Home Networking: Smart but Complicated

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Abstract. Internet connection at home has fundamentally changed the way that appliances are designed in the same way that the invention of electricity did. Having efficient and reliable home networking is the key to any modern home. The number of devices that need to be connected to a home networking system increases every day. Computers, televisions, tablets, gaming devices and sound systems are just some of the many appliances that need that connection. Despite the improvements to the hardware of networking devices, re-search shows that the software to set up networking devices along with their configuration are extremely complicated. This paper presents the results of several usability investigations on home networking devices including: a comparative study of different product brands, two series of user surveys, and empirical observations. The results of these investigations show that all of the major brands of home networking appliances use a complex, feature-oriented, rudimentary user interface (UI) design with terms that are understood by a very small percentage of people.

Keywords: Smart Device, Home Networking, Routers User Interface, Wi-Fi Network.

1 Introduction

With the growing number of smart appliances at home [1] that need to connect to the Internet efficiently and with the security to operate successfully, the Internet and Internet-based technologies have become a basic utility, like electricity, gas, or water. Thus the need for wireless connections at home to allow all devices to be connected and interconnect is an essential feature of a modern home. There exists a need for a high-speed Internet connection, a reliable and high-speed router/modem, device interconnectivity and discoverability in a network, and the ability to enable users to easily manage this network, set security criteria and most importantly, troubleshoot any issues [2], [3] & [4]

Not long ago, Internet connection was limited to one or more computers at home. Now, gradually within a “smart home” [5] a multitude of computerized devices are interconnected and interact with each other. Users should be able to not only configure them but also monitor them on a daily basis, while interacting with them and, more importantly, problem-solving any and all network issues.

Despite progress in the hardware of these devices, improvements in the usability of their software are still insufficient. Users commonly agree that managing home

networks is a tedious, difficult task that is out of reach for most users with limited networking experience.

Some research points out a variety of usability issues for home networking technologies [6] [7] [8].

The expansion of the smart home concept adds even more complexity to home networking. Pairing the devices with routers, selecting the right channels, conflicts, ranges, incompatibility of signal are some of the most common issues that users are confronted with [8], [9] & [10].

It is still believed that home networking should benefit elder adults who also tend to have an overall positive attitude towards this technology. A good example of how people benefit from this technology is the usage of health monitoring sensors or security devices in the home that enhance their lives [11]. Yet the ease of use of these applications is crucial for successful usage by elder adults.

Home network devices should make it easy to add computers or any other smart appliances to the home network, and establish interaction by offering users an easy to use and intuitive method of centralized management and monitoring of devices.

The results of a survey on home wireless usage reveal that currently 22% of people surveyed bought their wireless router based on speed, followed by 17% that based it on low price, and 1% for ease of use. However when participants were asked about purchasing a new wireless router, speed remained the top factor but its importance increased to 37%, and ease of use moved up to second priority with 17% [1].

Consequently, making home networking smart is not achievable unless the usability of the devices (software and hardware) along with their configurations, is extensively improved and accessible to all types of users. [12 & 13]

The goal of this study was to first identify the most important issues in usability and then to investigate how usability can be improved.

2 Method

After completing a comparative study of user interfaces of several networking router brands, two groups of participants were surveyed through two different online questionnaires: one on terminology and a second on home networking. Some participants participated in both studies.

In the terminology study, 84 participants (mostly college students and former graduate students in software engineering, human factors, and psychology) completed an online survey. 54% of participants were male, 45% female, with 54% under age 25, 24% ages 26 to 35, 12% ages 36-45 and 8% over 46 years. There were 54% with a formal education of college, 26% graduate schools and 14% with other. It is important to underline that 86% of the respondents owned a router at their place of living.

In the networking study, 67 participants (mostly college students and former graduate students in software engineering, human factors, and psychology) completed the online survey. 67% of the participants were male, 33% female, with 55% ages 18-25, 19% ages 26-35, 6% ages 36-45, and 19% over age 45. 6% of the participants self-evaluated their level of expertise in computer usage as "Expert", 25% as "Advanced", 52% as "Intermediate", and 16% as "Beginners." 30% of the participants had a graduate level education, 60% college and 9% high school.

3 Results

3.1 Comparative Study of Router User Interfaces

Comparing the user interfaces of four major brands of devices illustrated the similarity of the design among the different brands. (Basic screens of router interfaces for these brands are shown in Figure 1a, b, c and d). A quick review of the screens, despite some differences in color palette or layout, reveals that the UIs are built using the same terminologies. Each UI displays a number of parameters that are required for users to understand and set or configure without knowing the context, what the settings do, and the relationship among the parameters. All four UIs evaluated use a feature-based design approach targeted to advanced users with IT background.

Figure 1.a: NETGEAR- Field Labels

Figure 1.b: 2:Cisco-Linksys-Field Labels

Figure 1.c: D-link- Field Labels

Figure 1.d: Belkin Modem Router

Fig. 1. 1a, 1b, and 1c, show UI screens of the four router brands evaluated. The field labels and terminology seem very similar if not identical.

Figures 1.a to 1.d show the main page UIs of the four router brands. The field labels and terminology seem very similar if not identical.

Figures 2.a, b, and c show the information architecture of the left hand navigation. Terminology and concept again stay similar for all the three compared brands.

All of the major brands of home networking appliances use a complex feature-oriented rudimentary user interface (UI) design. Among other things, we notice a tremendous amount of text, very technical terminology, complex labeling and difficult navigation. The situation is not very different from one product to another among major brands.

a. NETGEAR	b. Linksys	c. D-Link
Home	Setup	SETUP
Internet	Basic Setup	INTERNET
Wireless	iPv6 Setup	WIRELESS SETTINGS
Parental Controls	Mac Address Clone	MEDIA SERVER
ReadySHARE	Advanced Routing	IPV6
Guest Network	Wireless	PARENTAL CONTROL
Home	Wireless Settings	ADVANCED
Internet	Guest Access	VIRTUAL SERVER
Wireless	Wireless Mac Filter	APPLICATION RULES
Parental Controls	Security	QOS ENGINE
ReadySHARE	Firewall	NETWORK FILTER
Guest Network	VPN Passthrough	ACCESS CONTROL
Router Information	Storage	WEBSITE FILTER
Internet Port	Disk	FIREWALL SETTINGS
Wireless Settings (2.4GHz)	Media Server	ROUTING
Wireless Settings (5.0GHz)	FTP server	ADVANCED WIRELESS
Guest Network (2.4GHz)	Administration	WISH
Guest Network (5.0GHz)	Access Restriction	WI-FI PROTECTED SETUP
Setup Wizard	Parental Control	ADVANCED NETWORK
WPS Wizard	Applications & Gaming	GUEST ZONE
Wireless	Single Port Forwarding	IPV6 FIREWALL
Internet Setup	Port Range Forwarding	IPV6 ROUTING
Wireless Setup	Port Range Triggering	TOOLS
Guest Network	DMZ	ADMIN
WAN Setup	iPv6 Firewall	TIME
LAN Setup	QoS	SYSLOG
QoS Setup	Administration	EMAILSETTINGS
USB Storage	Management	SYSTEM
ReadySHARE	Log	FIREWARE
Advanced Settings	Diagnostics	DYNAMIC DNS
Media Server	Factory Default	SYSTEMCHECK
Security	Firmware Upgrade	SCHEDULES
Parental Controls	Status	STATUS
Block Sites	Router	DEVICE INFO
Schedule	Local Network	LOGS
E-mail	Wireless network	STATISTICS
E-mail	Ports	INTERNET SESSIONS
Administration		ROUTING
Router Status		WIRELESS
Logs		IPV6
Attached Devices		IPV6 TOUTING
Backup Settings		SCHEDULES
Set Password		
Firmware Update		
Advanced Setup		
Wireless Settings		
Wireless Repeating Function		
Port Forwarding / Port Triggering		
Dynamic DNS		
Static Routes		
Remote Management		
USB Settings		
UPnP		
IPV6		
Traffic Meter		

Fig. 2. Left hand navigation in the three major router brands

Table 1. Labeling terms used in most router user interfaces
Cable Modem, Channel, DNS Servers, Domain Name, DSL Modem, Enable SSID Broadcast, FTP (via internet), Gateway IP Address, Guest Network, HTTP (via internet),Hitter, Internet IP Address, IP Address, IP Subnet Mask, IP Subnet Mask,IPv6,Media Server, Modem, Passphrase, Primary DNS, Router, Router MAC Address, Secondary DNS, Static IP Address, USB Settings, WEP, WPA/WPA2 Enterprise, WPA-PSK [TKIP],WPA-PSK [TKIP] + WPA2-PSK [AES],WPA-PSK WPA2-PSK [AES],

3.2 Terminology

If you have a home networking device, there is a good chance that you have experienced a variety of home networking user interfaces. You might have even asked someone with technical knowledge to help you with installing, connecting, and configuring the device that you acquired or had problems with. This might have happened for any type of device from a Wi-Fi router to more advanced de-vices such as storage, security systems, and interactive TV or sound systems.

The poor usability of these user interfaces (UIs) is not noticeable with only one or two brands of products. A simple comparison among the most common brands on the market reveals that all brands suffer to some degree from the same usability issues. Table [1] shows the 30 common terms used in configuration and setting of major Wi-Fi router brands.

The results of a survey with 84 potential users show that a very small percentage of people know the meaning of the terms used in these devices’ user interfaces (UIs). Many users do not understand even the more common terms shown in Table 2, such as DSL modem or IP address. For example, 41% of participants could not be certain of the meaning of the words “Passphrase”, 37% for “Media Server”, 46% for “WEP”, and even 4% for “Router”. (Chart 1 and Table 2).

Even for terms like “Modem”, “Router, and “IP address”, while the percent-age of participants who were “not sure at all” is low (3%, 4% and 6%), those who “know what it means but not sure” was very high (44% for Modem, 37% for Router and 43% for IP Address) (Chart 2, Table 2).

It is important to underline that 86% of the respondents own a router at their place of living.

Chart 1. Understandability of the terminology used on home networking device users interfaces

Considering that 80% of the participants have a formal education of college or higher and 54% are under the age 25, the assumption of this level of computer knowledge and understanding of terminology used is interesting to note, especially in consideration of the design of user interfaces for networking products. However, seeing as this survey was conducted out of the context of the UI it is hard to draw a global conclusion (Chart 1 & 2).

Empirical observations also support the extent to which users are unfamiliar with all terms used. Knowledge of terms and their meanings requires education, training and the reading of many pages of documentation and online help, which is another hard task for the average user. To underline the unfamiliarity with these terms, the readers of this article can check to see which ones they themselves are familiar with.

Table 2. Understandability of selected networking terminologies used in field labeling of router UI

Term	No sure at all	Know what it means but not sure.	Definition Provided
WPA-PSK [TKIP]	59%	9%	33%
WPA-PSK [TKIP] + WPA2-PSK [AES]	59%	14%	30%
WPA-PSK WPA2-PSK [AES]	56%	14%	30%
IPv6	56%	19%	26%
Secondary DNS	53%	20%	27%
IP Subnet Mask	53%	24%	23%
IP Subnet Mask	51%	24%	24%
Enable SSID Broadcast	50%	21%	29%
HTTPr	49%	26%	26%
Primary DNS	47%	23%	30%
WEP	46%	23%	31%
FTP(via internet)	41%	21%	37%
Passphrase	41%	27%	31%
DNS Servers	40%	24%	36%
Gateway IP Address	40%	36%	24%
Router MAC Address	39%	29%	33%
Media Server	37%	27%	36%
Static IP Address	36%	33%	31%
WPA/WPA2 Enterprise	36%	23%	26%
HTTP(via internet)	21%	54%	24%
Domain Name	16%	40%	44%
Channel	16%	50%	34%
USB Settings	16%	50%	34%
Internet IP Address	11%	50%	39%
Guest Network	10%	46%	44%
Cable Modem	8%	49%	42%
DSL Modem	7%	54%	39%
IP Address	6%	43%	51%
Router	4%	37%	59%
Modem	3%	44%	53%

Chart 2. Understandability of the terminology used on home networking device UI

3.3 Networking Survey Results

The second survey consisted of more detailed questions about networking usage and needs. In this section we will review a number of responses related to this survey.

One of the questions regarded how many people among the respondents handle their networking issues such as disconnected Internet. The result indicates that 64% of the respondents would handle it themselves, 10% their wives/spouses or partners, and 26% used another method. When they were asked who had installed their home networking, again 60% respondents reported themselves, 9% their wives/spouses or partners, 10% had it done by technicians, 4% by their friends, 11% another method, and finally 4% who were not sure who did it. Considering the demographic of the participants, 10% seems like a large number of people who chose to use a technician.

The results also indicate that 64% believe only 1 to 2 persons should have the ability to fully access the device and modify it versus 55% who believe 1-2 persons in the household should have limited access to the device for modifications.

In another series of questions, we tried to see what major tasks users would like to accomplish with their devices if they were easy to perform. Both Table 3 & Chart 3 show the main results. Overall, of the tasks asked about, all were rated over 5, showing a wish to do such tasks such as 'Block', 'Test and Measure your network connectivity', and most importantly 'Use the printer remotely' were high.

Chart 3. The main tasks that users would like being able to accomplish with their devices

4 Conclusion

The results of this study suggest that the user interfaces in all home networking devices are not built with users in mind. Most of the terminology used seems to be unfamiliar to most users while the user interface itself is complex. However users themselves feel that they would like to be enabled to accomplish some important tasks using their home networking devices if the interfaces were built in an easy-to-use manner.

Table 3. Ranking of the tasks that users would like to do on a router.

#	Task Raking	Ratio*
1	Use the printer connected to your network to print document remotely.	0.81
2	Test and measure your network connectivity speed in different locations of your home.	0.75
3	Block or allow computer/ devices access to your network.	0.74
4	Share folder(s) (picture, music or files) stored on your router storage with your social networking friends, such as Facebook.	0.72
5	Turn smart devices on and off remotely such as: lighting, sprinkler system and so on.	0.70
6	See which applications use the most Internet connection.	0.69
7	Back up my data on router hard drive.	0.68
8	Turn on and off connection access for a specific device.	0.65
9	Run a connectivity diagnostic test of your network remotely.	0.63
10	View your security camera(s) installed at home remotely.	0.61
11	Monitoring the download and upload activity within the billing cycle.	0.58
12	Set schedule network connections of specific computers or devices to your network.	0.55
13	Open and close garage door.	0.51

Ratio is established based on the total score given by the responds to each items divided by total possible score.

In an attempt to extensively enhance the usability of the home networking device, user interfaces (UIs) should focus on making common tasks of installing, configuring, and monitoring the network easy for the average home user according to each user's needs.

Based on this study the following concepts were identified that impact usability:

- Users' needs are different. All users don't need all the functionalities offered by devices. Consequently, the device functionalities should be scalable. The interface should not complicate the task of average users who need to complete only a few basic tasks
- The UI should use common and easy to understand terminology and avoid complex and technical language.
- The UI should offer a task-based interface in terms of what users want to achieve rather than a combination or a variety of features or parameters.
- Users should be able to install, configure, and monitor their network devices in the shortest time possible.
- The UI should let users install, set and monitor the application with the least number of navigation clicks.
- The UI should be appealing and not distracting when users have the application open for long periods of time.
- The UI should be built with minimal objects, the simplest behavior, general rules, understandable terminology, and should be consistent.
- The UI should use the most common paradigm that users are familiar with to reduce learning and remembering the design pattern.
- Comparison of several home networking device brands illustrates that most, if not all, target advanced users with some knowledge of IT networking.

Today's market is not about focusing on more features and functionalities. We are moving towards a situation where comparable products often offer the same functionality. The example of the mobile smart phone illustrates that despite the complex functionalities among smart phones, people will prefer the phone that is the easiest to use and operate rather than the one that offers the most functions. This philosophy is applicable to all types of technology. With the expansion of smart home appliances, success will fall to the home networking enterprises that offer a simple product, satisfying the most common users.

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