A Preliminary Study of the Role of Language in Home Network Troubleshooting

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ABSTRACT

We present the results of a preliminary study into the usability of troubleshooting terminology around home computer networks. Forty-seven participants classified 29 terms, selected from interview transcripts and online help forums, in an open card sort. We analyzed words participants explicitly indicated as unfamiliar as well as words that participants misclassified. The study serves as a proof of concept for a broader study to determine whether certain technical terms and/or their colloquial counterparts are understandable by technical novices and intermediates. Our findings indicate that participants found technical and colloquial terms equally problematic. These findings have implications for the design of troubleshooting tools and systems as well as the design of technical support scripts and training.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; **Empirical studies in HCI**; *Natural language interfaces*;

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KEYWORDS

open card sort; mental models; home networks; troubleshooting

INTRODUCTION

Activities like remote work, immersive gaming, streaming movies and music, and telepresence have shifted from structured and well-supported computer environments, such as the workplace or at university, to the home. Home networks are rarely solely for hobbyists, but rather are a means to accomplish an ever increasing list of life and work tasks. The new reality of complex computer networks within the home presents an opportunity to rethink network management and monitoring tools and systems, and in particular to examine the usability of such systems.

Network troubleshooting, setup, and maintenance falls increasingly to homeowners, many of whom are not technically inclined or have no desire to continue "being technical" in their off-hours. Researchers have long recognized the inherent challenges in designing effective and user-friendly home network setup and troubleshooting systems [4, 12]. Home network users tend to think of technology in terms of people and application usage, not devices, as well as situating technology within the "physical fabric" of the home [3, 5, 6]. Many tools fail to provide hooks for users to develop adequate conceptual models of their networks [13].

Technical terminology is often a barrier to home network users' expressions of desired network performance and of network problems. This disconnect in turn reflects erroneous mental models of the home network. This is problematic, as popular means for acquiring technical support include consulting family and friends [10], posting questions to online forums, or calling tech support phone centers. A key challenge in successful phone-based troubleshooting, as well as when consulting family or posting to online forums, is establishing *common ground* [11] between the respondent and client. Because this requires the client to adequately communicate the parameters of their network and describe the problem, and the respondent to infer the network model and calibrate advice to the client based on this communication, language and terminology form barriers to carrying this out successfully.

Past studies attempt to discern users' mental models of their networks via sketching exercises [5, 9], or shape users' mental models of bandwidth utilization via resource visualization [1, 2]. To the best of our knowledge, no studies have specifically examined the *terminology* used by tools, technicians, end users, etc. to communicate the nature of problems on a home network. A set of commonly understood terms helps those providing technical assistance, whether human or automated, match the mental model of home network users. In turn, shared language molds home network users' mental models of their networks over time, providing them a low-stakes way to acquire technical knowledge and skills [7].

Our participants:

- 19% between 18-24 years old
- 13% between 25-34 years old
- 36% between 35-44 years old
- 28% between 45-54 years old
- 4% 55 years old or older
- 79% hold bachelor's degree/equivalent or higher
- 48% hold masters' degree/equivalent or higher
- Top 3 troubleshooting strategies (of options listed): restart device (87%), use search engines (66%), consult online forums (47%)

Sidebar 1: Participant demographics

We present the results of a preliminary study into the usability of troubleshooting language around home computer networks. Forty-seven participants classified 29 terms in an open card sort into categories of their choosing. Terms were selected from interview transcripts and online help forums. We analyzed the classifications to determine which terms were least understandable to our participants, looking at words participants explicitly indicated as unfamiliar as well as words that participants misclassified as belonging to one category when it belongs to a different category. The study serves as a proof of concept for the viability of a broader study to determine whether certain technical terms, or their colloquial counterparts, are understandable by technical novices and intermediates. Our findings indicate that care must be taken when choosing both technical **and** colloquial terms to describe home network issues, as our participants found technical and colloquial terms equally problematic. This has implications for the design of troubleshooting tools and systems as well as the design of technical support scripts and training.

Table 1: Our word corpus. Technical terms are indicated in bold.

Capacity	
bandwidth	**bottlenecking**
buffering	**congestion**
data hog	**download**
freezes	**high traffic**
hogs the pipe	**mbps**
overage	**streaming**
throttle	**throughput**
upload	
slower/faster network	
sucking the data down	
Connectivity	
(connection) drops	disconnect
goes dark	goes out
in-and-out	**interference**
not connected	**outage**
unstable	
cleaned up (connection)	
knocked out (Internet)	
Other	
cycles through	

METHODOLOGY

A key aspect of designing effective and usable systems lies in ensuring that the *system image* presented by the system's interface matches the user's *mental model* of the system [8]. Visual feedback communicates and represents the system's internal state to the user. While beeps, flashing lights, or colors flag the user's attention, text instructions convey specific, nuanced information about system state. The terminology that appears in this text plays a key role in presenting the conceptual model of the system to the user. Language and terminology also play key roles in how users reason about and express their own mental models of system operation and state, both in text (through search engine queries and online forums) and verbally (posing questions to family, friends, and technical support staff, and receiving answers to these questions). The more closely the feedback terminology used by the system or help giver matches that favored and understood by end users, the more closely the conceptual model matches the users' mental models. Similarly, terminology can *shape* the mental models of end users, if used wisely, by bridging a user's current understanding of system operation with a more nuanced technical view of system operation. This could be done, for instance, by gradually mapping terminology that users understand to more technical, and more accurate, terminology, one way to provide *common ground* between help-seekers and help-givers.

An ongoing semi-structured interview study conducted by the authors targeting adult homeowners in a major metropolitan area, with similar demographics to our card sort participants, aims to discern common troubleshooting strategies in the home. Transcripts from these interviews included terminology related to two broad areas: connectivity and bandwidth utilization/capacity. The language homeowners favored differed from the terminology favored by technical experts: less technical, more colloquial. We wondered if our participants' terms reflect the mental models of the general population

more closely than the technical terms commonly found in troubleshooting tools and advice, and what other terminology non-experts utilize when describing technical issues on their networks.

We developed a list of 29 words (Table 1) used in troubleshooting environments to describe home network performance problems, around the themes of connectivity and bandwidth utilization/capacity. We extracted words from interview transcripts as well as manually from posts and replies on several randomly-chosen popular online technical support forums (Tom's Hardware, Bleeping Hardware, and Yahoo Answers). One term, *cycles through*, appeared often in the online forums but doesn't fit neatly into either "capacity" or "connectivity", so we list this as "other" in the table. We classified each term as *technical* (in **bold** in the table), *colloquial*, or *neutral* (terms sometimes used by experts, but that tend to be understandable outside of a technical context; we refer to all colloquial and neutral terms as "colloquial" for simplicity here). Our sources included a higher percentage of technical bandwidth terms than colloquial, and vice versa for connectivity. In future work, we plan to diversify our set of sources to obtain a more evenly divided word set. We acknowledge that this method, using both the transcript and forum data, is highly subjective and prone to researcher bias. Our goal in this study is to pilot this methodology as part of a larger, more comprehensive survey in future work.

EXPERIMENT

We conducted an open card sort online over a three week period in July 2018, using Optimal Workshop's OptimalSort platform[1] and a combination of snowball recruiting and social media recruiting (Facebook and Twitter) to gather participants. We did not allow participants to duplicate the virtual cards, requiring them to classify each word into a single category. Forty-seven participants completed the card sort, out of 133 who attempted, for a completion rate of 35%.

It is important to note that we did not aim for a representative sample, and we do not claim that our results are representative of the population as a whole. Rather, this study is intended as an exploratory study which will inform a larger, future study with a more representative participant base.

Sidebar 1 summarizes the demographics of our participant pool. We did not collect data on the self-reported technical experience of our participants, the amount of time they have maintained their home networks, or on gender. The age range is likely appropriate for our target audience of homeowners, but higher levels of education are overrepresented in our pool, which is something we will take into account when recruiting for our larger experiment. Note that two of the three top participants' troubleshooting strategies reflect the need for troubleshooting tools to use effective terminology.

RESULTS

Our participants assigned 218 unique category names to the terms, which we clustered into several themes. In addition to capacity and connectivity, "unfamiliar" emerged as a top theme. Table 2 lists a

Table 2: Sample category labels chosen by our participants

Capacity	
Crowd and hallway	Data transfer
Input/output	Maxed out
Space and restriction	Slow network
Throttle	Too many cooks
Connectivity	
Bad or no Internet	Connection issues
Dropped	I am gone
Lack of Internet	Network issues
Total disruption	Working Internet
Unfamiliar	
Huh?	Jargon (unknown)
No clue	Not familiar with
Unfamiliar	What
Term[s] I've heard but don't understand	

[1] http://optimalworkshop.com/optimalsort

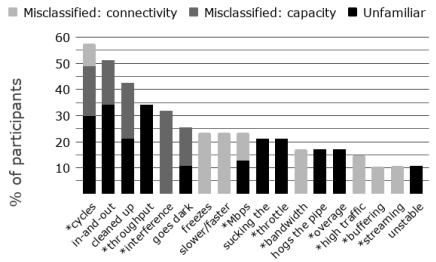

Figure 1: Terms classified as unfamiliar, or misclassified, by at least 10% of our participants. *denotes a technical term.

sample of these labels. To determine whether a label fit a particular category, the authors individually classified each category name independently by theme, then discussed any classification differences that arose, coming to a consensus about category name classification. Based on our analysis of category names, the majority of our participants are likely novice or low intermediate.

We concentrate here on terms our participants labeled unfamiliar or mislabeled, as mislabeling is an indication of unfamiliarity. Figure 1 graphs, in descending order, the terms that were labeled "unfamiliar" or misclassified by more than 10% of our participants. Just over half (56%) of these are technical terms; of these, 45% of the unfamiliar terms are technical, while 58% of the misclassified terms are technical. This result surprised us somewhat: slightly more participants *thought* they understood technical terms but didn't, than colloquial terms. While our small sample size precludes us from making strong inferences, this result suggests an unforeseen challenge in determining whether a technical term is universally understood, should we rely on participant self-reports.

Table 3 lists the terms that were ranked unfamiliar or miscategorized more than 20% of the time by our participants. We can use these lists as proxies for the most problematic terms in our study. Again, we see a mostly even split between problematic terms that are technical and colloquial. Both "cleaned up (connection)" and "cycles through" appear on both lists, indicating that these terms were commonly misunderstood on multiple levels.

Table 3: Top unfamiliar and misclassified terms. Technical terms are in bold.

Unfamiliar		**Misclassified**	
in and out	34%	**interference**	32%
throughput	34%	**cycles through**	28%
cycles through	30%	freezes	23%
cleaned up (connection)	21%	slower/faster network	23%
sucking the data down	21%	cleaned up (connection)	21%
throttle	21%		

There are several key takeaway points from this study. First, care must be taken when choosing technical **and non-technical** terms to include in troubleshooting scenarios, whether as error messages in tools or language used by technical support. Our participants were just as likely to find colloquial terms confusing as technical terms. Second, our word corpus was chosen from conversations with homeowners as well as commonly encountered words on technical support forums, meaning the words here are somewhat common in troubleshooting. The fact that our participants found many of these terms problematic points to an opportunity to design better troubleshooting tools, scripts, and mechanisms. Indeed, the results indicate that we may **not** be serving home network consumers well in allowing them to maintain their networks in the best way possible, and that changes in the terminology these systems and mechanisms use may assist in this regard.

CONCLUSION

This proof of concept study examines the familiarity of technical and colloquial terms in troubleshooting situations among home network users, to aid in the design of more effective and user-friendly network troubleshooting tools and scripts. Our participants found colloquial terms as confusing as technical terms in these contexts, indicating the need to consider the choice of terminology more carefully to better serve home network consumers in maintaining their home networks. In future iterations of this study, we plan to revamp our word corpus, identifying a better mix of colloquial and technical terms from a wider set of forums; expand our recruiting pool to better represent the pool

of homeowners with computer networks in their homes; specifically query our participants on their level of technical expertise; and move to a closed or hybrid card sort to provide more structure to our results.

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