Exploring Social Relationships Between Smart Homes and Their Occupants

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ABSTRACT
This position paper details the breakdown of possible relationships between smart homes and their occupants This breakdown includes: (i) individual occupant to single agent, (ii) individual occupant to multiple agents, (iii) individuals to single agent, (iv) individuals to multiple agents, (v) groups to single agent, (vi) and groups to multiple agents. In addition, it argues that more research should be focused on exploring numbers (v and vi) instead of the current focus on (i and iii).

Author Keywords
Ubiquitous computing, smart home, family, social interaction, agency, agent, multi-agent, application-based model, activity-based model.

INTRODUCTION
Ubiquitous computing strives to enhance the human-computer interaction experience by making many effectively invisible computers available throughout a physical environment [18]. Within the context of the home, this research goal has manifested itself in the concept of the "Smart Home". Research examples from industry and academia include: Georgia Tech's Aware Home [7], MIT's Changing Places/House_*n* (PlaceLab) [5], work done by the University of York's Center for Usable Home Technology [8], Philips Research's Homelab [4], etc. To date, the majority of the research conducted in the area of the smart home has focused on the technology such as Spinellis' work on the *Information Furnace* [14] or it has focused on the elements of the human-computer interaction such as the end-user programming *aCAPpella* system designed by Dey et al. [2]. To date however, very little research has focused on how smart homes will affect the social relationships between the home and its occupants. This paper details a model of family relationships based on behavior science explorations of people's interaction with computer agents. This model is intended for further exploration and evaluation.

In looking into the relationships between a smart home and its occupants we have developed a matrix to felt us better classify the range of relationships that can exist (Figure 1). These include a breakdown of family members on the left and approaches to home personification across the top. In considering the relationship the home can have with occupants, we see three natural classes: (i) relationship with an individual in the home or a relationship where the family is treated as a single entity with no individual variations; (ii) relationships with individual members of a family; and (iii) relationships with both individual members of a family as well as relationships with different groups of family members. For example, the system could have a relationship with Mom as an individual, with Mom and son as a group, and with Mom and Dad as another group. Depending on the activity, the home might engage different groups in different ways.

With respect to smart home interaction, we see a natural breakdown of social interaction in two ways. First, the home can be personified as a single agent that demonstrates complete control. Second, the home can be personified as a series of agents that users interact with. This multi-agent approach can be organized either by device/application or it could be organized around specific activities that might include many different devices and applications.

	Single agent	Multi-agent
Individual occupant/family		
Multiple occupants/family		
Multiple groups within occupants/family		

Figure 1. Matrix of family to smart home relationships

RELATIONSHIPS
The idea of relationships between people and technology is hardly new. One early exploration comes from the work on Apple Computer's Guides interface [10]. In developing

navigation system for a multimedia database, developers at Apple chose to use representations of people as guides through the content. What they discovered was that users developed relationships with the guide they were using, often wondering if the content represented the guide's opinion as opposed to just an encyclopedia. Another well recognized example comes from Bryon Reeve's and Clifford Nass' book *The Media Equation*, which details how people interact with computers socially, treating the computer as if it were a person [11]. Based on these and many other research findings in the agent communities, it stands to reason that families will develop relationships with their smart home. The questions for researchers remain what kinds of relationship we desire users to have with their smart home and how we can develop guidelines that lead technology/product developers in this direction.

Individual Occupant/Family

Today most "smart products" and smart homes treat the family as if it were a single person. A great example of this kind of thinking can be seen in products like TiVo's personal video recorder [15]. This device profiles the behavior of a family by observing the programs they record and explicitly rate. It then uses this information to recommend and automatically record new programs it thinks they might like. Treating the family as a single unit simplifies interaction. Users are not required to constantly identify themselves to the system so it can tailor its learning. However, this approach limits the relationship the device can have with the user. By recommending shows that the current user may not like, but that are appropriate for others in the family, TiVo undermines the potential for trust it could potentially develop with individual family members.

Multiple Occupants/Family Members

The ethnographic research by Rode et al. exploring the differences in how men and women approach programming tasks in the home indicates the potential benefit of a smart home that recognizes different users [12]. Their study reveal that men and women demonstrate expertise over different aspects of the home as expressed in their ability to program devices in the home. For example, they observed that men had more success programming VCRs, part of the electronic entertainment domain, while women had more success programming ovens to cook in advance, revealing their expertise and control of both cooking devices and the kitchen. Their work indicates that different family members should have different levels of status with respect to the various domains that could be control within a smart home. This also leads to the idea that the smart home might need multiple points of programming interaction or even multiple agents representing the various types of intelligence in the home.

One example of a smart product in the home that recognizes individuals can be seen in the *Touch and Drag* TV show recommender [19]. When using this device, users identify themselves to the system in order to explicitly state their viewing preferences or to see a personalized, ranked list of TV shows to record. This device addresses part of the challenge of TV viewing in the home, and while it offers a simplistic method of combining profiles, the results of these combinations were never evaluated.

Mobile phones also present a simplistic yet robust model for addressing the recognition problem. Instead of having one potentially smart phone (land line) in the home that must either recognize users or have users identify themselves, mobile phones simply provide a custom device and number to each family member. While the idea of assigning each occupant of a home their own living room or kitchen seems ridiculous, the idea of them each having their own remote control to entertainment content, bedroom, dining chair, mobile phone, and favorite seat in the living room seems more reasonable.

The question for ubicomp developers hinges on the value of identification. Does the *effort* by users required to constantly identify themselves to the system or the *cost* of deploying technology to infer who the user is add enough value to easily outweigh the cost and/or effort. In addition, what is the cost of an error either the system might make in trying to identify a person or a user might make by misidentifying themselves. Identification of individuals clearly improves the perception of intelligence of smart homes, but does it lead to a more valuable relationship between the family members and the system? Does it make people feel safer, happier, or better served?

Multiple Groups Within Occupants/Family

A more rewarding approach to developing rich relationships between smart homes and family members involves identifying not just individuals but also groups within the family. We first encountered the value of this during a workshop to develop the Touch and Drag TV show recommender [19], but have seen many examples in our research with users. During the workshop several participants expressed a desire to have the recommender know them both as an individual and as members of groups within the family. For example, a mother wanted the system to know what she liked to watch when she was alone, to know what she liked to watch with her children, and to know what she liked to watch with her husband. In addition, she wanted to keep parts of her profile private. She wanted to instruct the system to disregard certain shows she liked and might watch in private. She did not want these shows included if she blended her profile with her husband. In fact, she wanted the system to keep part of her behavior a secret.

Recognition of groups can add significant value to interaction with the smart home, but it also leads to behavior that may be perceived as quite inconsistent and unpredictable? In addition, the idea of a system keeping secrets within a family or becoming a *confidant* of individuals within a family places the home in a more

human role, a role that can make the home appear to have an agenda. These types of behaviors and relationships with family members can easily cross over into uncomfortable territory and conjure images of renegade computers from science fiction.

Single Agent

Looking at current research on ubicomp in the home, the dominant model of smart home interaction revolves around representation of the home as a single entity. A good example of this thinking can be seen in eMuu, an emotionally expressive character that appears either on a screen or as a physical robot, and provides a clear point of interaction for users in a smart home [1]. A single agent offers the advantage of allowing users to conceptualize all of the technology within a smart home as a singular, rationale, agent. The home appears to be a whole instead of a collection of parts. The wholeness of the home is perceived with patterns-models. Regarding these models, a smart home can be seen as an effector, as an assistant, or a hybrid of the two [16]. As an effector, home is a kind of operator. As an assistant it is a kind of agent that helps the user in doing tasks. It provides functionality and supports the user actions. The last model is an amalgam of the former ones. The home acts as an agent and as an effector. It makes shifts between agency and an operating system. These three models reflect the idea of single agent, which is the general tendency through today's ubicomp approaches.

Multi-Agent

While representation of the home as a single agent persists in the research community, it's probably not the logical first step for commercial products. As smart technology moves into the home it will most likely appear as many small systems that may have only a tenuous link to each other. For example, it's quite likely people will have smart entertainment systems that manage their content [19]; smart office assistants that assist on their desktop PCs [7]; smart kitchens that help keep up food stocks and assist with cooking [13]; and smart environmental controls that help keep the temperature, light, and humidity levels comfortable while minimizing the use of resources such as electricity and gas [17]. Think of this more as ubicomp zones or applications as a step towards a smart house.

In the case of smart zones, many questions remain. Do users develop individual relationships with the zones or do the relationships get passed from zone to zone? What makes the most logical sense both from the user's point of view while also considering the branding aspects, which companies will want to imbed in the products? In addition, how should these agents be organized? Should they be based on devices and applications as they currently are? Or should they instead take a more activity-based model? If they would have been based on applications, how can they relate between the applications? Should there be a hierarchy between the items or should the applications be autonomous? Should a hierarchy mimic the family relations like parent child relationship?

In the case of an activity-based model, how should the activities be classified? Truong et al. documented how users naturally interact with ubicomp systems in terms of the activity they wish to accomplish instead of thinking in terms of the devices they need to accomplish a task [16]. How can the system itself take this step to move past devices to activities? Ubicomp activities in the home can include food preparation: cooking, grocery shopping, general food/health; clothing management: washing, wearing, packing; family scheduling: knowing where kids are, who needs to go where, who is picking who up; etc. In realizing these activities, should a single agent be responsible for a single activity? Or should a single agent be in charge of all activities, of the entire smart house?

FURTHER DISCUSSION

How do we represent the family (as a unit, as individuals, and/or as groups) and how does a smart home begin to incorporate multiple devices that use a range of these approaches?

How does the home present itself to the family: as a single entity or as a set of entities? Does a singular home lead to a stronger bond? Does it make for an easier point of connection, or do people want different entities for the various activities and/or applications they collaborate on with the smart home?

Should the interaction between people (between family members) be a model for human to smart home interaction? What is the role of family in extending the agency issue?

This paper focuses on issues around the relationship between users and smart homes rather than the technical and interaction issues. In the smart home context, agency and relations in the family are key elements in understanding what people expect, accept, and desire. We have begun to explore the relationship by modeling the elements of the relationship:

1. Users as singular element to singular agent that controls the whole home.
2. Users as singular element to multiple agents that control different aspects of the home.
3. Users as individual elements to singular agent that controls the whole home.
4. Users as individual elements to multiple agents that control different aspects of the home.
5. Users as groups of elements to singular agent that controls the whole home.
6. Users as groups of elements to multiple agents that control different aspects of the home.

Today the ubicomp applications generally take place in one and three. However, we feel new research should be focused on five and six to enhance the social interaction. Having a ubicomp system recognize and change its behavior based on different groups of individual users allows the users to instill more agency to the smart home as the home displays both more intelligence and more human

like behavior. The question of a singular agent or multiple agents in charge of different activities or applications is much less clear. A single agent provides a model for the smart home to be seen as a single entity, providing a natural single point of interaction. A multiple agent approach, however, offers the advantage of a system that can grow by activity and where agents can demonstrate expertise such as an expert gardener or an expert cook. In our future research we plan to explore and evaluate both five and six to help us better understand the types of relationships people want with smart homes.

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