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Security Concerns in Proprietary and Opensource Software

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Table of Contents

1	Introduction	5
2	Proprietary Software	6
2.1	Definition.....	6
2.2	License	6
2.2.1	Rights granted.....	7
2.2.2	Exclusive Rights.....	8
2.3	Benefits.....	9
2.4	Drawbacks.....	11
2.5	Example: Windows Operating System	12
2.5.1	History of Microsoft	12
2.5.1.1	General	12
2.5.1.2	1972 – 1985.....	13
2.5.1.3	1985 – 1994.....	14
2.5.1.4	1995 – 2007.....	15
2.5.1.5	2007 – 2011	16
2.5.1.6	2011 – 2014.....	16
2.5.1.7	2014 – 2020.....	17
2.5.2	Security	18
2.5.3	Windows 11.....	19
2.5.4	License Terms.....	20
2.5.5	Shared Source Initiative	21
3	Opensource Software	23
3.1	Definition.....	23
3.2	License	24
3.2.1	Protective License.....	24

3.2.2	Permissive License	25
3.3	Benefits.....	26
3.4	Drawbacks.....	27
3.5	Example: Linux Operating System	28
3.5.1	History	28
3.5.1.1	General	28
3.5.1.2	Precursors	29
3.5.1.3	Creation	30
3.5.2	Kernel.....	30
3.5.3	Distribution	31
4	Discussion.....	33
	References.....	34

Index of abbreviations

API	Application Programming Interface
AT&T	American Telephone and Telegraph Company
BASIC	Beginners' All-purpose Symbolic Instruction Code
BETT	British Educational Training and Technology Show
BSD	Berkeley Software Distribution license
CEO	Chief Executive Officer
CP/M	Control Program/Monitor
EULA.....	End User License Agreement
FOSS	Free Opensource Software
FSF	Free Software Foundation
GPL.....	General Public License
IBM.....	International Business Machines Corporation
ISA	Instruction Set Architecture
LKML.....	Linux Kernel Mailing List

MINIX Mini-Unix
MIT Massachusetts Institute of Technology license
MS-DOS..... Microsoft Disk Operating System
Ms-PL..... Microsoft Public License
Ms-RL..... Microsoft Reciprocal License
MTIS..... Micro Instrumentation and Telemetry System
OEMs Original Equipment Manufacturers
OSI Open Source Initiative
OSS..... Opensource Software
PC Personal Computer
SSI Shared Source Initiative
UAC..... User Account Control
WPF Windows Presentation Foundation

List of Tables

Table 1: Proprietary license and rights granted in context of the copyright
(Wikipedia [SL], 2022) 7

Table 2: Protective license and rights granted in context of the copyright (Wikipedia
[SL], 2022)..... 24

Table 3: Permissive license and rights granted in context of the copyright
(Wikipedia [SL], 2022) 25

1 Introduction

As opensource software is becoming more and more popular these days, questions of the reliability and security arise, especially in comparison with proprietary software. Opensource software is not just only popular because the software is freely acquirable, it also benefits from the huge community in which developers as well as users share their knowledge and experience to enhance the software. Due to the rising popularity in opensource software, the proprietary software vendors feel threatened as they are afraid of losing customers to them. Thus, they are strongly in competition with each other.

Many academics have already addressed the topics regarding which software is better or which software is more secure than the other. There is no absolute answer to it, it depends on what the user wants or needs; do users want a software over which they do not have any control over? or do users want a software in which they can contribute to the development of the software?

This leads to the focus of the paper showing the distinction between proprietary and opensource software regarding their license arrangements as well as the benefits and drawbacks and using examples.

The paper is structured as followed: in the second section, the proprietary license arrangement is explained, then benefits and drawbacks are shown and finally Microsoft as proprietary software is analyzed. In the third section, the opensource license is explained, then benefits and drawbacks are shown and finally Linux as opensource software is analyzed. In the fourth section, the discussion and conclusion are given.

2 Proprietary Software

2.1 Definition

Proprietary software is also known as non-free software or closed-source software (Wikipedia [PS], 2022) and is any software that legally remains the property of its software vendors, whether that is an individual, an organization or a company (Thompson, 2020). That means software vendors own all rights to the product, including the intellectual property rights to the source code (Thompson, 2020).

The source code is usually kept a secret from users or any other people outside of the product engineering, hence the name closed-source software. Only software vendors know how the code works and thus can make changes to it. By concealing the source code, software vendors prevent users from tampering with the product and competitors from stealing the ideas behind the source code and using it as inspiration for their own product (Thompson, 2020). Software vendors usually charge a fee from users for the use of the product, hence the name non-free software.

Moreover, software vendors delineate the specific terms of use in an end-user license agreement (EULA) (Wikipedia [PS], 2022). EULA is a legal contract entered into between a software vendor and a user (Wikipedia [EULA], 2022). The agreement specifies in detail the rights and restrictions which apply to the use of the software (Wikipedia [EULA], 2022). Users usually purchase the software and before starting the software they have to agree and accept the license agreement which is usually not negotiable. Users can also reject the agreement but then they cannot use the software anymore. Thus, users will probably accept the license agreement since they usually cannot see the license agreement before purchasing the software.

2.2 License

A software license is a legal instrument governing the use or redistribution of the software and preserves the scope of the copyright protection (Wikipedia [SL],

2022). Based on the license, a licensee, typically an end-user, has the permission to use one or more copies of the software where such a use would otherwise violate the copyright law (Wikipedia [SL], 2022). Thus, the type of license shows which kind of rights are granted to users.

Software license is primary divided into proprietary and free opensource software (FOSS). In General, the distinct conceptual difference between them is the granting of rights to modify and redistribute the software obtained by a user (Wikipedia [SL], 2022).

2.2.1 Rights granted

The table below shows which rights are granted by using proprietary license. It demonstrates that proprietary license preserves the scope of copyright protection but has restriction in terms of modification, distribution, and sublicense. That means that users cannot modify and/or distribute the software in any of way, otherwise they would violate against the terms of license. As a result, software vendors can open a disciplinary procedure against users, violating the terms of use. Users usually agree to the terms by accepting the license before starting the program.

Rights granted	Proprietary license
Copyright retained	YES
Right to perform	YES
Right to display	YES
Right to copy	NO
Right to modify	NO
Right to distribute	NO
Right to sublicense	NO
Example	WINDOWS

Table 1: Proprietary license and rights granted in context of the copyright (Wikipedia [SL], 2022)

An example of proprietary license is the operating system Windows from Microsoft. Users have to accept the terms of use from Microsoft before using the program. The license terms of Microsoft state exactly what the user may or may not do, and what the consequence will be if the user fails to comply.

2.2.2 Exclusive Rights

The owner of proprietary software exercises certain exclusive rights over the software (Wikipedia [PS], 2022). The license restricts users by using the software, inspecting the source code, modifying the source code, and redistributing (Wikipedia [PS], 2022). Also, there may be other restrictions such as the compatibility with other software and hardware use (Thompson, 2020).

Following the restrictions in detail:

- **Use of software.** Software vendors typically limit the number of computers on which the software can be used and even prohibit users from installing the software on extra computers (Wikipedia [PS], 2022). This can be enforced through a product activation, a product key or serial number, a hardware key or copy protection (Wikipedia [PS], 2022).
- **Inspection and modification of source code.** While most proprietary software is distributed without the source code, some software vendors distribute the source code or otherwise make it available to users (Wikipedia [PS], 2022). The source code is covered by a non-disclosure agreement or a license that allows users to study and modify the source code, but not redistribute it (Wikipedia [PS], 2022). However, some software vendors allow distributing changes to the source code, but only to others licensed for the product (Wikipedia [PS], 2022). Even they pick up some of those modifications (Wikipedia [PS], 2022).
- **Redistribution.** Software vendors prohibit users from sharing the software with others and so another unique license is required for another party (Wikipedia [PS], 2022). Moreover, they may prohibit users from distributing their modification to the source code even in the case of the source code available (Wikipedia [PS], 2022).

- **Compatibility with other software.** Most proprietary software stores its data in specific file formats and communicates in certain protocols, which can be incompatible with those of other types of software (Thompson, 2020).
- **Hardware use.** Some licensing terms stipulate that the software may only be used on a specific set of hardware (Thompson, 2020). Such is the case for Apple, which limits the operating system macOS, using it only on Apple hardware (Thompson, 2020). The license is reinforced practically by specific design features of the software that makes its incompatible with other hardware (Thompson, 2020).

2.3 Benefits

Revenue (View of Developers)

The most obvious reason why developers offer their product under the proprietary license is to make profit. Hence, they spend a lot of time creating a software worth selling it. Also, a logical business plan is needed for that.

For instance, Microsoft make big profits by producing proprietary software – the bulk of its revenue comes from selling Windows and Microsoft Office (Thompson, 2020). Microsoft is one of the biggest companies in the US and is now worth over one trillion US-Dollars (Thompson, 2020). This makes it for prospective software developers very appealing to enter such market through proprietary license.

A clearer roadmap (View of Developers)

Developers are working based on a business model including a plan for the development and evolution of the product (Thompson, 2020). It is aimed at creating a sustainable product with paid upgrades along the way (Thompson, 2020).

Developers can take their time with the creation of the software as they do not have to race against any competitors to reach a solution before, they do (Thompson, 2020). Also, they can take their time to produce a quality product without being observed by other developers since they are essentially working in private (Thompson, 2020). Moreover, they can test the product and request feedback

before releasing it, giving it a better chance of succeeding once on the market (Thompson, 2020).

Product stability (View of Users)

The owner is usually responsible for the development of the product and thus it does not continually evolve and develop like an opensource software. Therefore, proprietary software is more stable than opensource software, for users who are not looking to develop or modify the software.

Customer service (View of Users)

It is the duty of software vendors to provide customer services to support them when things go wrong. It is in their best interest to offer such services as users usually purchase the software and thus would like to receive support accordingly when issues with the software occur. In most cases software vendors are on hand to help their customers, whether that is in the form of an allocated technical support consultant or through a general helpline (Thompson, 2020).

Good user interface (View of Users)

It is important to build user-friendly software as software vendors are depended on their customers buying their products (Haygot Technologies Ltd., 2020). Thus, developers need to provide a good user experience (Haygot Technologies Ltd., 2020). User interfaces are usually sleeker, and general usability is often of a higher standard (Thompson, 2020).

The proprietary software is also typically designed for a smaller range of uses (Thompson, 2020). As the focus of the software is narrower, so is the target the market (Thompson, 2020). Software vendors, therefore, put time and money into creating a product that aligns with expectations of their customers (Thompson, 2020).

2.4 Drawbacks

User dependency

A big drawback of proprietary software is that the lifespan of the software depends on software vendors (Haygot Technologies Ltd., 2020). Users have no control over the lifespan of the product when they decide to discontinue the software (Thompson, 2020). It may be a great loss while using the software in business when the software is removed from the market (Haygot Technologies Ltd., 2020).

In addition to that, users are at the mercy of their software suppliers in terms of updates, too, relying on them for bug fixes and improvements (Thompson, 2020). If software vendors decide to take the product in a direction which does not suit them, there is little they can do to stop it (Thompson, 2020). Users have the opportunity to change the software vendor, but it may be too expensive to do it and thus the user is pretty locked in (Thompson, 2020).

Bulky products

Another drawback of proprietary software is that it tends to be heavy on users' computer system, as a lot of components are installed which they do not need (Thompson, 2020).

Microsoft Office, for instance, has installed a lot of components that most users do not need, such as Publisher or Access (Thompson, 2020). It can be confusing for users to remove programs from their computers, or only download what they need, leading most users to blindly install a huge package (Thompson, 2020). It is a big issue to deal with, when having limited computer storage.

Less flexibility

Proprietary software is often rigid, finished product, created for specific purposes (Thompson, 2020) and thus users cannot modify the features according to their needs (Haygot Technologies Ltd., 2020).

Expenses

Not only does proprietary software usually costs quite a bit, but on top of the initial costs, there may be a whole host of extra fees of which users were not aware at the time of purchase (Thompson, 2020). There can be monthly or yearly fees, prices can increase on renewal, and there can be other hidden costs which are hard to spot (Thompson, 2020).

Licensing

Big companies, for instance, need to take care when it comes to their licensing arrangement (Thompson, 2020). Working out a licensing plan with Microsoft is very different than it is for individuals purchasing Microsoft Office (Thompson, 2020). There are experts whose job it is to stay on top of the companies' licensing arrangement when dealing with Microsoft (Thompson, 2020). It is not only expensive to hire experts for this, but if they breach a license, they can incur significant fines (Thompson, 2020).

2.5 Example: Windows Operating System

2.5.1 History of Microsoft

2.5.1.1 General

Microsoft Corporation is an American multinational technology corporation founded by Bill Gates and Paul Allen in April 1975 (Wikipedia [Mic], 2022). Microsoft acts in software development, computer hardware, consumer electronics, social networking service, cloud computing, video games, internet and even in corporate venture capital (Wikipedia [Mic], 2022).

In the 1980's, the company started the development of software and grow up to one of the biggest US companies in the last decades. It is considered one of the Big Five companies in the US information technology industry, along with Amazon, Alphabet (Google), Apple and Meta (Facebook) (Wikipedia [Mic], 2022). The success of the company is reflected in the profit they made in 2021, a whopping of

161 billion US-Dollars (Wikipedia [Mic], 2022). More than 182 thousand people worldwide works for the company (Wikipedia [Mic], 2022).

The well-known software products of Microsoft are the Microsoft Windows line of operating systems, the Microsoft Office suite, and the Internet Explorer as well as Edge web browsers (Wikipedia [Mic], 2022). Its flagship hardware products are the Xbox video game consoles and the Microsoft Surface lineup of touchscreen personal computers (Wikipedia [Mic], 2022). Some other products of Microsoft are the integrated development environment, known as Visual Studio, the telecommunication application Skype, the business and employment-oriented online service LinkedIn, and the file hosting service OneDrive (Wikipedia [Mic], 2022).

2.5.1.2 1972 – 1985

Bill Gates and Paul Allen sought to make a business using their skills in computer programming (Wikipedia [Mic], 2022). In 1972, Gates and Allen along with Paul Gilbert founded Traf-O-Data which aimed to read raw data from roadway traffic counters and create reports for traffic engineers (Wikipedia [TOD], 2021). After a few years, the company was dissolved but the experience they made was instrumental in the creation of Microsoft Corporation (Wikipedia [TOD], 2021).

In January 1975, the company Micro Instrumentation and Telemetry System (MTIS) announced their microcomputer Altair 8800 in the magazine Popular Electronics (Wikipedia [Mic], 2022). Allen was encouraged to suggest that he and Gates could program a BASIC interpreter for MTIS (Wikipedia [Mic], 2022). While Allen worked on a simulator for the Altair Gates had developed the interpreter (Wikipedia [Mic], 2022). Afterwards, Gates called MTIS and claimed that he had a working interpreter, in response MTIS requested a demonstration (Wikipedia [Mic], 2022). During the presentation, the BASIC interpreter worked flawlessly and thus MTIS agreed to distribute it, marketing it as Altair BASIC (Wikipedia [Mic], 2022). Due to the success of BASIC interpreter, Gates and Allen established Microsoft, with Gates as CEO, in Albuquerque, New Mexico (Wikipedia [Mic], 2022).

In 1980, Microsoft entered the operating system business with its own version of Unix called Xenix, but their follow operating system MS-DOS solidified the company's dominance in the field of information technology (Wikipedia [Mic], 2022). In November 1980, IBM awarded a contract to Microsoft to provide a version of the CP/M OS to be used in the IBM-PC (Wikipedia [Mic], 2022). Due to the partnership with IBM, Microsoft eventually became the leading operating system vendor (Wikipedia [Mic], 2022).

2.5.1.3 1985 – 1994

In November 1985 Microsoft released Microsoft Windows as a graphical extension for MS-DOS, despite having begun jointly developing OS/2 with IBM the previous August (Wikipedia [Mic], 2022). In March 1986, Microsoft went public with the resulting rise in stock making an estimated four billionaires and 12,000 millionaires from Microsoft employees (Wikipedia [Mic], 2022). In April 1987, Microsoft released its version of OS/2 to original equipment manufacturers (OEMs) (Wikipedia [Mic], 2022).

In 1990, Microsoft was being suspected by the Federal Trade Commission for possible collusion due to the partnership with IBM, marking the beginning of more than a decade of legal clashes with the government (Wikipedia [Mic], 2022).

Meanwhile, Microsoft worked on Windows NT, which was heavily based on OS/2 (Wikipedia [Mic], 2022). In July 1993, Microsoft launched a new modular kernel and the 32-bit Win32 application programming interface (API), making it easier to port from 16-bit (MS-DOS-based) Windows (Wikipedia [Mic], 2022). Due to the project of Windows NT, the partnership with IBM on OS/2 is disordered (Wikipedia [Mic], 2022).

In 1990, Microsoft launched Microsoft Office suite which bundled separate application such as Word and Excel (Wikipedia [Mic], 2022). In May 1990, Microsoft launched Windows 3.0, featuring streamlined user interface graphics and improved protected mode capability for the Intel 386 processor (Wikipedia [Mic], 2022). By the time Microsoft Office and Microsoft Windows became dominant in the field of information technology.

2.5.1.4 1995 – 2007

In May 1995, Microsoft began to redefine its offerings and expands its product line into computer networking and the World Wide Web (Wikipedia [Mic], 2022). Due to the internal *Internet Tidal Wave* memo from Gates to his senior staff, Microsoft was the only major and established company that acted fast enough to be part of the World Wide Web beside Netscape (Wikipedia [Mic], 2022). In August 1995, Microsoft released Windows 95, featuring pre-emptive multitasking, a new user interface with a novel start button, and 32-bit compatibility – similar to Windows NT (Wikipedia [Mic], 2022).

In January 2000, Gates handed over his position as the CEO to Steve Ballmer who has been employed at Microsoft since 1980 (Wikipedia [Mic], 2022). Ballmer has its focus more on devices and services than on software development.

In October 1999, various companies including Microsoft formed the Trusted Computing Platform Alliance to increase security and protect intellectual property through identifying changes in hardware and software (Wikipedia [Mic], 2022). Critics sharply condemn the alliance to enforce random restrictions over how consumers use their software, and how computers behave (Wikipedia [Mic], 2022).

From there it shows that users have less and less control of their purchased software and thus cannot make their own decision about the use of the software. Users could hardly change the software vendor since Microsoft took excessively a monopoly position at that time. In 2004, Microsoft even had to settle the declaration with the U.S. Department of Justice regarding abusing monopoly (Wikipedia [Mic], 2022).

In October 2001, Microsoft released Windows XP, unifying the mainstream and Windows NT lines of OS under the Windows NT codebase (Wikipedia [Mic], 2022). In the same year, Microsoft released the Xbox, entering the video game console market dominated by Sony and Nintendo (Wikipedia [Mic], 2022).

2.5.1.5 2007 – 2011

In January 2007, Microsoft released the next version of Windows, known as Vista, and focused on features, security and a redesigned user interface (Wikipedia [Mic], 2022). In the same year, Microsoft released Microsoft Office 2007. Both products showed strong sales and Microsoft had recorded a significant profit in 2007 (Wikipedia [Mic], 2022).

Gates was Chief Software Architect until 2008, after he had handed over his CEO position to Ballmer in 2000 (Wikipedia [Mic], 2022). Gates still retains other positions related to the company in addition to being an advisor for the company on key projects (Wikipedia [Mic], 2022).

In October 2009, Microsoft launched Azure, entering the cloud computing market for Windows (Wikipedia [Mic], 2022). In February 2009, Microsoft announced its intent to open a chain of Microsoft-branded retail stores and in October 2009, Microsoft opened their first retail Microsoft Store in Scottsdale, Arizona (Wikipedia [Mic], 2022). Also in October 2009, Microsoft released Windows 7 focusing on refining Vista with ease-of-use features and performance enhancements, rather than an extensive reworking of Windows (Wikipedia [Mic], 2022).

In the late 2000s, the smartphone industry boomed, and Microsoft had struggle to keep up with its rivals in providing a modern smartphone operating system and thus falling behind Apple and Android (Wikipedia [Mic], 2022). In 2010, Microsoft revised their mobile operating system, known as Windows Mobile and replaced it with the new Windows Phone OS (Wikipedia [Win], 2022).

2.5.1.6 2011 – 2014

From 2011 to 2012, Microsoft undertook a gradual rebranding of its product range and adopted the Metro design language of all their products, services and websites (Wikipedia [Mic], 2022). In July 2012, Microsoft launched the Outlook webmail service to compete with Gmail from Google (Wikipedia [Mic], 2022). In October 2012, Microsoft launched Windows 8 and Microsoft Surface (Wikipedia [Mic], 2022). Windows 8 is an operating system designed to power both personal

computers and tablets (Wikipedia [Mic], 2022). Microsoft Surface is the first computer made by Microsoft (Wikipedia [Mic], 2022).

In July 2013, Investors were concerned about the poor showings of Windows 8 and Microsoft Surface and thus Microsoft stocks suffered their biggest one-day percentage sell-off since the year 2000 (Wikipedia [Mic], 2022). The company suffered a loss of more than 32 billion US-Dollars (Wikipedia [Mic], 2022).

Due to the maturing personal computer business, Microsoft announced that it would reorganize the business in four new business divisions, namely Operating System, Apps, Cloud and Devices (Wikipedia [Mic], 2022).

2.5.1.7 2014 – 2020

In February 2014, Ballmer stepped down as CEO and Satya Nadella has taken the position of CEO, who previously led the Cloud and Enterprise division at Microsoft (Wikipedia [Mic], 2022). Nadella has its focus more on cloud computing than on devices and services (Wikipedia [Mic], 2022).

In 2014, Microsoft acquired some companies such as Nokia, Mojang, best known for Minecraft and Hexadite, an Israeli security firm (Wikipedia [Mic], 2022). In January 2015, Microsoft announced the release of their first interactive whiteboard, Microsoft Surface Hub and in July 2015, Microsoft released Windows 10 (Wikipedia [Mic], 2022).

In January 2017, Microsoft presented Intune for Education at The BETT show 2017 education technology conference in London (Wikipedia [Mic], 2022). Intune for Education is a new cloud-based application and device management service for the education sector (Wikipedia [Mic], 2022).

In June 2016, Microsoft announced the project Azure Information Protection which aims to help enterprises protect their data as it moves between servers and devices (Wikipedia [Mic], 2022). In November 2016, Microsoft joined the Linux Foundation as a Platinum member, each Platinum membership costs 500,000 US-Dollars per year (Wikipedia [Mic], 2022).

In January 2018, Microsoft released PowerShell Core 6.0 for the macOS and Linux operating systems (Wikipedia [Mic], 2022). In April 2018, Microsoft released the source code for Windows File Manager under the MIT License and further expressed willingness to embrace opensource initiatives by announcing Azure Sphere as its own derivative of the Linux operating system (Wikipedia [Mic], 2022).

In December 2018, Microsoft announced the opensource implementation of Windows Forms and the Windows Presentation Foundation (WPF) which will allow for further movement of the company toward the transparent release of key frameworks used in developing Windows desktop applications and software (Wikipedia [Mic], 2022).

2.5.2 Security

Windows for consumer were originally designed for ease-of-use on a single-user personal computer without a network connection and thus Windows did not have any security features built in from the outset (Wikipedia [MW], 2022). However, Windows NT and its successors are designed for security, including on a network and multi-user personal computers, but were not initially designed with Internet security as the Internet use was less prevalent in the early 1990s (Wikipedia [MW], 2022).

Windows is a frequent target of computer worm and virus due to design issues combined with programming errors such as buffer overflows and the popularity of Windows (Wikipedia [MW], 2022). A buffer overflow is an anomaly where a program, while writing data to a buffer, overruns the boundary of the buffer and overwrites adjacent memory locations (Wikipedia [BO], 2022). The programming languages C and C++ are vulnerable to buffer overflows as they do not provide any built-in protection against accessing or overwriting data in any part of memory (Wikipedia [BO], 2022). As Windows is usually written in C and C++, it poses a big problem for Microsoft and thus needs safety precautions against this vulnerability.

To ensure the safety of users, Microsoft releases security patches through its Windows Update service approximately once a month, although critical updates are made available at shorter intervals when necessary (Wikipedia [MW], 2022).

The Windows 9x series offered the option of having profiles for multiple users but they had no concept of access privileges and did not allow access at the same time and thus they were not true multi-user operating systems (Wikipedia [MW], 2022). Likewise, they implemented only partial memory protection (Wikipedia [MW], 2022). Due to the lack of security, they were widely criticized (Wikipedia [MW], 2022).

In contrast to Windows 9x, the series of Windows NT are true multi-user and implement absolute memory protection (Wikipedia [MW], 2022). However, a lot of advantages of being a true multi-user operating system were destroyed as the first user account created during the setup process was an administrator account which was also the default for new accounts (Wikipedia [MW], 2022).

Windows Vista introduced a privilege elevation system called User Account Control (UAC) due to the issues of user accounts (Wikipedia [MW], 2022). When logging in as a standard user, logon session is created and a token containing only the most basic privileges is assigned (Wikipedia [MW], 2022). In this way, the new logon session is incapable of making changes that would affect the entire system (Wikipedia [MW], 2022). When logging in as user in the Administrators group, two separate tokens are assigned (Wikipedia [MW], 2022). The first token contains all privilege similar to an Administrator while the second token contains privilege similar to a standard user (Wikipedia [MW], 2022). User application, including the Windows-Shell, are then started with the restricted token, resulting in restricted privilege environment even under an Administrator account (Wikipedia [MW], 2022). Requests an application higher privilege, then UAC will prompt for confirmation, if consent is given, the process will start under the unrestricted token (Wikipedia [MW], 2022).

2.5.3 Windows 11

Windows 11 is the latest major release of the Windows NT operating system and was released in October 2021, as a free upgrade via Windows Update and Windows 11 Installation Assistant on eligible devices running Windows 10 (Wikipedia [Win], 2022).

New features of Windows 11 are changes to the Windows shell, including a redesigned Start menu, separate “Widgets” panel on the taskbar, ability to create tiled sets windows that can be minimized and restored from the taskbar as a group and new gaming technologies (Wikipedia [Win], 2022). Internet Explorer has been replaced by Microsoft Edge as the default web browser, and Microsoft Teams is integrated into the Windows shell (Wikipedia [Win], 2022). Microsoft also announced to allow more flexibility in software that can be distributed via Microsoft Store, and to support Android apps on Windows 11 (Wikipedia [Win], 2022).

Regarding security concerns, Microsoft increased the system requirements for Windows 11 over Windows 10 (Wikipedia [Win], 2022). This means that Microsoft only officially supports the OS on devices using processors like an eighth-generation Intel Core CPU or newer, or AMD Ryzen CPU based on Zen+ and on more supported processors (Wikipedia [Win], 2022). The OS can be installed on unsupported processors, but Microsoft does not guarantee the availability of updates (Wikipedia [Win], 2022). Windows 11 also drops support for 32-bit x86 (Wikipedia [Win], 2022).

2.5.4 License Terms

The license agreement is between a user and the Microsoft Corporation and describes the rights of the user and the conditions upon which the user may use the Windows software (Microsoft Corporation, 2018).

Following the section installation and use rights form the Microsoft license terms 2018:

- **License.** It says that the software is licensed, not sold. Also, it grants users the right to install and run one instance of the software on their device (the licensed device), for use by one person at a time, so long as they comply with all the terms of this agreement. (Microsoft Corporation, 2018)
- **Device.** In this agreement, “device” means a hardware system (whether physical or virtual) with an internal storage device capable of running the software. (Microsoft Corporation, 2018)

- **Restrictions.** It says that the device manufacturer or installer and Microsoft reserve all rights (such as rights under intellectual property laws) not expressly granted in this agreement. For example, this license does not give users any right to, and they may not (Microsoft Corporation, 2018):
 - use or virtualize features of the software separately
 - publish, copy (other than the permitted backup copy), rent, lease, or lend the software
 - transfer the software (except as permitted by this agreement)
 - work around any technical restrictions or limitations in the software
 - use the software as server software, for commercial hosting, make the software available for simultaneous use by multiple users over a network, install the software on a server and allow users to access it remotely, or install the software on a device for use only by remote users
 - reverse engineer, decompile, or disassemble the software, or attempt to do so, except and only to the extent that the foregoing restriction is (a) permitted by applicable law; (b) permitted by licensing terms governing the use of open-source components that may be included with the software; or (c) required to debug changes to any libraries licensed under the GNU Lesser General Public License which are included with and linked to by the software; and
 - when using Internet-based features you may not use those features in any way that could interfere with anyone else's use of them, or to try to gain access to or use any service, data, account, or network, in an unauthorized manner.

2.5.5 Shared Source Initiative

The Shared Source Initiative (SSI) is a source-available licensing scheme launched by Microsoft in May 2001 (Wikipedia [SSI], 2021). A source-available software is software released through a source code distribution model that includes arrangements where the source can be viewed, and in some cases modified, but

without necessarily meeting the criteria to be called opensource software (Wikipedia [SAS], 2021).

The project includes a spectrum of technologies and licenses, and most of its source code offerings are available for download after eligibility criteria are met (Wikipedia [SSI], 2021). This allows individuals and organizations to access the source code of Microsoft for reference, for review and auditing from a security perspective, and for development (Wikipedia [SSI], 2021).

Microsoft released five licenses under the SSI while just two of them, Microsoft Public License and Microsoft Reciprocal License, have been approved as opensource license by the Open Source Initiative and as free software license by the Free Software Foundation (Wikipedia [SSI], 2021). Other licenses are still proprietary (Wikipedia [SSI], 2021).

Following the free and opensource licenses:

- **Microsoft Public License (Ms-PL).** This is the least restrictive license of Microsoft and allows for distribution of compiled code for either commercial or non-commercial purposes under any license that compiles with the Ms-PL (Wikipedia [SSI], 2021). Redistribution of the source code itself is permitted only under the Ms-PL (Wikipedia [SSI], 2021). The license and the Microsoft Reciprocal License (Ms-RL) was approved in October 2007 by the Open Source Initiative (OSI). According to the Free Software Foundation, it is a free software license but not compatible with the GNU GPL (Wikipedia [SSI], 2021). It provides a free and flexible licensing for developers, however, the source code may only be distributed under the Ms-PL (Wikipedia [SSI], 2021).
- **Microsoft Reciprocal License (Ms-RL).** This license allows for distribution of derived source code as long as the modified source files are included and retain Ms-RL (Wikipedia [SSI], 2021). It allows those files in the distribution that do not contain code originally licensed under Ms-RL to be licensed according to copyright holder's choosing (Wikipedia [SSI], 2021).

3 Opensource Software

3.1 Definition

The opensource software (OSS) grants users the right to use, study, change, and distribute the software and its source code to anyone and for any purpose (Wikipedia [OSS], 2022). The source code may be made freely available for possible modification and redistribution (Wikipedia [OS], 2022).

Following the main rights granted for users:

- **Inspection.** Users simply want to inspect the source code, using it as a learning resource for understanding how the code and software works, and to learn how to code (Thompson, 2020).
- **Modification.** Users may want to modify the source code, whether for learning exercises or wanting the software to serve a slightly different purpose (Thompson, 2020). Users are allowed to replicate the source code and add additional functions, remove certain features, or change it altogether (Thompson, 2020).
- **Redistribution.** Users may want to redistribute the software whether that is as it is, with their modifications or, sometimes, as a paid product (Thompson, 2020).

Furthermore, users have free control over the software without paying any fees to the creators (Entrepreneur Handbook Ltd., 2013). The ability to examine the source code facilitates public trust in the software (Wikipedia [OSS], 2022).

The OSS promotes open collaboration, meaning any capable user is able to participate in the development (Wikipedia [OSS], 2022). Due to the collaboration of users and developers from all over the world, the OSS is not an “end-product” like the proprietary software as it is constantly evolving (Entrepreneur Handbook Ltd., 2013).

3.2 License

3.2.1 Protective License

Copyleft (also protective license) is an arrangement whereby the software may be used, modified, and distributed freely on condition that anything derived from it is bound by the same conditions (Wikipedia [Copy], 2022). However, copyleft license prohibits that the software is incorporated into proprietary software whether the origin work or any modified versions of it.

The following table gives an overview of the rights granted by using protective license:

Rights granted	Protective license
Copyright retained	YES
Right to perform	YES
Right to display	YES
Right to copy	YES
Right to modify	YES
Right to distribute	YES, under the same license
Right to sublicense	No
Example	LINUX

Table 2: Protective license and rights granted in context of the copyright (Wikipedia [SL], 2022)

A notable protective license is the GNU General Public License (GPL) used by Linux. It stipulates that any modification, development or new software created from the source code must remain forever in the GNU GPL domain (Thompson, 2020).

Moreover, it requires that information necessary for reproducing and modifying the work must be made available to recipients of the software (Wikipedia [Copy], 2022).

This information is usually in the form of source code files, which contain a copy of the license terms and acknowledge the users of the code (Wikipedia [Copy], 2022).

3.2.2 Permissive License

The permissive license guarantees the freedom to use, modify and redistribute the software (Wikipedia [PSL], 2022). It even permits derivative works or future version of the software to be released as a proprietary software (Wikipedia [PSL], 2022). For users or developers, it might be valuable to have the right to modify and exploit the source code written by others and possibly incorporate it into proprietary software and make money with it (Wikipedia [PSL], 2022).

Moreover, the permissive license offers more extensive license compatibility than protective license, which cannot be freely combined and mixed, because their reciprocity requirements conflict with each other (Wikipedia [PSL], 2022).

Examples for permissive license are the BSD, MIT and Apache license.

The following table gives an overview of the rights granted by using permissive license:

Rights granted	Permissive license
Copyright retained	YES
Right to perform	YES
Right to display	YES
Right to copy	YES
Right to modify	YES
Right to distribute	YES, under the same license
Right to sublicense	YES
Example	APACHE

Table 3: Permissive license and rights granted in context of the copyright (Wikipedia [SL], 2022)

3.3 Benefits

Predominantly free

The OSS does not mean by default that the software does not something costs but in most cases it does not. It just says that the source code is openly shared and licensed without any restriction regarding usage, modification, or distribution. However, companies in particular can save a lot of money by using opensource software for their businesses.

Companies benefit from open sourcing their creations, as they can profit from the modifications, updates and improvements made by programmers worldwide, without paying any money for it (Entrepreneur Handbook Ltd., 2013).

Versatility

By using OSS users are not locked into using a particular vendor's system that only works with their other systems such as Apple products (Entrepreneur Handbook Ltd., 2013). Users can adapt the OSS to their needs and usually use it in conjunction with other vendors' products (Entrepreneur Handbook Ltd., 2013).

Security

There is far less room for errors as the OSS offers transparency. Programmers worldwide are continually studying, inspecting and reviewing the source code, meaning that somebody is bound to spot omissions or bugs and fix or remove them (Entrepreneur Handbook Ltd., 2013).

Rapid evolution

Users do not have to request permission from the software vendor to modify the software and thus the development of the OSS evolves rapidly (Entrepreneur Handbook Ltd., 2013) in contrast to proprietary software.

Community

The OSS inspires collaboration from a community of users and developers around the world to make the software the best it can be – this represents the philosophy of opensource software (Entrepreneur Handbook Ltd., 2013).

Training

The OSS promotes the exchange of knowledge between users and makes it far more accessible to people looking to learn about coding and programming (Entrepreneur Handbook Ltd., 2013).

It also provides a vast, ever-growing resource for programmers, allowing far more people to become proficient software developers and innovators (Entrepreneur Handbook Ltd., 2013).

Stability

There is little risk for companies that the software will stop being available as so many developers worldwide are constantly updating the software in the public domain – it makes it reliable for long-term products (Entrepreneur Handbook Ltd., 2013).

3.4 Drawbacks

User-unfriendly

The OSS can tend to evolve more in line with developers' wishes than the needs of the users, as there is no requirement to create a commercial product (Entrepreneur Handbook Ltd., 2013). Thus, the software is usually harder to use and less user-friendly - developers pay less attention to the user interface (Entrepreneur Handbook Ltd., 2013).

No mandatory support

In the OSS community no one is required to help if things go wrong, however, there is no shortage of help available in the worldwide community (Entrepreneur

Handbook Ltd., 2013). It may be possible to pay the price for external support to fix the problem.

Malicious use

The source code is not only available for users but also for malicious users who can potentially view it and exploit any vulnerabilities in it (Entrepreneur Handbook Ltd., 2013). This enables malicious users to mount an attack on people and/or devices.

3.5 Example: Linux Operating System

3.5.1 History

3.5.1.1 General

Linux is a family of opensource Unix-like operating systems based on the Linux kernel (Wikipedia [Lin], 2022). In September 1991, Linus Torvalds, founder of Linux, released the first operating system kernel (Wikipedia [Lin], 2022). Linux is typically packed in a Linux distribution which include the Linux kernel and supporting system software as well as libraries, many which are provided by the GNU Project (Wikipedia [Lin], 2022).

The GNU Project is a free software, mass collaboration project that Richard Stallman announced in September 1983, but the development was initiated in January 1984 (Wikipedia [GNU], 2022). The project is based on the GNU license which gives the users the rights to freely run the software, copy, and distribute it, study it and modify it (Wikipedia [GNU], 2022). It aimed to give users freedom and control in their use of their computers and computing devices by collaboratively developing and publishing software (Wikipedia [GNU], 2022). In December 1992, Linux was made available under the GNU GPL – one year after the first release of Linux (Wikipedia [Lin], 2022). Due to the GNU Project, Linux was the first operating system that was known as a free software (Wikipedia [GNU], 2022).

To support the free software movement, Stallman founded the Free Software Foundation (FSF), a non-profit organization, in October 1985 (Wikipedia [FSF],

2022). It promotes the universal freedom to study, distribute, create and modify software, with the preference for software being distributed under protective license like the GNU GPL (Wikipedia [FSF], 2022). From 1985 until mid-1990s, FSF's funds were mostly used to employ software developers to write free software for the GNU Project (Wikipedia [FSF], 2022). Since then, the employees and volunteers have mostly worked on legal and structural issues for the free software movement and the free software community (Wikipedia [FSF], 2022).

Linux was originally developed for personal computers based on the Intel x86 architecture but has since ported to more platforms than any other operating system (Wikipedia [Lin], 2022). Linux is common in many operating systems for instance the Android OS as well as the Chrome OS. Furthermore, Linux is the leading operating system on servers. It is also used on mainframe computers which are primarily used by large organization and the only OS used on TOP500 supercomputer with a high level on performance since November 2017 (Wikipedia [Lin], 2022). In addition, Linux runs on embedded systems which includes routers, automation controls, smart home technology, television, automobiles, digital video records, video game consoles, and smartwatches (Wikipedia [Lin], 2022).

3.5.1.2 Precursors

In 1969, Unix OS was designed and implemented by Ken Thompson, Dennis Ritchie, Douglas Mclroy and Joe Ossanna at AT&Ts Bell Labs in the US (Wikipedia [Lin], 2022). In 1971, Unix was released, written entirely in assembly language (Wikipedia [Lin], 2022). In 1973, Unix was written in the C programming language by Dennis Ritchie which made it easier to port Unix to different computer platforms (Wikipedia [Lin], 2022).

AT&T was forbidden to enter the computer business due to an earlier antitrust case and thus it was required to license the source code to anyone who asked (Wikipedia [Lin], 2022). As a result, Unix grew quickly and became widely adopted by academic institutions and businesses (Wikipedia [Lin], 2022). In 1984, AT&T separated itself from Bell Labs - freed of the legal obligation requiring free licensing - Bell Labs began selling Unix as a proprietary software (Wikipedia [Lin], 2022).

In 1983, Stallman started the GNU Project with the goal of creating a complete Unix-compatible software system composed of free software (Wikipedia [Lin], 2022). Thus, Stallman founded the FSF and worked on the GNU GPL. In the 1990s, many programs were completed for the OS, although some low-level elements were stalled and incomplete (Wikipedia [Lin], 2022).

A computer science professor called Andrew S. Tanenbaum created MINIX and released it in 1987 as minimal Unix-like OS targeted at students and others who wanted to learn OS principles (Wikipedia [Lin], 2022). The source code of MINIX was freely available but the licensing terms prevented it from being free software until the licensing changed in April 2000 (Wikipedia [Lin], 2022).

3.5.1.3 Creation

In 1991, Linus Torvalds became curious about operating systems while attending the University of Helsinki (Wikipedia [Lin], 2022). As MINIX was limited to educational use only at the time, Torvalds began to work on his own operating system kernel, the Linux kernel (Wikipedia [Lin], 2022).

Torvalds began the development of the Linux kernel on MINIX, and applications written for MINIX were also used on Linux (Wikipedia [Lin], 2022). Later, Linux matured, and further Linux kernel development took place on Linux systems (Wikipedia [Lin], 2022). For the new OS it was advantageous to use the freely available code from the GNU Project compared to MINIX (Wikipedia [Lin], 2022). Due to the redistribution of the source code in other computer programs, Torvalds initiated a switch from his original license, which prohibited redistribution, to the GNU GPL (Wikipedia [Lin], 2022). Developers worked to integrate GNU components with the Linux kernel, making a fully functional and free operating system (Wikipedia [Lin], 2022),

3.5.2 Kernel

The Linux kernel is a free and opensource operating system kernel designed by Torvalds in 1991. It was soon adopted as the kernel for GNU operating system, which was created as a free replacement for UNIX (Wikipedia [LK], 2022).

The benefit of Linux kernel is that it can be tailored for specific architectures and for several usage scenarios using a family of simple commands – without the need of manually editing the source code before compilation (Wikipedia [LK], 2022). Most of the Linux kernel code is written in the programming language C and with the use of architecture specific instructions (ISA) (Wikipedia [LK], 2022). This produces a highly optimized executable with respect to utilization of memory space and task execution times (Wikipedia [LK], 2022).

There is a Linux kernel mailing list (LKML) for announcing day-to-day development discussions (Wikipedia [LK], 2022). Moreover, changes are tracked using the version control system git, also created by Torvalds (Wikipedia [LK], 2022). Linux as a whole is released under the GNU GPL only, with an explicit exception of the Linux system calls, but it also contains several files under other compatible licenses (Wikipedia [LK], 2022).

3.5.3 Distribution

A Linux distribution is an OS made from a software collection that is based upon the Linux kernel and, often, a package management system (Wikipedia [LD], 2022). Users usually obtain their OS by downloading one of the Linux distributions, which are available for a wide variety of systems ranging from embedded devices and personal computers to powerful supercomputers (Wikipedia [LK], 2022).

A typical Linux distribution comprises a Linux kernel, GNU tool and libraries, additional software, documentation, a window system, a window manager, and a desktop environment (Wikipedia [LK], 2022). Most of the included software is FOSS made available both as compiled binaries and in source code form, which allows modification to the original software (Wikipedia [LK], 2022). Usually, Linux distribution optionally include some proprietary software that may not be available in source code form (Wikipedia [LK], 2022). Due to the structure of Linux distribution, Linux has the ability to meet the needs of many users.

The software is usually adapted to the distribution and then packaged into software packages by the distribution's maintainers (Wikipedia [LK], 2022). The software packages are available online in so-called repositories, which are storage locations

around the world (Wikipedia [LK], 2022). There are only a few packages that are originally written by the maintainers of Linux distribution (Wikipedia [LK], 2022), as users modify the software and publish it in the community, for everyone visible and available.

There are almost one thousand Linux distribution due to the huge availability of software (Wikipedia [LK], 2022). It has taken a wide variety of forms, including those suitable for use on desktops, server, laptops, netbooks, mobile phones and tablets, as well as for use in embedded systems (Wikipedia [LK], 2022). Also, there are commercially backed distributions like Ubuntu, and entirely community-driven distributions like Debian (Wikipedia [LK], 2022). Most distributions are ready to use and pre-compiled for a specific instruction set but some distributions are distributed mostly in source code form and compiled locally during installation (Wikipedia [LK], 2022).

4 Discussion

Both proprietary and opensource software have their advantages and disadvantages but it shows clearly that users of proprietary software have a lot more disadvantages than users of opensource software. It seems that users do not want to be dependent on their software vendors for fixing bugs or improving the software. Moreover, it seems that users do not want to have huge packages on their computer storage space when they do not need it. By contrast, users want to inspect the source code or even learn how to program – they want to be part of a community where they can share their knowledge and experience with other users or even developers.

Even Microsoft recognized the potential for sharing the source code with others and thus started the Shared Source Initiative in 2001. The Open Source Initiative and the Free Software Foundation acknowledged just two out of five licenses as free and opensource software. However, Microsoft still has their focus on proprietary software as it is their business.

Regarding the security concerns, opensource software has the advantage of having many users working on it and so detects vulnerabilities faster than proprietary software. As proprietary software usually keeps the source code a secret, it is very difficult as a user to detect any vulnerabilities in it. If there are any vulnerabilities detected, then users have to wait till an update is released by the software vendor.

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