

NPC-WIPER: File Wiper Tool using Non-Printable Characters

Fazirah Natasha Baharudin¹, Kamaruddin Malik Mohamad^{1*}

¹Faculty of Computer Science & Information Technology, Universiti Tun Hussein Onn Malaysia, Parit Raja, 86400, Malaysia

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Abstract: NPC-WIPER is a file wiping tool that is used to delete Pdf file type permanently from a device. This tool is proposed as the information that has been deleted still remains in device and can lead to loss of sensitive data. Other than that, a simple deletion and formatting is not enough in protecting the data from being loss. The objective of this tool is to ensure that the deleted file is not able to be recovered using recovery tools and can protect the user confidentiality by hiding the sensitive information from other people. The tool is developed using C# programming language and the methodology used to complete this project is Object-Oriented Software Development (OOSD). The NPC-WIPER will overwrite the Pdf file type with randomized non-printable characters. In conclusion, the sensitive information of user will be protected by permanently delete the file.

Keywords: File Wiping, Randomized Non-Printable Characters

1. Introduction

Our computer does not remove the data from the hard drive if we format or delete it. The deleted data can be recovered easily by using data recovery tools [1]. This can bring harm once our personal data is exposed. A study was conducted since 2000 to study the effects of information security events such as privacy violations [2].

In business industry, the company's information is very confidential. Once it is leaked, it can affect the company such as reputational damage, financial loss and loss of sensitive data about staff. Research was conducted by INRIA researchers where they study and analyzed over 39664 PDF files and results in able to recover sensitive information of 76% files that they analyzed [3]. Most of the recovered sensitive data will include device detail, email, operating system, author name.

Rapid growth of technology results in a lot of advanced technology discovered such as all information can be stored in one device. For instance, photos, videos, important documents and personal information. However, user does not know that their information remains in the device even after being deleted. User may delete it with the aim to protect their privacy but it can be recovered and used by cybercriminal or hacker because the data that has been deleted is not gone yet [4].

Sensitive information is really important for government field and big companies where they need to keep their information secured. Sensitive data that can be gained by cybercriminal or hackers are social security numbers, medical details and banking information [5]. With data wiping, the data will be permanently removed from hard disk or anywhere where it overwrites the data. Thus, it makes it unrecoverable using data recovery tools. Data wiping is the process of wiping a particular hard drive to remove all traces of data on it. Data wiping is used as a secure way of deleting unused files and made it unrecoverable.

Most people would go for formatting their data in hard disk to delete it permanently [6]. However, a study of comparing between deleting, formatting and wiping has been done and results in deletion and formatting are not a secured method [7]. The objectives of this project are to design a file wiper tool using randomized non-printable char (NPC-WIPER), to develop the NPC-WIPER, and to evaluate the security functionality of NPC-WIPER using data recovery tools. At the end of this project, a wiping tool using randomized nonprintable characters will be developed successfully.

2. Related Work

2.1 Data Wiping

Data wiping is a method of removing data from storage device in a secure way without being able to recover the data [8]. Data wiping is done by overwrites the data on the storage device. This wiping technique usually takes multiple passes and testing to assure total data deletion. A proper done wiping is an approved kind of data destruction that complies with privacy rules, alongside shredding hard drives and gadgets [9].

In overwriting process, the data is frequently overwritten with a single character, such as a 1 or a 0. Thus, it will leave you with a clean slate which it hides any prior code. To truly wipe the data, numerous "passes" may be required to verify that all traces have been deleted. Hence, this method could require a pass with a 1, then a 0, continues with a random character, and so on to put an end to any traces of previous data [10].

Non-printable character is a character that is not displayed within a context. Even though these characters are not visible in the context, however it can still give effects on the output [11]. The non-printable characters starting from the 0 to 31 characters and DEL character with value of 127. Some of the non-printable characters are tab, line feed, backspace, escape and can be referred in the ASCII Table.

Simple byte randomized method is the proposed wiping technique. This technique is used in randomized the byte chosen before overwriting it with non-printable characters. A random generator will be used to generate a sequence of numbers starting from zero until 32. The file will be overwritten by the set of randomized non-printable character.

2.2 Existing Data Wiping Tools

Darik's Boot and Nuke or called as DBAN is a tool that will erase your entire hard drive and all types of files on the drive. This program can be use in any other operating system since it requires user to reboot their computer [12]. This tool does not work for computer with SSDs. The wiping method used in DBAN are US DoD Standard 5220.22-M (DoD 5220.220M), Gutmann, Random Data, Write Zero, and RCMP TSSIT OPS-II.

The next existing data wiping tool is CBL Data Shredder is a wiping tool that overwrites the entire disk by using a pattern of bits. Unlike DBAN, this program can work in two ways which can be used in disk or flash drive and run in Windows 8 and Windows 10. Methods that are available in CBL Data Shredder are DoD 5220.220M, VSITR, Gutmann, Schneier and including RMCP DSX.

MHDD can erase any hard drives from booting it through a disc. This tool is known for its easy-to-use since it is downloadable [13]. The method that used in this tool is Secure Erase by overwriting all the data in the hard drive with a binary one or zero in a single pass.

2.3 Comparison Existing Data Wiping Tools

There are many existing wiping tools that offers a secure deletion. In this section, 3 existing tools were chosen and will be discussed in detail. The Table 1 shows the comparison of existing data wiping tools with NPC-WIPER.

Table 1: The Comparison Table of Existing Data Wiping Tools with NPC-WIPER.

	DBAN	CBL Data Shredder	MHDD	NPC-WIPER
Platform	Windows/Linux/Unix	Windows/Linux/Unix	Windows/Linux/Unix	Windows
Hard Disk Sanitization	Yes	Yes	Yes	No
File Selection	No	No	No	Yes
File Sanitization	No	No	No	Yes
Algorithm used	DoD 5220.220M), Write Zero RCMP TSSIT OPS-II, Random Data, and Gutmann.	DoD 5220.220M, Gutmann, DSX, Schneier and VSITR	Secure Erase	Randomized non-printable characters

Based on Table 1, all the existing data wiping tools can be use in Windows, Linux and Unix platform except for NPC-WIPER where it is limited to only Windows platform. Next, the DBAN, CBL Data Shredder and MHDD tools can be used in wiping the whole hard drive meanwhile NPC-WIPER only supports file selection and file sanitization. Lastly, multiple algorithms of data wiping are used in DBAN, CBL Data Shredder. Only one algorithm of data wiping is used in both MHDD and NPC-WIPER.

3. Methodology/Framework

C# is one of the Object-Oriented Programming Language (OOP). Therefore, Object-Oriented Software Development (OOSD) methodology is chosen for this project. OOSD consist of a feature that enables modifying the attributes where it makes the process of adjusting the relationships along existence function in the coding more convenient. Figure 1 shows the phases in OOSD.

Figure 1 present the phases in the Object-Oriented Software Development (OOSD). In this methodology, there are consisted of five phases which is starting with Planning phase. The second phase is Analysis phase and continues with the third phase, Design phase. Next, the Implementation phase and the Testing phase is for the fifth phase.

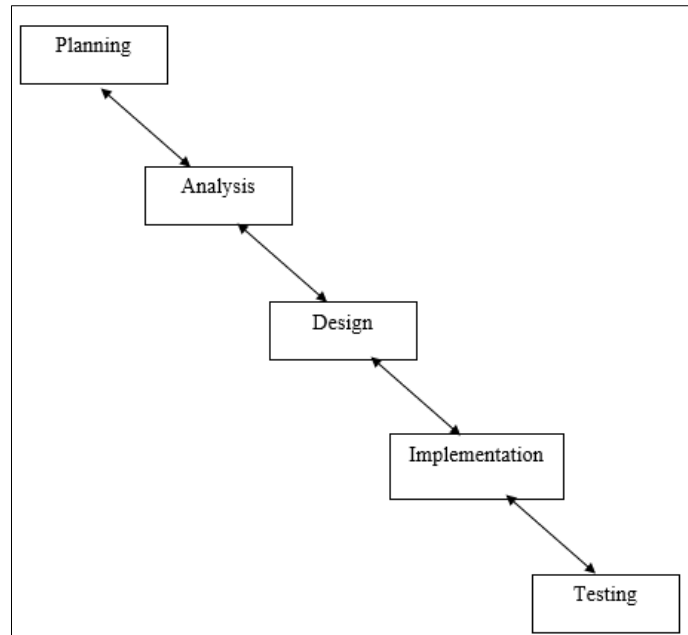


Figure 1: Phases in OOSD

3.2 Requirement Analysis

Functional requirements and non-functional requirements are the two categories of system requirements. These two system requirements are critical in the development of a system in which the requirements will explain the system clearly and accurately. In the functional requirement analysis, the tool’s function is discussed. Table 2 presents the functional requirements of NPC-WIPER. The non-functional requirement determines the tool's criteria. NPC- WIPER's non-functional requirements are listed in Table 3.

Table 2 Functional requirements for NPC-WIPER

Module	Functionality
User Registration	<ul style="list-style-type: none"> User required to register a new account by using email, username and password
User Login	<ul style="list-style-type: none"> User can login by inserting username and password if they already have an account. An alert will be displayed if the user entered the wrong username or password.
Select File	<ul style="list-style-type: none"> User can select the desired .pdf file from the library.
Overwrite File	<ul style="list-style-type: none"> The chosen file can be wiped by user using the randomized non-printable characters technique.

Table 3: Non-Functional requirement for NPC-WIPER

Requirement	Description
Performance	<ul style="list-style-type: none"> The tool’s function must able to interact with the user.
Operational	<ul style="list-style-type: none"> The tool can be operated without internet connection.
Usability	<ul style="list-style-type: none"> The tool’s design is simple and easy for the user to use.
Security	<ul style="list-style-type: none"> User need to login with the right username and password. A strong and complex password is required during the registration.

3.3 Design Phase

A Unified Modelling Language (UML) is a modelling language used to standardise the visual representation of a system's architecture. The UML includes the use-case diagrams, activity diagrams and sequence diagrams. Figure 2 shows the use-case diagram for the NPC-WIPER. The actor which is the user can interact with the system to perform User Registration, Login, Choose File, Wiper File, and Logout.

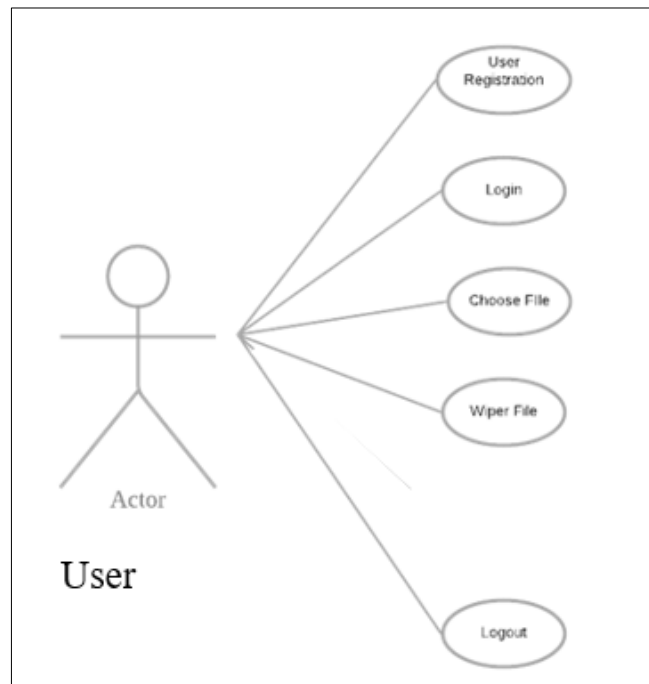


Figure 2: Use-Case Diagram of NPC-WIPER

Figure 3 shows the process when the start the program, the program will show the login page to the user and if the user does not have any account the page will be redirected to registration page. Once the user achieved a successful login, the main menu will be displayed by the system. Next, a file can be added by user to be wiped by the system using randomized non-printable characters. Lastly the user will be redirected to main menu and user can decide to exit the program or wipe another file.

Figure 4 shows the diagram of activity diagram of NPC-WIPER. The program starts with displaying the login page. A new user will need to register an account first and will be able to login the program. A successful login will be redirected to the main menu page where the user can choose a file to be wiped. Next, the user can wipe the file using randomized non-printable characters. Lastly user can choose if they want to logout from the program or back to the main menu and continue wiping with another file.

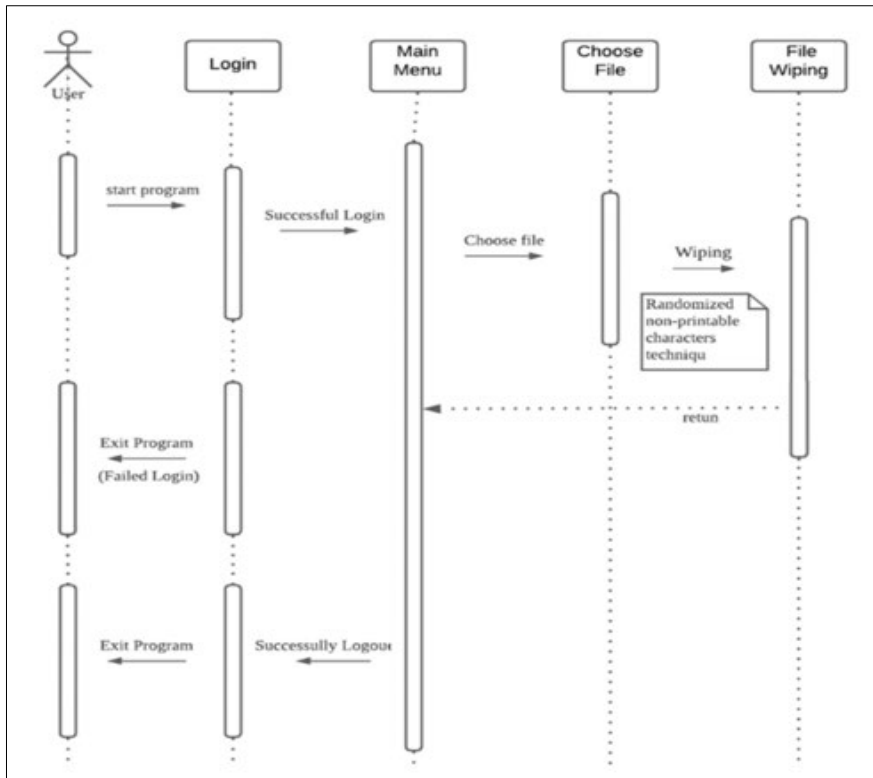


Figure 3: Sequence diagram of NPC-WIPER

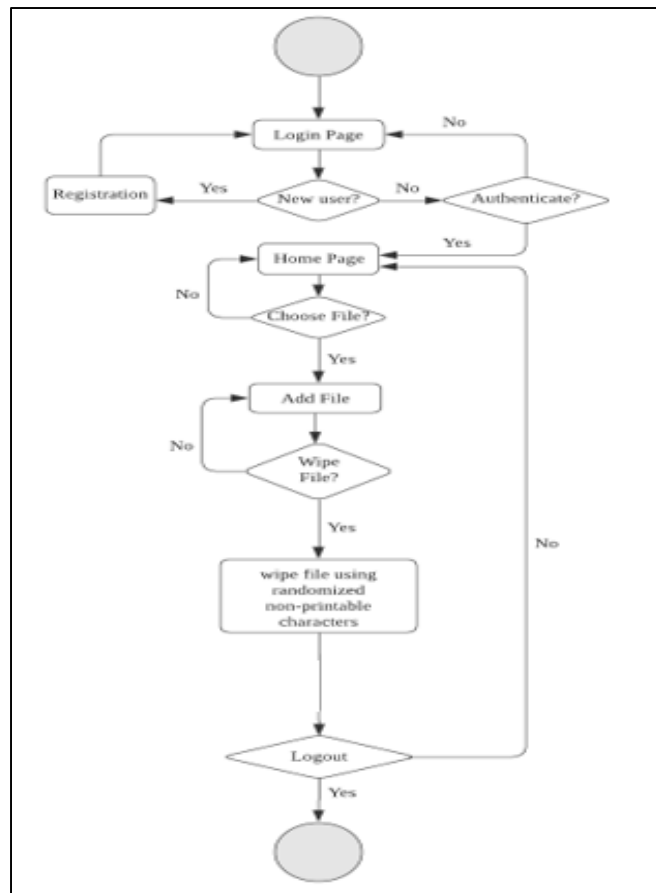


Figure 4: Activity Diagram of NPC-WIPER

3.3 Implementation Phase

Within this implementation phase, development process of NPC-WIPER is started. The coding is written in chosen programming language which was C#. The coding will be written in Visual Studio 2019 and the database will be developed. Table 4 shows the software and hardware requirements for this project.

Table 4: Software and Hardware Requirements

Software	Microsoft Visual Studio 2019
Hardware	Processor: Intel Core i3-8130U CPU speed: 2.20GHz 2.21 GHz Memory RAM: 4.00 GB of memory RAM

Table 4 shows the software and hardware requirements used in developing NPC-WIPER. The software that is required which is Microsoft Visual Studio 2019 for the coding. Next, the table shows the details of hardware needed which are the Processor: Intel Core i3-8130U, CPU speed of 2.20GHz 2.21 GHz and 4.00 GB of the memory RAM.

3.4 Testing Phase

Evaluating the functionality of NPC-WIPER is done in this phase. This process is done to ensure there is no bugs and errors in the coding and to ensure that the deleted file using NPC-WIPER is unable to be recovered. The functionality test will be carried out first, followed by the user testing. The testing will be done by using existing data recovery tools where the .pdf file will be inserted in a USB flash drive and deleted in different method and start the recovering process.

3.5 Maintenance phase

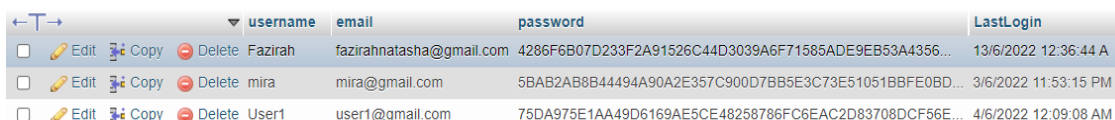
The maintenance phase of the system will be done by documentation process. The documentation process will record the implementation process and the suggestion on how to improve the system. The errors and bugs will be fixed in this phase.

4. Results and Discussion

In this section, it will consist of the demonstration and testing done during the implementation phase.

4.1 Implementation

The login page is the default start page of this system. The user will be allowed to login to their existing account by using the registered username and password. If the user is a new user, the user needs to register a new account by providing a username, email and password. A password policy is included in the registration process where the password should have minimum eight characters and maximum of 15 characters, at least one uppercase letter, one lowercase letter, one number and one special character. The password entered by the user will not be taken and stored in the database but the password will be salt with the username length and hashed by using sha256 encryption. Figure 5 shows the salt and hashed password stored in database. After a successful login, the user will be redirected to the main menu page and user can start the wiping process by choosing the file wiping button.



	username	email	password	LastLogin			
<input type="checkbox"/>	Edit	Copy	Delete	Fazirah	fazirahnatasha@gmail.com	4286F6B07D233F2A91526C44D3039A6F71585ADE9EB53A4356...	13/6/2022 12:36:44 A
<input type="checkbox"/>	Edit	Copy	Delete	mira	mira@gmail.com	5BAB2AB8B44494A90A2E357C900D7BB5E3C73E51051BBFE0BD...	3/6/2022 11:53:15 PM
<input type="checkbox"/>	Edit	Copy	Delete	User1	user1@gmail.com	75DA975E1AA49D6169AE5CE48258786FC6EAC2D83708DCF56E...	4/6/2022 12:09:08 AM

Figure 5: Salt and hashed password stored in database.

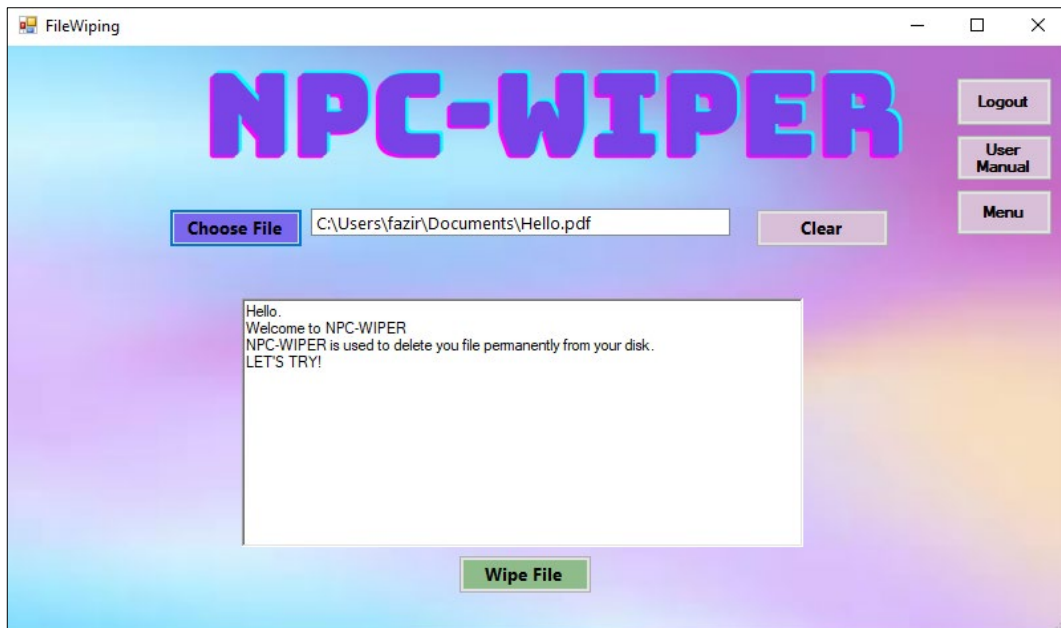


Figure 6: File Wiping Page Interface

Based on Figure 6. The user will be needed to upload a pdf file type and the system will display the file content. The user clicks the wipe file button to complete the file wiping process and the file will be automatically removed from the user disk.

```

90     1 reference
91     private void RandomizedNPC(string npc)
92     {
93         // npc characters = { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
94         // 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 }; // non printable character value in decimal
95
96         //open the file using File stream
97         using (FileStream
98             fs = new FileStream(npc, FileMode.Open))
99         {
100
101
102
103         while (fs.Length != fs.Position) //ensure the overwritten data does not exceed original file size
104         {
105             byte[] array = new byte[npc.Length]; //set the array size as the file length
106             Random rand = new Random(); //instantiate random number generator
107
108             for (int i = 0; i < npc.Length; ++i) //for loop to get random numbers size as file size
109             {
110                 array[i] = (byte)rand.Next(32); //insert the random number from 0 to 32 into array
111             }
112             for (int j = 0; j < npc.Length; ++j) // for loop to overwrite the file as the file size
113             {
114                 fs.WriteByte(array[j]); //Writes a byte to the current position in the file stream.
115             }
116         }
117         fs.Close();
118     }
119
120
121

```

Figure 7: Partial Code for overwriting the file

Figure 7 shows the code segmentation shows the function that is used in overwriting the file with randomized non-printable characters. The randomized non-printable characters are from the range zero to 32. The system will open the file by using the File Stream as shown in line 98. Then, a Random function is used to generate number as in line 106. The random numbers generated will be stored in an array as shown in line 110. The random number generator is set to 32 as the non-printable characters ends at 32. After that, the system will overwrite the file with the randomized non-printable characters as shown in line 114.

4.2 Functional Testing and User Acceptance

Evaluating the functionality of NPC-WIPER is done in this phase. This process is done to ensure there is no bugs and errors in the coding and to ensure that the system meets the user requirements. In order to test that the file is overwritten, a testing will be done by using existing data recovery tools where the .pdf file will be inserted in a USB flash drive and deleted in different method and start the recovering process. A form is used to determine results of testing the user acceptability with the system. The form is used as a guide to assist the test case within the system. The testing was successful as the deleted file using NPC-WIPER was unable to be recovered using the data recovery tool. The results of the testing are shown in APPENDIX A.

5. Conclusion

In a nutshell, a wiping tool will be developed to remove a file completely from hard disk and make it unrecoverable. With this tool, sensitive data and person's privacy can be protected and avoid from being stolen by cybercriminal or hackers. The objectives of this project are to design a file wiper tool using randomized non-printable char (NPC-WIPER), to develop the NPC-WIPER, and to evaluate the security functionality of NPC-WIPER using data recovery tools are achieved.

The methodology of NPC-WIPER development was the Object-Oriented Software Development. Next, the project's framework diagram also was discussed in detail which consist of 2 stages, selecting .pdf file and overwriting the file. Testing is also done and the results of each test is used to confirm that the developed tool meets the user requirements as proposed.

Other than that, upon the advantages of the system, there are a few limitations are found in the in the NPC-WIPER which are only one file can be wiped at a time, the tool only wipe (.pdf) file type only and user is unable to edit their username, password and email. Hence, there are some suggested improvements for the system to be implemented in the future which are User can wipe more than one file at a time, the tool able to wipe other file type such as document (.docx) and Excel (.xlsx) and the user is able to update their username, password and email.

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APPENDIX A

Table 5. NPC-WIPER Testing Category

Test category	Description
1	Test the system's functioning in terms of the user's ability to select, and wipe files.
2	Test the functionality of the system where the system is able to save the user data and manipulate it.

Table 6 NPC-WIPER Testing for Register Page

Test category	Description	Expected results	Actual results
2	Able to register a new account.	The registration button is displayed.	Pass
2	The data entered can be modified.	the user can input email, username and password.	Pass
2	Validation of the input.	i. Error message will be displayed if user enter a registered username. ii. Error message will be displayed if user fails to enter password more than 8 characters, contains at least one uppercase, lowercase, number and special characters.	Pass
2	Click on the submit button.	The submit button is displayed. The data insert is stored in database after click on the submit button.	Pass

Table 7 NPC-WIPER Testing for Login Page

Test category	Description	Expected results	Actual results
2	User is able to login to the system.	Login button is displayed.	Pass
2	Able to input username and password.	The user can enter the username and password.	Pass
2	Click on the login button.	User can log in with a valid username and password	Pass

Table 8 NPC-WIPER Testing for File Wiping Page

Test category	Description	Expected results	Actual results
1	Choose a file	i. The choose file button is displayed. ii. A clear button is displayed.	Pass
	i. Click on the choose file button. ii. Able to choose a file iii. Click on the clear button.		
1	Wipe a file	i. A wipe file button is displayed. ii. File is wiped after click on the button.	Pass
	i. Click on the wipe file button.		

Table 9 NPC-WIPER Security Check list

No	Check list	Result
1	Error alert when wrongly authenticate should display the “incorrect username or password” instead of “incorrect username” or “incorrect password”.	Pass
2	Apply password complexity by demanding the user to use mixture of alphabetic, numbers and characters.	Pass
3	Apply policy of password length. Example, the system requires user to have a minimum of eight characters in the password when register.	Pass
4	The password entered cannot be seen in the text box.	Pass

Table 10 NPC-WIPER Testing Form

No	Acceptance requirement	Test	
		Pass	Fail
1	The system able to run the process from start to end of the process.	Pass	
2	The user has the option of creating a new account and logging in to the system.	Pass	
3	The user has the option of selecting a file.	Pass	
4	The user has the option to wipe the chosen file.	Pass	
5	The system allow user to logout from it.	Pass	

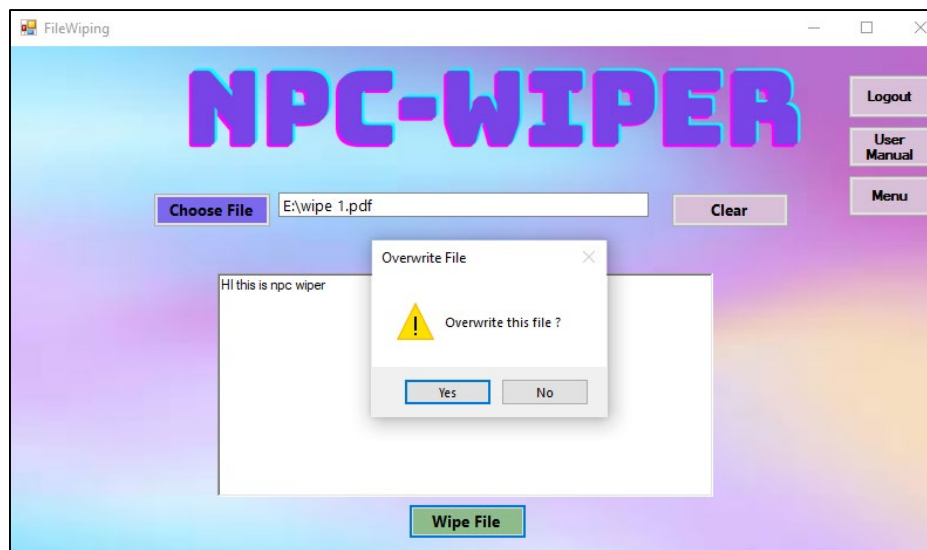


Figure 8: Sanitization of wipe 1 using NPC-WIPER

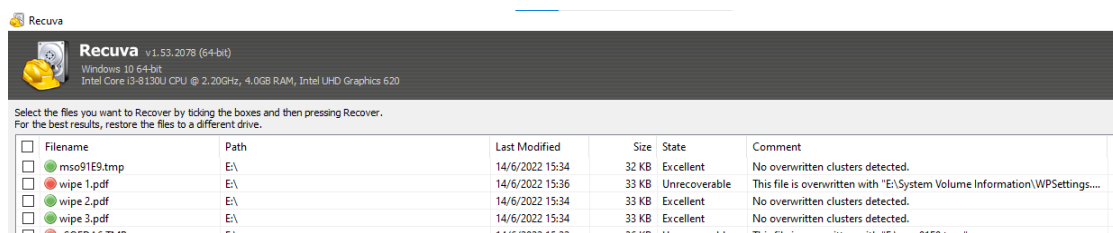


Figure 9: Result of file recovery using Recuva

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