series of codesign workshops with residents of cohousing led to interpretations of the prototypes that emphasized the role of ecological design in helping to articulate design opportunities that are outside of the mainstream. Without an ecological perspective, the prototypes might be understood as failures.

This theoretical framework describes what kinds of values built into objects and their ecosystems and how interaction with objects in these systems serve to reinforce and articulate them. It describes how computing technologies construct social structures into objects in ecological ways and is driven by design research into outliers of domestic life.

The ecological perspective on objects and their interrelation requires a commitment to speculation as a method. The scale and scope of a truly ecological approach means that speculation is necessary method to do design. When even the most mundane aspects of the system can be read into infinite regress, it seems clear that a complete, holistic knowledge of an ecosystem is clearly impossible. The term "speculative design" as it has been used to mean design work that seeks to propose alternative futures or provide arts- inflected understandings of current issues becomes outmoded—instead, all design is necessarily speculative, the work of designers bridging

the gaps of perfect knowledge to produce devices and systems that works in concert with existing or proposed ecosystems of people and things.

An ecological design process helps to explore the desiderata of design spaces that were previously unknown. This process offers designers the ability to speculate towards that which is not there and produce placements that describe what could be. Cohousing IoT is an attempt at building a set of objects that represent desiderata for the Internet of Things. The prototypes reflect a different set of values and assumptions about what domesticity is or should be, as well as the kinds of roles and services that technology *should* be taking on in future smart homes.

APPENDIX A: IOT SYSTEMS

Figure 47: IoT Devices. SmartThings Hub and Vera Edge.

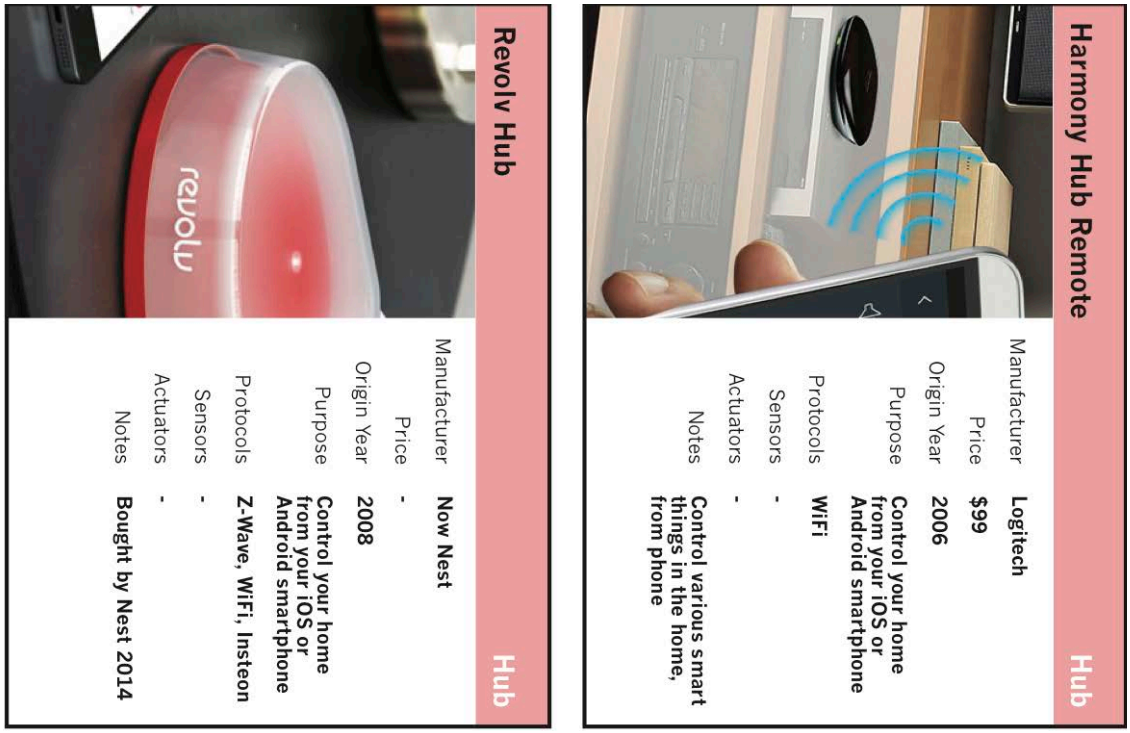

Figure 48: IoT Devices. Harmony Hub Remote and Revolv Hub.

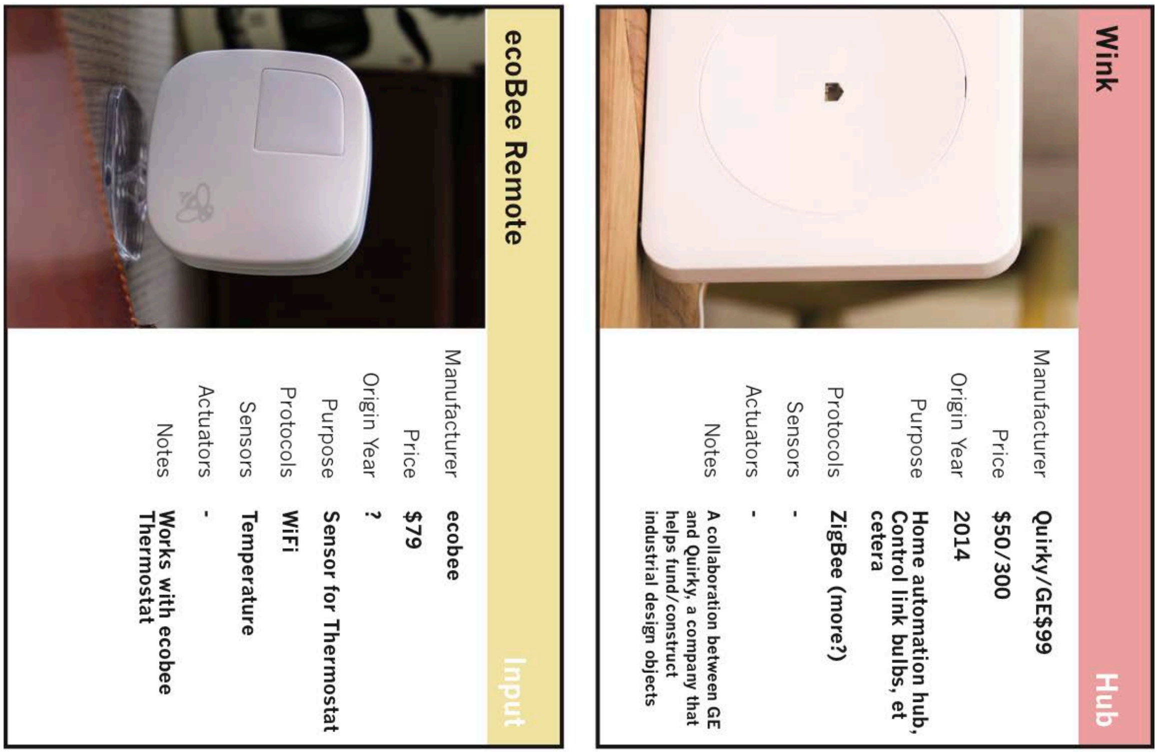

Figure 49: IoT Devices. Wink and ecoBee Remote.

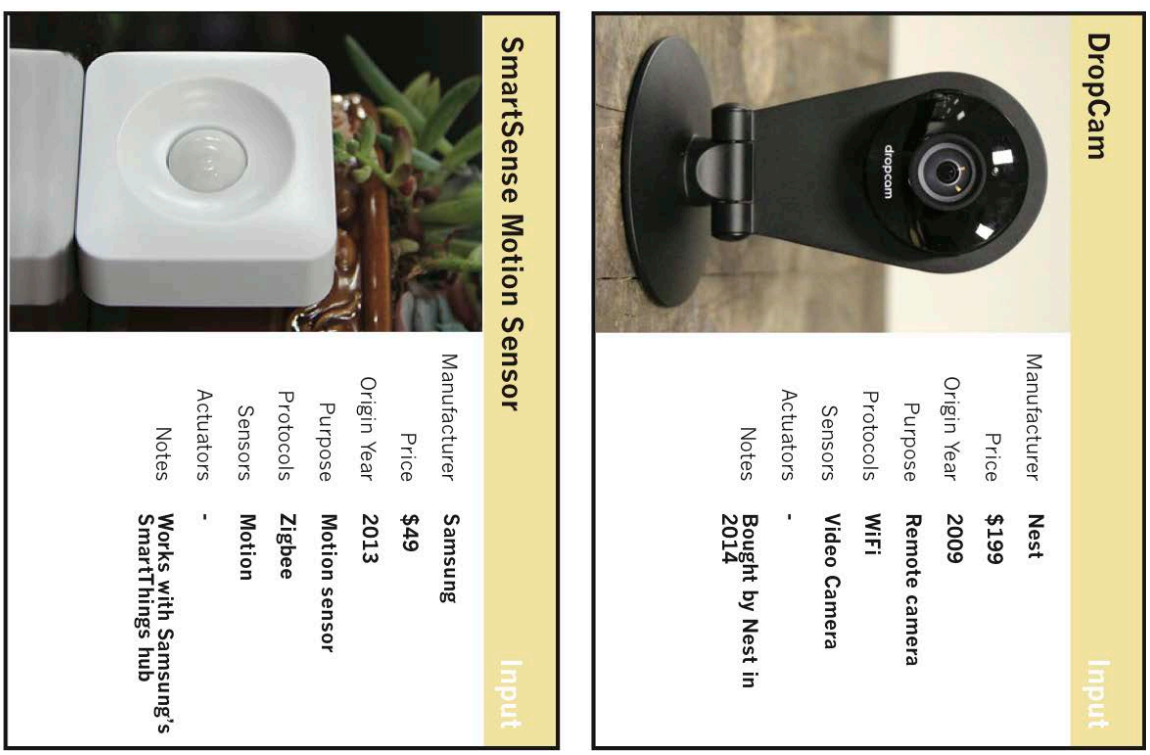

Figure 50: IoT Devices. Nest DropCam and SmartSense Motion Detector.

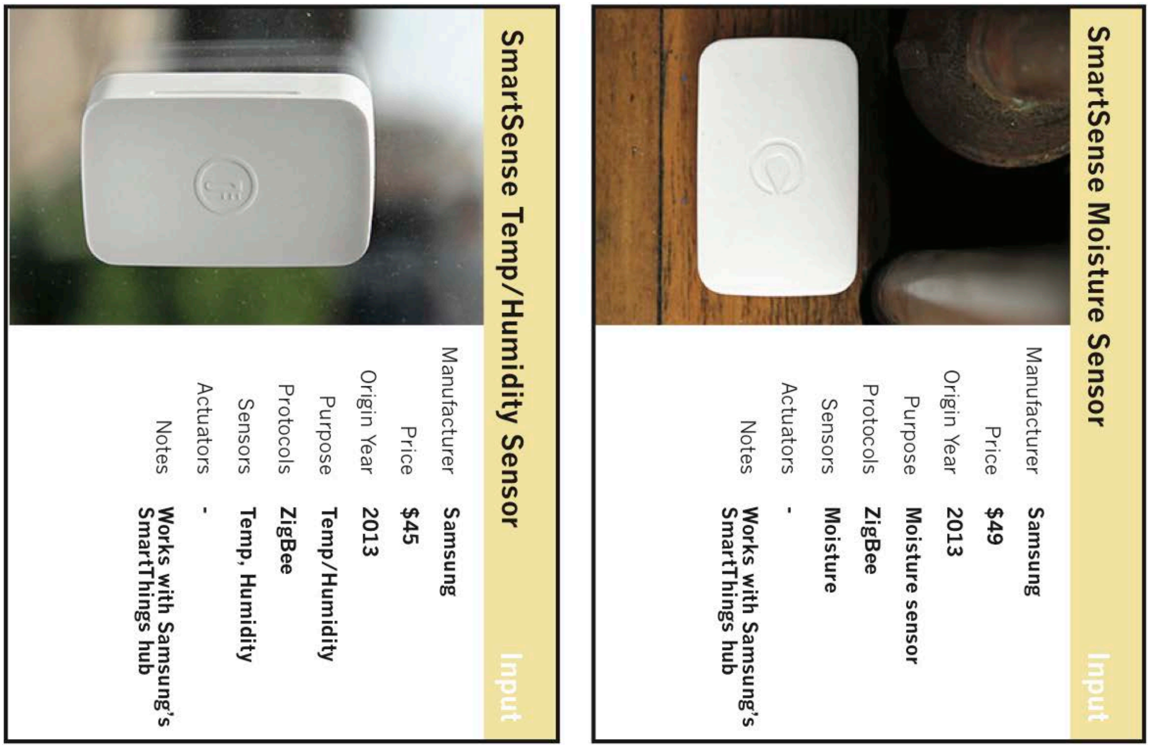

Figure 51: IoT Devices. SmartSense Motion Sensor and SmartSense Temperature/Humidity Sensor.

Figure 52: IoT Devices. SmartSense Open/Closed Sensor and SmartPower Outlet.

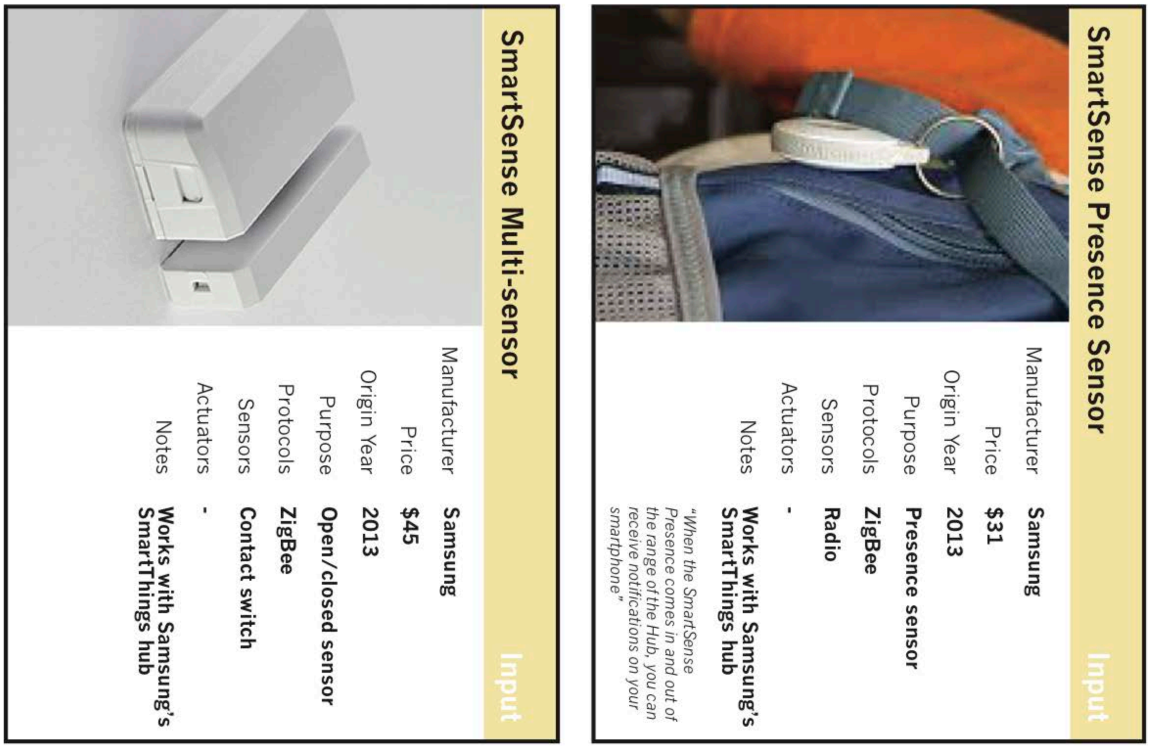

Figure 53: IoT Devices. SmartSense Presence Sensor and SmartSense Multi-sensor

Figure 54: IoT Devices. Link bulb and Nest Thermostat.

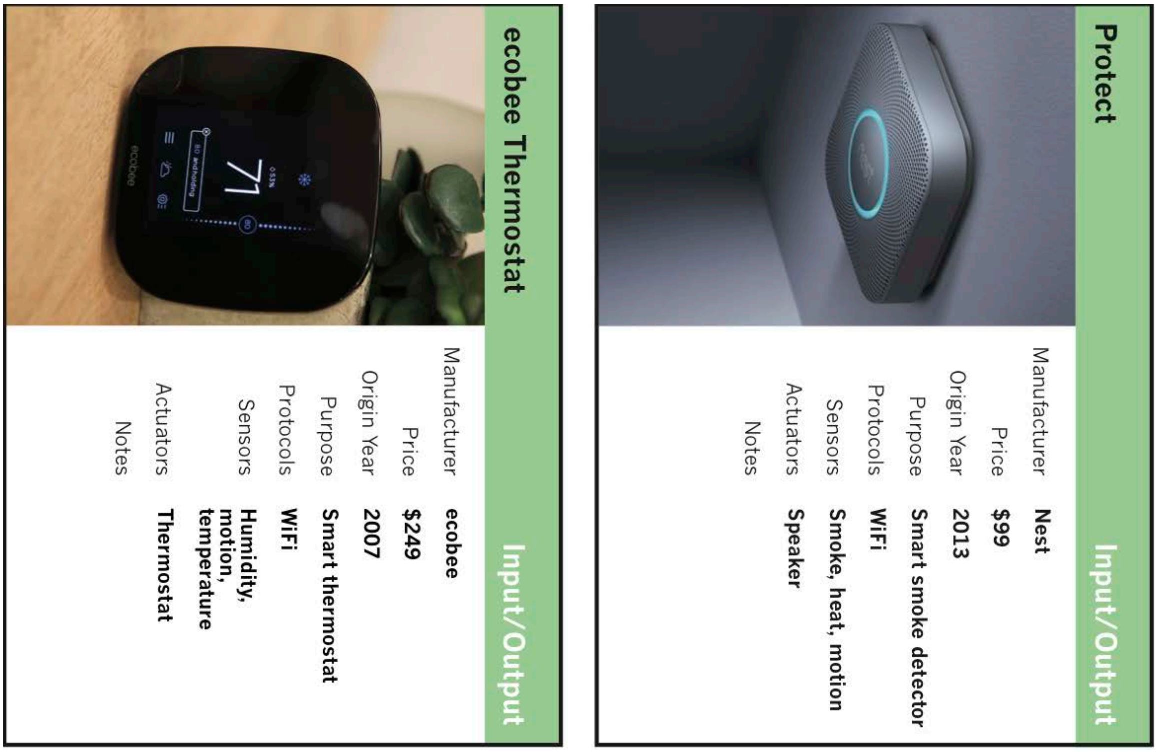

Figure 55: IoT Devices. Nest Protect and ecobee Thermostat.

Figure 56: IoT devices. Amazon Echo and Roomba.

APPENDIX B: IOT A VALUES

Table 16: IoT A Values for IoT devices surveyed

	Analytics	Connectivity	Convenience	Control	Data-driven	Decentralized	Digitizing the physical	Efficiency	Makes Internet Sensory	Managing	Measuring	Monitoring	Operationalizing	Computers in your home	Productivity	Profitability	Safety	Security	Time-saving	Transformational	Tracking	User autonomy
Harmony hub remote	0	9	9	10	0	3	5	5	0	10	0	5	6	10	7	3	0	0	5	7	2	6
SmartThings Hub	8	10	8	10	7	6	5	5	5	9	0	8	8	10	5	9	5	5	3	6	8	4
Vera	8	10	8	10	7	6	5	5	5	9	0	8	8	10	5	9	5	5	3	6	8	4
Revolv Hub	8	10	8	10	7	6	5	5	5	9	0	8	8	10	5	9	5	5	3	6	8	4
Wink	8	10	8	10	7	6	5	5	5	9	0	8	8	10	5	9	5	5	3	6	8	4
Dropcam	0	8	6	8	5	8	10	7	10	4	6	10	6	10	6	7	10	10	1	4	5	4
Ecobee Remote	0	8	9	5	6	10	10	5	4	8	9	10	10	8	4	8	3	1	5	6	5	6
SmartSense motion sensor	0	9	3	4	7	5	10	5	7	9	9	10	10	7	3	9	10	10	2	5	8	5
SS open sensor	0	9	3	4	7	5	10	5	7	9	9	10	10	2	3	9	10	10	2	5	8	5
SS temp. sensor	0	9	8	5	5	6	9	6	8	9	9	9	10	2	5	9	3	3	5	3	7	4
SmartPower outlet	0	9	8	10	7	8	2	7	6	10	5	10	9	2	6	9	4	3	4	4	7	6
SS presence sensor	0	9	8	9	8	8	8	5	5	6	8	8	6	4	7	9	3	5	5	6	8	6
SS multi-sensor	0	9	6	9	9	9	10	7	5	8	6	9	7	5	5	9	5	5	3	5	7	5
Sonos Speakers	0	8	9	10	0	3	0	5	9	8	0	0	7	5	3	9	0	0	3	6	1	6
Hue Bulb	0	6	7	10	0	2	0	4	9	8	0	0	5	3	3	9	0	0	3	6	1	6
Link Bulb	0	6	7	10	0	2	0	4	9	8	0	0	5	3	3	9	0	0	3	6	1	6
Nest thermostat	10	10	9	9	10	9	9	9	9	10	9	10	5	9	6	6	3	2	6	9	10	4
Nest Protect	4	10	9	6	10	8	9	6	5	10	9	10	9	9	6	6	10	8	6	6	10	4
ecobee Thermostat	9	10	9	9	10	8	9	9	9	10	9	10	9	9	6	6	3	2	6	9	10	4
Amazon Echo	10	10	10	9	8	9	6	6	9	7	6	10	9	9	9	9	3	3	9	9	10	7
Cat Genie	1	0	7	6	0	0	0	9	0	2	0	6	9	7	9	9	0	0	7	8	0	5
Roomba	1	0	10	4	0	0	10	10	0	2	0	5	10	7	9	9	0	0	9	8	0	0

APPENDIX C: VALUES

Table 17: A, B, and C values.

A	B	C
Analytics	Intuition	Affordability
Connectivity	Distinctiveness	Caring
Convenience	Willfulness	Community
Control	Abdication	Consensus
Data-driven decision-making	Emergent consensus	Cooperation
Decentralized intelligence	Cumulative wisdom	Diversity
Digitizing the physical	Supporting the ineffable	Education
Efficiency	Leisureliness	Family
Makes the internet sensory	Making sociality physical	Generosity
Managing	Delegating	Intentionality
Measuring	Reflecting	Joy
Monitoring	Participating	Outreach
Operationalizing	Interpreting	Participation
Computers in your home	Collaboration across space	Privacy
Productivity	Playfulness	Respect
Profitability through ubiquity	Site-specific utility	Responsibility
Safety	Freedom	Security
Security	Semi-permeability	Sharing
Time-saving	Time-sensitiveness	Simplicity
Transformational	Being supportive	Sustainability
Tracking	Forgetting	Efficiency
User autonomy	Object autonomy	Work

Table 18: Values of the IoT.

analytics	that data gathered from sensors and other appliances can be used to reveal trends in everyday life
connectivity	that devices are worthwhile when connected to one another and their data can be collated
convenience	that products should be designed and implemented to support a user's needs
control	the value that supports finer grains of a central user's agency in augmenting everyday objects being
data-driven decision-making	similar to analytics above, that products and services in an IoT ext should be motivated to gather data and use those data for decision-making
decentralized intelligence	or smart things taking some of the cognitive load off of a resident manager
digitizing the physical	part of creating the data to analyze for decision-making aspects of the physical world need to be represented via computation
efficiency	one of the core tenets of the IoT is that better-managed algorithmic objects can be more efficient than standard devices
making the Internet sensory	perhaps the most important aspect of IoT systems—here devices make they have accumulated salient and sensible in everyday life
managing	the idea that corralling these devices helps a user to exert deeper and richer control their environment
measuring	that data collected by devices is converted to a metered frame for comparison across contexts
monitoring	or the expectation that data collection is occurring at all times
operationalizing	how measured data are converted into actionable insights
placing computers in your home	the fundamental conceit of the Internet of Things
productivity	an implicit promise that automation increases output
profitability through ubiquity	that efficiencies gained (or data gathered) become more profitable or predictive at scale with respect to location and place

safety	a primary goal of many IoT systems is that better information will create safer lives
security	that real-time monitoring offers a means of providing command and control to any owner at any time
time-saving	one of the promises of gained efficiency through devices managing aspects of everyday life
transformative	the fundamental promise that the Internet of Things brings something wholly different and revolutionary
tracking	that data can be identified and traced across contexts and
user autonomy	the idea that the fundamental goal of all of this deployment is about the end user.

Table 19: Alternative values for the IoT.

intuition	that there might be issues and ideas worth sensing that can't be planned for in advance
distinctiveness	the idea that computing in everyday contexts might throw difference into relief instead of flattening the world for more straightforward data analysis
willfulness	that devices might have their own ends and goals and be resistant to taking up ours
abdication	that humans might not seek to manage certain contexts at all and would instead prefer to fully delegate to trusted technological partners
emergent consensus	that plural perspectives on the world through devices could negotiate some kind of ground understanding of events over time
cumulative wisdom	that these perspectives and ground understandings could be better informed or more valuable than strongly analyzed and data driven decisions
supporting the ineffable	having a kind of flexibility that doesn't rely on well-defined categories of internal representation
leisureliness	being able to address broader aspects of human experience than just control or efficiency

making sociality physical	that one role for computing to take on in the world might be to make human networks manifest instead of technological ones
delegating	being able to trust technological agents to handle decision-making on their own instead of being an extension of human will
reflecting	prompting reflexive behavior in everyday life
participating	being an active member of practices in the world
interpreting	leaving space for people to understand a device on its own terms
collaboration across space	emphasizing the content of a system and not the material
playfulness	a rejection of pure efficiency as a goal in the Internet of Things
site-specific utility	designing and building systems for specific contexts instead of for a broad market that is rendered indistinct
freedom	instead of being locked into particular vendors, APIs, and manufacturers
semi-permeability	that there are some conditions that don't extend to all parts of a network
time-sensitiveness	both in the sense that certain kinds of interactions are ephemeral as well as the idea that there is a right time
being supportive	that devices in the world are there to support goals, but not be instrumentalized in realization of them
forgetting	that data accumulated need not become part of a persistent and permanent record for marketing and model-building purposes
object autonomy	that devices in the Internet of Things operate towards their own end and goals.

Table 20: Cohousing Values.

affordability	controlling costs through smaller housing sizes or even direct subsidy
caring	broadly meaning the quality and depth of relationships between cohousing residents
community	perhaps the value most underlying cohousing as a practice, understood as a sense of general fellowship
consensus	managing the community and making decisions in a group through deliberation and unanimity
cooperation	a common sense of working with one another
diversity	open-mindedness towards and acceptance of differences in race, age, gender, sexuality, and ability and other aspects of identity and experience
education	Helping others to become informed about cohousing as a model of living and way to structure relations
family	a commitment to growing and supporting children, youth, and various family configurations
generosity	here meaning a generosity of spirit in interacting with community members
intentionality	living thoughtfully and deliberately, especially with respect to cohousing values
joy	taking pleasure in the community itself
outreach	serving as an example of lifestyle for the greater community outside of the walls of the community
participation	taking an active role as a resident in shaping the community that you want to have
privacy	in this case meaning valuing individual space as well as participation in the community at large
respect	treating residents with kindness and care
responsibility	understanding your part and commitment to the community at large
security	meaning that every member should feel comfortable and safe in the community

sharing	or willingness to contribute goods or services to another resident in need
simplicity	reflecting a minimalist lifestyle that supports richer personal experiences
sustainability	ecological sensitivity, not using more of materials or resources than is needed
efficiency	for cohousing, energy-efficiency in particular
work	helping to maintain the community by taking part in the labor that makes it run

APPENDIX D: PROJECT CONCEPTS

01 Hyperlocal radio
shows for an audience of 20 people, inside 100m range
weather, event, issues, grievances, music
(connectivity/participating/collaboration)

02 Competitive energy use monitors
automatically choosing things like shower temp
nest-like control of temperature, across spaces and homes
goal to bring down average energy use
(computers in your home/collaboration across space/sustainability)

03 Physical RSVP for common meals
like marble answering machine
get a pebble, place it in a cup to respond to invitation
(convenience/makes sociality physical/responsibility)

04 Committee process objects
material of object relates to frustration or smoothness
object refinement reflects process of committee
(productivity/makes sociability physical/process)

05 Dashboard for resident statuses
distributed system for understanding wellness across many axes
grid of lights: x-axis homes, y-axis issues
(monitoring/object autonomy/collaboration)

06 Homemade sensor kits
doors/temp humid/light/etc
easy to assemble, automatically report to dashboard
(computers in your home/supporting the ineffable/resident management)

07 Sharing economy within cohousing
storage issues, cup of sugar, a tool you need
(tracking/collaboration across space/collectivity)

08 Emotional intercom
some abstracted measure of every home shared with nearest neighbors
this is largely the affector but across homes rather than offices
(analytics/semipermeability/responsibility)

09 Coho.org
wikipedia style best practices guide for cohousing
(connectivity/interpreting/choice)

10 Work monitor that doesn't hold a grudge
(transformative/forgetting/resident management)

11 Github for bylaws
offer pull requests as amendment process
manage issues via comments, proposals via branching
(connectivity/supportive/transparency)

12 "Expert system" for decision-making process
feed in questions and problems and have a response for what to do
ticker tape machine :)
(data-driven decision-making/abdication/intentionality)
(tracking/delegating/intentionality)

13 Organic farms/garden technology
hard to ignore that this is a component of these places
(managing/site-specific utility/support)

14 Stranger detector
makes it clear when strangers are around
raise a flag, make a light glow or other output
based on unknown MAC addresses
(safety/interpreting/trust)

Figure 57: Project concepts based on the values generators.

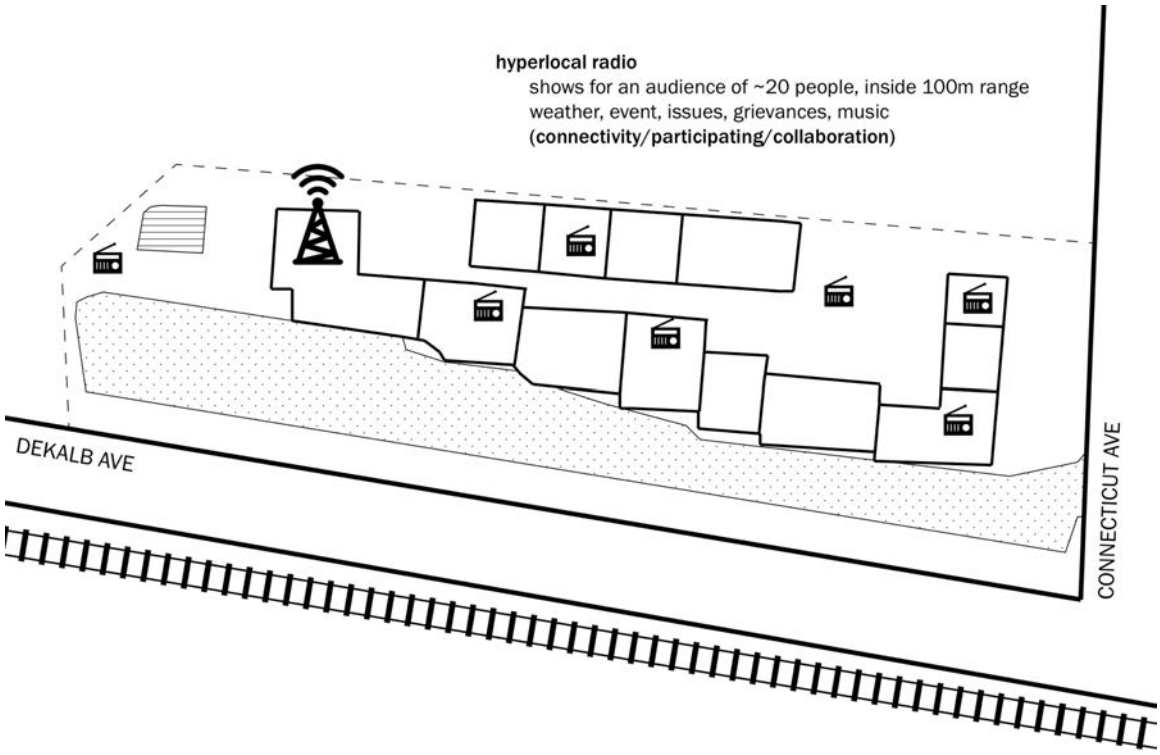

Figure 58: Hyperlocal radio concept, Lake Claire Cohousing.

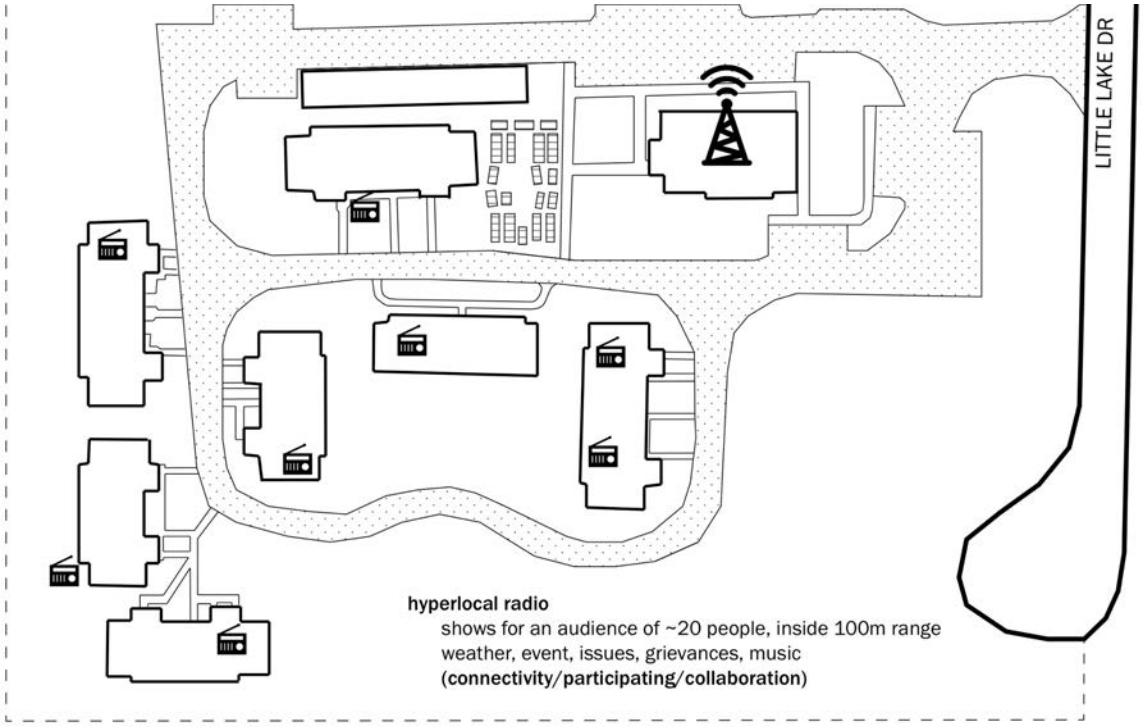

Figure 59: Hyperlocal radio concept, East Lake Commons.

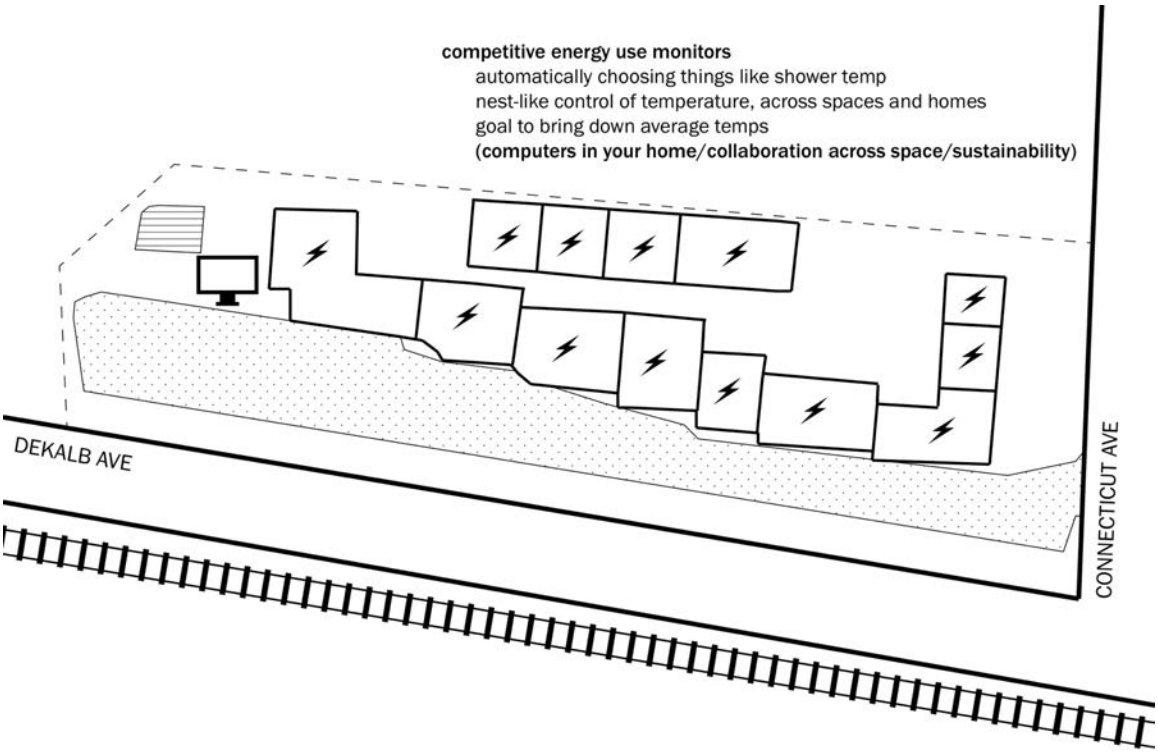

Figure 60: Competitive energy use indicators, Lake Claire Cohousing.

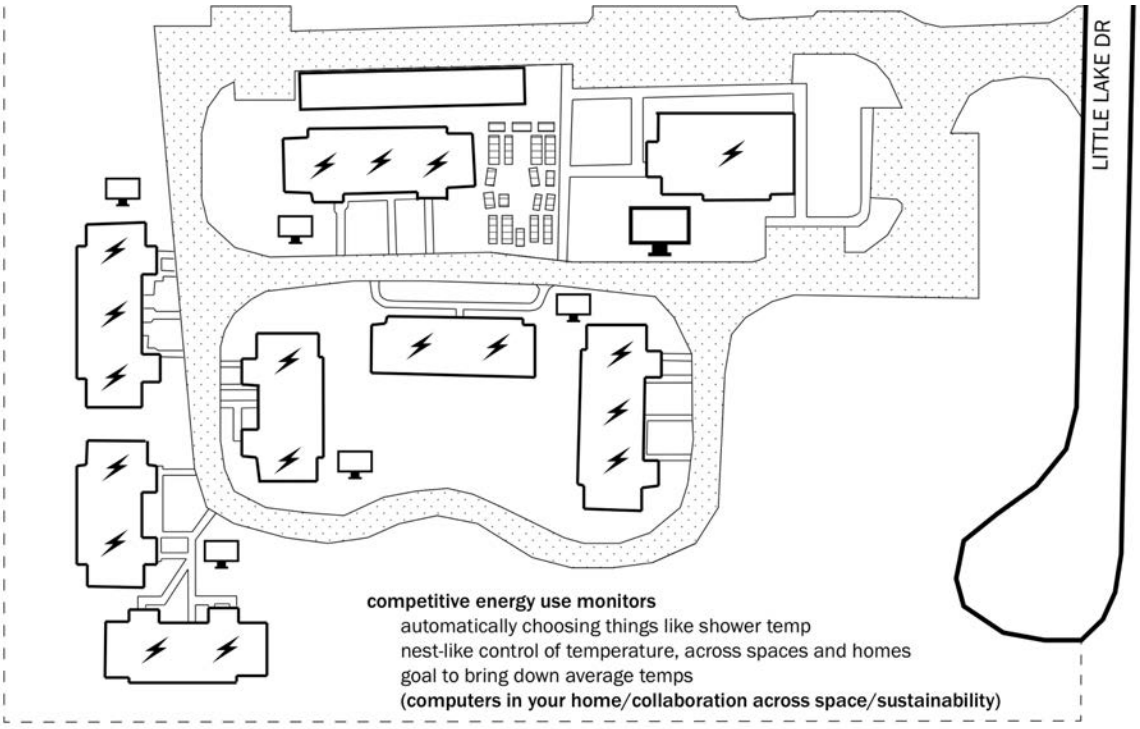

Figure 61: Competitive energy use indicators, East Lake Commons.

physical rsvp for cohousing events (common meals etc)
like marble answering machine
get a pebble, place it in a bowl to respond to invitation
RFID in ball corresponding to household members
(convenience/makes sociality physical/responsibility)

Figure 62: Concept sketch for Physical RSVP.

committee process objects
material of object relates to frustration or smoothness
object refinement reflects process of committee
(productivity/makes sociability physical/process)

Figure 63: Concept sketch for committee process objects.

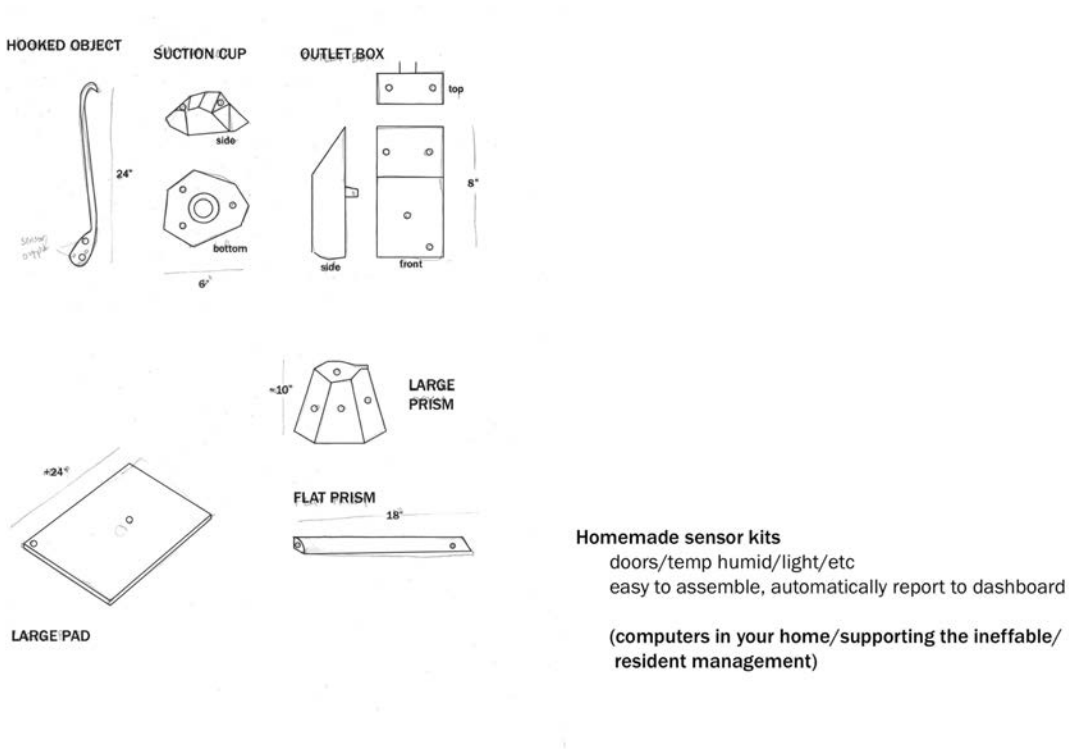

Figure 64: Concept sketch for homemade sensor kits.

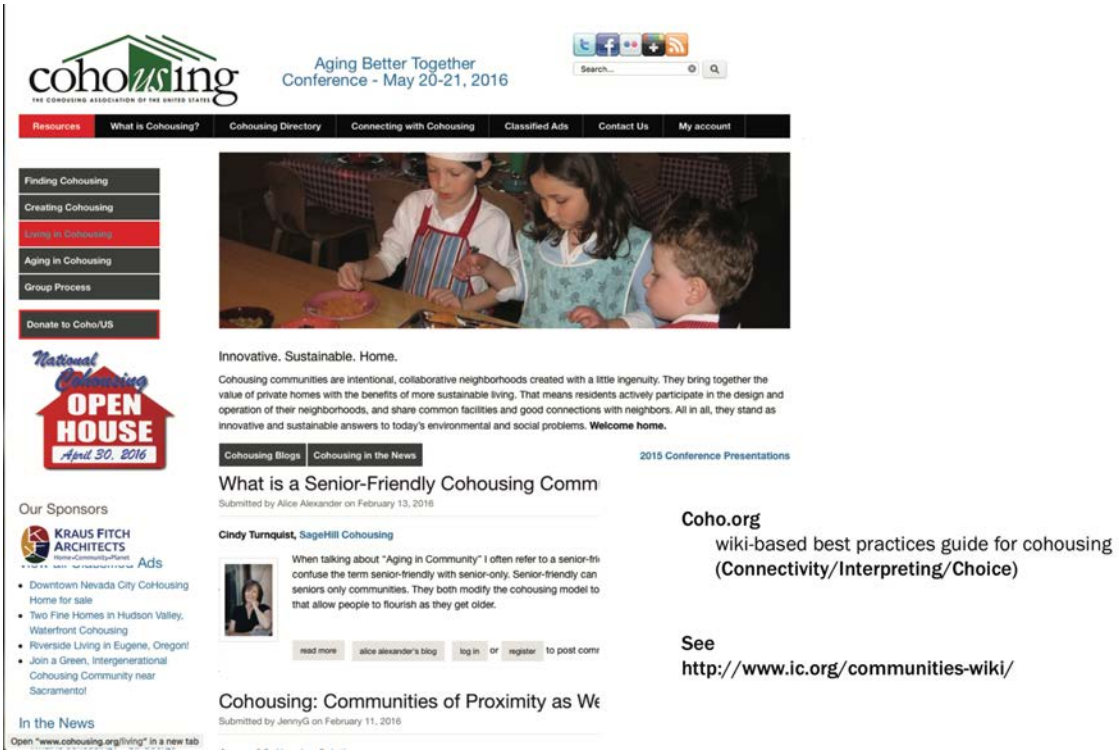

Figure 65: Concept sketch for redesigned/reimagined coho.org

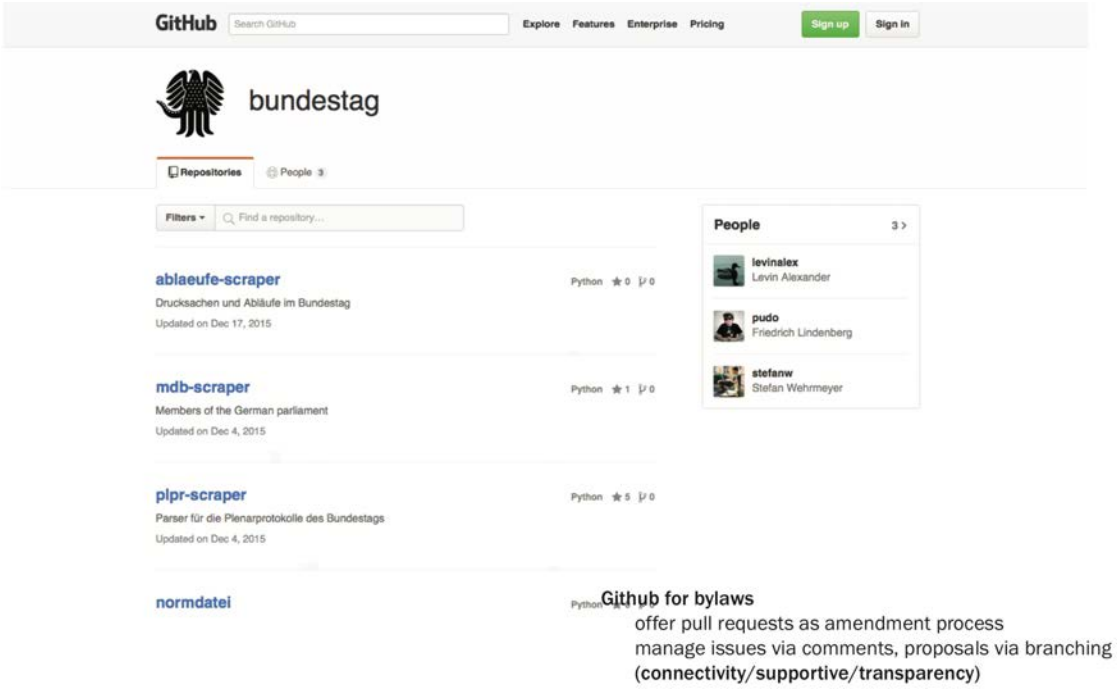

Figure 66: Concept sketch for a Github-like repository for cohousing bylaws.

Figure 67: Concept sketch for organic farming technology.

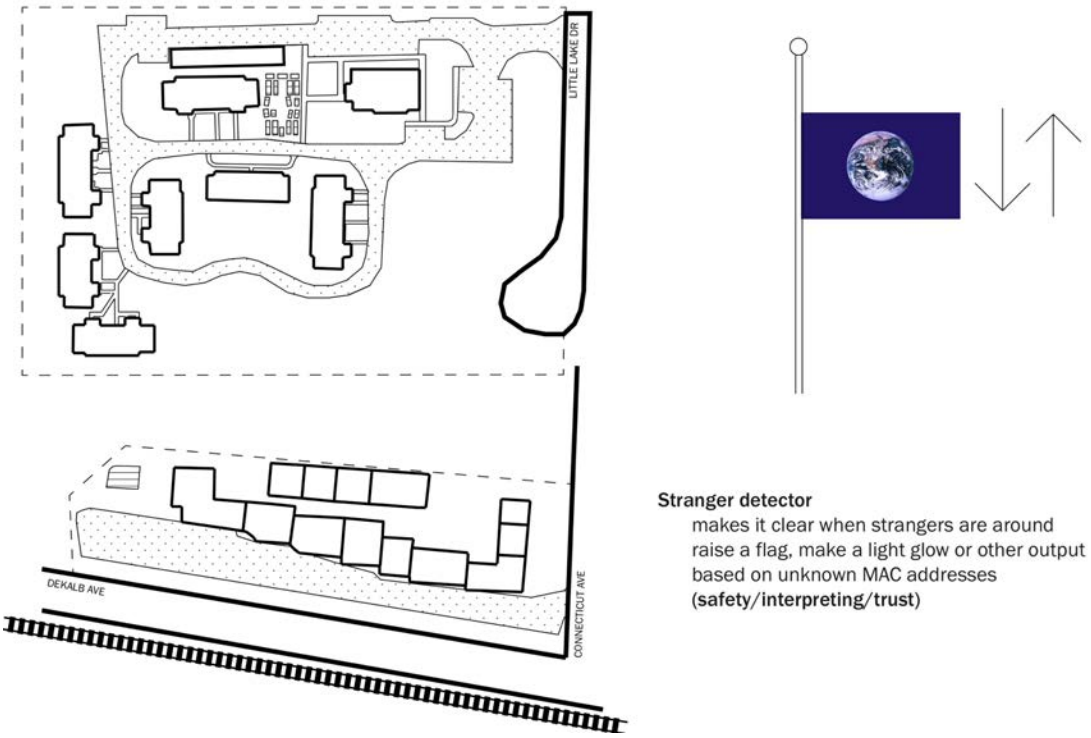

Figure 68: Concept sketch for a cohousing stranger detector.

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