Secure File Vault

Research Manual

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Abstract

A file vault protects individual files or data by encrypting them using different encryption methods. When the user wants to view the files, they login into the cloud to view the files or decrypt data for the user, I will also clarify why users and businesses should use cloud storage instead of storage on their own devices.

Have you ever run out of storage space on your laptop or computer and had to invest in external memory? Have you ever thought about any other options?

Unfortunately, this has happened to me and has led me to create my project. Many people each day run out of storage space on there on devices. But not many people think about using cloud storage to store their data. People are afraid of storing their data in a cloud because they don't know where the cloud is. A cloud is just a set of servers that are stored on an offsite location. Users are also afraid of how their data is being stored. Recently there have been many cyber-attacks on cloud systems. According to the 2020 Trustwave Global Security Report, attacks on cloud services have doubled from 2019 and have accounted for 20% of investigation incidents. Cloud systems are now the third most targeted environment for cyber-attacks. The purpose of my project is to create the most secure cloud system on the market. (Thomas, 2020)

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Introduction

In this research document, I will discuss how I will create a file vault infrastructure that will provide cloud storage for users. I will also clarify why users and businesses should use cloud storage instead of storage on their own devices. The growth of cloud storage is expected to excel in the next couple of years. The cloud storage market is excelling as small, medium, and large enterprises are investing in low-cost data storage services as it's the easiest way to protect user's data. Since the start of Covid-19, many companies have been forced to allow their employees to work from home. Ireland has had one of the highest rates of people working from home during the Covid crisis. The group's living, working and covid-19 survey has shown that 40% of employees worked from home in Ireland.

With this high amount of people working from home, Microsoft OneDrive and DropBox have seen massive growth in their applications. Employees have to use these cloud storage applications more frequently since they can't save important data to their own devices as it might not be encrypted to the correct standards or might not have enough space on their home device. This paper focuses on why enterprises and induvial users should use cloud storage to save and protect their valuable data. (ltd, 2020) (Burke-Kennedy, 2020)

Topics researched

Raspberry Pi

Relevance to Project?

For my application, I will need a cloud. For this, I will need a low-power computer to add external drives too. This will allow me to create a server for my cloud. A Raspberry Pi is a suitable product for my project.

Discovered during research?

A Raspberry Pi is a low-budget compacted computer that runs Linux, but it also provides a set of GPIO pins that allow the user to control electronic components for computing and explore IoT. It is a very powerful device that enables users to learn and explore computing technologies. The user can learn how to program in languages such as Python and Java. Raspberry Pi's are used worldwide for people to build hardware projects, do home automation and even use them in industrial applications. The raspberry pi can do everything your home computer can do. Raspberry Pi's can be used for cloud storage as you can connect a hard drive and set up a database where all the files will be stored. (What is a Raspberry Pi?, 2020)

How will this help me?

Raspberry Pi's are a vital part of my project as I will be mounting multiple hard drives to the device to create a cloud service.

Cloud Storage

Relevance to Project?

Cloud storage is a crucial part of my application as all of the files and data will have to be stored safely and correctly.

Discovered during research?

Cloud storage allows the user to store files and data in a cloud. You can access the cloud through either public or a private network connection. Once the data has been transferred, the cloud provider is now responsible for the data. Cloud storage delivers a low-cost way of

scaling up the storage for your business or for personal use. Cloud storage works by using servers to store the data. Most servers use virtual machines hosted on a physical server. When storage needs increasing, the provider creates new virtual servers to meet the demand. Cloud storage is available in private, public, and hybrid clouds.

- **Public cloud storage:** In this case, the user connects over the internet to a cloud that's operated by a cloud provider and used by other users or organizations. Providers usually make services accessible from just about any device, including smartphones and computers.
- **Private storage clouds:** Private storage clouds usually replicate the cloud model, but they use their home network**.** Using a physical server to create instances of virtual servers to increase the capacity. An advantage of this is you can take control of an on-premise private cloud. Companies that prefer private cloud storage include banks, colleges, or retail businesses due to the private nature of their storing and processing data.
- **Hybrid cloud storage:** Hybrid cloud storage combines components of public and private clouds, which gives users or businesses a choice of where they want to store the data. Private and confidential data such as names, passwords bank details should be stored in private clouds, whereas less sensitive data can be stored in the public cloud.

Cloud storage has three main types: block, file, and object. Each of these main types has advantages over the other.

- **Block Storage:** This is one of the most common types of cloud storage. Data is stored in large volumes called blocks. Each block is a separate hard drive. Cloud storage providers use blocks to separate vast amounts of data among multiple hard drives. Block storage has better performance over a network due to low IO latency. Block storage is best suited for large databases and applications. Block storage scales easily to help the growth of the business or application.
- **File Storage:** This method saves data in the file and folder structure. The data stored retains the same format whether it resides I the storage system or in the client

where it originates, and the hierarch makes it easier to find the relevant files. File storage is used primarily for development platforms and home directories.

- **Object storage:** This is different to block and file storage as it manages the data as objects. Each object has many characteristics, such as the data in the file, its associated metadata, and an identifier. Objects store the data in the format it arrives in, and it makes it possible to change the metadata in ways that the data is easier to access and analyze. Objects are stored in repositories that deliver virtually unlimited scalability.

Cloud storage security is essential, and most businesses store sensitive data like bank details, names, addresses, and even medical records. Cloud storage providers offer basic security measures that include user authentication, encrypted data, and access control. When data is being transferred, it is very vulnerable to security attacks. The providers of the cloud storage are responsible for securing data headed for the cloud. The providers can encrypt the data when it is being transferred to the cloud.

(us-en_cloud_learnhub_what_is_cloud_storage, 2020)

How will this help me?

This research on cloud storage has helped me decide what type of cloud storage I am going to use and how I will store the files and data. I am going to make a public cloud as it is the best for multiple devices, and numerous people can use it simultaneously. I am also going to use file storage as a way of storing the files and data. The file storage hierarchy is well known as people use it every day.

Similar Applications

Relevance to Project?

Providing the need for secure file storage solutions while improving existing technologies and removing their weaknesses.

Discovered during research?

DropBox is one of the most used cloud storage applications worldwide. It allows the users to backup files from their computers to the DropBox cloud. It lets the user share files quickly

and easily. There are many pros to using DropBox, such as Automatic file Backup. When a file is uploaded to DropBox, it is backed up straight away, giving the user insurance if they lose or delete the file. This also saves the users from backing the file to a hard drive and saves space for the user. Another pro of using DropBox is its software integration. DropBox runs smoothly with other applications such as Slack and Ms Teams. This function helps the users seamlessly transfer files from the applications to the cloud. There aren't many flaws to this application, but its Lack of security is a worry. In 2012 there was a data breach that ended up leaking the emails and passwords of 68 million users and in 2016 DropBox came out and said it was only the compromised emails. In 2017 users were noticing that deleted files reappear on their accounts. Some of these files were from six years ago and were never deleted, and could have been vulnerable to a leak. (Schmidt, 2020) (Solutions and Storage, 2020)

OneDrive is Microsoft version of cloud storage and is popular with businesses instead of individual users. The users can store any file, and they can access the file on multiple devices. Files are very organized, and it is easy to find the file you want. One key advantage OneDrive has over other applications is that it is part of the Microsoft platform and works perfectly with Microsoft Office apps such as Word and PowerPoint. When you open one of the Microsoft Office apps, you will see a list of recent documents saved to OneDrive. There aren't many downfalls to this application, but once again, security isn't the best. Users who use the standard OneDrive service will notice that their data is encrypted using SSL, but it will be unencrypted when the file isn't being used. Also, privacy is a concern as some users have noticed that Microsoft has the right to scan files saved to OneDrive to look for sensitive content or copyrighted files, or explicit images. This means that file security cannot be guaranteed as the files are being scanned. (Marketing, 2020)

How does this?

This research manual identifies the need for secure file storage that does not have critical vulnerabilities. The purpose of my application is to improve on the existing software and make cloud storage safe again.

Researched technology Stack

Relevance to Project?

It is essential to review each programming language and to see which one is best for my project. The two programming languages I am going to discuss are Python and Java.

Discovered during research?

Python

Python is a high-level intensity programming language that focuses on code readability. The syntax in the code helps the developer perform coding in fewer steps than other programming languages such as C++ and Java. Python is very popular with large businesses because of its multiple programming paradigms. Python has many benefits such as:

- **Extensive Libraries Support:** Python has one of the largest libraries for programming. Areas included in the library are string operations, web service tools, operating system interfaces, and protocols. Many of the most used programming tasks have already been added, limiting the length of the code produced in Python. (Python Programming Language, 2020)
- **Open Source:** Anyone can download Python as it is free and can start coding straight away. Its development is driven by the community, which cooperates through hosting conferences and mailing lists. (Moore, 2020)
- **Productivity and Speed:** Python is based on an object-oriented design, it adds process control capabilities and has strong integration, contributing to the increase in speed and productivity. (Moore, 2020)

Java

For many years, Java has been used by programmers and is one of the easiest programming languages to learn due to its simplicity. Java is an object-oriented language that allows you to write code once and run it on any platform such as Windows, Mac OS Linux, and Android. Considering these advantages, it is perfect for my Application. Java is said to be the most secure language compared to C++ and Python. Its security is gathered from an extensive library of APIs, tools, and implementing security algorithms and protocols. To make my application the most secure application on the market, I have to make sure hackers can't penetrate my application. To do does I will have to implement different ways to protect the app, such as:

Avoid complex coding? Serialization is helpful in that it allows Java developers to change inputs and objects into transportable byte streams, which can then be saved to a disk. This process can be changed back by using java deserialization. Java deserialization is vulnerable as it is impossible to tell, from a protected byte stream, what the original object was until after you decode it. If a hacker sends a serialized malicious object to your app, you must decode it first, at which point the app will have already initialized it. (BICKNELL, 2020)

Use query parameterization. According to Owasp, the top 10 web application security risks injection is number 1. Injection flaws usually consist of SQL, NoSQL, and LDAP. The most common injection for app development is SQL. Hackers typically use SQL injection in Java when you ask the user for input like a username. Instead of the username, the hacker enters a malicious script that can run on your database. (BICKNELL, 2020)

Top programming languages, TIOBE

Language	Percentage
Java	16.896 %
C	15.773 %
Python	9.7 %
C++	5.5 %
C#	5.3 %
Visual Basic .Net	5.2 %
JavaScript	2.4 %
PHP	2.4 %
Swift	1.7 %
SQL	1.5 %

SHARE

(Most Popular Programming Languages for 2020, 2020)

I have decided to choose Java over Python as it is the best language for security, and with my project being based on cloud security, I feel that this is a good choice. According to the top programming languages, TIOBE Java is one of the most used programming languages, whereas Python is third.

How will I implement this?

Java is a very complex language. To prevent java deserialization, I will have to remove vulnerabilities from my classpath. To avoid SQL injection in Java, I will create a prepared statement that an end user must use to access an app's database. Query parameterization separates the SQL code from the parameter data so that the query can't be hijacked.

Website vs Mobile Application

Relevance to Project?

For my project, I can either make a website or a mobile application. For this research manual, I will discuss each section, and at the end, I will pick which method is best suited for my project.

Discovered during research?

Website

Websites are a collection of linked web pages that share the same domain name. Websites are usually publicly accessible and can be created by groups or individuals. Websites come in different variations, such as news sites, educational sites, and so on. For my cloud server, a website would be perfect as it is easy to upload to the server. As we can see with the image below that desktop web application is less used than mobile applications. (Definition from Techopedia, 2020)

Mobile Application

A mobile application is a type of application designed to run on mobile phones or mobile devices such as a tablet. Mobile apps provide the user the same service as those accessed on a PC. Mobile applications are generally small software units with limited functions. (What is a Mobile Application?, 2020)

How will I implement this?

StatCounter Global Stats
Desktop vs Mobile Market Share Ireland from Oct 2019 - Oct 2020
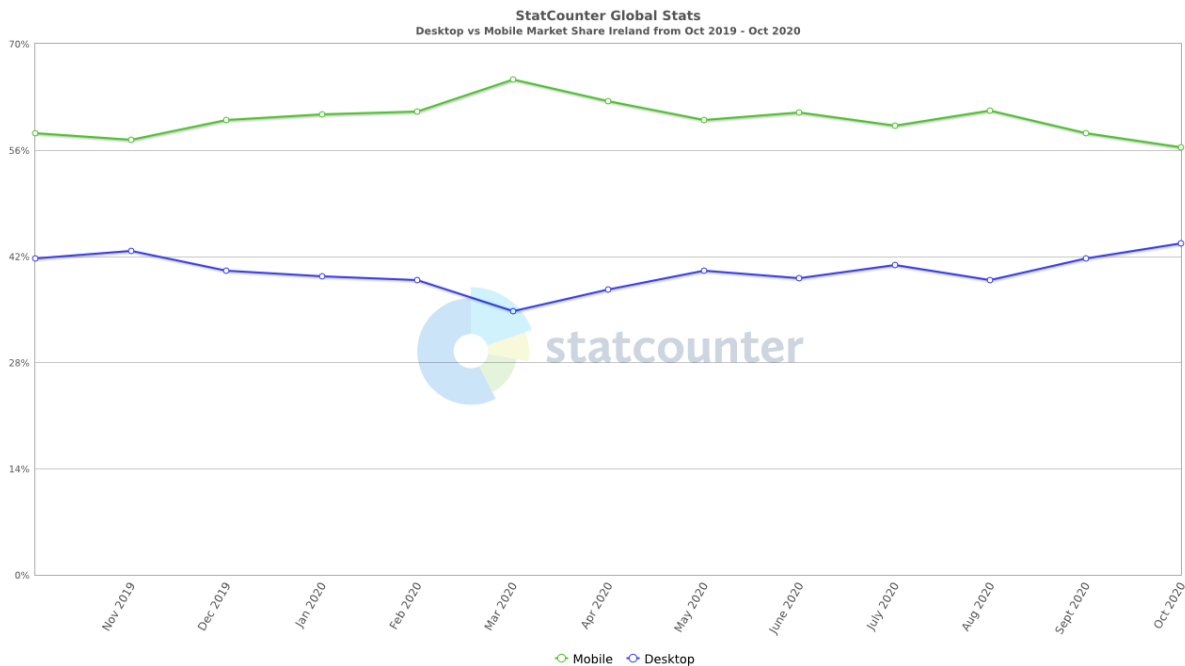
(StatCounter Global Stats, 2020)

As we have seen in the graph above, mobile applications are used more than web applications in Ireland. Following this research, I will design a mobile app, as I have never created a mobile application before, I feel it will be challenging learning and producing a mobile application. The user can upload data or files from their mobile device to the cloud and access and view the cloud's files.

Android vs iOS

Relevance to Project?

Since I have decided to make a mobile application, there are two distinct markets to choose from Android and iOS. Both have many advantages that I will discuss.

Discovered during research?

Android

Google developed Android in 2007 as it has become the leading mobile OS and application development. Android apps are created by using Java, C++, Kotlin, and Python languages. Google has made development tools that can be used to help programmers develop apps more efficiently. (What Are The Benefits Of Android App Development, 2020)

- **Android** Jetpack is a set of pre-built Android components
- **Firebase** is known as a comprehensive mobile app development platform
- **Android SDK** is a development kit that is connected to android studio, which is an integrated development environment.
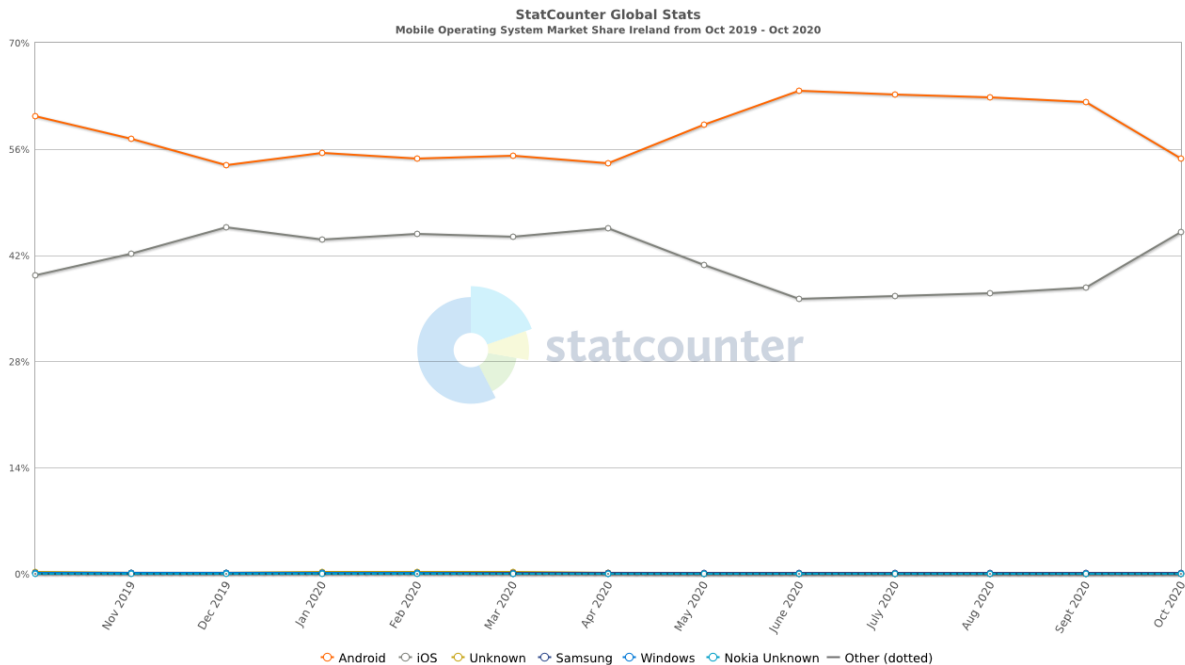
Android has many advantages over iOS, such as:

- **Open Source:** Android SDK is open source which means any developer can download and get programming straight away. Android development is cost-effective.
- **Enhanced Security:** Android development has made it more difficult for malware to locate the data structure. Also, Android has an automated system that sends out notifications to the user to update the application if necessary. (Top 5 Benefits of Android App Development for Businesses, 2020)
- **Greater Market:** Android has the largest share in the application development market. According to the graph below, Android has over 50% market share in Ireland than iOS, and Android has over 70% worldwide. (Android App Development, 2020)
- **Rapid Deployment:** Android applications have a quick development cycle that only lasts for a couple of hours. This is an essential advantage as companies want to transfer their idea into applications in no time. (Android App Development, 2020)

iOS

iOS is Apple's version of mobile application development. To develop iOS apps, you have to use Xcode, which is Apples IDE. Xcode has many features such as iOS SDK, tools, compilers, and frameworks that you will need to develop mobile apps. iOS has many benefits for app development, such as:

- **Better App Revenue:** iPhone apps return more revenue than Android apps.
- **High-Quality Standards:** iOS app development for businesses stays incomplete until the apps are entirely built to pass the Apple play store's quality standards. (AWS, 2020)
- **Low Fragmentation:** Unlike Android, 70% of iPhone users are using the current version of iOS. This is because Apple has complete control over the hardware and software of iPhones. (Srivastava, 2020)
- **High-Security Standards:** iOS apps protect the app against malware and firmware through stringent security measures such as:

- o   Integrated data handling systems
- o   Measures to prevent duplication of the data being stored
- o   Measures against loss of security due to data encryption

StatCounter Global Stats
Mobile Operating System Market Share Ireland from Oct 2019 - Oct 2020

(Mobile Operating System Market Share Ireland | StatCounter Global Stats, 2020)

How will I implement this?

Since the start of this year, Android has been the leading developer in app development. Android has more than 50% of the market share in Ireland. Following this research, I have decided to develop an Android application. Since Android has the largest share in the app development market in Ireland, more people will be able to use my mobile app than to choose iOS to develop my application.

Android Application security vulnerabilities

The primary purpose of the application is to be the most secure file vault on the market. The only way to be sure is to know what vulnerabilities are out there and how to mitigate against them. They are many vulnerabilities with android application development. Since

the start of 2019, there are seven main vulnerabilities that every application should mitigate against. Below are the top 7 vulnerabilities and solutions on how I should mitigate against them for my application.

1. Binary Protection

Binary protection is one of the most common vulnerabilities for android devices. Allowing rooting or a jailbreaking devices harms data protection and encryption algorithms on the application. When a device has been compromised, any form of malicious code can run on the device. The code can significantly alter the application's code and reverse engineer the application, and perform hidden functionality.

Solution

The application should never let rooted or jailbroken devices run the application. One way to prevent this is to add rooted or jailbroken devices to be detected. This adds an extra layer of security and risk mitigation to protect the data within the application from being exposed.

2. Insufficient transport layer protection

Many applications fail to encrypt network traffic when it is necessary to protect sensitive network data. Encryption must be used for all authenticated connections, especially internet-accessible websites. Backend connections should be encrypted as well as session tokens, to prevent malicious exploitation.

Solution

Encryption should be used whenever sensitive data is being transported, such as names, addresses, and bank details. Applications that use plaintext are more susceptible to malicious attacks.

3. Insufficient authorization / authentication

Authorization

Results when an application does not perform proper authorization checks to ensure that the user is performing or accessing data consistent with the security policy. Unauthenticated users should never have access to authenticated pages.

Solution

Reenforce an authorization framework scheme that emphasizes policy-based configuration files over hard-coded authentication checks wherever possible.

4. Improper Certificate Validation

Many applications are not validating SSL or TLS certificates or are utilizing an SSL or TLS certificate validation system that will not correctly verify that a trusted provider issued the certificate. The client should be configured to drop the connection if the certificate cannot be verified or is not provided. Any data exchanged over a connection where the certificate has not been correctly validated could be exposed to unauthorized access or modification.

Solution

Ensure that the application certificate validation is configured to correctly verify that the certificate is provided and from a trusted source like a reliable certificate authority.

5. Brute Force Attacks

There are numerous ways for an attacker to determine if a user exists in the system. A brute force attack can determine an unknown value bypassing an automated process to try many possible values. The attack takes advantage of the fact that the entropy of the value is smaller than perceived.

Solution

The user enumeration vulnerability typically occurs in the following functionality: Login, Registration, or Forgot Password. The application should not reveal whether a username is valid. The response to valid and invalid input in either field should be completely identical.

6. Session Invalid Expiration

After a user signs out of the application, the session token should be invalid. If the server fails to delete the token, the session may still be active. An attacker can impersonate that user and act on their behalf.

Solution

First, it is a best practice to ensure a logout button is implemented in the application, and second, when the user clicks this button, their session is properly invalidated.

7. Information Leakage

Sensitive data can be leaked from application caches, either through the main application code or via third-party frameworks. Mobile devices present a unique challenge with regards to secure data storage. The devices can be easily lost or stolen. Many users do not lock their devices. The cached data can be viewed by an attacker who is performing data forensics on the physical device.

Solution

Ensure the sensitive data is not accidentally leaked through the cache. Developers can prevent it by creating a threat model for OS, framework, and platform to check and verify the way data is handled during URL caching, keyboard press caching, logging, copy or paste caching, app background, browser cookies objects, HTML5 data storage and analytic data that is sent to the server or another app. (Casey, 2021)

Java Security and APIs

Relevance to Project?

Following the research on what programming language I have picked, Java, I now need to discuss what APIs I will be using and what encryption methods I will use to secure the users' data in the cloud.

Discovered during research?

Java has many features to improve security, such as APIs, tools, security algorithms, and protocols. The APIs span a wide range of areas such as cryptography, critical public

infrastructure, secure communications, authentication, and access control. Java security mechanism helps support the programmer with a comprehensive security framework. JDK is developed with a strong focus on security. The java language itself is type-safe and provides automatic garbage collection. (Java Security Overview, 2020)

Security providers

The java.security.providers class encapsulates the concept of a security provider in the java platform. It shows the provider's name and lists the security services that are being implemented. Many providers may be implemented at the same time and are listed in order of relevance. Most applications depend on the relevant getInstance method to request a security service from an underlying provider. (Java Security Overview, 2020)

Java Cryptography and Php

Java Cryptography Architecture is a group of APIs that help implement modern cryptographic algorithms such as digital signatures, message digest, asymmetric encryption, and key generators. Provider-based interfaces allow for many cryptography implementations. Numerous providers offer many cryptography operations in software other providers perform on hardware. JDK includes many built-in providers that use cryptographic algorithms, such as the RSA, DSA, and ECDSA signature algorithms and the Diffie-Hellman key agreement algorithms. All the built-in providers implement cryptographic programs in the java code. Most encryption is done in php code which is server-side code. Php has many cryptography functions that can be used to secure users data. (Cryptography Tutorialspoint, 2020)

Public Key Infrastructure

Public Key Infrastructure is a framework that enables the secure transfer of data on public-key cryptography. PKI uses two keys to achieve the underlying security algorithm. It allows sensitive data to be bound to digital certificates and provides a means of verification of certificates. JDK provides APIs and providers that support digital certificates as well as PKIX-compliant certification path building and validation. JDK stores the cryptographic keys and certificates via key and certificate stores. Java.security.Keystore class is used to show a key store, a secure place for keys and certificates. Java has two built-in features for working with key stores, certificates, and keys. (Tutorialspoint, 2020)

- Key tool which creates and mangers key stores
- Jarsigner which signs JAR files and is used to verify signatures on the Jar files that have been signed.

Secure Communication

Data traveling across a network can be very vulnerable to being accessed by someone who is not the intended receiver. When the data that is being transferred is sensitive such as passwords, bank detail, or even medical reports, precautions must be put in place. It is also vital that when you are sending data that the data hasn't been modified either by an attack or unintentionally during transport. Java flatform has many APIs and implements the SSL, TLS and DTLS protocols that include data encryption, message integrity, and server-to-client authentication. With these APIs, the files should be modified by an intruder or unintentionally when the data is being transferred from one party to another party. (Java Security Overview, 2020)

Network security

The Network Security Configuration feature lets apps customize their network security settings in a safe, declarative configuration file without modifying app code. These settings can be configured for specific domains and a specific app. The key capabilities of this feature are as follows:

- **Custom trust anchors:** Customize which Certificate Authorities (CA) are trusted for an app's secure connections. For example, trusting particular self-signed certificates or restricting the set of public CAs that the app trusts.

- **Debug-only overrides:** Safely debug secure connections in an app without added risk to the installed base.

- **Cleartext traffic opt-out:** Protect apps from accidental usage of cleartext traffic.

- **Certificate pinning:** Restrict an app's secure connection to particular certificates.

One of the most significant changes in Android 9 is that cleartextTrafficPermitted is set to false by default. This means that if you don't see this flag explicitly set to false and the app is targeting API levels lower than 28, the flag will be honored as true. Another

capability of the cleartextTrafficPermitted flag being used in the Network Security Config is the ability to enforce the true setting on specific domains and subdomains. Allowing the network security flag allows the android application to connect to the Raspberry Pi.

Conclusion

Since the pandemic and the first lockdown, the research has shown that many people are working from home in Ireland and must use cloud storage to store important files and data. Millions of people each day upload data to the cloud. With all this information, many cloud providers must have the best security for their applications otherwise, they will be vulnerable to cyber-attacks. Dropbox has had many security breaches in the last couple of years which is very worrying for users. This research has shown me that security is the most important part of cloud storage. The study also shows that I will be creating an Android mobile application that is programmed in Java. The mobile application for secure cloud storage will be the most secure application on the market, making it impossible for common attacks to be performed on it. In conclusion, the proposed solution is for making a secure file vault that stores the data in the cloud.

Glossary

GPIO stands for General Purpose Input/Output. It's a standard interface used to connect microcontrollers to other electronic devices.

IoT refers to the billions of physical devices around the world connected to the internet, all collecting and sharing data.

APIs are a computing interface that defines interactions between multiple software intermediaries.

JDK is an implementation of either one of the Java platforms.

IDE is a software application that provides comprehensive facilities to computer programmers for software development.

SSL stands for Secure Sockets Layer. In short, it's the standard technology for keeping an internet connection secure and safeguarding any sensitive data that is being sent between two systems.

TLS stands for Transport Layer Security, is just an updated, more secure version of SSL.

DTLS stands for Datagram Transport Layer Security (DTLS), a communications protocol designed to protect data privacy and prevent eavesdropping and tampering.

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