Final report

DoorSine / Digital Assistant for Staff Office Door

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University of Essex

CE301 Final Year Capstone Project

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Description automatically generated

# Acknowledgments

First and foremost, I want to thank my supervisor Doctor Shoaib, Jameel. During my second year at Essex he was one of the supervisors for our team project, and through the year I got to know him as a professional lecturer with an abundance of wisdom and optimism.  
Upon learning about this project, and after a few discussions about the scope and goal of the project, I decided this project was what I wanted to do. This project has really helped me grow as a computer scientist and I want to thank Doctor Shoaib Jameel for giving me the opportunity to do so.

I also want to thank my family, who has supported me every step of the way. These three years of university has not been what I envisioned, but with the guidance and support you have given me I have battled through and come out on top. I am forever grateful for having a family like you.

Lastly, I want to thank my friends who I have also relied on for emotional and sometimes physical help with problems and challenges. You guys are what has made these three strange years of university bearable and most of all enjoyable.

# Abstract

Title: DoorSine / Digital Assistant for Staff Office Door

Name: Knut S L Blakkestad

Reg No: 1904341

Location:  
The aim of the project was to create a digital assistant for an office door that would allow the owner to communicate and display information to anyone outside their office.  
Several similar products exist on the market, but they are more focused on managing entire  
workspaces.  
What makes this project stand out is that it is aimed at managing offices for individuals, rather than managing workspaces and rooms for corporations.  
It can be utilised by as few as a single office worker, and by as many as an entire corporation.  
The impact the project has is that it shrinks the time it takes to communicate with i.e. a lecturer from a day or two via email, to a quick message or a call.  
It also makes booking meetings and getting up to date information accessible and easy.  
I have learned so much during this project, and have had the opportunity to grow as a data scientist using the newest technology in app development.

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# 1. Project Context

## 1.1 Description

Below is the description of the project provided by Doctor Shoaib Jameel as the outline for this project on the Project Database.

The idea is to develop software which could run on a mobile device that connects to the network and takes commands remotely.   
The goal is to place this device outside every staff office door so that anyone who wants to visit the staff knows that current status of staff - whether the staff is in the office or out of office, whether the staff is in a meeting, or on leave.   
We could do plenty of cool pieces of stuff with this device such as scheduling a meeting by directly interacting with the device and viewing your marks on this device using facial recognition (I am going too much overboard!).   
The initial goal would be to first build the software that works on a mobile device such as a mobile phone.   
If you are interested, please feel free to drop an e-mail to discuss what exactly you wish to work on including its scope[[1]](#footnote-1).

## 1.2 Aims and Objectives

**The aims and objectives agreed upon with Shoaib.**

**What problem has been solved, and why is it important?**

After selecting this as my final year project, Doctor Shoaib Jameel and myself discussed and agreed upon exactly what the aims and objectives of the project should be. The initial goal was to develop the groundwork for the application and implement the following features.

* The staff should be able to set their availability so that anyone visiting their office could know if they currently are available or busy.
* A student can check when the staff is available next and book a meeting without disturbing the staff.
* Someone at the door could interact directly with the staff through messaging

Through the report, these features as well as additional ones will be highlighted and explained, showing how the needs of user have been solved.

## 1.3 Motivation

App development has always intrigued me, but throughout the first two years of university there had been little to no focus on it. So when the chance presented itself to try developing an application from scratch with freedom to do what I wanted with it, there was no doubt in my mind that this was the project I wanted as my final year project.

Statistics from Statista highlight the importance smartphones, and the applications on them have on our life. A survey on the number of smartphone subscriptions worldwide from 2016 to 2027 shows that the amount has been increasing substantially since 2016 and is forecasted to keep increasing in the coming years. At the end of 2021, the number was at 6.259 billion and is forecasted to grow into 6.567 billion in 2022 [1].  
Another survey shows the increase of smartphone usage of age groups 16 to 65 and up from 2012 to 2020. The percentage shows smaller increases in the combined age group 16-44, ranging from 12% at the lowest to 27% at the highest. In the combined age group of 45+ the increase is even larger, ranging from 49% at the lowest to a 62% at the highest [2].  
These two surveys highlight that the usage and reliance of smartphones shows no signs of slowing down, and proves that the need for user friendly and reliable apps are higher than ever.

These surveys also support what I have experienced and continue to experience in my daily life. Born right before the turn of the century, I have experienced smartphones going from something that was non-existent to something that is used and often needed in the daily life of almost everyone.  
This provides the reasons for why I wanted to do this project, and the reason why I believe this is a good time to do it.

## 1.4 Background Reading

Before looking into languages and environments to create the app in, I wanted to understand what makes an app good in the eyes of the user. I also wanted to look at the challenges app developers face and possibly how to overcome them.

A research paper titled “Real Challenges in Mobile App Development” from 2013 investigates the challenges in mobile app development both using qualitative data from 12 interviews with senior developers and quantitative data from 188 answers to a survey answered by people from the mobile development community.   
One of the main revelations of the study is that one of the biggest challenges in mobile app development is dealing with the various mobile platforms. Since the different platforms vary in build and functionality, the developers often found themselves creating a separate app for every platform and manually checking that the functionalities are preserved across the different versions [3].  
A criticism of the study could be that is older, and that there has been a lot of development in the field of mobile app development. A quick web search shows that this is still the case for most of app development. Articles naming the top 5, top 10, etc. like this Medium article[[2]](#footnote-2) or this SpinxDigital article[[3]](#footnote-3) all mention Java and Kotlin as the most used languages for Android development, and Swift as the most used for IOS development.

“Factors Influencing Quality of Mobile Apps: Role of Mobile App Development Life Cycle” is a paper published in October of 2014 and investigates what makes applications fail, and by proxy then also describes what to do to not make an application that will fail.  
According to the report the were about 6.4 billion applications downloaded in 2009, with the number increasing at an accelerated rate to 76.9 billion by 2014 [4].  
This projected increase is further backed up by numbers from Statista, showing that the number of mobile app downloads in 2016 was at 140.68 billion and in 2021 was at 230 billion [5], showing that the mobile app industry is bigger now than ever.  
The report describes a bad app as having the following flaws:

* Poor design/UI
* Too much clutter on screen
* Poor navigation
* Does not meet the user requirements
* Does not address the specific issue
* Has security issues
* Fails at essential times
* Downloading issues
* Inconsistencies across platforms
* Compatibility issues
* High battery usage
* Slow replication function
* High ad frequency
* Not appropriately priced
* No endeavours made to solve any of the mentioned issues

In short, apps should be fast with a simple and understandable interface and should work as advertised without any issues relating to security, loading or battery consumption.

As previously mentioned, I had little experience with app development. I had no knowledge of what language was the most used languages, compilers or frameworks. The background reading regarding this started by looking at articles like “Top 5 Programming languages for Mobile App Development”[[4]](#footnote-4)  
This article and others like it mention Kotlin and Java as leading languages for Android development, Swift is mentioned as the leading language for IOS development, and JavaScript is mentioned as the leading language for Web development,  
But throughout all of these articles, a language I had never heard about caught my attention, Dart.

“Dart is a client-optimized language for fast apps on any platform”[[5]](#footnote-5). It is an open-source and object-oriented programming language released by Google in 2011, and has seen continuous improvements and development since its initial release.  
It was created to “offer the most productive programming language for multi-platform development”[[6]](#footnote-6). Further reading and looking at what other developers have created with Dart and Flutter, I was convinced that this was the language and environment I wanted to create my app in (REWRITE THIS PARAGRAPH, NOT HAPPY WITH IT).

## 1.5 Related Technologies

A big part of the background reading also consisted of looking at similar products already publicly available to gain insight into how they function, what their customer base looks like and to look at how they have succeeded. It was also helpful to gain inspiration for design and layout, and to look at what can be improved on.

The major technologies looked at are *Door Tablet* with clients like *Michigan State University* and *Plymouth Marjon University*[[7]](#footnote-7), *Meetio* with clients like *Duchy Homes* and *Three*[[8]](#footnote-8), *Condeco* with clients like *Vodafone, Nestle* and *Comcast*[[9]](#footnote-9), and lastly *Pronestor* with clients like *United Nations* and *Siemens*[[10]](#footnote-10). These products are all mainly aimed at the office industry sector, but some of them have customers in the school sector as well.

Similarities between these apps and the project include some basic functionality. They all work on both phones and tablets, but this is true for most applications. They all provide the possibility of booking meetings, and they all provide the user with general information they might need.

Differences between the project and the other products are many. The major difference that serves as the basis of most the differences is that this project is aimed at managing one-to-one communication between an office user and a person at their door, while the other products are aimed at managing entire workspaces.   
Their main purpose is to manage the office space by giving the users the ability to book desks, rooms and more. They can plan group meetings, access floor plans and display room information.  
This projects purpose, as mentioned, is one-to-one communication between an office user and a person at their door. The person at the door can see the office users current status, can get some basic information on them and has the option of messaging, calling and booking meetings with the office user.

Looking at the similarities and differences, it is clear that similar products do exist on the market already and the different companies compete for the biggest share on the market. But the amount of differences show that this project is something not available on the market yet and would not struggle to compete with these other companies, but rather fill a gap in the market that is missing.

## 1.6 Implemented Technologies

There are many requirements and functionalities needed to create a modern app, and having to design, code and create everything from scratch would have taken away development time from the actual app. For this reason, several modern solutions have been implemented into the project to reduce the amount of time and work focused on smaller aspects of it. This however does not mean that the development has been easy. All these technologies still need to be understood and managed, as well as having to be implemented into the project using code. What it has done is allowing the development to be focused on creating an app rather than developing the tools needed to create an app.

* Dart: A programming language created for cross platform app development[[11]](#footnote-11), used for the backend code of the app
* Flutter: A framework that uses Dart to create apps from a single codebase[[12]](#footnote-12), used for the frontend code of the app
* Firebase: An online database and analytics service[[13]](#footnote-13), used for storing user data, sending messages and manage user login
* Agora: An online hosting service for voice and video calling[[14]](#footnote-14), used to host the video calling functionality
* Heroku: A cloud computing service host[[15]](#footnote-15), used to host the token server that creates tokens for secure video calling
* Azure: A cloud computing service by Microsoft for application management[[16]](#footnote-16), used to connect with Microsoft and enable Microsoft login

## 1.7 Sustainability

The sustainability of the product

The sustainability of a product like this is based on what work is done on it after release. If it were to be implemented and used at this very moment, there would be no software issues and it would work as expected. If it then was left at the current stage and was not sustained through updates and reworks, it would likely break within a year or two as the functionality of many of technologies it relies on would be updated and changed to no longer work with how the code for the app was written.  
The only way to keep it, and for that matter any app, working as expected for longer periods of time is through incremental updates and changes. Through its lifecycle, new versions of Android would be released, and the app would need to be adapted to these changes. Major upgrades and changes to Dart and Flutter could severely effect the structure of the app, potentially breaking it as older methods, variable types and frontend building blocks become deprecated. Firebase could change how data is accessed and stored, and updated privacy rules could change what is permitted to store and access from it. Cloud services like Heroku and Azure could fundamentally and functionally change how they work, and would in turn break the app.  
App development is also a technology with constant development and incremental improvements, meaning any app that wants to stay relevant needs updates and changes. That is why a major company like Meta, formally Facebook, constantly updates Facebook and Instagram with new features. The same behaviour is mirrored by Google with constant updates to their apps, especially YouTube. They have managed to stay relevant and are still in use over 10 years after their creation because of technical updates and improvements through their existence.

## 1.8 Legal

One of the major legal problems any system with a login system and information storage is it must comply with GDPR. The app saves personally identifiable information (PII) such as name and email, which are both needed for the functionality and use of it.  
The system used for storing this is Firebase, more specifically Cloud Firestore and Firebase Authentication, both of which have passed the ISO 27001[[17]](#footnote-17), ISO 27017[[18]](#footnote-18) and ISO 27018[[19]](#footnote-19) certification processes as well as completing the SOC 1[[20]](#footnote-20), SOC 2[[21]](#footnote-21) and SOC 3[[22]](#footnote-22) evaluation processes.  
All data received from and sent to Firebase is encrypted using the HTTP protocol and the entirety of the data is only accessible to people with admin privileges.  
Firebase Authentication is additionally secured by only keeping logged IP addresses for a few weeks, while any other authentication information is kept until the Firebase customer (System administrator) initiates deletion, at which point the data will be removed from live and backup systems within 180 days. The same system is in place for Cloud Firestore.  
In addition the users have full access to the information stored on them via the app and can alter it if wrong or if it needs updating.

## 1.9 Ethical

Ethical issues and problems that arises from the project

DON’T REALLY SEE ANY ETHICAL ISSUES. MAYBE PEOPLE ACCESSING THEIR INFO? BUT THAT IS WHAT THE APP IS SUPPOSED TO DO. MAYBE PEOPLE THEY DON’T WANT TO ACCES THEIR DATA?

## 1.10 Intellectual Property

NOT SURE WHAT TO PUT HERE, OR IF IT IS NEEDED

## 1.11 Challenges

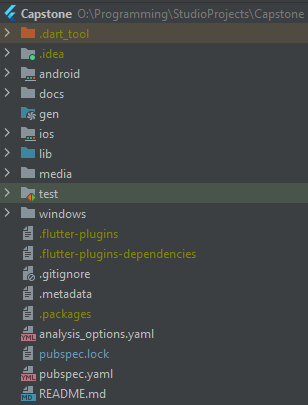
Talk about the challenges I faced working on this project

Creating an app from scratch has certainly not been an easy task. As mentioned several times already in this report, I had no prior knowledge of it and we haven’t been taught anything about app development during the years at the University of Essex.  
NOT FINISHED, OBVIOUSLY

# 2. Project Implementation

## 2.1 Code Implementation

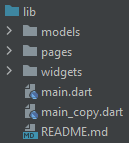
Much of the project structure is created based on the template provided when creating a new Flutter project in Android Studio. The following picture displays the project structure.



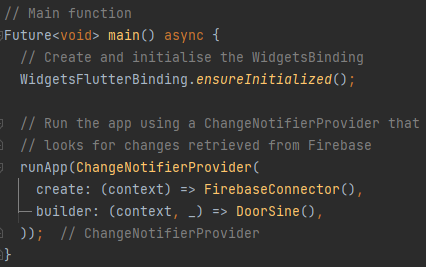
Several of the folders like *android* and *iOS* contain files that are necessary for the application to run and compile on the respective platforms, and little development happens in them. There were however smaller changes to configuration files that were needed as the complexity of the program changed and expanded.  
Some of the folders frequently used during development like *lib* and *test* were also provided when creating the project and contain the application class files and application tests respectively,  
A couple of folders like *docs* and *media* were created manually for document and media storage.  
The *README.md* file in the project gives the viewer a quick description of the project as well as detailing the major features. The *lib* folder and all folders within it contain separate *README.md* files that give a short explanation of the folders content, while the class files themselves contain more detailed information and explanation of what each part of them does.

### 2.1.1 Lib Folder

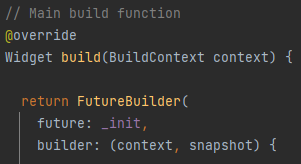
Most of the app framework is contained within the *lib* folder and it is structured like this.



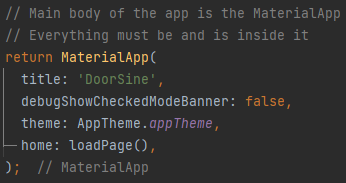
The only class files contained directly within *lib* is the *main.dart* file as well as a copy of it needed when running two simulations of the app at once.  
When running the app either through simulation or on a physical device, the process is started using the *main* method.



This initialises the *WidgetsBinding* which all the app widgets need to function and starts the app under a *ChangeNotifierProvider* which makes sure the app looks for changes retrieved from the custom class *FirebaseConnector*. Finally, it creates the app instance by calling the *DoorSine* class, which automatically calls the classes build method.



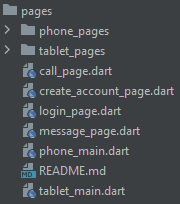
Since the build method of the *DoorSine* class needs to wait for the connection to *Firebase* to be established, it is structured using a *FutureBuilder*, which tells it to wait with certain actions when building. Several other classes use the same builder or variations of it, and will be covered later in the report. These builders do not actually return anything themselves but rather has several widgets returned within them based on the status of what they are waiting for to load, their snapshot.



The main return of the builder is a *MaterialApp*, a constructor that uses material design to create an application base that all the other widgets build upon. The *MaterialApp* is given a title, a custom theme defined in *app\_theme.dart* and is given a route to the home widget.  
This is a call to a function that returns three different widgets based on the status of the snapshot. If the snapshot has an error, it displays an error message, if the snapshot is loading it displays a loading indicator, and if the snapshot has finished loading it returns the *LoginPage* class, effectively taking the user to the page where they can log in.

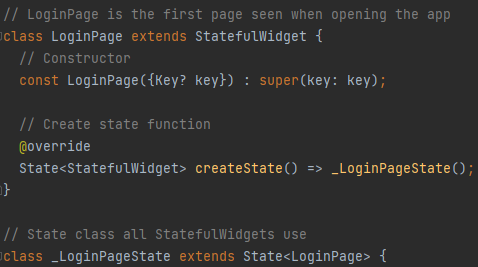
### 2.1.2 Pages Folder

The *LoginPage* class is stored in the *pages* folder, which contains shared pages as well as individual pages for the phone side of the app and the tablet side of the app. These are stored in the *phone\_pages* folder and *tablet\_pages* folder respectively.



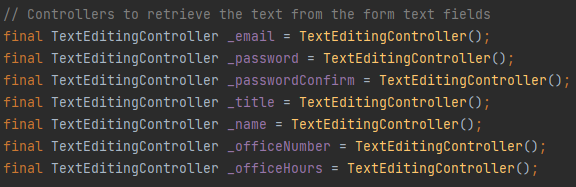
Other files in the *pages* folder are *call\_page.dart* which is a shared page that both the phone and tablet sides of the app uses for calling, *create\_account\_page.dart* where new user can create an account for themselves, *message\_page.dart* which works similarly to *call\_page.dart* only for messages instead, and *phone\_main.dart* and *tablet\_main.dart* which are the main pages for the phone side and tablet side of the app respectively.

The *LoginPage* class is the first class encountered that extends *StatefulWidget*, since the *DoorSine* class extended *StatelessWidget*. The main difference between them is that a *StatelessWidget* is only built once and does not change through its lifetime, while a *StatefulWidget* is expected to change based on user input. The *StatefulWidget* does not have a build function like the *StatelessWidget* but has a function that creates a mutable *State*. This state is what has the build function, and when changes are applied to the *State* it is rebuilt with the changes.

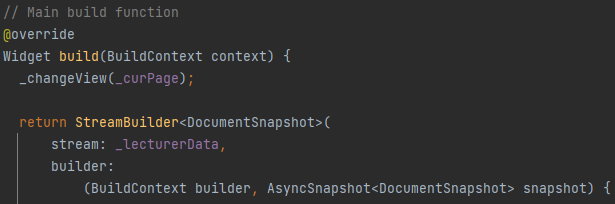


The *LoginPage* uses a form to take user input of their email and password, then sends a request to *Firebase* to see if the user exists. If the user does not exist or has entered the wrong email and password combination an error message is shown. If the user has provided the correct email and password combination, a pop up prompts the user to choose if they want to launch the phone or tablet side of the app. There is also an option to sing in using a Microsoft account if the accounts have been linked. This was implemented with the University of Essex usage of Microsoft services in mind, but anyone can choose to create their account in this manner.

The *CreateAccountPage* works similarly to the *LoginPage* as it uses a form to take user input. If creating an account manually, all fields must be filled before the account can be created with an error message displaying what information is missing. This form and all others use a *TextEditingController* for every input field, which is used both to check that the input text is correctly formatted, as well as retrieving the text when creating the account. If the user wants to create an account using the Microsoft login the form does not need to be filled in, the app retrieves the information it can from the Microsoft account.



The *PhoneMain* and the *TabletMain* functions differently from each other. While the *TabletMain* functions like a homepage the *PhoneMain* is more of a wrapper to all the phone pages. It provides the app bar which displays the lecturers name and title, and the navigation bar at the bottom of the page to change between the different pages. It uses a different type of *FutureBuilder* called a *StreamBuilder* which uses a *Stream* to display information from a source and updates the information based on changes to the *Stream*. The *Stream* in this case is a direct connection to the lecturers database that stores information regarding the given user, and when the user updates the information on the client side it is reflected by changes to both the server side and client side data.



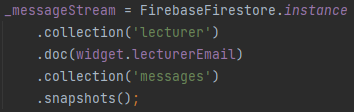
The *TabletMain* also uses the *StreamBuilder* to look for updates in the given lecturers database information and change the displayed information accordingly. As mentioned it works like a home page with buttons taking the user to different pages with different functionalities and information.

There are two joint pages that both the phone side and the tablet side of the app uses being *call\_page.dart* and *message\_page.dart*. Both sides originally had their own pages for these but they were very similar in design and functionality, so by changing and optimising the code both now use the same two pages.

*CallPage* uses *AgoraIO* to host the video calls and uses *Heroku* as an online token generation service. Even with these two interfaces, there is a lot of initialisation and preparation needed to be done on the client side before the *CallPage* is ready. Every time either the lecturer or the visitor tried to join the channel it must be initialised as keeping it online constantly drains the battery of the device and uses valuable server space for other potential users. Event handlers for all events are also created so that when users i.e. joins, leaves or loses connection the app handles it correctly. Like most video calling apps the caller fills the screen while the receiver can see themselves in a small video window in the corner. The build function of *CallPage* looks very simple, but this is because most of the widgets are created in separate functions only to be combined in the build function. Below is one of these functions, showing how the large video view is created.



*MessagePage* uses a database connected to the given lecturer database in *Firebase* to store messages sent between the user and the visitor. When a message is sent it is uploaded to the database and the new message is retrieved and shown for both users using a *StreamBuilder*. The messages are created using a custom created widget *Message* and are displayed differently based on which user sent the message. Below is a screenshot showing the *Stream* that retrieves the messages.



### 2.1.3 Phone Pages

Show some phone pages

### 2.1.4 Tablet Pages

Show some tablet pages

### 2.1.5 Models

Show the lecturer model

### 2.1.6 Widgets

Show some of the widgets

## 2.2 Visual Implementation

Images displaying various pages, showing how they work and what they look like.

# 3. Project Testing

Show some evidence of testing, might not be necessary.

## 3.1 Manual Testing

Manually testing of the product, both sides

### 3.1.1 Phone

Manual testing of the phone side of the app

### 3.1.2 Tablet

Manual testing of the tablet side of the app

## 3.2 Automatic Testing

Look into automatic testing to see of it is viable, may not be necessary but would look nice.

# 4. Project Planning

Show use of Jira and GitLab. Mention how bad accessing it through Horizon has been.

Talk about performance and what I have learned.

Was my methodology suitable? What does that mean…?

## 4.1 Planning

Maintaining momentum, adapting to change

## 4.2 Operation

Highlight how Jira and GitLab was used to stay on track

## 4.3 Risk Management

Identifying and dealing with risks

## 4.4 Jira

<https://cseegit.essex.ac.uk/ce301_21-22/CE301_blakkestad_knut_s_l>

## 4.5 GitLab

<https://cseegit.essex.ac.uk/ce301_21-22/CE301_blakkestad_knut_s_l>

# 5. Conclusion

Text must have impact, like the abstract but longer.

Summarize the work that has been done.

What the intended goals and what was achieved.

Highlight achievements.

Future scope, what could be worked on if it was to be continued, extension to be added and overall improvements.

## 5.1 Achievements

The three points mentioned in the “Aims and Objectives” section of the “Project Context” chapter was the original project scope and was supposed to occupy the work for the entire project. By the interim presentation before the end of autumn term, the application had the following features implemented.

* The staff could set their status as available or busy, as well as indicate whether they were in or out of office. This was done using the app on their phone, and changes appeared instantly on the tablet on the door.
* Messaging was implemented and working.
* The staff could change their basic information easily through their app if office hours or related info changed.
* An account creation system was created so anyone who wanted to use the app could create their own account.

Looking at what had been achieved so far, and with the functionality of booking meetings being the only remaining feature to not have been implemented, it was agreed that another feature was needed to fill the hours required for the project. This feature was the ability for someone at the staff door to call the staff using video. With this, the final iteration of the project has the following features in addition to what has been mentioned before.

* A person can book a meeting if they are at the staff door. The app interacts with the staff’s calendar to display when they are busy or available. Meetings cannot be booked if they overlap with other events.
* Calling is implemented and working.
* Every page has a button that give some basic information about the given page of the app, to help users unfamiliar with it.
* Visual improvements to make the app more user friendly.
* Software improvements to make the app run smoother and more efficient.

With all these features, the app has evolved beyond its initial scope of being a digital assistant for a staff office door. It can be used in any environment where offices are abundant, and can be used by as few as a single person to as many as an entire corporation.

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## Future Development

Talk about possible extensions and improvements that can be made if development was continued.

# References

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| [1] | S. O'Dea, “Number of smartphone subscriptions worldwide from 2016 to 2027,” Statista, 23 February 2022. [Online]. Available: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/. [Accessed 23 March 2022]. |
| [2] | S. O'Dea, “Do you personally use a smartphone?,” Statista, 15 June 2021. [Online]. Available: https://www.statista.com/statistics/300402/smartphone-usage-in-the-uk-by-age/. [Accessed 23 March 2022]. |
| [3] | A. M. a. P. K. M. E. Joorabchi, “Real Challenges in Mobile App Development,” 2013. [Online]. Available: https://ieeexplore.ieee.org/abstract/document/6681334. [Accessed 23 March 2022]. |
| [4] | D. D. K. T. K. M. I. Venkata N. Inukollu, “Factors Influencing Quality of Mobile Apps:Role of Mobile App Development Life Cycle,” 16 October 2014. [Online]. Available: https://arxiv.org/abs/1410.4537. [Accessed 2022 March 28]. |
| [5] | L. Ceci, “Number of mobile app downloads worldwide from 2016 to 2021,” Statista, 31 January 2022. [Online]. Available: https://www.statista.com/statistics/271644/worldwide-free-and-paid-mobile-app-store-downloads/. [Accessed 28 March 2022]. |

1. <https://moodle.essex.ac.uk/mod/book/view.php?id=759993&chapterid=19559>, 18.03.2022 [↑](#footnote-ref-1)
2. <https://medium.com/javarevisited/top-5-programming-languages-for-mobile-app-development-in-2021-19a1778195b8>, 23.03.2022 [↑](#footnote-ref-2)
3. <https://www.spinxdigital.com/blog/mobile-app-development-languages/>, 23.03.2022 [↑](#footnote-ref-3)
4. <https://medium.com/javarevisited/top-5-programming-languages-for-mobile-app-development-in-2021-19a1778195b8>, 15.09.2021 [↑](#footnote-ref-4)
5. <https://dart.dev/>, 22.03.2022 [↑](#footnote-ref-5)
6. <https://dart.dev/overview>, 22.03.2022 [↑](#footnote-ref-6)
7. <https://www.door-tablet.com/door-app/home>, 28.03.2022 [↑](#footnote-ref-7)
8. <https://www.meetio.com/customers>, 28.03.2022 [↑](#footnote-ref-8)
9. <https://www.condecosoftware.com/>, 28.03.2022 [↑](#footnote-ref-9)
10. <https://pronestor.com/uk>, 28.03.2022 [↑](#footnote-ref-10)
11. <https://dart.dev/overview>, 31.03.2022 [↑](#footnote-ref-11)
12. <https://flutter.dev/>, 31.03.2022 [↑](#footnote-ref-12)
13. <https://firebase.google.com/>, 31.03.2022 [↑](#footnote-ref-13)
14. <https://www.agora.io/en/>, 31.03.2022 [↑](#footnote-ref-14)
15. <https://www.heroku.com/>, 31.03.2022 [↑](#footnote-ref-15)
16. <https://azure.microsoft.com/en-us/>, 31.03.2022 [↑](#footnote-ref-16)
17. <https://firebase.google.com/downloads/gdpr/NOV2021_Firebase_ISO_27001.pdf>, 31.03.2022 [↑](#footnote-ref-17)
18. <https://cloud.google.com/security/compliance/iso-27017>, 31.03.2022 [↑](#footnote-ref-18)
19. <https://cloud.google.com/security/compliance/iso-27018>, 31.03.2022 [↑](#footnote-ref-19)
20. <https://us.aicpa.org/interestareas/frc/assuranceadvisoryservices/aicpasoc1report>, 31.03.2022 [↑](#footnote-ref-20)
21. <https://us.aicpa.org/interestareas/frc/assuranceadvisoryservices/aicpasoc2report>, 31.03.2022 [↑](#footnote-ref-21)
22. <https://firebase.google.com/downloads/gdpr/DEC2021_Firebase_SOC3_Report.pdf>, 31.03.2022 [↑](#footnote-ref-22)