Unremarkable Networking:
The Home Network as a Part of Everyday Life

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ABSTRACT

This paper extends the focus of current research into home networks. It represents a shift in perspective from the home network as something that is essentially understood as a technological object by the inhabitants of the home, to something that is understood by household members as a sociological object wrapped up in the organisation of their everyday lives. This shift in perspective is significant. It moves the focus of design from developing home network technologies that better support users' management of the home network and the devices that hang off it, to developing home network technologies that support household members' *management of everyday life* and the social activities that compose it. Through a range of ongoing ethnographic studies we elaborate this turn to the social, and a number of sensitising concerns informing the continued development of home network technologies.

Author Keywords

Home networks; ethnography.

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J.4 Computer Applications - Social and Behavioural Sciences: *Sociology*.

INTRODUCTION

Home networks are commonplace in the developed world. A body of work within HCI has emerged over recent years that seeks to understand 'the work to make the network work' [6] charting the ways in which people weave home networks into their everyday lives [7,13,14], the problems that accompany this [e.g., 3,4] and the issues these raise for the ongoing design of network systems [e.g., 10,11]. This paper reflects upon and extends this research trajectory by considering the ways in which household members' orientation to home networks has changed and the issues this raises for research into user-centered home networks.

When we contrast current studies of home networks with early studies we are struck by the extent to which they have been domesticated [9]. Early studies took place in a context where home networks were still relatively novel. Grinter [6]

highlights this in her 2005 study:

> "Our choice of such early adopters was motivated by a desire to understand the routines and tensions that result from such complex networks, which we believe will be representative of more and more homes in the near future."

This surfacing of 'tensions' shaped a research agenda addressing the opaque character of home networks, which makes it difficult for users to understand and control network infrastructure. Subsequent solutions therefore emphasize matters such as 'visualisation', 'accessibility' and 'awareness' [10,3,4]. For example, Chetty's 2010 study [3] is oriented around exposing bandwidth use:

> " … there are very few easily accessible tools to help households understand, diagnose and manage their home bandwidth use."

The dominant emphasis here is on reasoning from the technical network *outwards* to its users and revealing the nature of the technological artifact to them. In turn, and as Chetty et al. (ibid.) point out, revealing these technological features impacts the social nature of the home:

> " … revealing resource usage in the home affects different types of households, by surfacing household politics and enabling new forms of contention."

While this work on revealing the nature of the network has been taking place, domestic networks have undergone considerable change. Things have moved on rapidly. Broadband uptake is now widespread and is routinely exploited by household members to generate and consume digital media and to access a burgeoning array of online services. The home network is no longer a novelty. It is just another ordinary feature of everyday life, taken for granted by a great many people. In short, the home network is no longer *remarkable* for its users.

This shift in how users orient to home networks raises significant challenges that may require us to reframe the research agenda. Early on home networks were, for many, curious technological objects of interest in their own right and open to household discussion and reflection as people tried to figure out how to make them a part of their home's infrastructure. Home networking research was established on these grounds and still largely operates upon the same set of assumptions. However, the fact is, that innumerable homes now have such networks and use them all the time as a wholly unreflected upon resource that underpins the ordinary, unremarkable, mundane things that people do with computing technology in their home.

This suggests the need to reverse the polarity of research from something that requires us to reason from the technical network outwards to its users to something that requires us to reason *from household members towards the network*. We believe this occasions the need for design to adopt a commensurate orientation towards the network. At a practical level this means that the home networking community needs to become far more reflective about the kinds of design interventions it undertakes, questioning every step of how interventions surface the network to people in the home. Will interventions facilitate and blend naturally into people's ordinary activities? Or will they place the network itself *in the foreground*, as a feature that must first be manipulated to bring ordinary activities about, making the working of the network the first order activity and pushing the interest in managing the mundane social organisation of the home into second place?

Our goals in this paper are twofold. First of all we set about charting, through the presentation of ethnographic materials, the various ways in which people orient to their home networks as aspects of the social organisation of their homes, and how the management of the network is implicated in that organisation. This will involve recurrently bringing into view the distinction between orienting to the network as a sociological object and orienting to the network as a technological object, the latter still often being the norm in home networking research. Secondly, we seek to elaborate through the ethnographic materials something of what the reframing we are calling for might consist of and imply for the ongoing development of the home network.

THE HOME NETWORK AS A MUNDANE FEATURE OF EVERYDAY LIFE

This paper draws on a range of ongoing ethnographic studies to elaborate how the use and management of home networks is interwoven with, and reasoned about within, the wider social organisation of the home. The studies include 24 different households in the UK and France and have so far been running for about 3 years. The data gathered during these studies is of varying degrees of richness and includes direct *in situ* observation of network use, non-structured interviews, technology tours, self-logging, and machine logging.

The households themselves span a wide variety of format, living conditions and demographic make-up. They include apartments, terraced houses, semi-detached houses and detached houses, in town and in country. The households include single occupancy, shared occupancy, couples with young children, retired couples with no children remaining at home, couples with older children at home, couples with younger children and with babies. The professional characteristics of the adults in the homes vary across the unemployed, factory workers, restaurant workers, artisans, teachers, business proprietors, preachers, academics and a range of other professionals.

We draw on the various materials gathered in these settings to inform ongoing ethnomethodological investigations into the *naturally accountable* character of network use [5]. The principal example we draw on here to elaborate this has no particular significance beyond its usefulness to make perspicuous the reasoning surrounding the ordinary and occasioned use of the home network. It could, as such, be replaced with any number of examples from within our corpus of materials. However, it has the virtue of providing us with an economical way of presenting the primary considerations we wish to point to. Additional examples are used in subsequent sections where they serve to elaborate the key issues our studies raise for design.

Living with the Home Network: Here and Now

Dave (48) and Chloe (41) live in a detached house in south-eastern France with their four children, two boys and two girls aged between 19 and 6. Dave is a consultant and Chloe makes novelty cakes. Dave and the three older children all use the network extensively. When Dave is at home he works out of a screened-off office area in his and Chloe's bedroom. The following vignette elaborates something of the mundane work involved in managing the network in this particular home:

The network has gone down. Dave goes out to look at the modem, which is situated in the upstairs hallway. All the lights are lit up at once. Dave looks at the airport base station and the lights on that. The centre light is the most visible with the right one flashing intermittently rather than the outer two being the most notable which is its normal configuration.

Dave walks through the bedroom to his desk and looks at his laptop. Then he brings up the Vuze window (bitTorrent client). Looking at the figures at the bottom, they read zero for both upload and download rates. Dave heads back out to the landing.

Dave turns on the light, lifts up the Livebox and unplugs the power cable then plugs it back in. Then he puts it back on the shelf. After this he unplugs the power cable on the airport base station and plugs it back in. Then he goes to look at the pattern of lights on the Livebox. There is a single light flashing. The box runs through its start up sequence. Dave turns off the light and comments: "That should all be working." He then heads back to his office, sits back at his laptop and brings the Vuze window up again.

Problems with the network were recurrent in this household and the vignette shows us that Dave has developed routine ways of handling the situation. More importantly, however, despite the fact that the vignette focuses upon the activities of one individual, without any direct interaction with others in the family, and whilst involved in handling issues that have arisen solely with his own access to the network, there are manifold ways in which Dave's 'management of the network' speaks to ordinary concerns at the forefront of the *social organisation* of the home and how the network is woven into and elaborates the management of domestic life.

Household Roles and Responsibilities

Foremost amongst these are matters of household relations and the *differing rights and responsibilities* of those who live within the home. What do we mean? An important feature of the above vignette is that Dave presumes without hesitation that he has the right to go out and fix the network, including messing with the power supplies to two

of the network's central components. Not just anyone can do this. In Dave's household there are 6 people, yet only Dave and his eldest son ever touch the modem and base station. Indeed, the matter of not just anyone having the right to mess with the network is testified to by that fact that when the network failed, Dave's other children would routinely tell him that the network had gone down, rather than fix it themselves, even though they might be capable. For instance, here's Dave's eldest daughter talking to him about a particular incident:

> When I was on Facebook earlier I noticed it seemed to be stuck. I was going to tell you about it but you were on the phone at the time.

What this underscores is that people's activities at home are organised around a presumptive set of *differential rights*. For any component of the network, and any activity realised through the network, these differential rights can be seen to apply. Thus, different people are allowed to do different things with different devices at different times of the day and in different places. Breaching this requires some kind of account. Failure to provide an adequate account usually leads to some kind of sanction. Households the world over are organised this way in relation to pretty well anything that happens within them. Home networks are *no exception*. Indeed, they are just another place where these differential rights are accountably exercised, making them in no sense special or different to other ordinary 'things' in the home.

A strong counterpart of having these kinds of intervention rights in a household is the shared expectation that the people who have them will undertake those interventions when necessary, with them being held accountable for any failure to do so. On this occasion Dave orients to fixing the network as a thing to be done straight away. However, although this expectation exists and it is incumbent upon Dave to fix the network when it fails, it should also be noted that it is not simply a case of when the network breaks that Dave goes straight off and fixes it. Something to grasp here is that what he does with the home network is itself differentially organised *in relation to other household concerns*. Thus, it might take priority when he's sat there working and notices it's gone down; it might take priority when one of his children comes and tells him there's a problem; but how about if he's doing the washing up, or in the middle of cooking, or on the phone, or everyone's sat down to watch a film? The point is that just what action is undertaken is itself accountable in terms of the *priority* it's given in relation to whatever else is going on in the home.

Household Routines and Domestic Accountability
Everyday household reasoning about what it is appropriate to undertake, on what occasion, and in relation to whatever else is going on, is tightly bound up with reasoning about things like household routines. Consider, for instance, if Dave had come out of his bedroom and stood and looked at the modem at, say, three o'clock in the morning. How could and would this be reasoned about by others in the home?

For what is known of Dave and his habits, his taking a sudden interest in the workings of the network at a time when he would usually be fast asleep would require some specific kind of account. He might be seen to be working exceptionally late for some reason. This, however, would turn upon certain situational features, such as him being fully clothed rather than in his dressing gown. Members might also reason that he's not fussing about the performance of the network at all, but rather has heard a strange noise or thinks he can smell smoke, etc., which are much more ordinary kinds of account for Dave being out on the landing nosing around in the middle of the night.

Whatever the reasoning might be, it is almost certain that looking at the modem at three in the morning would result in anyone encountering Dave calling him to account. Thus we can see that the ordinary reasoning that people engage in about 'network management' turns upon a host of local organisational issues known by household members about the household and the habits of those within it. The presumptive thing that might be reasoned to implicate someone in going to look at a modem at half past ten in the morning is not the same thing as at three o'clock in the morning. So the very nature of what others might be understood to be up to in relation to their networks can be seen to turn upon these kinds of things, which are *nothing to do with networks* themselves and everything to do with patterns of living within the household.

This holding of people's conduct *accountable to the ordinary rhythms of the household*, and what everyone might be reasonably doing at different times of the day, does not stop at the work of restoration. In fact, it can be equally applied to any kind of activity on the network. More than this, it can be equally applied to *any kind of activity in the home*. Reading books, eating, washing, watching television, doing homework, making phone calls, sleeping, playing games, building bookshelves, hanging out the washing, hoovering, and so on, are all open to the same kinds of concerns and are all reasoned about in the same kinds of ways: as just another part of the 'stuff' that happens in the home and that is answerable to how the home is organised and the relationships within it managed.

Think about it. All of the above could have been about Dave getting out the vacuum cleaner and doing the hoovering, with a whole bunch of similar considerations about rights and responsibilities, how it made certain family relations visible, and how it had to be undertaken at certain times in order to fit within the broader routines of the home. For designers the apparent novelty of home networks and potential for doing new and interesting stuff with them is utterly seductive and so they are easily thought of as *special* things to be handled in *special* ways, with this somehow all being obvious to householders as well. In fact, doing online banking, checking your emails, looking at Facebook, calling Grandma, watching TV programmes that happen to be streamed or previously downloaded, etc., is *no different* to any of the other things we just mentioned when it's made

by members *to fit in with everything else* that is already going on in a household.

The hoover could break down whilst Dave is doing the hoovering, and under the auspices of the same kind of differential rights and appropriate priorities he might try there and then to fix it so he can carry on hoovering, or might find that he can't and have to ask for expert help. When the network goes down he's doing the same order of thing so he can carry on working. It might be that we can provide exciting ways of making it much easier for Dave to get his network running again, but we shouldn't lose sight of the fact that for Dave and the rest of the household, *it's just another part of domestic life that needs managing* so that the real business of life at home can proceed.

Unremarkable Computing
This orientation to the network as simply another part of the fabric of the home that its inhabitants somehow need to make work *as part of domestic life* is in contrast with many of the underlying assumptions in network management [2]. One of the things we particularly wish to stress here is the tension between the ways in which a traditional design focus on networks as an ensemble of technological objects risks rendering network management a *remarkable* activity, whereas for inhabitants it has necessarily become just another *unremarkable* activity in the home.

Original discussions regarding 'unremarkable computing' [12] and the ways in which computing systems are made to 'disappear' within people's homes emphasize, as we have done above, the extent to which the use of technology in the home becomes just another part of the home's day-to-day organisation. In a great many respects one might wonder how it could be otherwise? The domestication of technology [9] turns upon it becoming an unremarkable feature of everyday life. Treatment of features of technology in the home as remarkable, as a source of comment and wonderment by everybody therein, situates them outside of the day-to-day business of the home. Yet nothing can hold *special attention* for very long if it is to become a recurrent part of everyday life, even such things as troublesome routers.

Thus, as home networks have come to be taken for granted so they have started to disappear into the fabric of the home – they have been made by members into unremarkable objects managed in routine ways. This orientation to them as a routine feature of the home environment has led to them being reasoned about in the same way as other routine features of the home environment are reasoned about. This hinges upon them not standing separate to but rather as an ordinary part of the routine activities and relationships that make up everyday life in the home and, as was pointed out in the original articulation of unremarkable computing, these routines are the very "glue of domestic life" (ibid.).

This raises new challenges for the ongoing design of home networks. If designers want future home networks to become a wholly accepted and unproblematic part of the home's infrastructure then they need to take it into account that home networks will be reasoned about in this way. To do otherwise is to risk making networks constantly remarkable and thus problematic. In the next section we explore in more detail how the domestic network is made to work by its inhabitants, how this stands in contrast to conventional technical reasoning about networks, and what this might mean for future approaches to the management of domestic infrastructures.

MANAGING THE NETWORK IN USE

From a technological point of view, management of the network is traditionally an end in itself, whereas within the home, network management is essentially *subordinate* to the mundane activities of its occupants: it is merely one of the many things that household members must manage in order to work, relax, parent, socialize, etc. In this section we present and analyse ethnographic data from a range of studies too highlight the shift in perspective occasioned by members' orientation to the home network as an unremarkable feature of everyday life. We articulate this shift by contrasting existing technology-centric views with members' orientation to the home network as a mundane sociological object.

We adopt this approach towards exposition as we believe there is critical need for the HCI and infrastructure development communities *to engage with one another* to address the future challenges of home networks. The skills of various design communities are required to address these challenges and actually build (rather than mock up or simulate) effective systems. It is, then, important that we convey our results not only in terms that are readily digestible by members of the HCI community but beyond those to technical communities who realise many of the core technical mechanisms underpinning home networks.

Seen from a technological perspective, the routine management of networks can be considered in terms of three closely related drivers:

– *Provisioning*, which focuses on ensuring that resources are available to meet user needs and that they have effective access to the network.

– *Performance*, which focuses on the reliability, efficiency and robustness of the network and the flow of traffic through it.

– *Protection*, which focuses on the integrity of the network and the protection of users from both external attack and the negative effects of others' network use.

We employ these technology-centred categories to frame interdisciplinary discussion and engagement with our work. In the following sections we discuss each in turn, introducing its technical conception before picking up on key aspects of how users actually address these issues in practice as a mundane and unremarkable part of making the home network work.

Provisioning

Provisioning refers to the process of planning, acquiring and deploying resources to meet customer requirements. Some of these will be physical (e.g., installing gear), some virtual (e.g., managing resource allocation to VPNs and per-protocol tunnels, or purchasing capacity from larger network providers), both will happen at different levels of aggregation. For example, a backbone network operator will be concerned with buying raw connectivity from their network to other networks, while an enterprise network operator may care more about managing connectivity between sites or buildings, or the deployment of wireless access points at appropriate densities. Within the home, we identify two primary concerns that we place under this heading: *resource allocation* (how different applications and users are allowed to use the network) and *access control* (which devices are able to connect to the network).

Resource Allocation

How then do users make the home network work, and practically manage the issues of resource allocation and access control? Consider the following vignette:

> **Chloe**: We have had big rows about Tim stealing the Internet. Emma said to him "You've stolen the internet!", 'cause he's uploading to YouTube and the whole thing just like grinds to a halt for everybody else. We have had to say, "You put it on overnight Tim when nobody else needs it."
>
> **Tim**: Yeah, so normally I just upload overnight. And that's it. Normally what I do is if the video files are under 50 megabytes I upload it because it only takes 5 or 10 minutes, but normally if it's bigger than that I do it overnight.

Seen from a sociological rather than a technological point of view, this vignette touches upon the ways in which resource allocation is utterly embedded in broader reasoning about the household routine. For example, it is not that uploading of videos to YouTube is problematic *per se*, but rather that it can't be done with impunity when the broader use of the network by others in the household is thought about. This is awfully reminiscent of common disputes in households about people occupying the bathroom or using up all of the hot water in ways that are disruptive to the routine needs of others in the home. Our studies provided us with several cases in which members displayed a distinctive orientation to resource allocation with respect to the household routine.

Consider the following two vignettes by way of example. In the first, the householder works from home but his son, a DJ, also sometimes works there, often downloading large music and video files, and this leads to conflict:

> What I want to make sure is that whatever that large course of data that he does, doesn't interfere – it doesn't become a disadvantage to me – I want to prioritize whatever this computer does at this end, I want to prioritize its data and communications.

In this second example the householder also works from home but on a more irregular basis, resulting in a more flexible articulation of the same kind of concern:

> I use a lot of presentations. I do a lot of PowerPoint stuff and I use a lot of photographs in them, so sometimes my computer can be really slow when downloading stuff like that … I think that "I'm doing that activity, give me priority now", because it's not the sort of thing I do every day.

The bottom line is this: reasoning about resource allocation is inextricably bound up with people's *activities* and how those activities might potentially *conflict* with one another in specific situations. Here is a case in point:

> We routinely have an issue with Skype. I download torrents – TV series, films, that sort of stuff – and it's running for days at a time. We recently had a baby girl and our families are distributed across the UK and Europe and Skype has become a daily feature of our lives. Sarah is always Skyping them and she has to coordinate with me 'cause the torrents screw Skype up; it won't work properly with both running, there's just not enough bandwidth out here in the sticks. So she asks me if it's OK to switch the torrents off if I'm around and if I'm not she just turns it off – and I'm always bollocking her for not turning it back on again.

The exception here is when bandwidth consumption is capped by the service provider and extra charges or new tariffs apply. However, even in cases like this the technical object, understood through a measure of consumption, becomes a sociological object with *moral reasoning* attached to it, particularly those commonly attached to matters of household expenditure rather than the use of allocated resources as a technical measure in its own right. The following vignette, drawn from an ongoing study of novel network consumption interfaces deployed in the home, illustrates this kind of consideration:

> The info displayed on the devices is too fluid to be of any real help. I would like to see consumption of data by month/week/day by each device. This is important to me because we keep exceeding the Internet allowance. It has gone up 5 fold because we have an international student living with us. I don't think she believes it's her who's eaten up all of the allowance!

Access Control

Although this might seem to be a matter of security, when treated as a sociological matter questions regarding access prove instead to be subsumed within a veritable battery of moral concerns regarding how members manage the household. So, whilst at its crudest level this may simply seem to be about who you allow to access the network, when one considers how you do things like provide access to guests, it is not just seen as a means of enabling them to use their own devices on your network, but as one of the many ways in which you practice being a 'good host', though this can bring along its own troubles:

> To be honest I tend to frig things to make sure they work for them … sometimes this becomes a pain as I forget to reset things when they leave.

As being a good host is fundamentally a sociological consideration, and tied up with giving rights to access and use your resources, the departure of guests in the larger part of householder experience neatly manages reconfiguration or revocation of access. But if network access is reasoned about by designers as primarily technical in nature the management of it as a sociological concern, where it gets get wrapped up with a whole bunch of other day-to-day considerations, never gets brought into the picture.

Here is another mundane concern about access, in this case for people who never even physically enter the home:

> Our next door neighbor is an old lady. She's in poor health so her daughter comes round a lot. I've given them access to the network so she can check her email and do a bit of work while she's here. I've no idea how often they access, I've just given them the key.

This is similar to the issue of having guests and wanting to be a good host, except here it is about being a good neighbor. The reasoning here is wrapped in moral accounts that cumulatively justify why someone who is not even a transient part of your household might be given access.

Access can also become an especially nuanced way of managing moral accountability within the household. In this case refinements can include things like blocking people within the household from access as a means of punishing or preventing inappropriate behavior:

> I know a family with teenage children and they do things like, the router is locked in Dad's office. If the kids are being silly about the Internet and staying up half the night he switches it off, and locks the door. I don't think it's a routine thing, but if it's all getting a bit out of hand he'll say "well I'm switching the router off at eleven because you should all be in bed, not staying up half the night".

The presence of the router in the father's office here and the fact that he can control network access through this placement and locking of doors speaks of something else we have encountered recurrently: how access can get managed by means of the topology of the home rather than through technical means. The following is a case in point:

> We had discussion before we moved in that we wouldn't have television points in the girls bedrooms because they escaped to their bedrooms too much and I wasn't happy about the amount of time they spent on their own. The laptops don't work in their bedrooms – fantastic! – so they have to be in the sitting room which is where I'd rather it be: a communal thing so there's people about, more social interaction, we get to share more.

In Dave's family we see a distinct choice that is just as meaningful in terms of social reasoning in the home, in this case by placing the router where it is accessible to everyone and where it ensures coverage throughout the home. Ultimately what we see here are people already managing network access quite artfully through the active positioning of things in the home in ways that go beyond reasoning about devices as purely technical objects.

Performance
Network performance management focuses on traffic. Are the routes installed in the network meeting the necessary service agreements between operators (in terms of metrics such as packet loss rates and latency)? Is the load on different links in the network reasonably well balanced? Is network equipment performing as expected (in terms of metrics such as throughput, loss, latency, reliability)? Does the network respond appropriately in the face of component failure? Etc.

Reliability
When the network is viewed and reasoned about as a sociological object the interest is rarely in technical measurements but rather in matters of *trust*. Something that

typically proves to matter for any household is "can it do what I'm asking it to do right now?" and equally, "if I start doing that now, can I trust that the network will let me do it?" Here is a forceful case in point, taken from another member of Dave's household, where another known problem was that answering the telephone could prompt the network to crash:

> **Tim**: During the night's about the only time I'm ever certain of getting anything downloaded 'cause at any point in the day someone can answer the phone and kill it. … If I have something downloading, you can get up to just about any point in it and then if someone answers the phone I've lost the whole download. I have to start again from the beginning. If I hear the phone ring it depends on the state of the download. If it's over 50 percent then it's already been running for quite a while and I'd prefer people didn't answer the phone, so I'll ask them not to. But if it's still only up to about 20% I don't bother. I also have a post-it-note by the telephone. Sometimes if I remember I try to stop people picking up the phone by physically sticking it on the phone. It reads 'Do not answer. Download in progress'. We've even instructed other people who are phoning us to make it clear by phoning again. If someone phones two or three times we're more likely to answer it coz we know it's somebody who specifically needs to talk to us. Otherwise we tend to let it pass ... Because it tends to bring the network down.

This illustrates both what it is like to live with and have to manage an unreliable network, and the extent to which householders will seek workarounds to achieve things like reliability as long as this is adequate to the accomplishment of routine household activities, including answering the telephone. Only when activities are completely thwarted does the clamor for repair become deafening:

> My wife who uses it for her PhD work, she's definitely going to get on to me – "hey, the machine's broken, I don't know what's going on" – and then if I'm at work we have this whole protracted distant negotiation about stuff … Things need dealing with pretty quickly because y'know [she] wants to get on and do her work so she really hasn't got much other option and if I'm sitting down to do something then it's rare I'll just walk away from it, just leave the machine knackered, so that all gets done pretty much straight away.

Optimization
When it comes to the optimization of performance, one of the principal issues regarding the applicability of this kind of reasoning to the home is that activities in the home are not reasoned about in technical terms and opened up to technical measurement in the way optimization might be thought about by network designers. The reasoning is not technical but again moral. We touched upon this above with regard to how people in Dave's home reason about the sub-optimal character of the network and the way in which they are prepared to live with it. Indeed, as one of our colleagues once observed, "who in their right mind would want to optimize their household?" However, this is not to say that network optimization is never a topic of reference for households. One place it can be open to householder reasoning is the case of setting up networks, as in the following instance where Jack, Jim's son-in-law, is helping him with just such a task:

> **Jack**: I'm just about to do a speed test on the DSL line, 'cause it seems it a bit slow to me. (Running test.) That's really slow

loading up; suggests it needs some different DNS settings. It's giving me one and a bit on a download, which is pretty poor. 1.36 mega bits per second! Jim!, look at that. Jesus, that's truly awful: 0.10 on the upload! That's bad. That's dire. Something not good there. What's it supposed to be?

Jim: 5.4

Jack: It is a Friday night, it is busy, but, I mean, 1.3 – oh well, we'll play with that tomorrow.

This interest in monitoring upload/download rates is something we witnessed in a number of households, not only at the point of setup, but also during their routine operation. The critical thing to appreciate however is the ways in which this is embedded within highly specific activities and is reasoned about as a feature of that activity itself, not as a matter of general preoccupation. In the above example the focus is upon helping a relative get their network up and running, and this is one of the coherent parts of being able to say one has accomplished that successfully. Whilst this example is to do with getting a network running in the first place, rather than managing it once it is already in use, it neatly illustrates how reasoning about optimal performance is itself embedded in commonsense reasoning: in this case what performance should look like on a Friday evening, which is not the same as at other times and on other days.

This is underscored by the original example where Dave also makes judgments about what appropriate performance might look like at various times. This is part of how he manages to exercise judgments about (a) the network being down and (b) the network having been successfully restarted where much hinges upon what he expects to see in a BitTorrent client window. In fact, household reasoning about optimization is entirely about *appropriate* performance. This is not the same as technical optima, even if many ordinary users could understand these. Instead, it's all about *practical adequacy*, about whether or not it 'looks right' for the activities members are engaged in 'here and now', in view of what else they know about what other people might be doing.

Recovery

While there are clearly occasions when the home network goes down, and members may have need of 'debugging' tools, for the vast majority of people now using home networks this is something that happens only very occasionally: networks run for long periods of time without any obvious technical troubles at all. Perhaps more importantly however, when debugging does occur it does not happen outside of the ordinary and occasioned management of the home and this has profound consequences for how it gets handled. For example, note in our first vignette how there is a sense in which Dave is not debugging at all, he is simply bringing the network back into a working state. He is not investigating the causes of the network failure although the household had lived with network fragility for some considerable amount of time.

Getting the network working here is about being able to continue with email, continue downloading, continue using

Facebook, continue watching TV, continue talking to Grandma on Skype, etc., and it is reasoned about in that way. Once this much is accomplished, the job is done for the household members concerned. So active debugging – actually drilling down into a problem and fixing it once and for all – may actually be at odds with household concerns. Everyone in the household is busied with doing the things they do and bringing all of those things to a halt whilst definitive work is undertaken on the network is something that comes to impact not just on management of the network but management of the household itself, and of the various relationships within it.

In another of our studies we saw that a householder only tried to fix a problem with his network, which was caused by a guest, when there was no one else in the house (particularly the guest in question). This underscores how debugging is embedded within a broader set of concerns with how to manage the social relationships 'at work' in the home. Indeed, confronted with the accountability of remedial action and its impact on those relationships, it is hardly surprising that partially broken and/or sub-functional systems are tolerated on an ongoing basis, despite regular complaints and mutterings about getting around to fixing them, and that holds more generally. Debugging the network cannot be expected to sit outside of this *practical orientation*. Rather, support for debugging needs to respect that, for household members, it will eternally sit in the frame of practical adequacy and under the auspices that "some kind of working is good enough for now".

Protection

As a final topic we consider protection: in essence, ensuring that useful work can be carried out using the network. This covers protection against both internal and external factors: by internal protection, we refer to management of contention for resources among devices legally connected to the network. Traditional mechanisms to manage this contention come under the heading of quality-of-service (QoS) and include particular techniques such as *prioritization*, shaping, and rate limiting. By external we mean remote attackers, script kiddies, port scanners, botnets, anyone who is trying to gain access to the network without first obtaining *permission*. Traditional protection against this kind of access is by firewalling, or running software on the router to drop traffic deemed unwanted.

Prioritization

We have already touched upon the subject of prioritization in our elaboration of resource allocation. This points to the complexity involved in members' reasoning about priority, *that it is never about just priority alone*, but also about other things such as managing shared resources, individual rights, and the household routine. Our studies also suggest that when network priority is treated as a sociological object it gets bound up with two issues critical for design. One of these is that priority relates not to machines in their own right but rather to actual *people*, as in the following:

I see myself as using the Internet to bring in income, so I can justify that pretty well everything that I do takes priority.

In the case of the excerpt above the householder in question worked from home on a number of different devices, but felt he should have priority regardless of which device or application he was currently using. Priority need not be based on work, however, but can be occasioned by guests:

One thing that I try to do is to schedule my work around them … if they are watching TV on their machine or using Skype I tend to back off from the network for a while and let them do that.

The other matter of moment is that members' reasoning is never about absolutes; it is implicitly bound up with reasoning about people's *activities:*

With my activities, I mean if I only call off emails it doesn't take a lot unless I have large attachments. But I think Danny has no real concept of being economical in what he does … I don't really have any large requirements on film or music downloads. Danny's requirements are far larger than mine, but I don't want his to be so large that my relatively small data requirement becomes slow.

This is underscored by any number of examples regarding how people reason about varying priorities of resource usage, including the use of physical spaces within which technology is situated in the home. Here, for instance, is an excerpt from a study of a set-top box trial some 12 years ago [8], where a young couple talk about the use of their living room, showing that although technologies may change the reasoning is consistent:

Mary: "Yeah, but you do think of this room as being the relaxing room."

Steve: "Yeah, I suppose that's true"

Mary: "…because when I'm working in here … sometimes I work in here to have a break from working next door, in the bedroom, and Steve wants to put music on and play the guitar or watch the television … and he always has … whoever wants to relax in here has priority, and the person who's working has to leave."

Ultimately these are things that offer endless scope for *negotiation*, and negotiation itself revolves around matters that have little to do with priority as a technical object but everything to do with the different people that have moral claim and the differing activities that are deemed appropriate at any moment in time in people's homes.

Permission

As with access control, which we discussed in the context of provisioning, reasoning about permission is considerably richer than arranging a bunch of technical settings. Often this is profoundly wrapped up with considerations regarding the *in situ* management of access to services. In the following example it reflects a profound concern exhibited by many parents regarding what their children might have access to on the Internet:

They're always on the computer. I can't remember what they did the other day but they were searching for something reasonable and it came up like the gay version of Barbie doll, which I came in to see. Y'know, a group of gay men on the page and them finding it absolutely hilarious. But it only needs to go another step too far. That was quite explicit at age nine I think.

However, in the next example we begin to see that the way people reason about the ordinary accountability of the things they get up to on the Internet is about much more than just policing children, it's also about being seeable by others to be *actively managing* these matters:

Joe's mum doesn't like giving the password out … I was wondering about getting one of those 3G things to let him get on the network to play that World of Warcraft without worrying her … when he has visitors over … I am always checking up with him to see what it is he is doing … when he is on the web… I get a bit worried… it's mainly those games … with him and his mates … but as he gets older I'm more worried about him looking up dodgy stuff… I can deal with it if he does it… but I don't want his mates coming round here to look up porn ...

Again, and in similar ways, when we ask householders what they might like to do with the network but can't, we see that they reason about permissions as a way of bringing about compliance in the doing of things like homework:

So if teacher says she's not doing homework and I think she's not doing it because she's spending her life on Facebook, I could block them and say "I'll let you have them back when your homework's done". You see that might be handy, if you could do it at the level of saying- You know, it's easy enough for me to say "show your homework, right that's done", type something, "right you can have Facebook now".

This reflects members' concerns to make use of home networks as they can any other sociological object, such as the TV or phone. What we are seeing here then, is that giving network permissions is inextricably bound up with the moral management of the home and the activities that members get up to within it. In this respect permissions equate to the management of rights, where both having the right to do something or not and just how that right is exercised, are dependent on routine matters in the home, such as doing homework. Home networks are already profoundly sociological objects, locked into ordinary reasoning and natural accountability, with much of what goes on through their use being organised around mundane concerns with moral conduct rather than technical issues. It is this *embedding* of network considerations *in* ordinary everyday reasoning about rights and responsibilities, about routines and routine activities, that helps householders make networking an unremarkable, and thus undemanding, feature of their lives.

SIGNIFICANCE FOR USER CENTRED NETWORKS

We have presented a view of some of the mundane ways in which home networks are made to work as part of the ordinarily accountable work of managing domestic life. We have argued in our presentation that the ongoing domestication of home networks suggests the need to reframe how we consider research into home networks as they have matured. This is not to suggest that the issues surrounding Poole and Edwards initial call to arms for the HCI community [10] is no longer relevant. Networks are difficult for users to understand and the means through which they are exposed to users are problematic.

Nonetheless, while it is true that current networking technology is problematic in how it presents itself to users and presumes too much expertise of household members, it is notable that it is *somehow* managed to the point that it

has become mundane and unremarkable. This suggests the need to consider how networks are reasoned about as sociological objects to balance current considerations to do with exposing and managing the technological features of the network. In short, what might this shift in perspective mean in practice and why might it be important? In this section we wish to highlight a number of key *sensitizing concerns*. These are aimed both at members of the those in the HCI community who would seek to design interfaces to infrastructures, and at those in the infrastructure communities involved in constructing the underlying mechanisms of inspection and control.

Managing the Activities of the Network

Our first observation is that the members don't reason about the network *in technological terms,* either of configuration or management. Rather, they reason in terms of the *activities* they and their companions accountably engage in over the course of their everyday lives. People seldom speak of accessing a web service or a protocol. Rather they speak in terms of activities they do on the network. They shop, play games, download music and videos, use Skype to communicate with distant relatives and friends, etc.

Mundane reasoning poses strong challenges to the technical community, who must adjust their approach to provide mechanisms that take account of this. For example, and as discussed in more detail by Brundell *et al.* [1], the wide range of available traffic management mechanisms must be made applicable to services, applications and even particular *uses* of applications. Activities for which members wish to protect bandwidth are video (not RTMP), Skype (not VoIP) or banking (not HTTP), etc. This relies on both accurate identification of traffic with useful categories, and automatic determination of bandwidth requirements and impacts of traffic management.

This issue is further compounded by the need for a categorization of traffic that makes sense to users to support control. Users often use application names (Facebook, Skype, iPlayer, YouTube, Vuze) as indexical terms into the activities for which they are used. The development of an appropriate categorization of activities requires some significant rethinking of traffic measurement and control techniques at all levels of the network stack.

The Locus of Management and Control

Mundane reasoning occasions the need for us to explicitly reflect on the locus of management and control. When we speak of network management what is the focus of management and where does this management takes place? A natural tendency is to place the network at the center of our considerations of management with the provision of controls that modify the technical features of the network (e.g., prioritizing traffic or controlling machine access). However, consideration of the network as a mundane feature of the home might suggest the need to consider the issues of control more broadly than this. We make two specific observations in this regard.

Firstly, management and control of the network can be achieved both technically, through mechanisms within the network, and socially through modification of peoples activities involved in using the network. It is clear that both are at play and we need to think of how these occur in tandem. For example, we may need to balance techniques to prioritize different machines within the network with techniques to provide users with lightweight awareness of endeavors on the network in order to allow people to modify their behaviour and give others priority access.

Secondly, control and management of the network is already socially negotiated through dialogue and discussion in the household. Family members speak of access not in terms of a technical mechanism but as a social phenomenon. Access is granted in terms of its social framing and with considerable tacit agreement on issues of trust. Technical mechanisms of access need to be seen in this light – that is, that they are likely to be used a last resort in a series of negotiations. This might require control and management mechanisms be tied, then, to a range of measurement techniques that can be used as resource *in negotiation*. It might also require lightweight ways to override control and management mechanisms in order to support the differential rights and responsibilities of household members.

Household and Network Management

The wholesale shift to media consumption and access to a burgeoning array of online services brings into focus the issue that home networks are increasingly central to the management of everyday life in the home and that domestic life is increasingly managed through use of the network. Consequently, when we are considering the development of management and control techniques, we need to ask the critical question, what is being managed and controlled - *the network or the household?*

Management of the network is closely, indeed inseparably, intertwined with the everyday activities that animate and order domestic life. Consequently, the developers of network control and management facilities need to be aware of the impact of the social and moral ordering of domestic activities and the host of relationships and situated judgments involved. When people restrict their children's access to particular sites they are parenting through the network. When users deprioritize another's traffic they are making a judgment on the importance of the related activity. When they set up guest access they are being hosts to their relatives and in-laws, etc. Management of these situations requires nuanced judgment in the home, so designers must be aware of what they should encode into and present via the system, and of the degree to which control should be done within the system or be negotiated and enacted by members themselves.

We would suggest that issues of access, permission and control should be seen as a part of the manifold processes of negotiation involved in managing the home. This is not

to say that control mechanisms to prevent access should not be provided, but rather that they should be seen as one tool to be used in negotiating appropriate behavior on the network, while what constitutes 'appropriate' is, of course, a locally accountable matter. Consequently, control mechanisms with interfaces that provide a range of situationally relevant views on the activities mediated by the network must be supported to allow members to engage in accountable discussion about resource allocation, priorities, permissions, and all the mundane concerns that make the home network into an unremarkable feature of everyday life.

CONCLUSION

This paper has extended work on studies of home networks by emphasizing the *unremarkable* nature of running networks. Thus, we have discussed how networks are oriented to as sociological objects in everyday life and how the activities of the network are intertwined with the day-to-day activities of the home. We have elaborated how this is reflected in the provisioning, performance and protection of the network, and how users make the network work.

Our studies show that ordinary members of households now reason about the home network as a mundane feature of their everyday lives. Situated in its real world, real time context, the home network is not in its use reasoned about by members as a black box off which a hang a host of devices that they must continually inspect and manage. Rather, *in use*, the network is reasoned about in terms of a local ensemble of social activities that span work, entertainment, leisure and play that go to make up everyday life in the home. For most people the home network has ceased to be a technological object and has become a *sociological* object, of interest in terms of how it can continue to support the social practices it enables: in other words it is 'invisible in use' [12].

Nonetheless, many design interventions continue to focus on making the home network not less visible (and thus less remarkable) to members of households, but rather *more*, for instance by overlaying overt management interfaces that can assist the technology in announcing its workings to householders at every available opportunity. We should stress, in saying this, that it is not the case that all of the issues with home networks have been solved or that there is no more interesting research to be undertaken in this space. However, in a contemporary context the 'work to make the network work' consists not only of such things as administering the home network [6], digital plumbing [14], digital housekeeping [13], etc., but also, and in *significantly greater part*, in managing everyday life in the home.

Whatever the technical characteristics of home networks, they have become just another site where the practical concerns of everyday life are played out on a daily basis by *all* members of the household, not only those who hold sway over the operational characteristics of the network. The home network has become just another feature of the home through which the social organisation of everyday life is brought about and it is, for members, reasoned about primarily in that way. In that case, to continue to work outwards from the technological point of view towards the user point of view rather than the other way round will continue to lead to the design of systems that may prove anything but invisible in use and unremarkable. And if home networks cannot be rendered unremarkable they will serve to disrupt rather than assist people's ordinary efforts to embed their use within everyday life.

ACKNOWLEDGMENTS

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