Usability Testing & Evaluation of Chores in GNU/Linux for Novice

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Abstract

A challenging issue of GNU/Linux: usability has been studied in this report. Usability is considered as one of the core component in any system software. System software should be efficient, effective and satisfying for users. Different studies on usability issue have been conducted in different distros but there is no specific study on Ubuntu 8.10.

Ubuntu 8.10 is considered for usability evaluation of GNU/Linux system software and a multi-phased research approach is adopted. Participants (students) from different disciplines and level are taken to conduct the usability test. The system software is evaluated on the basis of usability test results and user’s opinion. An interview is designed and conducted to validate the tested findings of the system.

GNU/Linux is serving the whole community as being used by different distros. The current set of interface guidelines and default softwares used by Ubuntu does not provide efficiency, effectiveness and satisfaction for novice users. It is very important aspect that software should have uniformity and complete control in applications. There is need to improve or redesign the default softwares for better usability in terms of interface, message windows, bugs and help etc for novice users.

Keywords: Testing, Evaluation, Usability, GNU/Linux, Ubuntu 8.10
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Introduction

GNU/Linux is getting popularity day by day with free availability, long standing, security reasons etc. GNU introduced gnome Graphical User Interface (GUI) and developed whole system software which can be used as alternative system software. Majority of people in the world know or call GNU work as Linux but GNU called its project as GNU/Linux after using Linux as a kernel. Now days every other distribution (Debian, Red Hat, Fedora, SUSE, Ubuntu etc) is using GNU/Linux as main platform with other open softwares as well.

The reason to choose this area of study is that many people in Pakistan are not familiar with the contribution of GNU/Linux and its different flavors. Author’s origin is from Pakistan and before this study authors do not have much knowledge about Linux and never heard about GNU. Even though authors heard about Red Hat and Lindows GNU/Linux based system softwares yet authors had never chance to use or study. Authors have discussed this study area and topic with fellow students studying in Sweden and also in homeland. Majority of students do not know the work of GNU/Linux-Ubuntu and usability work on it which motivated authors to conduct this study. Although a user performs many tasks in a day but authors will take the important and necessary tasks of everyday routine life and perform test on these specific tasks.

According to our best knowledge, many people from Pakistan did not have much knowledge about Linux and especially about Ubuntu. Organizations and government institutions are not using GNU/Linux. The concept of this study is to provide interest and motivation to novice users of GNU/Linux. Authors selected most of participants as novice where novice refers to the new users of GNU/Linux system software. Our study can be used and helpful as a guideline to introduce and implement GNU/Linux for home users, government, private sector and different educational levels. This can stimulate a number of GNU/Linux users in a competitive market of different system softwares.

In this study, Ubuntu 8.10 is selected according to “strong focus on usability and ease of installation [40]” (as it is claimed). Although there are different standards related to usability but authors are more specific about efficiency, effectiveness and satisfaction and Nielsen’s usability parameter for system acceptability. Different methods are available for testing and evaluation but authors use thinking aloud protocol for usability test in Ubuntu. Interview is also planned to recheck or validate the results which are collected through test.
Chapter 1: Background

This chapter provides the introduction about research area. Section 1.1 explains the relevant study, motivation and background knowledge about research field. Section 1.2 shows the exact picture of challenges and research questions. Goals and results of this study are described in Section 1.3. Overview about methodology is explained here in Section 1.4 and further details about research methodology are explained in Chapter 3. Section 1.5 gives the idea about thesis sections or outline.

1.1 Prologue

Operating systems has evolved through many generations. Earlier generations of computers used different media (Punch Card, Drums and Magnetic Tapes etc) for IO operations. In 80s, Operating System (OS) has got much success with the induction of Disk Operating System (DOS). An OS is a set of software that besides other things helps to run different user application softwares in computer(s). OS has the responsibility to give and take instruction between applications and devices from the user(s) and behave like a real life traffic sergeant. [1]

Human Computer Interaction has become an integral part of software. Usability as a one key aspect of HCI has an important role in the success of any software. Usability can be elaborated with efficiency, effectiveness, safety, utility, learnability and memorability. Efficiency means how a user performs a task in minimum time. Effectiveness means how a user succeeds to do a task or not. Safety means how a user performs a task to avoid undesirable results or conditions. Utility means how a system is utilized to do a task with the right and proper functionality for the user. Learnability is how a system helps the user to learn and perform a task with ease. Memorability is based on easiness of system functions to perform same task again. [6]

Graphical User Interface (GUI) revolutionized OS and APPLE introduced first commercial GUI OS in 1984 [1, 3]. Microsoft introduced first DOS independent GUI called Windows95 with much focus on usability which gained a lot much popularity [1, 3]. GUI and enhanced usability factors can be seen in successors of Windows and Microsoft became a major player in GUI based system software which was compatible with all computer hardware manufacturers (IBM, Dell, etc). [1, 3]

GNU stands for “GNU not UNIX” started as independent software in 1984 by Richard Stallman and he had almost done work on GNU in 1990 [4]. In 1991, Linus Torvalds rebellionized the entire computer community by developing Linux [4]. Linux and GNU both were working for the same cause which was distribution of free and open source software(s). GNU needed “Kernel” to act as a complete system software. In 1992, GNU used Linux as kernel and became GNU/Linux. GNU/Linux has tremendous capability to change its visual appearance due to availability of a variety of GUI environments. [4]
GNU/Linux communities developed different strong graphical environments which are useful for computer beginners and experienced users as well. GNOME and KDE are most popular GNU/Linux environments used by different distros like Ubuntu, Debian, Gentoo, Red Hat etc. [21] Developers are still emphasizing on enhancing GNU/Linux user interface (UI) to increase usability.

Ubuntu is free high quality GNU/Linux Debian based system software. It was started by a businessman named Mark Shuttleworth. Ubuntu runs GNOME by default but it can also run KDE. Ubuntu has become number one distribution in recent years due to strong back end support, usability, focus on user centered design and a schedule of six months version. [5]

The meaning of African word “Ubuntu” is humanity which can be elaborated as a drudge for human beings. Ubuntu is free like other GNU/Linux distros and will remain free until its life. Ubuntu gives user(s) power like freedom to use, build and change with ease and authority. Almost all tasks that users perform in Windows can also be performed in this GNU/Linux flavor. [5]

1.2 Challenge/Problem Focus
During this study following questions will be answered:

- Does GNU/Linux-Ubuntu provide enough support to user(s) according to efficiency, effectiveness and satisfaction?
- How usability features can be improved to make user interface easier?
- How reliable is third party free softwares used in GNU/Linux-Ubuntu?

1.3 Goal/Result
The main goal of this study is to test, evaluate and validate the usability of Ubuntu 8.10. Following are the objectives as road map to obtain these goals:

- Detailed literature study on usability and free open source software (F/OSS).
- Design and conduct usability test on Ubuntu 8.10.
- Design a structured interview.
- Compile and analyze the usability test and interview results.
- Evaluate and validate the tested usability of Ubuntu 8.10.

1.4 Method/Approach
A mixed research approach is accomplished for this research. Detailed literature study is performed which will provide a better understanding of GNU/Linux and Ubuntu usability. It also helps to design and conduct usability test and evaluation. Usability test is performed with different students. Interviews are conducted from GNU/Linux experienced users. Results collected from usability test are evaluated and validated through interviews.
1.5 Thesis Breakup

This section provides the thesis construction breakup:

**Chapter 2** (Problem Definition/Goal) explains the definition of the problem. Section 2.1 provides knowledge about relevancy of the problem with research domain. Section 2.2 describes the goals to address this research.

**Chapter 3** (Methodology) explains the research methodology that will be used for this research study. An overview about research methodology, literature study, informal meeting and discussion with students to introduce the research field, testing approach for usability test and evaluation and interview technique for validation will also be described.

**Chapter 4** (Theoretical Work) describes the theoretical work and literature study to support the research. Section 4.1 explains the Computer Interaction. Section 4.2 is about Human Computer Interaction (HCI). Section 4.3 defines the Usability, Nielsen work on usability and different ISO standards related to usability. F/OSS usability is described in Section 4.4. Section 4.5 provides the knowledge about GNU and Linux. GNOME and KDE desktop environments are explained in Section 4.6. Section 4.7 describes Ubuntu overview. Thinking aloud protocol and interview are explained in Section 4.8.

**Chapter 5** (Empirical Study) is about empirical study and conduction of test. Section 5.1 describes pilot test planning and conduction. Testing equipments provided to testers is discussed in section 5.2. Redesigning of tasks is described in section 5.3. Selection of participants is described in section 5.4.

**Chapter 6** (Results) is about results which are conducted through usability test. Section 6.1 explains the test data with tables and graphical representation. Observations on different task and user’s opinion are described in Section 6.2. Section 6.3 is about validation of results.

**Chapter 7** (Discussion/Analysis) contains discussion/analysis of the results which are obtained during test. Section 7.1 is described ISO usability standards parameters and Jakob Nielsen usability view as a part of system acceptability which is covered during the test with participant’s performance. Overall system behavior is explained in section 7.2. Section 7.3 is about answer to research questions.

Conclusion

Recommendation

Future Work
Chapter 2: Problem Definition/Goal

This chapter explains the definition of the problem. Section 2.1 provides knowledge about relevancy of the problem with research domain. Section 2.2 describes the goals to address this research.

2.1 Problem Definition

Although there are many other ways to interact with the system but here we use and define Human computer interaction as the field of computer science concerned with the design of computer system that are safe, easy, comfortable and efficient to use [6]. In HCI, GUI systems are more usable than text interfaces due to the application of graphical design patterns [8]. With the popularity of Graphical User Interface, usability has become necessity for the success of any software. Generally speaking, usability is referred to the easiness and less time to finish a task for user(s) with computer. A complete and comprehensive discussion about usability will be done in Chapter 4.

In past, softwares are built according to the technicalities of the product and developers do not concentrate on usability issues. The main concern of the developers is on functionality of software and there is a different team for software testing to improve functionality. Usability has become a vital issue for researchers both from HCI and software engineering (SE) community from last two decades. Despite of this there is much confusion (especially for software developers) in understanding usability [18].

The trend has been changed and usability experts keep track of this whole procedure (production of software) to obtain highly usable features in software.

Despite of all this, every software has usability flaws. Usability testing and user feedback can be helpful to minimize flaws after software deployment but usability is still a big question mark. Problems relating to usability can be easily located in F/OSS. Developers from all over the world are participating in different applications to make F/OSS better. By this everyone can become a contributor for the improvement of F/OSS. [9]

Usability is beneficial for both customers and producers. For producer’s perspective, usability is good for competition, cost, support and quality areas whereas for user’s point of view, usability can be beneficial in terms of satisfaction, easiness, effectiveness, efficiency, time saving and back end support [22].

The reason to conduct this study is that no such study document is available to author’s knowledge on usability analysis and evaluation at academic level on Ubuntu 8.10. Although some research on other distros are available but only in industrial domain. In this study our focus is to find out and highlight the usability features used in Ubuntu 8.10. This study will also provide help
to boost the learning capability of the participants and readers. There is a need for work to be done to decrease the difficulties faced by novice users, increase usability features and give feedback/suggestions to developers for improvement in Ubuntu 8.10.

2.2 Goals
The main goal of this study is to test, evaluate and validate the usability of Ubuntu 8.10 for novice users with the help of routine tasks. Individual / unit goals will be achieved to get the main goal in a step by step process.

Following detail describes the efforts which will be done to find out solution of the problems which are identified in the research questions.

A detailed literature study is done to get a better understanding of usability at initial stage. This helps authors to figure out usability perspective attributes and relating issues in F/OSS. This also helps authors to design pilot-test, actual test and interview. A test is conducted to investigate the usability of Ubuntu interface for novice users and the problems faced by them.

Interviews are conducted and feedback from Ubuntu community is provided to validate the collected data. Different F/OSS used by Ubuntu is also tested through usability test to find out the reliability of these softwares. All these unit goals finally lead towards main goal at the end of study. Our research study will give a good and clear picture to end-user(s) about Ubuntu GUI. This study also provides suggestions and future work on usability of F/OSS.
Chapter 3: Methodology

This chapter explains the research approach which is chosen for this study. Section 3.1 is about overview of research method. Section 3.2 describes the literature study resources, informal meetings. Discussion with students about study area is explained in Section 3.3. Introduction to usability test is defined in Section 3.4. Section 3.5 explains the interview which is used for validation in this study.

3.1 Research Method Overview

According to [7] a mixed research approach is chosen to conduct this study as needed on different phases to accomplish the research. In initial phase, a detailed literature study is carried out to know and understand the GNU/Linux, (F/OSS), GUI & HCI, usability, standards relating to usability, GNU/Linux desktop environments, overview of Ubuntu, testing and evaluation methods. This literature study helps to perform the usability test and evaluate the GNU/Linux with GUI guidelines. Think aloud evaluation method is selected to execute the usability test. After performing the test, results are compiled for analysis. Numbers of persons are interviewed to verify and validate the results.

Figure: 3.1 Research Methods Overview
3.2 Literature Study

Literature study is performed in initial phase to get in depth understanding of GNU/Linux and F/OSS usability test and evaluation. For this purpose a systematic approach is adopted to search the study literature. Authors defined some search terms to find out the relevant material in published literature. Different search engines are used to surf and search the material e.g. BTH Samsök, ELIN, Google Scholar, Google and Web based F/OSS communities and resources. Relevant articles and journals are considered from 2000 to 2008 and tried to be focused on last five years papers. Mostly selected articles and journals are from IEEE and ACM portal.

3.3 Informal Discussion

Informal meetings and face to face discussions are being made with friends and other fellow students to introduce the GNU/Linux system. Other sources like phone and chat softwares are being used to contact them and tried to get their knowledge about the system. It helps students to aware and makes interest with the system.

3.4 Usability Test

Usability test is designed to evaluate the system after the detailed literature study and some informal discussion. Thinking aloud protocol and on-sight observations are selected for usability test and evaluation. For this purpose individual students participate to perform the test. A pilot-test is conducted with two students to cope with actual usability test. During test, participant’s activities on tasks are recorded, noted and observed.

Figure: 3.4 Usability test & Interview
3.5 Interview

Interviews are conducted from selected individuals to validate the results obtained after the test. Open ended Interview questions are designed carefully and asked to know the subjective thoughts of the interviewees.

To obtain the credibility in results, a research methodology should be clearly known. Undefined and wrong methodology can lead to wrong and undesired results.
Chapter 4: Theoretical Work

This Chapter describes the theoretical work and literature study to support the research. Section 4.1 explains the Computer Interaction. Section 4.2 is about Human Computer Interaction (HCI). Section 4.3 defines the Usability, Nielsen work on usability and different ISO standards related to usability. F/OSS usability is described in Section 4.4. Section 4.5 provides the knowledge about GNU and Linux. GNOME and KDE desktop environments are explained in Section 4.6. Section 4.7 describes Ubuntu overview. Thinking aloud protocol and interview are explained in Section 4.8.

4.1 Interaction Design

Interactive products to make every day life easier and supportive are generally referred to as interaction design. The link between interaction design and software engineering is the same as the link between architect and civil engineer. Informatics, computer science, computer supported cooperative work (CSCW), human computer interaction (HCI) and many more are different interdisciplinary fields of Interaction Design. [6]

The major concern of interaction design is to achieve usability and user experience goals in interactive products. In figure 4.1 usability goals or simply usability and user experience goals are inner and outer circles respectively.

![Figure: 4.1 Difference between Usability and User Experience Goals][1]
4.2 Human Computer Interaction

HCI is defined as "Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them."[11]

The design of a computer system for human use should be easy, safe to use and aesthetically pleasing as well. Cognitive Psychology, Ergonomics, Philosophy, Artificial Intelligence, Computer Science etc are most important disciplines related to HCI. The emphasis of HCI is on user centered design in which user participation and influence is kept on top priority while contribution from different disciplines to HCI and testing are two important aspects while designing an interface. [11]

4.3 Usability

"A picture is worth a thousand words. An interface is worth a thousand pictures.” – Ben Shneiderman.

The interaction of human with computer (HCI) is made through an interface while usability is the ease with which HCI is performed to achieve specified goals. Usability can be categorized in two sub headings as:

- Hardware usability (Hardware usability consists of maintaining layout design, cost, volume, weight etc. up to the mark) and,
- Software usability (Software usability features consists of interlink between user interface, its structure and its usage).

[13] Categorizes of software usability according to different properties (which refer to three different target audiences). This includes

- As an end-user (requires good usability features to perform expected tasks faster and efficiently).
- As a manager (usability influence his decision when choosing a product).
- As a software developer (software should have quality, completeness and maintainability features).

As Usability is a quality key attribute so in this thesis usability evaluation is being done by considering usability as an external quality which in turn is the first kind of target audience discussed above.

4.3.1 JaKob Nielsen’s Historical View on Usability

Jakob Nielsen, a leading usability expert and consultant took initiative in 90's to work out on usability as a sub part of system acceptability and made his own way about usability. System acceptability is a wide term which explains system as good enough to be acceptable by all stakeholders like users, clients and managers and satisfies their needs and requirements. [10]
His definition about usability is still valid and widely accepted in whole computer science community. Following figure describes usability as a sub part of system acceptability.

![Usability Diagram](image)

Figure: 4.2 Nielsen’s view on usability as part of system acceptability [10].

**Easy to learn:** How novice users accomplish basic tasks in a rapid time.

**Efficient to use:** How experienced users can quickly perform the tasks.

**Easy to Remember:** How users can recapture / redirect the same design after an interval to complete tasks.

**Few Errors:** How many and how severe errors users make and how they can recover from it.

**Subjectively Pleasing:** How pleasing is the design to use to satisfy user

### 4.3.2 International Standards Organization (ISO) Standards on Usability

ISO has provided different standards relating to software quality and usability. Two different usability related standards are discussed here. ISO 9126 narrates usability as an independent factor or contribution of software quality while ISO 9241-11 describes usability in context of usability requirements of display terminals of computers.

Usability and user centered design standards can be seen as a logical relationship in the following figure:
Life Cycle Process: Organizational capability (through human centered design, proper evaluation etc) is required to fulfill life cycle process to achieve a product finally [13].

Development Process: Ergonomics, safety, human factors etc are influencing factors here. This includes specifying the context of use, specifying requirements, development and evaluation. Process quality and usability is achieved through user centered process (UCP) [13].

Product: Product Quality is achieved through user interface and interaction.

Product Effect: The objective is to obtain highly usable product in the required context after completing all above parts [13].


It is a sub part of ISO 9241 model which is about ergonomics requirements for office work with visual display terminals. According to this standard usability can be defined as:

“The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. [2]

The key components in this standard describing usability are:

Effectiveness: How well users achieve intended goals while using the system.

Efficiency: The resources consumed to achieve those goals.

Satisfaction: What is the user feeling about using the system?

This standard describes usability in terms of whole system (product, user, task and environment) and not as a product. The approach of this standard is process oriented, not as product oriented. Effectiveness, efficiency and satisfaction achieved in this standard are not very specific about goals, as this standard interprets itself as from different stakeholder’s point of view. [13, 19]

ISO/IEC (presented in 1991) describes usability as an independent factor of software quality specifically in product oriented approach. Usability can be seen as an independent contribution to software quality and not as independent factor in product oriented approach. [13, 20] In this perspective definition of usability is revised in ISO/IEC 9126 (2000-2002). This model consists of four parts while ISO/IEC 9126-part1 describes usability as “The capability of the software product to be understood learned and liked by the user, when used under specified conditions”. [13]

4.4 Usability and Free/Open Source Software (F/OSS)

F/OSS provides complete authority and independence to use softwares. These softwares are good in design, graphics and functionalities. There is no such big difference between free software and open source software because both are working in the same direction to avoid the proprietary softwares. Free Software gives the ideology of free like freedom for use, copy, modify and re-distribute under the same License [21, 26]. Open Source Software (OSS) offers the same but with the motive of “integrity of author’s source code” which means one has to publish the modified code as an extended version and not as his own work [28]. Many companies prefer to develop OSS having own license under Open Source Initiative (OSI) certification instead of GNU General Public License (GPL) [29]. Almost all distros use both Free and Open Source Softwares to help the world. GNU/Linux has introduced a pure Free Software distribution called GNewSense which includes all softwares that follow the GPL [21].

Although F/OSS has got a lot of success day by day through better functionality and graphics but at the same time there are lot of usability concerns of these softwares. Developer is not a user to check the usability with his point of view. In F/OSS the developers are still making applications without following the Human Interface Guidelines (HIG). F/OSS projects also lack in availability of usability experts. Developers have interest in usability and want to work on it but in practice they are more concerned with functionality. [14, 15]

F/OSS lacks in user centric design (UCD) and usability engineering. UCD is considered as active user involvement in technology which is vital to make useable software [17]. Only application developer has the responsibility to address the particular usability issue. There is no such target user identification and mostly developers work according to their own approach and mind. One of the problems with F/OSS is that most of the applications included in distros are developed by different developers and some of them are built by distro itself. [14, 16, 17]
According to [17] quality and assurance about usability is an important aspect for F/OSS. “Naive” user’s interest and participation don’t show their expertise in this field [17, 9]. Even though the user feedback has importance but still they are not expert and have not typical knowledge in this field which usability expert have [9, 14, 15, 17].

4.5 GNU/Linux

GNU/Linux is an system software which is freely available for everyone to participate, use and change according to own taste. “GNU’s Not UNIX” is an system software which was started by Richard M. Stallman with the motive of Free Software [4, 21, 26]. Free means “freedom” everybody has freedom to download, install, use, change, re-build and distribute as free software [26]. Stallman has started work on GNU in 70’s in MIT Artificial Intelligence Lab and would not want to be part of any kind of disclosure agreement. He wanted to make free software where hacker(s) “someone who loves to program and enjoy” could participate without any restrictions [21]. He quitted from AI lab and GNU project was officially announced in 1983. They had almost done with GNU instead of kernel in 1990. At the same time they were working on GNU kernel which was named as GNU Hurd [4, 21].

Linux is also UNIX like O.S which is freely available to use, change and modify [5, 27]. In 1991, Linux development was started as a network project by Linus Torvalds who was a student in Helsinki, Finland [5]. He was really impressed from MINIX (a UNIX like O.S developed by Andrew S. Tanenbaum) and wanted to make an O.S which should be free for everybody usage [4, 5, 27]. Linux is very successful because of its robustness and long standing nature and has become part of most server, home computers and office computer systems [27].

GNU and Linux both were working for same cause that was free software. In 90’s, work on GNU had almost finished except kernel. GNU group was also working on “Hurd”, a GNU kernel [21]. After the release of Linux, GNU group decided to use Linux as kernel to complete and launch the GNU O.S [4, 5, 21, 26]. After using Linux as kernel, GNU became GNU/Linux and now it is available in different distributions (distros). Many companies, home users are successfully using GNU/Linux based distributions like Debian, Red hart, Fedora, Mandriva Ubuntu etc, and enjoying the real freedom of free software [21, 26].

GNU/Linux also provide very strong desktop environment GNOME and KDE which are described as below.

4.6 Desktop Environment

Desktop environment is the environment in which user can interact with the system and pass information while using it. GNU/Linux provides a variety of
GUI desktop environments which includes GNOME, KDE and Xfce etc [30]. Here we discuss most used and featured interfaces GNOME, KDE and Xfce.

4.6.1 GNOME

GNOME stands GNU Network Object Model Environment is a GNU supported project and started in 1997 [32]. “The GNOME provides two things: The GNOME desktop environment, an intuitive and attractive desktop for users, and the GNOME development platform, an extensive framework for building applications that integrate into the rest of the desktop” [31]. GNOME developers are using different languages (C, C++, C-sharp, Python) and The GIMP Toolkit (GTK+) for development [32, 33]. GNOME is focused on usability and using Human Interface Guidelines (HIG) to make the interface more attractive for the users [32, 34]. GNOME 2.24 is available till to date and looking forward for GNOME 2.26 according to six-month schedule release.

4.6.2 KDE

KDE Stands Kool Desktop Environment started in 1996 with the use of QT toolkit [35]. KDE is more graphical and attractive environment in UNIX like O.S. KDE is available under different licence agreements like BCD, QPL and GPL [36]. KDE developers are using mixture of languages C++, Python, Perl etc [37]. Novell, Intel Corporation and Mark Shuttleworth are the major patrons for KDE. Developers from whole world are participating in KDE projects while strong development and conferences are being made in Germany [36]. Most recent major released version of KDE is 4.1 and maintenance release 4.1.3 is also available for testing and bug fixing [35, 36].

4.6.3 Xfce

Xfce is founded in 1996 and stands for XForms Common Environment. It is very light weight Desktop Environment and available for all systems but is especially designed for old systems [38]. "Xfce is a lightweight desktop environment for various *NIX systems. Designed for productivity, it loads and executes applications fast, while conserving system resources” [39].

First two versions are released under XForms licence which was free only for personal use. In later release Xfce has adopted GTK+ and become free environment for any use [38]. Xfce have released version 4.0 which is available with many distros like Debian, Gentoo, Xubuntu etc [38, 39].

4.7 Ubuntu Overview

Ubuntu is free, usability focused GNU/Linux based distribution. It was started in 2004 by a businessman named Mark Shuttleworth. GNOME is the default interface for Ubuntu but it is also available in KDE and Xfce interfaces with the name of Kubuntu and Xubuntu respectively. Ubuntu has become number one distribution in recent years due to back end support and a
schedule of six months release and has got popularity among user(s). [5, 40, 41]

Ubuntu came from African languages “ZULU” and “Xhosa” [40]. Ubuntu means humanity which can be elaborated as a drudge for human beings. Ubuntu is free like other GNU/Linux distros and will remain free until its life [41]. Ubuntu gives user(s) power to use, build and change with ease and authority. All tasks which users perform in other system softwares can also be done in Ubuntu [5]. Many derivatives of Ubuntu are available in the market like Kubuntu, XUbuntu, Edubuntu, Ubuntu studio and midubuntu etc [40].

4.8 Usability Testing and Evaluation Methods
There are three types of usability evaluation methods which can be considered in different softwares on different stages. These are Testing, Inspection and Inquiry [43]. As testing involves the real time interaction of users with the system or softwares so testing as a main method is used to evaluate the Usability in this study. There are many different testing techniques for evaluation e.g. coaching method, question-asking protocol and remote testing etc but think aloud protocol technique is adopted to perform the test among users by providing the real system software interface of Ubuntu. On-sight observation is also done to observe the ease and difficulties of the participants with the interface.

Validity is vital to cope with the results which are gained through usability test. In this study we consider the validity through interview after getting the hand on test. Authors have also decided to check the validity of study through Ubuntu forum community by putting tasks and getting feedback.

4.8.1 Thinking Aloud Protocol
Think Aloud Protocol is widely used to investigate the usability for softwares. This method is typically being used for psychological research and later it has become a frequent part for HCI evaluation [10]. Participants speak loudly and express their thinking, feeling and opinion about the prototype or interface during the test [43]. This method demonstrates the ease and difficulty of a particular interface task for participants, and observer(s) can observe through their response to each task [10].

Think aloud protocol covers the two important factors of usability features: effectiveness and satisfaction which are explained earlier. Testers can get useful and reliable qualitative data with the small group of participants. The demerit of this technique is time consuming while performing complex task and need to explain or divide into sub task. Participants can be asked and requested to speak loud continuously if they stop talking. The occurrence of silence is also a problem for this method. [11, 43]
This method can also be performed with a group of two people to judge the complexity and compare the performance of individuals in the group where both users can share their thinking while interacting with the system [10].

4.8.2 Validity

Interview is a technique which is used to evaluate and validate the usability test results of a system [43]. Interview is an indirect method and mostly designed according to the user’s interest on an issue. Somehow interview is very similar to survey. Both techniques may have questionnaires but interview is done by face to face with the involvement of interviewer and respondent rather than presented on paper or on other media [10].

Interview can be conducted with an individual or in a group but it is necessary for the interviewer to avoid any explanation and revelation of own views. The user or interviewee’s response should be recoded and noted during interview. [11, 43] Interview has three types which are structured, semi and unstructured interviews. Structured interview is based on close-ended questions and all questions answered with “yes” or “no” [10]. Unstructured interview is based on open-ended questions and mostly used on early stage of usability evaluation [43]. Open-ended questions give chance to user(s) to express his/their thoughts and incidents with the system behavior [10]. Open-ended questions can be asked like “What do you think of this new feature?” [10]. Semi-structured interview is based on both open and close ended questions. Structured interview approach with Open ended questions is used in this study.

Interview is mostly started with a few warm-up questions which are about user background and general information, complex question asked after that. Interview is ended with relatively easy questions by thanking the user. [11, 43]
Chapter 5: Empirical Study

This chapter is about empirical study and conduction of test. Section 5.1 describes pilot test planning and conduction. Testing equipments provided to testers is discussed in section 5.2. Redesigning of tasks is described in section 5.3. Selection of participants is described in section 5.4.

5.1 Pilot Test Planning and Conduction

After getting knowledge from literature study, a pilot test is better to cope with actual scenario. Two students from C.S community are selected randomly to perform pilot test. Initially ten tasks are performed during pilot test. No help is provided to them to complete a task. Each student took almost one hour to perform ten tasks. Authors observed that participant have become bored during task eighth, ninth and tenth. Without active user participation, usability testing does not have any importance. Fifty five and fifty seven minutes have been taken by first and second participant respectively to complete the tasks. Average time is fifty six minutes. Findings from pilot test showed that number of tasks should be reduced. Pilot test helped a lot to conduct the actual test. Authors have redesigned and reduced ten tasks into six tasks. Many improvements (like ambiguity about tasks are resolved) were made from participant’s feedback.

5.2 Testing Equipments

Three different laptops (equipped with Ubuntu 8.10) are provided to participants with default settings (no additional software or package is installed after Ubuntu 8.10 installation). Two laptops are used in pilot and actual test. The reason to use these laptops is to check hardware compatibility with Ubuntu system and to use third one as backend support. Laptop specifications are as following

- Sony Vaio, Core 2 Duo 2.4 GHZ, 300 GB, 2GB RAM, Intel 965 Graphics Card,
- Toshiba Equium, Dual Core 1.47 GHZ, 120 GB, 2GB RAM, Intel 965 Graphics Card
- Hp, Intel Celeron 1.73 GHZ, 40 GB, 512MB RAM, Intel 915 Graphics Card.

Internet connection, a sample audio CD, mic are provided to every user. A friendly atmosphere is being created to perform tasks up to their own will. Authors believe that individuals from a specific community or region can give homogeneous results which can be better to evaluate and conclude. All participants belong to same region.
5.3 Redesigning of Tasks

After pilot test, Authors feel a need to redesign tasks. Authors redesign tasks and divided in three different categories which almost cover the common and routine tasks of user. Each category contains two individual tasks. All tasks are being created keeping in view of novice user during test design phase. The objective of making three categories was to provide easiness and a clear message about each task. Three categories and six tasks are described as following

File Handling
1) Create an office document, write and save it as “Sample Document” with “.doc” extension and close it.
2) Search “Sample Document” with search option, delete and restore it.

Entertainment & Internet
3) Play audio CD, Search an online video through browser and play it.
4) Sign-in on Internet Messenger using your MSN ID.

Desktop Related
5) Uninstall Audio CD Extractor software.
6) Apply Screen Saver and change Screen Resolution and restore.

5.4 Selection of Participants

A general concept of author's objective about usability test is explained to fellows. This has been done either by one to one or in a chat messenger. A total of ten students are selected to perform actual task. There is no restriction of gender, either participant is male or female but all participants are male. All of these students are well educated. Four students belong to Physics and Electronics and doing master. Three students are doing PH.D in computer science. Other students are also doing or have done masters in computer science, software engineering and information technology.

Every participant is being briefly explained about think aloud technique before starting of test. As many participants use Ubuntu first time so five minutes are given to participants to get a knowhow of system. A brief overview of system, purpose of test and tasks to be performed are being discussed with each participant. This takes about five minutes on average to individuals. Authors play observer role and do not provide any help to participants. One author observes participant’s behavior and attitude towards system while other focus on writing notes. Audio recording is being done with participant’s prior permission. This helps authors to record precise statements, analyze and validate data in future. This would also help other researchers to take help in future. Our tasks cover some possibilities of daily usage tasks since it is not possible to cover all tasks in this study. The right choices to complete selected tasks will be provided as screenshots in appendix 1. Selected tasks are designed to find out usability attributes and ultimately research questions.
Chapter 6: Results

This chapter is about results which are achieved through usability test. Section 6.1 explains the test data with tables and graphical representation. Observations on different task and user’s opinion are described in Section 6.2. Section 6.3 is about result validation assessment.

6.1 Test's Data/Test Results

Usability test results of all individuals in each group are summarized in Table 6.1 with respect to time (Minimum, Average and Maximum) which they spent during each task. Table shows bit difference of time during task completion in each group. According to authors the reason between time variations can be “participant’s experience” about GNU/Linux and can be less “interest” with new type of system software Ubuntu. Participant’s previous experience and usability test results are shown in Table 6.2 and 6.3 in detail.

Table 6.1: Overall Usability Test Results

<table>
<thead>
<tr>
<th>Test’s Participants</th>
<th>No. Of Participants</th>
<th>Minimum Time (Minute)</th>
<th>Average Time (Minute)</th>
<th>Maximum Time (Minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH.D</td>
<td>3</td>
<td>19</td>
<td>23.7</td>
<td>28</td>
</tr>
<tr>
<td>Computer Science (C.S)</td>
<td>3</td>
<td>22</td>
<td>26.3</td>
<td>32</td>
</tr>
<tr>
<td>Other Disciplines</td>
<td>4</td>
<td>22</td>
<td>25.3</td>
<td>28</td>
</tr>
</tbody>
</table>

Table 6.2 shows participant’s previous experience of using system software which is asked before and during the test. All participants have a good hand on Windows and its daily usage with different applications. Two participants have experienced with Ubuntu and three other distros respectively and rest didn’t have any.

Table 6.2: Summary of Participant’s Previous Experience

<table>
<thead>
<tr>
<th>Test Phase</th>
<th>Participant’s Discipline</th>
<th>Participant’s previous Exp. About System Softwares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Windows</td>
<td>Ubuntu</td>
</tr>
<tr>
<td>Actual PH.D</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Actual PH.D</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Actual PH.D</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Actual C.S</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Actual C.S</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Actual Physics</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Actual Electrical</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Actual System on Chip</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Actual System on Chip</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Participants in all phases of usability test belong from Pakistan. In pilot phase participants are master students and study in computer science and average age of this group are 23 years. In actual test phase all participants are divided into three groups which are PH.D, computer science and other disciplines. Selected PH.D participants are doing their research in computer science field and the average age of this group is 30 years. The educational level of computer science (C.S) participants is also masters and their average age is 27 years. Participants from other disciplines are from electrical, physics and system on chip (electronics) departments and their average age are 24 years. Overall average of all participants is 26 years old. One participant from PH.D group and one participant from C.S have experience on Ubuntu. On the other hand one participant from PH.D and two participants from other disciplines have experience of other distributions as well.

Table 6.3 is about total task duration (minutes) and task status. Time per task of each participant, total time per task in each group, total time of individual to do whole tasks, average time per task in each group, average time per group and task status is explained in this table. Task status “S”, “HS” and “U” is also shown. “S” stands for successful completion of a task, “HS” means half successful to do a particular task and “U” stands for unsuccessful in completion of any task. The task status representation and details can be seen in Graph 6.1 and in table 6.3 respectively.

Graph 6.1: Successful, Half-Successful and Unsuccessful participants in different tasks by Category
<table>
<thead>
<tr>
<th>Phase</th>
<th>Groups</th>
<th>Task 1 (min.)</th>
<th>Status</th>
<th>Task2 (min.)</th>
<th>Status</th>
<th>Task 3 (min.)</th>
<th>Status</th>
<th>Task 4 (min.)</th>
<th>Status</th>
<th>Task 5 (min.)</th>
<th>Status</th>
<th>Task 6 (min.)</th>
<th>Status</th>
<th>Total Time</th>
<th>Avg. Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Test</td>
<td>PH.D</td>
<td>1</td>
<td>S</td>
<td>1</td>
<td>S</td>
<td>6</td>
<td>U</td>
<td>2</td>
<td>U</td>
<td>4</td>
<td>U</td>
<td>5</td>
<td>S</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>PH.D</td>
<td>2</td>
<td>S</td>
<td>2</td>
<td>S</td>
<td>10</td>
<td>HS</td>
<td>1</td>
<td>S</td>
<td>6</td>
<td>U</td>
<td>7</td>
<td>S</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>PH.D</td>
<td>3</td>
<td>S</td>
<td>2</td>
<td>S</td>
<td>7</td>
<td>U</td>
<td>2</td>
<td>U</td>
<td>3</td>
<td>U</td>
<td>7</td>
<td>S</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>Computer Science</td>
<td>1</td>
<td>S</td>
<td>1</td>
<td>S</td>
<td>8</td>
<td>HS</td>
<td>1</td>
<td>S</td>
<td>5</td>
<td>S</td>
<td>6</td>
<td>S</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>Computer Science</td>
<td>1</td>
<td>S</td>
<td>7</td>
<td>U</td>
<td>8</td>
<td>HS</td>
<td>5</td>
<td>S</td>
<td>4</td>
<td>S</td>
<td>7</td>
<td>S</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>Computer Science</td>
<td>2</td>
<td>S</td>
<td>5</td>
<td>S</td>
<td>5</td>
<td>HS</td>
<td>3</td>
<td>S</td>
<td>6</td>
<td>S</td>
<td>4</td>
<td>S</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Total &amp; Avg. Time per Task</td>
<td></td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>1.7</td>
<td>23</td>
<td>7.7</td>
<td>5</td>
<td>1.7</td>
<td>13</td>
<td>4.3</td>
<td>19</td>
<td>6.3</td>
<td>71</td>
<td>23.7</td>
</tr>
<tr>
<td>Actual Test</td>
<td>Other Discipline</td>
<td>2</td>
<td>S</td>
<td>2</td>
<td>S</td>
<td>8</td>
<td>HS</td>
<td>2</td>
<td>S</td>
<td>4</td>
<td>S</td>
<td>6</td>
<td>S</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>Other Discipline</td>
<td>2</td>
<td>S</td>
<td>1</td>
<td>S</td>
<td>7</td>
<td>HS</td>
<td>4</td>
<td>S</td>
<td>4</td>
<td>U</td>
<td>4</td>
<td>S</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>Other Discipline</td>
<td>3</td>
<td>S</td>
<td>1</td>
<td>S</td>
<td>8</td>
<td>HS</td>
<td>4</td>
<td>S</td>
<td>6</td>
<td>S</td>
<td>5</td>
<td>S</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Actual Test</td>
<td>Other Discipline</td>
<td>1</td>
<td>S</td>
<td>2</td>
<td>S</td>
<td>7</td>
<td>S</td>
<td>2</td>
<td>S</td>
<td>9</td>
<td>U</td>
<td>7</td>
<td>S</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Total &amp; Avg. Time Per Task</td>
<td></td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>1.5</td>
<td>30</td>
<td>7.5</td>
<td>12</td>
<td>3</td>
<td>23</td>
<td>5.8</td>
<td>22</td>
<td>5.5</td>
<td>101</td>
<td>25.3</td>
</tr>
</tbody>
</table>
A graphical representation of above table with respect to average time per task used by each group is shown through following graph.

Graph 6.2: Average time utilization on per task (minute) in different groups

6.2 Observation and Opinions

Authors described every individual task to participants before the test. Authors have written all observations of participants during the usability test and opinions are being noted before test, during test and after test. Interviewee’s response about each task is used for validation but also described here with each task. Authors classify all this information into four categories which are description, author’s observations, participant’s opinions and interviewee’s view point.

6.2.1 Task 1

Description

You have to create an office document. Write any line/s of your own choice, save it (as a .doc file extension) at any location and close the document.

Author’s Observation

Participants do not feel any difference between open office and MS office. All participants do not know the default file extension of open office which is “.ODT”. Two participants open gedit, create and save a file as office document. Three participants write “.doc” extension manually instead of choosing file type from drop down list. Overall participants do not feel any hurdle to perform this task.

Participant’s Opinion

- It is very efficient and almost same as Microsoft office.
• I liked document protection during saving of file.
• It is easy to locate and use open office in Ubuntu but a little bit difficult to find extensions.
• OpenOffice is better in terms of taking less time in loading and closing the file.

Interviewee’s View

Working in OpenOffice is quite easy and fast. Both interviewees feel no difficulty in using and think that nobody has any problem while using.

6.2.2 Task 2

Description

You have to search the document which you have just created and saved. You have to search it out with a specific option. You are also required to delete the file and then restore it.

Author’s Observation

One participant cannot find particular “Search for Files” option to search their saved file. Two participants open file system of Ubuntu to search their saved file. A number of participants get confuse while searching the document. One participant tries to search the specified document with different options (searching it manually e.g. file system, hard drives). All participants are expecting “delete” option instead of “move to trash” option. Participants feel no problem to restore the deleted file.

Participant’s opinion

• It is easy to search, delete and restore file.
• This task is easy and simple to perform.
• It is very irritating when I right click and cannot find “delete” option in first look.
• The name of “move to trash” should be changed by delete option.

Interviewee’s View

Both interviewees have no problem while doing this task. It is easy and simple.

6.2.3 Task 3

Description

You have to play any song from audio CD and after that you are required to play an online video through browser.

Author’s Observation

All participants cannot understand Rhythmbox Audio player behavior and how to run music file even though seven participants somehow succeed to play music. The general thinking of participants is to play audio CD as auto
play or by just doing double click on the file. Four participants close Rhythmbox music player and try to play it with other softwares. They are pretty sure that by double clicking on music file icon will open the music. Participants become surprise when it is not opening. All participants find online videos but the browser require plugins to run video. All of them except one try to install but cannot succeed. One participant know how to run online video by installing plugins and he complete the task.

**Participant’s Opinion**

- Rhythmbox music player is not easy to use. It is very complicated to understand it.
- There is no button to stop a particular track. There is no display for pause a track.
- Naming captions in Rhythmbox are not good and not easily understandable.
- Why music files are going on Totem movie player by double clicking rather than to default (Rhythmbox) audio player.
- Participant think there is problem with this particular track, volume or may be in this audio CD.
- Participant cannot believe that it is not playing by double clicking on the icon.
- Why is Totem media player not opening audio CD files?
- It started streaming while playing Audio in Totem media player, but could not play. It is taking too long time to play. I will not appreciate to use this.
- It is almost same in other system softwares to demand flash player plugin so I do not feel difficulty to install plugin but why it is not playing since I have installed flash player plugin?
- Why should I close the initial window and start again Firefox to play video on YouTube?

**Interviewee’s View**

First interviewee finds Rhythmbox as good player with some shortcomings but as a whole satisfied with it. No problem in playing an online video after getting flash plugins. Second interviewee uses CD Player instead of Rhythmbox player and feels no problem playing audio.

**6.2.3 Task 4**

**Description**

You have to sign in on internet messenger by using your MSN id.
Author’s Observation

Somehow all participants find Pidgin internet messenger. Eight participants succeed to sign in while others cannot proceed to sign in. Participants try to locate MSN messenger and three of them sign in at www.meebo.com. Two participants also try to locate a default messenger (like MSN messenger) to sign in. One participant tries to locate messenger from “file system”. One participant tries to locate it from terminal through command.

Participant’s Opinion

- It is really nice that I have many messengers under one tree but they should have complete help or description about how to use in the beginning.
- No problem to locate and sign in on pidgin messenger.
- Having many protocols under one messenger is very good and I feel very relax and easy whenever I use pidgin.
- I am sure it would be here but I’m doing something wrong.
- It is not possible that messenger is not present in Ubuntu.
- As I do not know the exact software to sign so I will not sign in here due to security reasons.

Interviewee’s View

Both interviewees have no problem in using of Pidgin internet messenger.

6.2.4 Task 5

Description

You have to uninstall already installed software through specific option (Add/Remove).

Author’s Observation

Participants take a lot of time to locate uninstall option for removal of application, even five of them cannot succeed. Three participants try to remove the software from “file system”. Four participants are confused while performing this task. Three participants found Add/Remove option in application and try to uninstall the software by right clicking and get surprise by not performing this utility. One participant tries to uninstall software from “Synaptic Package Manager”. Five participants open software sources to perform this task.

Participant’s Opinion

- Uninstall any software in Ubuntu is easy as all softwares are managed in different categories.
- If I have done this before, it would be easy for me to do this now.
- I really do not have an idea what to do and how to do.
- It is very time consuming and lengthy procedure.
• I cannot find any remove button to perform my operation.
• I am uninstalling audio CD extractor software at this time but I am not sure whether I am doing right or wrong.
• I have uninstalled it from system using Add/Remove Utility but it is still visible here.
• I have done this by chance otherwise there is no proper way I used.
• This option should be in system part of panel rather than in applications as I tried to locate it there.

Interviewee’s View

Both interviewees know the utilization of Add/Remove utility but the common suggestion is that if a message box or help appears on screen after uncheck the box then it can be better representation.

6.2.5 Task 6

Description

You have to apply a screen saver. After this, you are required to change screen resolution to any other (your own choice). You are also required to restore the default resolution.

Author’s Observation

All participants try to perform this task by right clicking on desktop and then try to find an option there. Participants are surprised when they do not see any option in right click. It is not present there so they try to locate it from panel. All participants open desktop appearance, background to apply screen saver. Two participants are sure that they have applied screen saver even if there is no apply button while rest of participants are not sure and check it by waiting for one min. that either it is applied or not. One participant tries to find screen saver by giving command on terminal.

Almost all participants change screen resolution easily as this option is just beside screen saver. Participants do not think to restart, ask login and password from system while changing resolution. All participants change resolution easily but when restored then all experience a problem. Working area did not come to its original position. Working area reduced in size and went in upper left corner of screen. Even participants cannot move to other work space. It forced participants helpless and the only solution is to login in or restart the system.

Participant’s Opinion

• I am not sure screen saver has applied or not without a apply button.
• I feel unhappy when I do not find screen saver in right click option.
• It is difficult to find and apply screen saver and resolution in Ubuntu.
• It will be really easy and usable if screen saver and resolution are accessible in right click.
• If screen saver and resolution are in system then why there is a need to put one of the system function (desktop appearance) under right click?
• I do not like to change resolution option and restore procedure in Ubuntu.
• Restoring screen resolution is a problem and Ubuntu should resolve this.

Interviewee’s View
First interviewee knows the location and usage of screen saver and resolution but do not have any need to change any one of them.

Second Interviewee finds no problem in using screen saver. He experiences a problem in changing resolution.

6.3 Validation
Validation is a vital part in any type of research study. Mixed research approach is used in this study while the major concern is on qualitative way. A usability test is conducted to make observations and to achieve precise data. Interviews are conducted from two GNU/Linux-Ubuntu experts to validate the results. A face to face discussion is recorded in audio recorder which is based upon designed questions. This discussion is formalized and summarized in appendix 3. Interviews and Ubuntu community response are used for validation.

Trochim [44] discusses four different validity assessment attributes for qualitative research which are used by authors in this study for validation. These are described as:

6.3.2 Credibility
Credibility means the reasonable results of a study to be trusted by participants [44]. A systematic and step by step approach is used in order to conduct test and collect results. Interviews are conducted in order to validate the results. The results from interviews and Ubuntu Community validate the credibility of results and satisfy the internal validity of this study.

6.3.3 Transferability
To generalize qualitative research results to other perspective or settings is called transferability [44]. Ubuntu also follows same gnome guidelines of GNU/Linux used by other distros. The conclusion from this research study can be generalized with other settings as it is evident from results, interview and Ubuntu Community response. This shows transferability of this study except one threat. One possible threat can be that all participants belong to same culture and previous educational background. The results may change with different culture and educational system.
6.3.4 Dependability
Dependability is about (reliability) occurring of changes during the study over time which means to conduct the study in a smooth, persistent and consistent way [44]. As participants are students so usability test is conducted according to their convenience and availability. Different timings of participants may affect the results. One possible threat can be the hardware specification (as mentioned in section 5.2) of computers which are used during usability test. Change of hardware can give different results. Think aloud technique makes impossible to conduct the test at the same time with all participants.

6.3.5 Conformability
Conformability is the level to which the results can be confirmed by researchers of same field [44]. Think aloud technique On-sight observation, interviews and Ubuntu Community is used to conduct, evaluate and validate the results. Each phase of this research study is properly documented and critically analyzed. Interviews and response from Ubuntu Community are conducted to check the conformity of this study.
Chapter 7: Discussion/Analysis

This chapter contains discussion/analysis of the results which are obtained during test. Section 7.1 describes ISO usability standards parameters and Jakob Nielsen usability view as a part of system acceptability. Overall system behavior is explained in section 7.2. Section 7.3 is about answer to research questions.

7.1 ISO standard and Nielsen’s view
A test is performed to understand the usability and its different parameters in GNU/Linux system software. To evaluate it in better way, a mixture of ISO usability standard and Nielsen’s view about usability is judged during the test. These all parameters are also considered here for discussion/analysis.

7.1.1 Efficiency
Efficiency as an ISO usability parameter of the system is checked when participants are interacting with it. Efficiency is the completion of any task in minimum time. In the case of Ubuntu, participants experience is not so good. Authors note that Ubuntu system has a problem with respect to efficiency. Participants get problem when they move from easy to a bit hard task (according to authors these are not hard). Extra time is taken by participants to complete some tasks but in vain and they just quit and move on to other task.

Nielsen sees efficiency as an efficient in use of system. According to participants and authors, Ubuntu uses different naming captions like application, places, system, move to trash and Add/Remove etc. to interact with the system. Participants spent time while finding search option, delete, uninstall, play music, changing screen saver and screen resolution etc. Display messages of confirmation in different applications can increase efficiency of system.

7.1.2 Effectiveness
Effectiveness is concerned with achieving particular goals. In the case of Ubuntu, participants have a problem with respect to effectiveness in 3rd, 4th, 5th and 6th tasks which is evident from the tables. Complexity of Rhythmbox application, less appropriate display message in Add/Remove, non availability of stop/pause button in Rhythmbox and less help in Pidgin internet messenger are the reasons for not achieving the tasks.

Nielsen explains effectiveness of a system as easy to learn and easy to remember. The system does not provide the above two concepts in Rhythmbox, Pidgin internet messenger, Add/Remove in case of novice and somehow in experienced participants.
7.1.3 Satisfaction

*Satisfaction* is the third important usability parameter of ISO standard. Participants do not find system as according to their interest and feeling. System is not according to the satisfaction level of participants in almost all tasks and application softwares have still usability issue.

Nielsen finds *satisfaction* as *few errors* and *subjectively pleasing*. A good system is to take less time to recover from errors while Ubuntu 8.10 has problems in 3rd and 6th tasks in recovering from errors. Less help and different directory structure of files lead to dissatisfaction. System gets stuck while performing 6th task and participants become helpless and are not able to recover from error. Log in again, quit forcibly and restart is the only option to recover from it. Participants do not get the expected outcome in 3rd and 6th tasks which are the cause of frustration and uneasiness to them. Ubuntu system is deployed from couple of years so it still needs refinement in contents. Although participants completed many tasks yet they are not subjectively pleased and satisfied with the system.

7.2 Overall System Behavior

Overall system is good and participants approximate Ubuntu as alternative system software. Interface of Ubuntu 8.10 is beautiful and most of the participants like the GNU/Linux work which provides the GUI on Linux. Long range of free software and packages in GNU/Linux and on internet can be downloaded and installed. Participants like the availability of different desktop environment (KDE, GNOME etc). Participants feel that Ubuntu is faster in boot and shutdown time. It is more secure when you try to perform any illegal and administrative task as system requires an administrator password.

Ubuntu system application and third party softwares usability and functionality are questionable at different level during the test. Authors observe many problems and gaps in Ubuntu. In OpenOffice nobody is familiar with “.ODT” extension with the document which can be issue with doc files in Windows. With “Search for files” option to find files and folder from hard disk is not useful if you forget the folder or place where you saved the file. In Ubuntu 8.10, during search there is no such category which you can select and locate your file on whole hard disk. Restore the deleted file from trash make the file readable even the file is still available for writing. Restore option is still available when you right click on the restored file which makes no sense. By pressing restore option file becomes write-able again and pressing restore on folder makes folder disappearing.

Play audio and video is not easy in Ubuntu and Rhythmbox as a default audio player in Ubuntu is very complex and has many problems. It doesn’t have any clear understanding of playing the music form CD and lack in interface
design and functionality. One can pause the song by pressing the play button again without any clear pause sign or button but there is no stop button to stop the particular track. Other problem with audio file is that if you double click on file, it is opened in Totem media player instead of Rhythmbox. Totem is also unable to play the audio files on its default settings. Online video is hard to play without installing the adobe flash player while using the Firefox as default browser in Ubuntu. Even if you have installed the flash player yet you are failed to run any video file without restarting the browser. Using internet messenger is quite easy but some time create problem because of insufficient help and support and it does not provide voice and video functionality. It is very good to have all messenger protocols under one umbrella but there is still need to improve it.

Ubuntu also have one duplicate function placement according to participants. Appearance and change desktop background is duplicate function which is available in System and also by right clicking on desktop.

7.3 Answer to Research Questions
A stepwise study is adopted throughout the thesis to answer the research questions. Usability test and evaluation is the primary source to find the answer which is complemented and also validate by interviews and Ubuntu Community response. All data results which are collected in above mentioned phases encounter and answer the research questions in a systematic way.
Conclusion

The importance of GNU/Linux and F/OSS has dramatically increased due to fast flourishing desktop environments in recent years. Usability of F/OSS is a hot issue in different desktop environment. Poor usability in distros can destroy the GUI purpose of GNU/Linux to compete with other system softwares at that era. Usability in F/OSS is not considered as primary concern as these are developed by different developers instead of that particular distribution. The contribution of this thesis is to have a well organized document in education field to have a better knowledge about usability evaluation of chores in GNU/Linux (Ubuntu 8.10). Usability evaluation is done on experimental basis by involving a number of students in test. The test is conducted in a balanced environment which is in between of controlled and free atmosphere. On the basis of usability test findings and interviews, it is concluded that Gnu/Linux has potential to be used as alternative system software in usability perspective.

GNU/Linux-Ubuntu does not provide enough support to user(s) according to efficiency, effectiveness and especially in satisfaction.

User interface can be made easier by improving contents, consistency, proper help and proper placing of commands.

Third party free softwares used in GNU/Linux-Ubuntu do not provide full reliability.
Recommendation

Authors have some recommendation after this study which can be helpful to make the system better in respect of efficiency, effectiveness and satisfaction. Recommendations are based on author’s observation, participant’s opinion, discussion/analysis, interviews and Ubuntu forum.

Search option might perform better if they include the option to find files or folder from the whole disk (partitions). The utilization of Add/Remove option may be good if it is placed in System instead of Application menu. Duplication of same function with different names should be removed.

Selection of default softwares which are available in new installation of Ubuntu should be tested with application functionality and usability aspects like in Rhythmbox and Totem media player. All plugins and support for all formats should already be included in Rhythmbox and Totem media player.

There is no need to have restore option when a file is fully recovered and restored from the trash. Install/Uninstall the software option can give better understanding if a message prompts when user check/unccheck the box whether the software is available for installation or un-installation.

Screen resolution and screen saver may give better understanding under the right-click and change desktop background. A apply button on screen saver window should be included for user confirmation. Moving from one screen resolution to other might be appreciated by users without restarting the system. There should be some regularity while moving from one resolution to other and restoring the same resolution. There should be a solution or facility for resizing the window when user selects the smallest resolution (640X480). Minimize item on panel and shortcuts of application should remain same on their place while changing the resolution. The desktop should not be cut or disappeared when user try to restore the default (1280X800) resolution. This problem is shown in appendix 1.

GNU/Linux and its distros cannot compete in the market with other system softwares without taking the responsibility of usability and functionality of default software in that particular distribution. Free Software Foundation (FSF) should make some standards or guidelines as default which should be followed by all distribution to have usability. The developer’s team should take the responsibility of all those softwares with all aspects which they are going to include as default softwares on Ubuntu.
Future Work

Usability testing and evaluation can be performed with same set of procedures and conditions on other desktop environments like Kubuntu or Xubuntu. The same study can also be conducted with other GNU/Linux distros as well. This test can also be performed with experienced users of GNU/Linux with the default settings which are provided by Ubuntu 8.10. Parallel to this study, the same test can be performed by changing the participant’s culture. The same study can also be conducted with server side of GNU/Linux distros. A study can also be conducted on file system and security of GNU/Linux system software.
References

Books & Articles


[7]. Creswell, J., Qualitative, Quantitative & Mixed Method Approaches, Sage Publication Ltd. 2003


Web Resources


Appendix 1: Screen Shots of Tasks

Create Office Document

Search a File
Delete a File

Restore a File
Play Audio CD

Browse Firefox to Play Online Video
Sign on Internet Messenger using MSN ID

Uninstall Particular Application
Change Screensaver

Change Desktop Resolution
Problem raised by restoring Desktop Resolution
Appendix 2: Top Ten Distribution’s Screen Shots

Ubuntu 8.10
http://www.ubuntu.com/

OpenSUSE 11.0
http://www.opensuse.org/
Fedora 10

http://fedoraproject.org/

Debian GNU/Linux 4.0

http://www.debian.org/
Mandriva Linux 2009
http://www.mandriva.com/

Linux Mint 6
http://linuxmint.com/
PCLinuxOS 2007
http://www.pclinuxos.com/

Slackware Linux 12.2
http://www.slackware.com/
Gentoo Linux 2008.0
http://www.gentoo.org/

CentOS 5.2
http://www.centos.org/
Appendix 3: Interviews

Interviewee 1

How do you feel working in Open Office?

I feel comfortable with OpenOffice and find no difficulty using it. Open office has “.ODT” extension as default but I know how to use .doc extension as well.

How do you see the search, delete and restore utilities in Ubuntu?

Search for files, delete and restore option provides good functionality to locate a file. I find these utilities unproblematic to perform. As Ubuntu uses move to trash option instead of delete option by right clicking on screen, it can be confusion for naive user but later on I think users do not have any problem.

What do you think about playing audio and video in Ubuntu?

Rhythmbox is a good audio player and I prefer to use it. It can be complex for novice users having too many options in one place. It is beautifully delivering all the basic needs required in running media contents except the pause button. Yes, there is no problem in playing online videos after installing plugins.

What is your opinion of using internet messenger in Ubuntu?

Signing in on Pidgin internet messenger with many protocols in one umbrella is very good approach used by Ubuntu. Still no voice and video facility is provided in pidgin but as a whole I am pleased with pidgin.

How do you see Add/Remove utility to uninstall an application?

Uninstalling software is very efficient and easy in Ubuntu. Ubuntu has a bunch of softwares and packages present in library which is good feature.

What do you think about easiness in changing the Screen Saver and resolution feature in Ubuntu as compared to Windows?

I know both utilities and their usage but I have no interest in using both.

What is your overall assessment about GNU/Linux and Ubuntu?

Everybody is widely using Ubuntu these days due to its various excellent features and easiness. Ubuntu consists of many F/OSS with full back end support and have become the first choice for free software lovers. I love the concept of GNU/Linux and its different distro. One can use it according to own choice and can take a part as volunteer developers in its development.
**Interviewee 2**

**How do you feel working in Open Office?**

A clean, brief and very simple interface of Open Office lets user to perform tasks very easily. I am satisfied with all the functionalities and interface of OpenOffice.

**How do you see the search, delete and restore utilities using Ubuntu?**

GNU/Linux uses a different approach to manipulate the directory structure. I have no difficulty in searching a file, delete and restoring it. Restoring a file or folder from trash is an issue in previous version and now it has been resolved. Ubuntu is also equipped with “search” feature in almost every window pane.

**What do you think about playing audio and video in Ubuntu?**

Playing a track from Audio CD is easy. I use CD Player for Audio CD tracks and I am very comfortable using it. After installing adobe flash plugins, there is no problem in playing videos.

**What is your opinion of using internet messenger in Ubuntu?**

Pidgin internet messenger fulfill user’s need by running quite number of messengers on the same platform. Therefore, it is not difficult for a user to configure and use MSN id.

**How do you see Add/Remove utility to uninstall an application?**

Having well defined and organized categories at one place makes this utility an interesting and easy feature. I am satisfied with this feature.

**What do you think about easiness in changing the Screen Saver and resolution feature in Ubuntu as compared to Windows?**

The location of screen saver is changed is Ubuntu but there is no such issue in applying screen saver. Novice users might not be aware of the exact location at first place. Restoring the default screen resolution creates a problem and until yet Ubuntu has not found any solution for this.

**What is your overall assessment about GNU/Linux and Ubuntu?**

In my opinion, Linux could be a compromised selection of operating system among users who would like to prefer open source or free software distribution, thought they have to lack with many salient features commonly provided by windows OS products. In terms of stability, Linux based operating systems are well-known since they maintain their file system very precisely and function very close to the command interface technique rather than using intensive forms and menus options as available in Windows.

However, from the perspective of ordinary home users, selecting Linux as a primary operating system for performing everyday task might be a hectic solution for home computing at first run. After that it can be a good choice
among researchers, students, open source developers, home user and other IT personnel who are engaged with the support and custom-development of open source tools related to their field. Users interested in learning new operating systems and increasing their knowledge to different operating system environments may also consider Linux and can experiment a lot new things inside.
Appendix 4: Ubuntu Community Response

Question 1: Is the default file extension of OpenOffice is .ODT. ? And how can I change it to .DOC so that whenever OpenOffice starts, it saves in .DOC. automatically.

Responses:

- Yes, the default file extension is .ODT.
- You can change it under the Tools/Options/load/save section in Oo to make "doc" the default.

Question 2: How can I search a file if I do not know the name or location of file?

Responses:

- Type in terminal like this
- Locate “name of the file”
- Linux assume exactly what are you doing.
- There are some commands you can use which are locate, find and where is and then the file name
- sudo find / -name or filename
- You can also use the GUI to do this, if you don't want to use the terminal.
  Places --> Search for Files...
- sudo find /-iname filename
  and this will perform a case-insensitive search of the entire computer for the file called file_I_want. Almost limitless possibilities with the 'find' command.

Question 3: How can I use Rhythmbox for audio CD. Whenever I insert an audio CD and double click on a track, it goes to totem movie player, it streams over there but does not play any song. I do not know what to do. Can I use totem player as audio player?

Responses:

- Go to system>administration>hardware drivers... then, see if you have any drivers or restricted drivers to install. If so install them. I don't exactly know what that does, but it worked for me.
- If you didn’t installed it yet do it now
- Code:
  sudo apt-get install Ubuntu-restricted-softwares
- And add Medibuntu repo to your source list like it is described here.
- In "preferences" ---- "standard applications" or something like that (I've got a Dutch translation here ) you could also make Rhythmbox the default for multimedia.....When I insert an audio CD, a window pops up which asks me with what application to open the CD between. I don't think this is codec-related. Does the CD give an icon on the desktop, i.e is it mounted properly?
• I'm no linux guru but you may just need to install some codecs, try installing all the gstreamer stuff and all the xmms2 stuff. I followed a tutorial on how to install ubuntu and after installing all this I can play just about every media.

• https://help.ubuntu.com/community/RestrictedFormats

• There are lots of players (amarok, banshee, exaile, audacious, totem-xine ect.) but for the moment just try Rhythmbox. First click on Places -> Home Folder. When that opens click on Edit -> Preferences -> Media and you'll see a box for CD Audio. In the drop down choose Rhythmbox. Now when you insert an audio CD Rhythmbox will open. If you want to double left click on a .wav and have Rhythmbox open (instead of totem) then double click on the audio CD icon. Then on one of the .wav -> right click -> properties -> open with. Find Rhythmbox in the list and select it. If for some reason it's not in the list then click 'add' and find it there. You do not need additional codecs and or libraries to play audio CD or .wav's (I like Amarok because it's one of the few players where you can stick a CD in the drive(s) and it will start playing automatically.

**Question 4:** I have installed Adobe flash plugin to run online video on youtube but still it is not working? Do I need to restart the system?

**Response:**

• You shouldn't have to reboot. But you might wanna try restarting Firefox. If it still doesn't work try:
  • sudo apt-get install flashplugin-nonfree
  • In the terminal, (Applications --> Accessories --> Terminal). Then restart firefox and it should work. Hope this helps.
  • It might also help if you remove gnash as it can interfere with flash. To remove it is easy, go to system then to administration then to synaptic package manager search for gnash and next to the packages marked gnash there are probably green boxes right or left click these boxes and select "mark for complete removal" hit apply and if you get a screen asking if you want to remove additional packages again hit reply, synaptic is easy to figure out.

**Question 5:** Can I sign in to internet messenger using my MSN id in Pidgin internet messenger? Can I enjoy voice and cam in Pidgin?

**Response:**

• Yes, you can login using your msn id. I have not tried voice or cam though. What you could do is to install pidgin in windows and see exactly what features it has for yourself.
• There is no sound (voice) and cam on pidgin. You could try other applications like amsn or emesene which have those options available.

**Question 6:** I want to uninstall Audio CD Extractor software. How can I do this graphically?

**Response:**

- Click on applications -> Add/Remove
  now search using the name of the program, uncheck the box and click apply. You can also go to synaptic. This is in System -> administration -> synaptic package manager. Now search of the package name click on the green box a select mark for removal or mark for complete removal and then click apply. This is assuming you are using the gnome desktop (if it is the default Ubuntu install). To remove a package in the command line write like this in terminal
  - `sudo apt-get Remove Package Name` Or for complete removal
  - `sudo apt-get purge Package Name`

**Question 7:** How can I find screen saver from a location? And how to apply it?

**Response:**

- You will not get it by right clicking. The screensaver should be in System > Appearance > Screensaver or system > administration.

**Question 7:** If I change my default (1280x800) desktop resolution to any other resolution, it demands from me to log in again. This works fine but when I restore the resolution, all the shortcuts on panel becomes undisturbed and the screen goes in disorder and I become helpless to work anymore. The only solution is to log in again. I have two laptops. Sony vaio with Intel graphics card 965 and Toshiba with Intel 965 graphics card but this problem is same on both laptops. I have checked that there is no proprietary software installed.

**Response**

I do not think it is a genuine problem... actually it could be a behavior of Ubuntu while adjusting screen resolutions. You should try with refreshing your screen, hope it may help you in fixing your desktop or else you can simply logout and login again since it refreshes your entire desktop by refreshing your session. Sometimes I've also experienced the same problem but I do not bother it much since it can be solved with either of the solutions I mentioned above or perhaps, it may also depend on person to person behavior and their demands to work with operating systems.