Problem Solving Probes: A Method for Discovering Conceptual Disconnects with Digital Living Technologies

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ABSTRACT
As people adopt a digital lifestyle the associated digital devices are brought into the home and family. Yet the difficulty of getting networked digital media devices to interoperate is frustrating for many households. Our research is examining how households resolve interoperability issues with digital media ensembles; sets of networked media devices. We describe our methods for studying households and some of our preliminary results. We have found that our participants have problems at different conceptual levels. Resolving problems or misconceptions at a lower level may only result in uncovering another problem at a higher level.

Author Keywords
Home Networking, Ensemble Computing, Ubiquitous Computing.

INTRODUCTION
As more and more people adopt a digital lifestyle, that lifestyle and the associated devices will be brought into the home. In the home, devices and media types that were largely designed for work settings often do not serve well and many households are having difficulty adopting technologies that make a digital lifestyle satisfying. Consider a typical scenario;

Upon returning from a trip to Tahiti, Lisa plans a party featuring a photo slide show of Tahitian scenery. The images are stored on a desktop PC in her home office, and she wants them to appear on her large-screen TV in the living room. She's heard of "media adapters" that wirelessly stream pictures and audio to a TV. She decides to buy one and begins to install it. Soon she has photos streaming to the TV, but unfortunately she has trouble getting music to play with the photos. Is the problem the wireless router, her PC, device settings, audio formats, or the wrong software?

Lisa's problem is typical of users who adopt digital living devices and similar networked devices. The growing complexity of interconnected devices makes it difficult for users to understand where breakdowns happen. How an average user approaches the wide range of potential problems to address interoperability issues has not been systematically studied.

Our research is broadly exploring the way households are adopting a digital lifestyle. The study described here focuses on how key members of a household come to understand and solve interoperability problems with multiple networked devices. In particular, we are interested in *ensembles* of network devices, two or more devices that must interoperate to provide new and desirable capabilities in the household.

METHODOLOGY AND THE PARTICIPANTS
Our qualitative study of network ensembles is based on a combination of focused interviewing and a three-week field deployment. Participants were involved in only one condition either the focused interviews or field deployment. There were 12 participants in the focused interviews and 14 participants in the field deployment.

We recruited participants from the broader Seattle area through flyers in public areas, postings to craigslist, and through word-of-mouth. We screened participants through email, requesting information about the sizes of their media collections (music, digital photos, and videos), the number of devices on their network, and an open-ended question about how they used their home network on a day-to-day basis. Participants had to say that they were the "home network administrator" to be eligible for participation.

Focused Interviews
We used two-hour focused in-situ interviews to understand the role of the network in the home, the way the network is used, the types of devices on the network, and how problems with the network are resolved. During the interview we ask the participant to sketch their home network including as many things on their network as they can remember. A set of standard prompts was used to help the participant recall unusual or potentially overlooked devices (e.g., Do you have a networked printer? Do you have any portable game devices on the network? Do you have a TiVO or DVR on the network? Do you have a PDA or cell phone that can use the network?). Immediately after sketching, individuals were asked to fill out a paper-based

Digital Home Inventory (DHI). The DHI has fields for device specific information (i.e., device type, manufacturer, and model), network connection information (physical and logical), security settings, and a number of more advanced router settings (e.g., DHCP, QoS, Port Forwarding and DMZ). The majority of the interview sought to explore the types of problems the participant has with their network and the techniques used to solve them. Participants were prompted to think of issues or problems with the network, describe the problem and what was done to try and solve the problem. Our method for focused interviews is similar to those used in prior studies of technology in the home [1, 3, 5].

Field Deployment

One problem with retrospective interviews such as the focused interviews above is that participants do not always remember the details of a problem nor its solution. We used *problem solving probes*, a method based on technology probes [2, 4, 6] as a way to further situate conceptual issues and problem solving practices.

During a problem solving probe, the participant is provided commercially available equipment to install and use for at least three weeks. We loaned the participant two pieces of equipment; a network attached storage (NAS) device with a UPnP AV compliant media server and a UPnP AV compliant media adapter that can be connected to a stereo or television. A pre-deployment interview asked the participant about their media collection, security settings on their network, and how they used their current network. The primary objective of the pre-deployment interview was to make sure that there were no prior reasons the loaned equipment would not work. One week after the deployment, a mid-deployment interview was to validate that the participant was making an effort to install and use the loaned equipment. The mid-deployment interview asked if the participant had any specific problems while they are fresh in mind. The mid-deployment interview was conducted over the phone.

The post-deployment interview was structured just like the focused interviews described above, but prompts were oriented toward the devices loaned rather than general issues or problems with the home network. The post-deployment interview also collected network sketches and DHI for each participant.

Six different device setups were created based on two different brands of NAS/media servers (Buffalo Technologies LinkStation Live and LaCie Ethernet Disk Mini) and three different brands of media adapter devices (Roku SoundBridge M1001, Sony VGF-WA1, and Netgear EVA 700). Interoperability among all combinations of NAS/media server and media adapter was established prior to purchasing the equipment for the device setups. Each of the six setups was deployed to at least two participants. After the first deployment, the equipment was tested to make sure it was still functioning and reset to initial conditions before being redeployed.

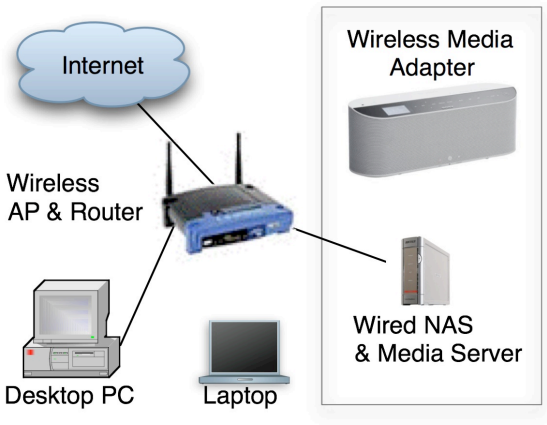

Figure 1. A media ensemble. Devices like those on the right were loaned to the participants during the field deployment.

All interviews were conducted in the participants' homes. Audio recordings were transcribed and are being analyzed using a Grounded Theory approach [7]. In the following we present some of our preliminary findings from the study.

THE BASIC MEDIA ENSEMBLE

Before describing our preliminary findings it is important to understand the media ensemble model as it is commonly being sold by device manufacturers. Our study is focused on the open system approach, which can be contrasted to the closed system approach that is used by Apple with iTunes, Apple TV, iPod, and Airport Express. In the open system approach the idea is that adherence to standards allows the home user to pick from a wide range of compatible devices, any of which can interchangeably provide the desired functionality.

The basic home media ensemble requires at least two devices. The user must first have some form of media server that is designed to serve content streams of audio, pictures, or video (e.g., TwonkyVision, Mediabolic, Windows Media Connect, and iTunes music sharing). The media server needs to be running and available anytime some media would be viewed or heard. Secondly, the user must have a compatible media renderer also called a digital media adapter (e.g., Roku SoundBridge, Logitec Sqeezebox, Netgear EVA700, Linksys WMA11B, Sony VGF-WA1, etc.). Figure 1 illustrates a sample home media ensemble, highlighting the types of devices loaned during our field deployment.

PRELIMINARY OBSERVATIONS AND FINDINGS

While we are still in the early stages of our analysis a number of things are beginning to emerge. The analysis presented here is mostly oriented around what we are learning from our field deployment and the problem solving probe technique. Through the problem solving probes we

have identified a set of conceptual layers that seem to be the origins of our participants problems. Before describing those levels we contrast some of what we are learning from the focused interviews and what we are learning from our problem solving probes.

Focused Interview versus Field Deployment

One use of our focused interview data is to compare what we are learning from the focused interviews to learnings from the field deployment. The problems with retrospective interviews are well known and through our use of problem solving probes we attempted to mitigate those issues. The idea for using two distinct methods was to elicit a broader range of issues and problem solving practices around ensembles and to facilitate comparison between what could be learned from any single approach.

Our screening, however, had some impact in the types of insight that could be provided. When screening participants for focused interviews we specifically sought participants who had rather large networks with a range of devices. In contrast, our screening for the field deployment sought more typical home networks, with relatively fewer items and less complexity. On one hand, when comparing methods for the types of problems uncovered it gives each method its best chance. In particular, complex networks are likely to have more interoperability problems that would occur more frequently, thus allowing a focused interview to identify a wider range of problems. Alternatively, if smaller networks are indicative of less sophistication with networking, then individuals in the field deployment would have more problems installing and using new and unfamiliar equipment, thus revealing a wider range of problems.

Misconception Layer Model

Based on a preliminary analysis, it seems clear that our participants had a range of misconceptions about networking and media ensembles. Those misconceptions appear in levels or layers. Resolving a problem at one level might simply uncover a new or different misconception at the next higher level. Figure 2 illustrates the levels we have currently identified. For each level we have provided a characteristic question to help distinguish the types of misconceptions that occur in each layer.

Content Control How do these devices handle restrictions on content?
Content Format What content can these devices exchange?
Communication How do these devices communicate?
Connections How does the device get on the network?
Device What does this device do?

Figure 2. Misconception Layer Model

Device Layer

At the device layer participants had misconceptions about the purpose of the device. During deployment interviews many participants expressed that they had interests in similar media devices and suggested that they were interested in the idea of media streaming in their home. However, several participants used the NAS as simply an external hard disk, connecting the device to their desktop or laptop computer through a USB cable. During a mid-study interview another participant expressed concerns about why he would want a device connected to his stereo when his stereo could only play one CD and his digital music collection was thousands of tracks. He had the conceptual model reversed, believing that the media adapter served out his stereo rather than making his stereo a client to some other media server. Misconceptions about the device are surprising given the number of participants who indicated they were familiar with the types of devices we loaned.

Connection Layer

The connection layer deals with how any one device is attached to the network in the home. While this has gotten simpler over time, this was not completely intuitive to several participants. In this layer the types of problems are less conceptual because many participants have dealt with putting other devices on their network and thus have some idea what should happen. In many cases media devices are set to automatically connect to the network with help from an existing DHCP server.

More often the problems at this layer are somewhat mundane such as clear instructions that don't seem to make sense. In particular one of the media adapters used in the deployment prefers that users have a V//V compliant PC. Few of our participants had such a machine. Following the steps for the non-V//V installation, instructs the users to use an Ethernet cable to connect the ***wireless*** device to the network! Another common problem at this layer was how to initiate the currently preferred form of network security on the new device. For many devices, network security is only set up once, so how it is done is always slightly murky.

Communication Layer

Misconceptions at the communication layer illustrate the problems that occur when many different devices communicate using multiple protocols. Many participants used some form of media player on their laptop or desktops that include media streaming capability (e.g., Windows Media Player 11, iTunes, and Rhapsody). While logically these streams are part of the basic media ensemble model, they can cause confusion.

Numerous participants never realized that the NAS actually contained a media server that they might need to activate. This is striking because during the deployment interviews, we told participants that the NAS had a media server that was compatible with the media player also being loaned. Two of our media adapters recognized more than just the UPnP AV protocol, and thus would recognize other

compatible server streams when they already existed. The previously existing, but invisible, server streams were uncovered by connecting a compatible player. Most people do not know that a piece of software is already attempting to communicate with another device because the protocol is invisible to the participant until a compatible device is added to the network.

Content Format Layer

The content format layer is where different codecs available in different devices intersect with the participant's desire to have their music, pictures, and video simply play or display. Many participants have some familiarity with the general problem because they have downloaded some media type that their laptop or desktop would not play. Participants reported that because of prior experiences, they attempt to limit the number of formats they maintain. A few participants maintained lossless versions of their media (e.g., RAW for pictures, WMA or ALS for music), but the majority relied on JPG for pictures and MP3 for music.

When participants talked about their experience with whether media played, the majority commented that their media eventually played on the devices, but that was not always without glitches. In many cases, those glitches resulted from not knowing that a song/track was in an unexpected format (say when a song/track was a "gift" from a friend or acquired via P2P sharing) or when the song was purchased/licensed from an online retailer who still uses some form of DRM.

Content Control Layer

At the top layer is how participants understood the way the media ensemble handled content control or DRM (Digital Rights Management). While the far majority of our participants ripped their own CDs or acquired music through P2P file sharing, there were participants who had content that was under some form of DRM. In most cases content is sent to the media player/adapter with DRM still embedded and if the manufacturer of the player/adapter has licensed the DRM decoder then the content will play or display. In those cases, there is still a license check or validation step that can cause a glitch. Participants who had DRMed music often reported that rebooting the media server and media adapter resolved the problem.

Legacy DRM is another issue. One participant had worked for a defunct media company and had a large collection of DRMed music for which licenses would not be renewed nor validated. While he had a player that would still play the music, he understood that this was a problem for any new media ensemble he might use in the future. His solution was to identify a piece of shareware that would effectively strip the DRM from each of his songs. Unfortunately, either the stripping was ineffective, or the stripping introduced other problems into the song files which resulted in few of his DRMed (or DRM stripped) songs from actually playing.

CONCLUSION

Our study considers how households understand and resolve problems with sets of networked media devices; media ensembles. Through a combination of focused interviews and a field deployment, we found a set of conceptual levels that are sources of problems. Resolving a problem at one level may simply uncover another problem or misconception at a higher level. The difficulty households have adopting networked media devices could be mitigated by understanding the levels and helping users traverse the levels.

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