

Draw It or Lose It

# **CS 230 Project Software Design Template**

Version 3.0

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## [Document Revision History](#_grjogdjh5fi8)

| Version | Date | Author | Comments |
| --- | --- | --- | --- |
| 3.0 | 12/10/2023 | Margarita Kiseleva | A software design document meant to provide executive summary of the project, introduce the software design problem, identify design constraints, and present a solution. |

## [Executive Summary](#_sbfa50wo7nsh)

*The Gaming Room company is looking to develop a web game based on their existing one which is called Draw It or Lose It. This game must be similar to the 1980s television game Win, Lose or Draw, where teams compete guessing what is being drawn. The existing game only runs on Android devices. The new game must be web-based and run on multiple platforms.*

*In order to expand Draw It or Lose It to other computing environments, I am proposing to choose Windows as our operation platform. The main reason for that is the fact thar Windows is compatible with most of the tools needed for game development, and most of the target platforms, which will broaden our abilities when it comes to developing and deploying the game. For additional reasons, please consult such sections of the document as* ***Evaluation*** *(page 5) and* ***Recommendations*** *(page 6).*

## Requirements

* *The game must be able to accommodate one or multiple teams.*
* *Each team in the game must be able to accommodate multiple players.*
* *When choosing a name for a team, users must be able to check whether the name is available to make sure the team names are unique.*
* *The game must always have only one instance of the game in its memory.*
* *The game must have a library with a certain number of stock drawings.*
* *The game must be web-based and run in a distributed environment.*
* *The game must run on multiple platforms in addition to Android.*

## [Design Constraints](#_2et92p0)

*Platform constraint: The game must be developed in a way that will allow its operation on multiple platforms in addition to Android. We must ensure that the game is optimized for each platform and provides a positive user experience. Additionally, unique features of distributed systems and networks must be taken into consideration (please see page 7 for more details regarding such systems).*

*Coding constraint: The game must be able to handle one or multiple teams playing it simultaneously. It must also account for the fact that each team will most likely have multiple players. Only one Game instance can exist withing the game at any given moment. Each Game, Team, and Player must always have unique names. This can be achieved by creating unique identifiers for each instance of the Game, Team, and Player. Additionally, the game must have a library for storing stock images (please see page 7 for more information on storage management).*

*Coding language constraint: Given that the game must run on various platforms, the code should be written in one language that will target those platforms. As it is decided to develop a web game, it is highly recommend using JavaScript as our coding language. JavaScript code will run equally well on other platforms in addition to Android.*

*Security constraint: The game must ensure that personal information of the users is protected from cyber-attacks and malicious software. Such protection can and must be achieved through secure coding practices, data encryption, and user authentication architecture. Additionally, built-in and additional security features of Windows must be incorporated and utilized effectively (please see page 9 for more details on security features).*

## [System Architecture View](#_ilbxbyevv6b6)

Please note: There is nothing required here for these projects, but this section serves as a reminder that describing the system and subsystem architecture present in the application, including physical components or tiers, may be required for other projects. A logical topology of the communication and storage aspects is also necessary to understand the overall architecture and should be provided.

## [Domain Model](#_8h2ehzxfam4o)

*We will begin analyzing the UML class diagram noting that it consists of seven classes. A* ***class*** *is a data type created by a developer, and it normally has* ***attributes*** *and* ***methods****. When creating a class, developers simplify it down to the attributes and methods that are needed specifically for the code. There is no need to describe each class in its entirety. This principle of object-oriented programming is referred to as* ***abstraction****.*

*The first class we consider is called* ***Entity****. This class has two attributes: id and name. Each attribute takes a specific type of an* ***argument*** *(id takes a data type long and name takes a string data type). Both attributes are marked* ***private*** *(“-” symbol is used). The fact that those attributes are private means that those properties can only be accessed by the same class that declared them. This is a good example of such principle of object-oriented programming as* ***encapsulation****. Access to the object's data must be controlled by the developers so that users cannot change it arbitrarily and break something. Additionally, Entity class has five methods, one private (Entity) and four* ***public*** *denoted by the symbol “+” (Entity, getId, getName, and toString). As we can notice, there are two methods with the same name (Entity). The difference between them is that the first one is a constructor method, and it takes no arguments. The purpose of this method is to ensure that only one instance of Entity is created and exists at any given moment. The second Entity takes two arguments: id of type long and name of type string.*

*Entity class is a* ***parent class*** *for three* ***children classes****: Game, Team, and Player. This demonstrates such principle of object-oriented programming as* ***inheritance****, where parent classes can pass their attributes and methods to descendant classes. The reason why we know that the Entity class is a parent for those three classes is because they are connected with the* ***inheritance arrow****. This basically means that Game, Team, and Player classes inherit attributes and methods of Entity class. Thus, developers will not need to declare those again and again. Additionally, each of the children classes have their own attributes and methods which make them unique. For example, Game and Team classes have a List attribute, which will help developers keep track of all instances of these classes that were created. Player class, for example, has a method which allows developers to take note of player’s ID and name. This will help us ensure that each player has a unique identification and name.*

*We see that children classes Game, Team, and Player are connected by* ***association lines****. This means that these are* ***peer classes****. There is also a* ***cardinality*** *denoted on those lines (“0…\*”). This means that there can be from 0 to more of those classes.*

*Additionally, there is a class GameService associated with Game. This class has six public accessor methods (the ones starting with “get”), one private constructor, and one public method which adds a new Game to the list of Games.*

*At the top left of the diagram, we can see two classes: ProgramDriver and SingletonTester. Ther are connected by an arrow showing that ProgramDriver sends a synchronous message to SingletonTester. Synchronous call typically represents an operation call which sends message and suspends execution while waiting for response.*

**"The Gaming Room UML diagram. The top of the diagram is labeled as com dot gamingroom. Test boxes are placed in two layers. The first layer has three text boxes and the second layer has four of them. In the first layer, the 'ProgramDriver' textbox points to 'SingletonTester' textbox. The 'ProgramDriver' textbox contains the text 'asterisk main round brackets.' The 'SingletonTester' textbox contains the text 'asterisk testSingleton round brackets.' The arrow between these two text boxes are labeled 'open two angle brackets uses close two angle brackets'. In the second layer, there are 'GameService', 'Game', 'Team', and 'Player' text boxes. The 'GameService' textbox has texts arranged in two layers. The first layer contains games colon List open angle bracket Game close angle bracket, nextGamesId colon long, nextPlayer Id colon long, nextTeamId colon long, and service colon GameService. The second layer contains GameService round brackets, getinstance round brackets colon GameService, addGame open parenthesis name colon String close parenthesis colon Game, getGame open parenthesis id colon long close open parenthesis colon Game, getGame open open parenthesis name colon String close open parenthesis colon Game, getGameCount round brackets colon int, getNextPlayerID round brackets colon long, and getNextTeamId round brackets colon long. The 'GameService' box is connected with the 'Game' textbox with a line labeled 'zero dot dt dot asterisk'.  The 'Game' textbox also contains text in two layers. The first layers contains the text teams colon List open angle bracket Team close angle bracket. The second layer has Game open round bracket id colon long comma name colon String close parenthesis, addTeam open parenthesis name colon String close parenthesis Team, toString round brackets colon String. The 'Game' textbox is connected with the 'Team' textbox with a line labeled 'zero dot dt dot asterisk'. The 'Team' textbox also contains text in two layers. The first layers contains the text players colon List open angle bracket Player close angle bracket. The second layer has Team open parenthesis id colon long comma name colon String close parenthesis, addPlayer open parenthesis name colon String close parenthesis colon Player, and toString round brackets colon String. The 'Team' textbox is connected with the 'Player' textbox with a line labeled 'zero dot dt dot asterisk'. It contains the text Player open parenthesis id colon long comma name colon String close parenthesis and toString round brackets colon String. The 'Game', the 'Team, and the 'Player' boxes point to the 'Entity' textbox in first layer. The 'Entity' textbox contains text in two layers. The first layer has the text id colon long and name colon String. The second layer has Entity round brackets, Entity open parenthesis id colon long comma name colon String close parenthesis, getId round brackets colon long, getName round brackets colon String, toString round brackets colon String.**

## 

## [Evaluation](#_2o15spng8stw)

| **Development Requirements** | **Mac** | **Linux** | | **Windows** | **Mobile Devices** |
| --- | --- | --- | --- | --- | --- |
| **Server Side** | *Mac OS is based on Berkeley Software Distribution, which essentially means that it is rather stable and* ***well-equipped for managing various hosting challenges****. Mac OS is a property of Apple; thus, the* ***licensing price is included in the price of the Apple hardware****, and any updates are normally easily available to and free to download. However,* ***Mac OS is only available on Apple hardware****, which represents a certain constraint for the developers. Additionally, it is important to note that* ***Mac is normally used for hosting web applications on a rather small scale****. Large scale applications can also be developed with Mac, but it is a less common practice****.*** *The most popular way to deploy web applications with Mac is* ***hosting them on a built-in Apache server or a separate software MAMP.*** | *Linux is well-known for being* ***a stable platform which can run even for several days without the need to be rebooted****. Linux* ***rarely experiences malware, cyber threats, or other security errors****. Linux distributions have almost completely taken over the web server market. According to the rating of the analytical agency W3Techs, 75.1% of websites are deployed on Linux servers. Because Linux is an open-source software,* ***there is no licensing cost associated with the server operating system. However, for enterprise-level support, certain paid subscriptions might be require****d. For Linux, the most popular server-based deployment method* ***is hosting web applications using Apache or Nginx web servers.*** | | *Almost all Microsoft developments (ASP, Microsoft SQL Server, ASP.NET, Microsoft Access, Microsoft SharePoint, Microsoft Exchange, Visual Basic, Remote Desktop, C#, etc.) are classified as* ***proprietary software****. It will be necessary to* ***purchase a Microsoft Windows Server license****, pay for the use of application software and applications. The cost will be determined primarily by the OS version and licensing. For reference, Windows 10 Home costs approximately $139, and Windows 10 about $199. The most popular server-based deployment method for*  *Windows is* ***hosting web applications using Microsoft IIS or Apache****.* | *Firstly, it is important to note that operating platforms for mobile devices are not limited to* ***Android*** *and* ***Apple******iOS****, but also include such platforms as* ***Microsoft Windows Phone****,* ***Google****,* ***Sailfish****,* ***Blackberry****, etc. However, android and Apple iOS are dominant on this market. Performance-wise, mobile applications are normally speedy due to the fact that they are hosted on local databases. The main disadvantage of mobile devices is their lack of security when it comes to personal data of users.* ***Normally, no license needs to be purchased as it comes built into the device****. Both leaders in the mobile device industry,* ***iOS and Android, offer native development frameworks that are used to develop mobile applications****. Once developed, the* ***mobile application communicates with the back-end web application while running on the server using various web APIs****.* |
| **Client Side** | *Mac OS combines design, development, programming, and testing tools into one system. The ability to run server-side applications and engines locally on your computer along with standard web development tools provides faster performance and efficient testing.* ***However, it is important to have a person or multiple people on the team who are experienced with all the tools provided by Mac OS.*** *Many developers enjoy working on Mac laptops because Mac OS itself is very stable, and the hardware in Apple computers is also reliable and durable.* ***This software system is the best option for full-fledged software development for Apple hardware: Mac Books, iPads and iPhones****. A unified developed ecosystem with AirDrop, iMessage, FaceTime, iCloud work seamlessly together, and the transition between apps is smooth. Most Mac OS users hardly ever encounter problems from viruses and malware, even if they don't have antivirus, which is a great plus for the budget****. To ensure the application is compatible with all web browser platforms and mobile devices, the team of quality assurance specialists will need to test the game on different devices and in various browsers.*** *This way we will ensure the correct execution is taking place.* ***It is important to account for possible inconsistency in design on different platforms.*** *There are some differences between user interfaces and user experience on different platforms. For example, Windows has a start button, but macOS doesn't have an analogue.* | | *The most important thing to mention when it comes to Linux is that it is admittedly* ***difficult to use, especially for those with no technical experience****. Thus, in order to fully benefit from this platform,* ***developers must be familiar and comfortable with using Linux****. The platform actually has a lot to offer. Linux supports different security* ***parameters that protect against viruses, slowdowns, malware, crashes****. This is the main reason for the popularity of this OS among developers. Of course, Linux is not a 100% secure OS, but it is less vulnerable than others. Many organizations have modified Linux by releasing their own distributions. The most popular ones are Debian, Ubuntu, Linux Mint, Arch Linux, MX Linux, Fedora, Manjaro, and CentOS. Linux Mint and Ubuntu are suitable for beginners, while Arch Linux, Fedora and Debian are suitable for experienced developers. The distribution can also be built by yourself. Admittedly, the interface of most versions of Linux differs significantly from the familiar Windows and macOS, which can represent a certain difficulty for unexperienced developers.* ***To make sure the web game is working correctly, it must be tested by the quality assurance team. They will need to run it on different devices and in various web browsers to see if the game behaves as it is supposed to.*** | *Windows provides an environment that is similar to our good old home computers, and it is easy to use.* ***It is tremendously easier to find developers experienced in working with Windows than with any other OS****. Windows fans note that this system is easier to customize, and it's also more functional and suitable for more tasks. Also,* ***Windows is the best option for gamers****. On macOS and Linux, the selection of games is very limited. The best gaming computers with powerful graphics exist only in the Windows world. Many people like the fact that Windows supports MST: closing a window closes the application as well, and the audio mixer allows you to adjust the volume of each application separately, not just all of them at once. Plus, it's more convenient to work on windows using only the keyboard. According to many developers,* ***Windows is better suited for the corporate work environment****. When it comes to Windows,* ***there is no need to overpay for a brand****. You can fully use the operating system from Apple only if you are a happy owner of branded equipment. In the meantime, anyone can buy and install a copy of Windows on their device.* ***Just as with any other OS, a team of software testers will need to run the web game and make sure it works on other platforms as well as it does on Windows****.* | *The main characteristic of mobile devices is their portability, which makes it very appealing for users to access websites, apps, and web-based games through their smartphones****. It is important to have a developer experienced in dealing with mobile devices as in addition to the cross-platform, any mobile device can use different web browsers.*** *For example, a user with an Android phone can access a web site using both the default browser and Opera Mini, Firefox Mobile, or Yahoo.*  ***Common problems for developers working with mobile devices are screen size, orientation, and touch sensitivity.*** *There are a lot of mobile devices, and they all have different sizes. Moreover, each new model comes in a slightly different dimensional variation. This means that a* ***developer can't make a cut and paste design, it has to be customized****. It is necessary to take into account* ***possible difficulties with app marketplaces. The mechanism and requirements for cross-platform applications in Apple App Store and Google Play Store marketplaces are different****. Going through all the bureaucratic procedures, checks and tests can be time-consuming and cause some difficulties. Another important detail to note when it comes to mobile devices is* ***that cross-platforms applications have lower performance and reliability than native apps****. Loss of flexibility in development will also mean loss of opportunities for performance improvement and optimization. In other words, all things being equal, cross-platform solutions will not be as fast, reliable, secure, and smooth as native applications. Thus****, it is important to work towards minimizing this gap****.* |
| **Development Tools** | *Web apps to be deployed on Mac are typically developed using* ***JavaScript, Python, or Ruby for the back-end****, and* ***HTML/CSS/JavaScript for the front-end****. Mac OS also supports* ***Objective-C, Swift****, and* ***C++****.*  *For server-side development, Mac uses tools such as* ***PyCharm*** *or* ***WebStorm****. The most well-rated development tools for Mac OS are* ***Xcode****,* ***Visual Studio Code****,* ***AppCode****, and* ***Sublime Text****. Xcode is Apple's official integrated development environment (IDE).* ***Xcode provides extensive capabilities for creating and debugging Mac OS applications****. It includes a variety of tools such as code editor, device simulator, debugger and more****. Visual Studio Code is a popular free code editor that has support for extensions for various programming languages, including Swift and Objective-C****. Visual Studio Code provides modern development features such as code autocomplete, version control integration and debugger.* ***AppCode is an intelligent development environment designed specifically for developing Objective-C, Swift, and C/C++ code for Mac OS****. AppCode is packed with powerful features including code analysis, automatic bug fixing, refactoring support, and more****. Sublime Text is a lightweight and flexible code editor that allows you to develop programs on Mac OS****. Sublime Text supports many languages, and it extensions and has many useful features such as multiple cursors, fast file navigation and command line. You can also use the following tools to work with databases on Mac OS:* ***MySQL Workbench, PostgreSQL****, and* ***MongoDB Compass****.*  *MySQL Workbench is a tool for working with MySQL databases, providing opportunities to create and modify schema, write and debug SQL queries.*  *PostgreSQL is a powerful open-source DBMS that provides extensive data storage and processing capabilities. MongoDB Compass is a graphical interface for working with MongoDB database, allowing to visualize and analyze data.* | *Web-based apps for Linux are developed with languages like* ***JavaScript, Python, or PHP for the back-end, and HTML/CSS/JavaScript for the front-end****. Linux developers use text editors such as* ***Visual Studio Code****,* ***Sublime Text****, and* ***Vim*** *for coding. For server-side development, they utilize IDEs like* ***PyCharm*** *for Python or* ***WebStorm*** *for JavaScript. The best IDEs for Linux are* ***Eclipse****,* ***Bluefish****,* ***NetBeans, Zend Studio****, and* ***Komodo****.* ***Eclipse*** *is a* ***free*** *open-source editor designed for heavy development in Java. Can work with the following programming languages****: Ruby, Java, C, Perl, Python, PHP, C++.*** *Among its perks are support for a large number of programming languages, availability of any plugins for extending capabilities, tools for Java EE projects, tools for Java development, plugin development environment, Junit integration, and git system support.* ***Bluefish*** *is a* ***free*** *and open-source project that is oriented both to Web-developers and ordinary programmers. It can work with:* ***ASP .NET, HTML5, C++, C, CSS, JS, Pearl, Ruby, Java, PHP, SQL, and XML****. It is fast, clean, and lightweight. It also supports multithreading.*  *Bluefish has Auto-recovery after crashes and a powerful search and replacement tool.* ***NetBeans*** *is a* ***free*** *and open-source IDE from Sun Microsystems. It supports such languages as* ***Java, Python, C++, C, Ruby, PHP, JavaScript****. It has a user-friendly interface, and it is cross-platform. NetBeans has dynamic and static libraries, a multi-session GNU integrated debugger, and it supports universal run and debug commands. PHP programmers use Zend Studio to write code quickly, solve problems easily, and integrate freely into the cloud. Zend Studio, PHP Unit, and Composer form a single unit and become a powerful tool for mobile and PHP developers.* ***Zend Studio*** *supports most databases, and it has a real-time error detection mechanism.*  *Zend Studio supports code refactoring and has source code management options.*  *Komodo IDE has won many awards. It supports the following programming languages:* ***Python, PHP, HTML, Perl, RHTML, C, CSS, CSS, C++, JS, Ruby, Django****. This IDE is cross-platform, and it has graphical debugging mechanism, advanced editing features with multi-window and split view along with lots of add-ons and customization options.* ***The regular and educational licenses of Komodo IDE are free, while the personal and enterprise versions are $99 and $295 each, respectively.*** | | *Web-based apps for Windows are created with* ***JavaScript, Python****,* ***and such languages as C# for the back-end, and HTML/CSS/JavaScript for the front-end****.*  *The most popular IDEs for programming on Windows are* ***Visual Studio, NetBeans, JetBrains Rider****, and* ***IntelliJ IDEA****. As we have covered both Visual Studio and NetBeans in the previous column, now we will take a closer look at the remaining three.* ***JetBrains*** *Rider is a powerful IDE, and it is cross-platform. This IDE took all the best features from IntelliJ and ReSharper, and it offers great live code analysis in addition to refactoring system. Additionally, JetBrains Rider offers testing and debugging tools, database integration, and unit testing. This IDE is extremely popular with game developers, and the main reason for this is that Rider has unique features for developing on such platforms as Unity and Unreal Engine. Rider is also distinguished for its high speed and user-made plugins support****. Rider from JetBrains does not have a community or learning edition, it only has a paid version****.* ***IntelliJ IDEA*** *supports Java, JavaScript, Python, and other programming languages. It features an extensive set of tools for refactoring and optimizing code****. IntelliJ IDEA Ultimate is a professional paid version****. IntelliJ IDEA Ultimate is designed for full-stack development and creating enterprise applications. It supports a wide range of frameworks and technologies for backend and frontend and includes tools for profiling and working with databases, HTTP-client and many other features.* ***IntelliJ IDEA Community Edition is free for personal and commercial use****. Compared to the Ultimate version, its functionality is significantly reduced: there is no built-in HTTP client, no database tools, no support for collaboration and remote access.* | *Web-based apps meant to be deployed on mobile devices can be developed in* ***HTML/CSS/JavaScript using libraries to support the front-end and general-purpose languages, such as Java, Python, PHP, and Ruby. You can use the following tools to develop iOS mobile apps on Mac OS: Apple Developer, React Native, and Flutter.*** *Apple Developer is a suite of tools for iOS app development including Xcode and iOS.*  *React Native is a framework for developing mobile apps for iOS and Android using JavaScript.*  *Flutter is a framework from Google for creating cross-platform mobile apps. Android Studio is an IDE for working with the Android platform. It allows you to develop applications for smartphones, tablets, watches, TVs and other devices running on this OS. It is suitable for interaction in Java and Kotlin languages. With its help, developers create applications for mobile devices, tablets, TVs, watches and other devices. This IDE contains tools for developing, debugging, testing, and tracking application performance.* ***Android Studio is free and runs on Windows, Mac and Linux****. Applications can be immediately published to the Google Play store. Android Studio helps you save time in screen layout and avoid syntax and logic errors in your code.* |

## Recommendations

**Operating Platform***:*

*Considering what is best for our web-based game Draw it or Lose it, the choice would be between Windows, MacOS, and Linux. If we were planning to build a game that was only going to be released on mobile, and iOS specifically, then MacOS would be the best option. Linux is an excellent OS for many goals, however, as of today, game development is not one of those.* ***Given that we are planning to target various platforms, I would highly suggest that we go with Windows.******Windows is compatible with most of the tools needed for game development, and most of the target platforms. This will help us expand Draw It or Lose It to other computing environments.***

*It wasn't that long ago that it seemed like Windows OS was doomed. Developers would give Apple software and hardware a strong preference because MacOS is a derivative of BSD-Unix, which allowed developers to quickly install the same toolsets on their laptops as they would on their servers or in the cloud. If the right applications were not available, developers could install a Parallels Desktop virtual machine and run the right Windows applications as if they were part of the MacOS desktop.*

*Developers are pioneers, and no matter where they go, everyone else will eventually follow. It was the time for Windows to change by providing a developer-centric environment without changing the way everyone else uses their PCs. This has been a challenge for Microsoft, but the company has come a long way toward accomplishing it.*

**Operating Systems Architectures***:*

*Windows OS architecture is a complex system divided into several subsystems, which interact with each other to ensure the operation of the operating system as a whole. Knowing the basic concepts and structure of the Windows architecture is essential to understanding its operation and capabilities. The main components of the architecture include the* ***operating system kernel, user mode subsystems, and kernel subsystems****.*

*Windows* ***operating******system kernel is responsible for managing and controlling access to computer resources****. It provides basic operating system functions such as task scheduling, memory management, disk input-output, and interrupt handling. In addition, the kernel interacts with the hardware layer of the computer through device drivers.*

*The* ***user mode subsystem is a component that provides an interface for user interaction with the operating system****. It provides the execution of user applications, including displaying the graphical user interface, processing input, and launching applications. Also, this subsystem contains components such as file system and multitasking support.*

***The kernel subsystem is a component that provides interaction between the operating system kernel and the user-mode subsystem****. It provides interfaces and services for interacting with the operating system kernel and transferring data between subsystems. The kernel subsystem also provides control and security for operating system functions.*

*Windows operating system architecture includes many other components and modules that work together to ensure system stability and performance. All those components interact with each other to ensure that the operating system is fully functional and meets the needs of the user.*

***The Windows operating system is based on several key concepts that define its structure and operation****.*

*The first concept is* ***multifunctionality****. Windows provides a wide range of features and capabilities for working with different types of applications and tasks. It supports a variety of graphical interfaces, including a window interface that allows us to work with multiple applications in different windows at the same time.*

*The second concept is* ***multitasking****. Windows allows multiple programs to run at the same time, ensuring that system resources are allocated efficiently between them. This allows the user to work with different applications in parallel and without rebooting the computer.*

*The third concept is* ***separation of rights and data protection****. Windows provides a mechanism for differentiating user rights, which allows us to restrict access to certain system functions and data. This provides security and information protection.*

*The fourth concept is* ***extensibility and modularity****. Windows allows us to expand the functionality of the system by installing third-party applications and drivers. This provides flexibility and the ability to customize the operating system to meet individual user needs.*

*The fifth concept is* ***compatibility****. Windows is designed to be compatible with previous versions of the operating system and with other software and hardware. This allows existing applications and devices to be used on newer versions of Windows without having to modify or replace them.*

**Storage Management***:*

*Data Storage is used to hold all data that can be recovered after the PC is turned off. Storage holds all files, documents, programs, operating system, and other data that the user needs.*

***In Windows OS, there is a section called "Storage" for data management, which allows us to get detailed information about how much space on the hard disks is occupied and clean it from temporary files, trash, and unnecessary applications****.* ***In addition, here we can set a particular place to save data (documents, videos, music, etc.)****. To use this tool, we need to open the Settings panel by clicking the Start button on the taskbar and selecting Settings. In the Options panel that opens, we will select System. Next, we will select the "Storage" section. Here, we will see a list of available disks and the amount of free space on each of them. By selecting a particular disk, we will see what is taking up space on it. The next window will give us a detailed layout of the types of data that are taking up disk space. Different categories respond differently when we click on them. Clicking on each category will give us more information as well as the ability to delete files and folders that are not needed. Also, scrolling down to the bottom of the page within the "Storage" section, we will see that we can save various kinds of data to a specific location. This option comes in handy if you want to automatically save certain data to another partition on the disk or to an external storage device, such as an SD card or a flash drive.*

*I would like to point out a relatively new feature of Windows that allows you to automatically delete temporary and unused files on your computer, clean out old items in the Recycle Bin, which is called* ***Storage Sense****. Normally, Storage Sense on Windows is disabled by default. But if there isn't enough free space on the system disk, Windows automatically brings up the Storage Sense interface and prompts you to use it to delete unused files. The user can control the Storage Sense cleanup settings in Windows from Settings -> System -> Storage.*

*At the top, there is an on/off switch to enable the memory monitoring feature. Here you can specify whether to delete unused temporary files, OneDrive files (only unused files will be deleted from the local disk, cloud files will remain in place), files in the Downloads folder, and files from the Windows Recycle Bin. Using the "Clean Now" button you can delete all the specified files immediately, which is useful when you urgently need to free up disk space. If you enable and configured memory control, Windows will automatically delete selected files, freeing up disk space for you.*

*The following files that Windows considers temporary are deleted:*

* *Temporary installer files;*
* *System cache;*
* *System files;*
* *Browser cache;*
* *Temporary Windows update files;*
* *Unused drivers in FileRepository directory;*
* *Memory dumps and minidumps;*
* *Old system log files.*

*Additionally, Windows OS offers* ***Cloud Server*** *storage options providing developers with plenty of storage space needs. Data stored in a cloud can be easily accessed from any device.*

**Memory Management***:*

*Memory is a temporary storage of data used to perform a task. It allows you to quickly access and process information. All the information that the computer is processing at the current moment in time is in memory. Memory is one of the most important components of a computer, which is responsible for storing and processing data. Without it, you cannot run any program or game. However, memory is limited, and if it is exhausted, your computer may slow down or freeze.*

***Memory Manager*** *is a component of the Windows kernel that handles the physical memory of the operating system. Physical memory is the actual amount of RAM available on the computer. The Memory Manager performs the following basic tasks:*

* ***Virtual management****. For each process Memory Manager creates its own address space aka virtual memory. Virtual memory is a logical representation of physical memory that allows processes to work independently of each other and not conflict for resources. Virtual memory can be larger than physical memory because some of it can be stored on the hard disk as a swap file. Memory Manager is responsible for mapping virtual memory to physical memory, that is, what data and where it is stored in RAM or on disk.*
* ***Dynamic management****. Memory Manager allocates and frees memory at the request of processes. When a process starts, it gets a certain amount of memory for its needs. When the process terminates, it returns the memory back to the system. In addition, a process can dynamically change its memory needs depending on its operation. For example, if you are opening a large file in a text editor, it needs more memory than if you are just typing text. Memory Manager monitors these changes and reallocates memory between processes according to their priorities and activity.*

*In order to manage memory efficiently, Memory Manager uses various parameters and algorithms. For example, it takes into account:*

* ***Process working set****. This is the amount of memory that the process is actively using at the moment. The larger the working set, the faster the process runs because it does not need to access the disk for data. However, if the working set is too large, it can take up memory that other processes need. Therefore, Memory Manager periodically reduces the working sets of processes that are inactive or low priority.*
* ***Memory pages****. These are the minimum units of memory that Memory Manager deals with. The page size depends on the processor architecture. Memory Manager divides virtual and physical memory into pages and monitors their state. Pages can be free (not in use), busy (containing data), modified (containing data that has been changed from disk), or prepared (containing data that is ready to be written to disk). Memory Manager moves pages between RAM and disk depending on their state and the needs of the processes.*
* ***Page lists****. These are data structures that store information about memory pages. Memory Manager uses several page lists for different purposes. For example, there is the Free Page List, which contains pages that are not used by any process and are available for allocation. There is the Modified Page List, which contains pages that have been modified from disk and need to be written to disk. There is a Prepared Page List (Standby Page List), which contains pages that have been unloaded from RAM but have not yet been overwritten on disk and can be quickly restored. There is a Zero Page List, which contains pages that have been cleared of data and are ready for use. Memory Manager moves pages between these lists depending on their state and the needs of the processes.*

*In addition, Memory Manager uses various algorithms to optimize memory usage. For example, it applies:*

* ***LRU (Least Recently Used) algorithm****. This is an algorithm that determines which memory pages should be unloaded from RAM to the swap file or freed for other processes. It is based on the principle that the longer a page has not been used by a process, the less likely it is to be used in the near future. Therefore, the memory manager prioritizes those pages that have been used recently and unloads those that have been used for a long time.*
* ***PFN (Page Frame Number) algorithm****. This is an algorithm that determines which memory pages should be written to disk or loaded from disk. It is based on the principle that the higher the page frame number (physical memory address), the less likely it is to be used in the near future. Therefore, the memory manager prioritizes those pages that have a lower frame number and writes or loads them first.*

*Thus, Memory Manager is a complex and feature-rich component of Windows that manages the physical and virtual memory of the operating system. It uses various parameters and algorithms to allocate and optimize memory between processes.*

**Distributed Systems and Networks***:*

*A* ***distributed system*** *is a set of independent computers that are presented to the user as a single coordinated system. Computers in a distributed system communicate with each other to achieve a common goal. They can reside in a single physical location or be dispersed.* ***The main advantage of a distributed system is that it can beat a single computer system in terms of performance, reliability, and availability.***

*The key components of distributed systems are multiple* ***nodes****,* ***communication networks*** *and* ***distributed middleware*** *that manages communication between nodes. Nodes are independent computing entities that communicate with each other. The communication network acts as a medium for information exchange between the nodes. Distributed middleware in distributed systems refers to the software layer between distributed applications and the underlying network infrastructure, providing services such as communication, coordination, and resource management to ensure efficient and reliable distributed computing. Distributed systems architecture is designed to achieve fault tolerance (the ability to continue operating in the presence of node failures or network problems), scalability, and high availability.*

***For distributed systems to work, a task must be divided into smaller subtasks and distributed to multiple nodes or computers on the network. These nodes or computers then communicate with each other to accomplish the task.***

*Distributed systems are used in many applications, including social networking platforms, cloud computing, online commerce, and web-based games and apps. Below are distinctive characteristics of distributed systems which set them apart from any other computer system.*

* *Multiple processes can be happening at the same time, and this feature is called* ***concurrency****.*
* *To accommodate growing workloads and allow more users to be engaged, distributed systems must be able to scale horizontally by adding more nodes, which is called* ***scalability****.*
* *Distributed systems must be able to withstand failures of individual nodes or components so that the overall system is not affected, which is referred to as* ***fault tolerance****.*
* *Nodes may have different hardware, software, and network configurations, and this is known as* ***heterogeneity****.*
* *Distributed systems must offer consumers transparent access to network resources and services as users do not need to be aware of the complex operation of the underlying system, and this feature is referred to as* ***transparency****.*
* *To protect against unauthorized access, data leakage and other cyber risks, distributed systems must be built securely, and this feature of distributed systems is known as* ***security****.*
* *In case of simultaneous updates and failures, distributed systems must keep data consistent across various nodes, and this ability is called* ***consistency****.*
* *Distributed systems must be able to perform at an acceptable level despite the increased transmission costs and other complexities associated with distribution, and this feature of distributed systems is known as* ***performance****.*

*Of course, when it comes to distributed systems, the fact that they consist of multiple components means that they are susceptible to such issues as* ***power outages and connectivity problems****. In order to prevent or manage such issues, it is necessary to make sure the company’s servers are strong enough to accommodate a large number of players. Additionally, it is critical to have backup power sources in case an outage occurs.*

**Security***:*

*As one might expect, the number of malicious programs for an operating system is directly proportional to its popularity.* ***Windows dominates the market and is therefore the most popular target for cybercriminals****. When you look at the actual numbers, it seems that there are virtually no threats to Linux, for example. This is one of the reasons why some consider Linux to be a more secure system than Windows.*

*In recent years, Windows Microsoft has made many changes to its code base designed to improve security. The company developed its own* ***Microsoft Defender antivirus program****, improved the* ***firewall****, and integrated an isolated* ***Windows Sandbox*** *environment to restrict applications from accessing RAM and other programs. Microsoft Defender scans for viruses, malicious software, and other security threats that are abundant nowadays. By default, current versions of Windows will warn you if you download an executable file from the Internet using a technique called "****Mark of the Web****".* ***Digital signature checks*** *are also performed on executable files to ensure that the software comes from a trusted source. As threats to security are constantly changing, the system updates automatically to keep itself up-to-date and to ensure the safety of user information.*

*Microsoft claims that Windows 11 is the most secure Windows ever. However, Windows security improvements require new system specifications and requirements. Therefore, to take full advantage of the security improvements, your Windows PC must have TPM (****Trusted Platform Module****) 2.0 installed. It must also support secure boot to prevent malware from attacking the boot process. The computer uses the TPM 2.0 chip to store encryption keys and support other security features, including BitLocker to protect data and Windows Hello to protect personal data. It's not just your security systems that use TPM. Applications like Firefox, Chrome, and Outlook use it for certain encryption tasks. The operating system also requires at least 4 GB of memory, 64 GB of disk space, and a dual-core 1 GHz processor compatible with 64-bit.*

*Windows 11 comes with Microsoft Defender antivirus built in. In previous versions, the antivirus was always considered terrible due to its inability to detect malware. However****, over the past few years, Microsoft has made welcome changes that have improved Defender, and it is now one of the Best Free Antivirus Apps****. The antivirus can detect, block, and neutralize malware and is rated better than some competing paid options.*

*The operating system also includes* ***Microsoft Defender SmartScreen****, a service that Microsoft Edge uses to keep you safe while browsing the Internet. SmartScreen checks the websites you visit against a list of known malicious sites. If it finds a relevant site, it is blocked.*

***In addition to security features provided by Windows, it is also important to use secure coding practices, data encryption, and user authentication architecture****. These extra steps will help us ensure that the developed game is secure and accountable for user data protection. Finally, it is aways recommended to conduct regular security checks and tests to detect and fix possible vulnerabilities in the application architecture.*