

DEVELOPING AN ANDROID-BASED RUNNING APPLICATION

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Abstract

There are many types of exercise that people do to achieve healthy lifestyle and one of them is running. Runners track their activities to know their progress and help them achieve their goals. One of the alternatives to monitor is through a fitness application which has also become a platform for runners to connect with their friends. As a running shoes manufacturer, XYZ Company wanted to help runners monitor their time, distance, pace, and calories burned while running. In addition, the company also wanted to support the running communities to grow bigger. This thesis project aimed at developing an Android-based application that provides feedback on users' activities while they are running, as well as features that lets them connect with their friends. Moreover, users are also able to schedule a run, compute their heart rate, and run with their friends. The application was developed using Java and utilized Google Maps API and Firebase. An application unit testing as well as unit acceptance testing both to users and client were performed to ensure that the application functions properly. The testing showed a satisfactory result and several recommendations for future development were also proposed. To conclude, the application was able to deliver all the client's requirement and achieve the aim of this thesis project.

Index Terms -- Android, BMI, Fitness, Location Tracking, Running Application, Social Media

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INTRODUCTION

A healthy lifestyle means being able to have a balanced nutrition and to involve in regular exercise. Regular exercise offers several benefits for human body. According to [1], exercising helps blood circulation to brain which can improve brain memory, reduces indication of depression, refines skin health, prevents Alzheimer symptoms, and recovers from major disease. There are many types of regular exercise that people usually do such as cycling, aerobics, swimming, running, and others.

Running is one of the simplest exercises because it does not need to be done in certain sports places and require specific sports equipment other than shoes or sportswear. It also helps reduce the percentage of early death by 25 to 45 percent [2]. In addition, running for 5 to 10 minutes a day is good to eliminate the risk of death caused by heart disease [3]. Running in a group can help people get motivation from their running buddies. Research has proved that running with friends can improve pace rather than running alone [4]. In other words, runners can get motivation by their friends' running pace which may help them improve theirs. To know their workout progress, some people track their activities. A journal book becomes one of the alternatives to monitor workout sessions. After working out, people need to write down their current progress and goals for the next session. Nowadays, technology keeps evolving and smartphone has become another alternative for monitoring physical exercise activities. Of all existing health applications in the market, regular exercise and weight loss are the most popular health category with 96% of the users who are committed to the application they use [5]. Several reasons on why smartphone and internet are being used for monitoring health are because it offers flexibility, provides accessible information, reduces cost, and delivers valuable feedback to the users [6].

Fitness applications help users obtain feedback on their workout activities. As for runners, they can be informed their running time, distance, pace, and calorie burned. These pieces of information can become a motivation to improve their progress on the next run. Sullivan and Lachman also stated that a fitness application that allows the users to acquire feedback on their

activities is useful to encourage them to change their behavior and achieve their next goals as well as to boost self-confidence [7].

Another way to keep user motivated to do physical exercise is reward. Some existing applications have implemented reward system when their users achieve some set of goals. A study on money-based and nonmoney-based reward system was conducted in which rewards were given when the users achieved a certain number of steps [7]. The study proved that both systems were effective as it increased the participants' average number of steps by 108% [7]. One way to implement reward system in an application is through gamification. Beside gamification can motivate the users to keep on exercising, it can also improve user engagement and experience with the application.

In addition, some fitness monitoring applications have implemented social feature. Fitness applications have become a platform for people to share their workout activities. By integrating social media into the application, people are able not only to share their experience, but also to connect with their friends using their existing social media account. Padhye, in his article, stated that social media integration can enhance the functionality of the application. Moreover, social login also improves user experience as it simplifies the process of login and registration in the application. Runners can also get motivated from their friends' activities shared through the social media.

The existence of fitness application as a tool for tracking workout activities has inspired XYZ Company to create a mobile application for running. XYZ Company is one of local running-shoe companies based in Indonesia. Their mission is to design and produce high-quality and comfortable running shoes. The company wanted to build Hashiru as a tool to promote their company and products. In addition, the company also wanted to help the running communities grow bigger.

This thesis project was conducted to develop an Android-based mobile application for running.

The author mainly focused on creating the front-end side of the application which consists of:

- Users' running information
- Location tracking
- Heart rate calculation
- Activity graph
- Friends
- Scheduled Run
- Run with Friends
- Push Notifications
- Gamification
- Share to Facebook
- News and Posts

This thesis project aimed at developing an Android-based mobile application that tracks users' location, total distance, pace, calorie-burned, and heartrate while and after running. It also intended for helping runners to connect with their friends and track their friends' real-time location and running pace. Moreover, it also aimed at creating features that lets users compute their heart rate, see their pace graph and achievements, and schedule a run. Furthermore, the benefits offered to the users from the application are as follows:

- Users can get information about their running duration, pace, distance, calories burned as well as their running routes
- Users can see their heartrate
- Users can share their running history to Facebook
- Users can interact with other runners through social features (i.e. friends and feeds feature)
- Users can track their friends' real-time location and pace
- Users can see their pace histories in form of a graph
- Users can see their achievements
- Users can read news available in the application.

THEORETICAL FOUNDATION

A. General Theories

Running is one of many types of exercise. Several advantages offered from running are that it helps to overcome symptoms of depression and anxiety, protects the brain from aging effects, and develops creativity [8]. It also helps improve sleep quality and mental functioning, which has been proved by a study on groups of adolescents who performed 30-minute running in the morning during weekdays in 3 weeks [9]. Furthermore, running also offers several benefits for human body. It can help prevent the risk of some severe diseases such as type-2 diabetes, high blood pressure, cancer, heart disease, and osteoarthritis (joint pain) [10].

Pace defines how many minutes a person can reach a kilometer or a mile. It specifies if a person is running too fast or too slow. Running too fast or hard can overwork muscles and increase recovery time which can trigger fatigue and injuries [11]. Pace is calculated by dividing total running time with total distance run. Calorie defines the number of stored and used energy. Regular exercise plays an important role in burning calories. There have been many available online-calorie calculators which help people assess their calories burned during exercise. One of them is Omni Calculator which provides an online calculator to solve various problems including health [12]. Equation (1) is the formula to calculate users' calories burned where the MET (Metabolic Equivalent) value for running is 7.5 [12].

$$\frac{\text{Duration (in hours)} * 60 * \text{MET} * 3.5 * \text{Weight (in kg)}}{200} \tag{1}$$

According to Compendium of Physical Activities, each activity has different MET value which defines how much energy the human body uses per hour throughout the activity.

Heart rate is the number of heart beats per minute. One of the

ways to measure it is by using a smartphone, which can be achieved by placing fingertip over the camera's flash (contact) or simply showing face to the camera (non-contact). However, an experiment on the two methods has proved that non-contact method resulted in a fluctuating and inconsistent result [13]. Moreover, another research also found that there were 20 beats per minute differences in the heart rate application compared to the medical heart rate devices, electrocardiogram [14]. This thesis project implemented an open-source Android heart rate monitor library developed by Justin Wetherell. The library uses camera's flash to capture and measure the red pixel of the image when the fingertip is touching the flash [15].

B. Development Technologies

Mobile application is an application programmed and designed to run on mobile devices such as smartphones or tablets. In earlier phones, mobile applications were only able to do phone call and messaging or perform simple calculations. However, in 2000, people began to develop mobile applications that can connect its users to internet [16].

Android is a mobile operating system developed by Google. With 37,93% share of worldwide operating system Internet market, it became the most popular operating system in 2017 [17]. There are several components that build up an Android application, which are activity, service, broadcast receiver, and content provider. Android has several versions of operating system with Android 8.1 (Oreo) as the latest version.

Clean Architecture was first introduced by Robert Martin. This architecture emphasizes on the separation of concern of the application. Fig. 1 [18] shows how the relation between each components of the architecture. Changes on application should not affect the entity layer as well as external changes should not alter the application [19]. Dependency rule is important in an application that implements clean architecture. According to the rule, dependencies should point inward. In other words, any components in the inner circle should not know anything in the outer circle. Thus, to communicate between layers, dependency inversion principle needs to be implemented. Dependency inversion principle defines that high-level modules cannot depend on low-level modules, and both modules should depend on abstractions. Tight-coupling modules can cause some disadvantages such as changes in one module can affect other modules, and module cannot be tested individually.

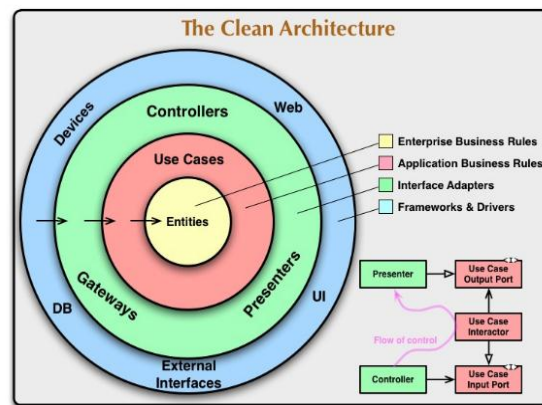


Figure 1. Clean Architecture Components

MVP (Model-View-Presenter) is one of architectural patterns which can be used in an Android application besides MVC and MVVM. The pattern is able to be used either in simple or complex project, and has been widely used because of scalability, testability, readability [20]. In MVP pattern, the View layer only contains the UI and has no logic related to the

information or data being displayed. The presenter fetches data from the model and notify the view when to update. In clean architecture, the model layer is the use-cases that lives in domain layer or in other word, a provider for the data that will be displayed to user. Fig. 2 shows the sample flow of an application using MVP pattern [21].

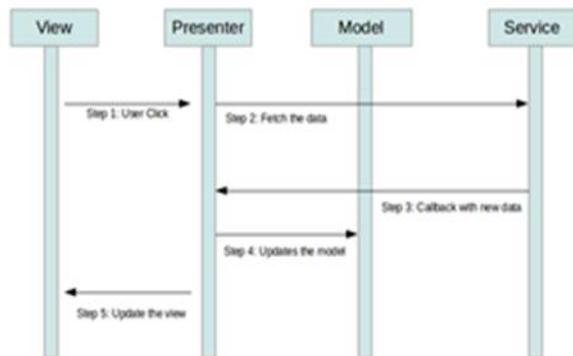


Figure 2. Data Flow in Model-View-Presenter (MVP) Pattern

Application Programming Interface (API) is set of functions or tools used by developers for creating software application. This thesis project used Google Maps API to incorporate maps inside the application. By using the API, developers can customize the map size and the marker color. It also allows developers to style the map or draw a polyline. To integrate the features from this API, developers need to generate a Google Maps API key which is free to use. The API key will be used by the application to requests information from the Google Maps server (i.e. get a static map or showing a map in the layout).

Firebase, developed under Google infrastructure, is a cloud service provider which provides real-time data and storage for mobile (iOS and Android) and web applications [22]. It offers several products that can be utilized by developers to grow and enhance their application quality such as analytics, crash reporting, real-time database, cloud messaging, and others. The two Firebase products that were used in this thesis project are as follows:

1. Firebase Cloud Messaging (FCM)

Firebase Cloud Messaging (FCM) provides reliable connection for server and devices to send and receive messages and notifications [23]. Using FCM, notifications can be delivered right away or on scheduled. It can also choose whether the notifications need to be sent to all devices or to a specific user. Each device has its own FCM token that will be used to specify which device is being targeted to receive the notification. In Android, FCM token is generated automatically when an application is clean installed. Moreover, developers can also delete an existing FCM token programmatically and generate a new token. This is sometimes used when user logged out from the application.

2. Firebase Real-time Database

Firebase Real-time Database is a cloud database which stores data in JSON format. The application can subscribe to specific data in the Firebase to get real-time updates. It keeps data locally even when the connection is off and attempts to synchronize the local data with the remote data when the connection is online [24].

Facebook, founded by Mark Zuckerberg, is one of the most popular social medias. As can be seen in Fig. 3, the number of monthly active users in Facebook is increasing every year and reached 2.2 billion of users in the fourth quarter of 2017 [25]. As the result, there are many existing applications that has

integrated Facebook features, such as login using Facebook or share to Facebook. As the author mentioned previously, implementing social login could simplify the process of login. It can minimize the number of accounts and password users have to remember. The application can also make use the data from the users' Facebook account such as email address, full name, or profile pictures.

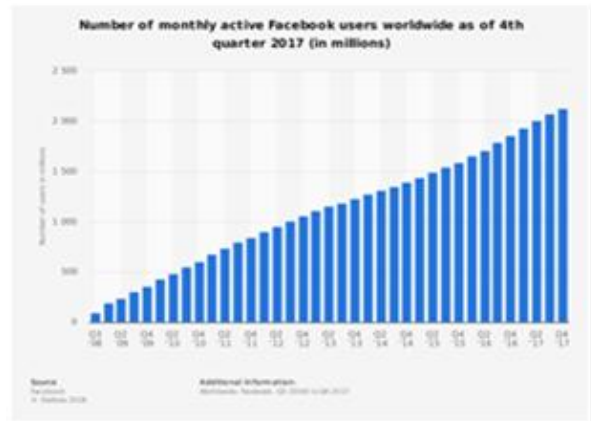


Figure 3. Number of Facebook's Monthly Active Users in 2017

Gamification is a process of incorporating game elements into non-game activities. Game mechanics is important components for implementing gamification. There are many types of game mechanics which developers can use in their application, such as leaderboards, rewards, points, levels, and others [26]. Gamification helps improving engagement between the application and the users, as well as increasing users' commitment to the application [27]. It can also help the company to improve their application sustainability and attract more users to use their application.

C. Research Methodology

There were several steps done by the author to achieve the aims and benefits of this thesis project. The author started by collecting and analyzing the problems and requirements given by the client. The author then did some research from Internet and conducted an online survey which was participated by 59 people to validate the problems. Then, the development of the proposed solution was done using Scrum methodology. Finally, the testing was conducted to the end users and the client to assess and evaluate the quality of the proposed solution.

1. Agile Development Methodology

Agile Development Methodology is one of development methodologies which is incremental and iterative. According to Szalvay, agile methodology emphasizes on delivering product frequently and involving customers in the testing process to obtain more feedback [28]. In a large and complex project, it is difficult to develop a product that immediately fulfills all user requirements. A sudden changes or feedbacks may occur in the middle of development process. Agile methodology allows the development team to implement those new changes on the next iteration to produce the right product for the customers.

Native framework for mobile systems and the Laravel framework for backend systems and Content Management System (CMS). The REST API architecture is used to integrate mobile systems with backend. Whereas MySQL is used to build database systems. In the final stage, the deployment process is carried out by User Acceptance Testing (UAT) using the black box testing method to test the functionality of the "LaundryPlaces" application system based on the Success Scenario. The testing process itself is carried out by Bina Nusantara University students and representatives of the Laundry Vendor.

RESEARCH METHODOLOGY

A. Existing Problems

There are two problems that were found by the client. The author then conducted a preliminary survey to analyze and validate the existing problems. The survey was done online using Google Form. It was participated by 59 people, with 52% of them run once a week, 34% run more than once a week, and 14% run every day.

1. People want to monitor their distance and pace
 Many people who exercise regularly want to track their workout activities, including runners. It becomes a way to acquire feedback on their pace and distance. In addition, tracking running may also help them to improve and surpass their goal. The respondents were also asked about the importance of monitoring time, distance, and pace while running. 81% of the respondents agreed that measuring time, distance, and pace while running is important. Measuring pace allows runners to observe if they are running too fast or not. It is critical to prevent fatigue or injuries. Moreover, Ewen North, coach of Revolution Running, stated that pace is essential for people as it practices endurance and helps them run longer [29].

2. The use of fitness application as social tools
 Some of the existing fitness applications have social media integrations (i.e. Facebook, Instagram, and others) and social features (i.e. friends, feeds, and others). The respondents were also asked on the importance of social features in fitness applications. Based on Fig.4, the two most selected answers are to connect with their friends who like running and to get motivation from their friends' record.

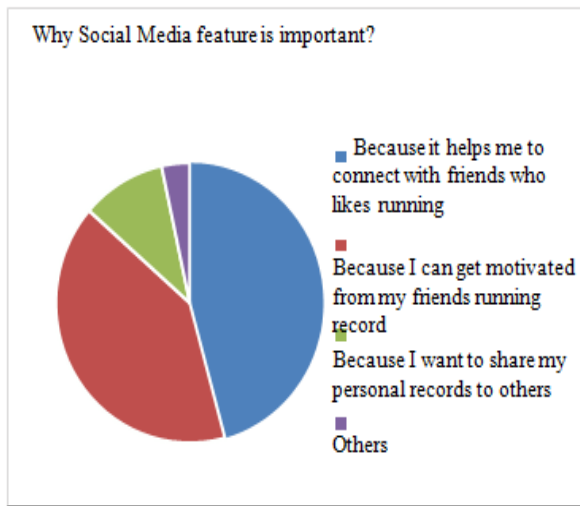


Figure 4. Importance of Social Media Feature in Fitness Application Survey Result

In addition, the client also proposed to include BMI feature. During the preliminary survey, the participants were also asked on other important aspects in fitness application besides distance, pace, and duration. Based on the survey result shown in Fig. 4 above, out of 81 total answers, 56% of them are heart rate followed by calories burned with 33%. It was concluded that there are not many people who currently aware that measuring BMI is important.

BMI or Body Mass Index is a body fat calculation based on proportion of weight and height. It allows people to know if they are being overweight, underweight, or at normal weight. National Institute of Diabetes and Digestive and Kidney Disease stated that being overweight may endanger health and causes some diseases, including heart disease, diabetes, stroke, kidney

disease, and certain cancers [31]. Nevertheless, the four existing applications do not have any BMI feature yet.

As a solution, Hashiru was developed to help people, especially runners, who want to track workout activities. The application incorporated some features that have existed in the current solutions such as location tracking and feedback on users' activities (i.e. pace, duration, distance, and calories burned). Moreover, to utilize the application as a social platform for the runners, the application includes not only social feature (i.e. Facebook sharing and friends feature), but also a feature that allows users to run with their friends. While running with their friends, users are able to see one another's running map and pace. Users are also allowed to schedule a run and know their updated BMI through a reminder. Furthermore, the application also provides a heart-rate calculation feature that utilizes phone's camera.

SOLUTION DESIGN

A. System Architecture

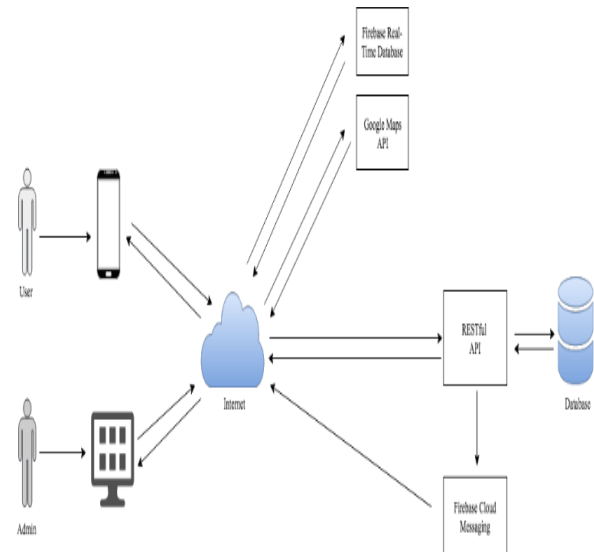


Figure 5. Hashiru System Architecture

The figure above shows the system architecture of this thesis project which includes both the mobile application and the dashboard web application. By having an Internet connection, the user or admin is able to input or store.

In addition, the client also proposed to include BMI feature. During the preliminary survey, the participants were also asked on other important aspects in fitness application besides distance, pace, and duration. Based on the survey result shown in Fig. 5 above, out of 81 total answers, 56% of them are heart rate followed by calories burned with 33%. It was concluded that there are not many people who currently aware that measuring BMI is important.

B. Development Methodology

Scrum is a product management framework that implements agile methodology. Scrum presents the concept of "Sprint", a certain period of time to deliver and create potentially usable product increment [32]. It begins with sprint planning to discuss the deliverables for the sprint and how the task will be carried out by the development team. Daily scrum is a 15-minute daily meeting to discuss what the development team has done on the previous day and what they will do during the day. It also examines the issues that defer the work of development team. At the end of sprint, sprint review is done by the team to present their deliverables during the sprint. Finally, sprint retrospective

is held to evaluate the last sprint process and improvement for the next sprint. Scrum, as agile framework, offers several advantages such as transparency, adaptability to changes, continuous improvement and feedback, and customer oriented [33].

C. Use Case Diagrams



IMPLEMENTATION AND TESTING

A. Software Requirements

Hashiru is compatible for Android 4.4 Kitkat (API level 19) devices and above. It requires devices equipped with camera and flash and connected to Internet. Furthermore, the file size of Hashiru is 13.2 MB.

B. Development Tools

The specification of devices used during the development process are:

- Apple MacBook Pro
Operating System: macOS High Sierra Version 10.13.1
Processor: 2.3 GHz Intel Core i5
Memory: 8 GB 2133 MHz LPDDR3
GPU: Intel Iris Plus Graphics 640

- Samsung Galaxy S5
Operating System: Android 6.0 or Marshmallow
Resolution: 1080 x 1920 pixels
CPU: Quad-core 2.5 GHz Krait 400
GPU: Adreno 330

In addition, several software that were used by the author to support the development of this thesis project are as follows:

- Android Studio 3.0.1, as the Integrated Development Environment (IDE) for Android.

- BitBucket, as Git version control repository
- MeisterTask, as the tool to manage and track tasks in each sprint.
- Slack, as the communication tool for the developers.
- Zeplin, as the tool for developers and designers to build the user interface for the application.

C. Testing

There are two types of testing that were conducted which are application unit testing and user acceptance testing (UAT). The application unit testing was done by the author, meanwhile the UAT was done to the users and the client. For the application unit testing, several test-cases were made to compare the expected result and the actual outcome.

For the UAT, the users were also asked to give score on each feature based on their experience using the application. The devices specification used by the users are shown in the table below.

Table I. Devices Specification Used in Testing

No.	Device Name	Android Version
1.	OPPO R7sf	5.1.1 or Lollipop
2.	Xiaomi Redmi 3	5.1.1 or Lollipop
3.	Xiaomi Redmi 3 Pro	5.1.1 or Lollipop
4.	Sony Xperia C5 Ultra Dual	6.0 or Marshmallow
5.	Asus Zenfone 2 Laser	6.0.1 or Marshmallow
6.	Xiaomi Mi Note	6.0.1 or Marshmallow
7.	Xiaomi Redmi Note 3	6.0.1 or Marshmallow
8.	Samsung S7 Edge	7.0 or Nougat
9.	LG G6	7.0 or Nougat
10.	Xiaomi Redmi Note 4	7.0 or Nougat

The UAT showed satisfactory result both from users and client. However, there are several recommendations that were proposed for the future development.

DISCUSSION

A. Development

The development phase was started from February until May 2018. The author and the team developed the application in 5 sprints. Each sprint consists of two weeks. On 23rd of February, the author asked the client about the background of the project. The client also explained the problems they want to solve in this project and the requirements for the application. The author then conducted an online survey to further validate the problems defined by the client.

On 24th of February, the author conducted sprint planning for the first sprint. The development for the first sprint began from 12th March until 23rd March. The features that were developed by the author during this sprint are run, news list, and news detail. Before developing the run feature, the author learnt about implementing map, location tracking, and drawing polyline.

Sprint 2 was started on March 26th and was completed on April 13th. Because of the author wanted to prepare the materials for the pre-defense presentation, Sprint 2 was done in three weeks. During this sprint, the author created the running summary, heart rate, and notifications features. To develop the heart rate feature, the author did some research on existing Android heart rate monitor library and found an open source library in GitHub developed by Justin Wetherell. The author also implemented Firebase Cloud Messaging on the Android application to allow the applications received notifications sent by server. Because

the backend service has not deployed yet during this sprint, the author used Firebase Console to test sending the push notifications to the device.

During the third and fourth week of April, which is Sprint 3, the author started to implement the design for the mobile application. The author used *Zepplin* to view the design created by the designer and implement it on the mobile application. The author also developed other features such as share to Facebook, pace graph, notifications list, and latest running summary. To develop pace graph feature, the author did some research on how to implement a graph on Android. The author then found an Android library to integrate various types of charts, including graph, called *MPAndroidChart*. The author also learned about Facebook sharing from the documentation available on the Internet before developing the share feature as the author has never implemented Facebook feature in Android application.

Sprint 4 was started on April 30th and ended on May 13th. During this sprint, the author focused on working friends features which consists of friends list, friend requests, add friend, search friend, and accept or decline friend request. Besides working on friend's module, the author also developed the posts and comment feature. The author also fixed some minor and major bugs found in the application.

The last sprint was held from May 14th to May 25th. During this sprint 5, the author focused on scheduled run, run with friends, and achievement feature. The scheduled run feature consists of create a scheduled run, view run schedules, edit a scheduled run, and view run invitations. Before developing the run with friends' feature, the author learned and researched about implementing Firebase Real-time Database to allow users track their friends' real-time locations.

B. Testing

Before the users test the application, an Application Unit Testing was performed by the author to check whether each feature works properly or not. The author also conducted a User Acceptance Test (UAT) which was participated by 10 people. The UAT was done to examine all the features in the application and gain feedback from the testers. The testers were also asked to fill in a survey form based on their experience using the application. The survey result concluded that the testers showed positive responses to most of the features in the application. However, some of the testers agreed that there are some features that needs to be improved in terms of user interface and user experience.

After testing the application with the users, the application was then given to and tested by the client. The client showed positive response to the mobile application and the dashboard. The client also gave several recommendations for future development of the application.

C. Constraints

During the development of this thesis project, the author experienced several difficulties which are as follows:

- Inexperience with some Android libraries
This thesis project used some Android libraries which were never used by the author before, such as Reactive Location for location tracking or Facebook SDK. Thus, the author experienced some difficulties while implementing it on the first time. However, because each library has provided official documentation as well as tutorial through internet, the author was able to implement and incorporate it in the application.
- Inexperience with Google Maps API and Firebase Real-time Database
The author also encountered some problems while developing

run feature, as the author has never used Google Maps API to implement a map based on users' current location with a polyline. In addition, the author also experienced some difficulties while implementing Firebase Real-time Database. To overcome these problems, the author then learned from the official documentation as well as from some tutorials available on the Internet.

- Time Constraint

Due to the limited time to develop this thesis project, the running with friends' feature was not included during the User Acceptance Testing (UAT). However, this feature has been tested by the author during the application unit testing.

CONCLUSION AND RECOMMENDATION

A. Conclusion

A fitness application is a useful tool to help people monitor their workout activities. It helps people gain feedback to motivate them to improve their skill on the next exercise. Some runners have benefited from the fitness applications as they can get information such as duration, pace, distance, or calories burned while and after they are running. Some of these applications have also become a platform to connect them with other runners.

XYZ Company, a local running shoe company based in Indonesia, wanted to help people track their running workouts. The company wanted to build an application which is not only able to monitor pace or distance, but also connect its users with other runners. Thus, an Android-based mobile application, Hashiru, was developed which become the outcome of this thesis project.

As a fitness application, Hashiru is able to track users' location and provide some important data on users' activities while running (i.e running duration, distance, and pace). It also calculates users' calorie-burned after running. By using their smartphone, users are now able to calculate their heart- rate after running through the built-in device's camera. Moreover, users can get information on their BMI or read latest news about running. Hashiru also helps users to connect with other friends who enjoy running through the friends and feeds feature. Users are also allowed to schedule a run on a specific day and invite their friends to run together. The application has also been tested through Application Unit Testing and User Acceptance Test which showed satisfactory result both from the users and client.

To conclude, this thesis project has been developed based on the client's requirements and the scope of work. The author hopes that this thesis project can help runners track their activities and engage more people to run. As a final word, the author also hopes that this thesis project will be helpful to the client to promote their brand and products.

B. Recommendations

Although the application has delivered all the requirements, there are several things that can be considered for the future development of the application. The recommendations below were collected from the users who joined the User Acceptance Testing as well as the client.

- Improves the application design (UI/UX)
- Provides friend suggestion as another way to add friend
- Provides push notifications when a friend request is accepted or declined, or when a comment is posted on users' post
- Allows news sharing to social media
- Allows users to tag friends in comment
- Provides a weekly and monthly leaderboard
- Allows users edit invited friends in scheduled run
- Integrates with Google Calendar

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