Development of a Gamified Cycling Mobile Application for Fitness and Touring with Community

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***Abstract*—Road cycling is a popular sport for fitness and recreation throughout the world. In many urban areas, the sport has spurred communities or clubs that not only provide opportunities for its members to play the sport, but also provide a medium for developing sport performance through group rides and activities. Many mobile applications have been developed for activity tracking and providing important metrics while doing sport activities as well as gamification through leaderboards in comparing performance with others. No mobile application, however, has been developed for community based activities where members not only can develop themselves, but also improve the interactions and engagement of group rides. The Bike App as a prototype application was developed for such purposes. The development of the app involved a cycling community based in Jakarta.**

Keywords—gamification, health and fitness, bicycle, mobile application

I. INTRODUCTION

Being part of a community is an important aspect for the lives of many people. This is certainly important for many who are detached from the more 'traditional' lifestyles in rural areas [1]. Studies have shown that sports can play a role in that community integration and cultural understanding by enhancing relationships, even in areas of high conflict [1]. This relationship building through sports does not necessarily provide a vehicle for sports clubs to engage their members in promoting a healthy lifestyle for their members; in many cases, sports communities engage their members to simply provide a chance for them to play the sport [2]. Robertson et al. (2018) further stated that the most important role of sports communities is to provide inclusion and participation for their members and stakeholders. Cycling as a recreational sport not only improves one's well-being due to its health benefits, but it also provides enjoyment for many people. As a group activity, cycling pushes people to perform and keep up with others in a group ride.

Milagro Cyclist, the subject of this field research, is a cycling community that provides its members of like hobby a chance to participate in organized club rides in Jakarta, Indonesia. Formed on November 11, 2010, the club of road cyclists was started by individuals who wanted a healthier lifestyle. By 2015, three of its members participated in the 2015 Southeast Asian Games in Singapore [3]. During organized club rides, cyclists will ride in pace as a peloton, the cycling pack where riders need to keep up the pace. Those rides will typically be 50 km to 75 km in distance. Riders who cannot keep up will be "dropped" or left behind. This community of cyclists was eager to take part in developing the Bike App. The objective of developing the app is for cycling community members be able to develop themselves in terms of cycling performance, so that they are able to effectively partake in the community group rides while at the same time monitor their performance during and after the rides.

II. THEORETICAL FOUNDATION

A. Innovation in Community Sports

Innovation can be simply defined as the creation and adoption of new ideas. Additionally, the adoption of innovation at the organizational level can be of a new product, service, process, technology, policy, structure, or administrative system [4]. In the case of community sports organizations, innovation is an important competency due to its influence as to organizational effectiveness, organizational survival, and the competitive advantage of the organization [5]. Hoeber et al. (2015) also revealed that the practices of innovation in community based sports mostly tackle the needs and interests of the members directly or are process related in the organization. Based on research, it has been shown that community based organizations strive to innovate in improving processes for the good of the community.

B. Gamification

The term gamification came to popularity when Nick Pelling introduced the word in 2002 [6]. The term describes the assignment of game-like characteristics to something that is not a game. That transfer of characteristics is useful for users (in the case of Bike App) by improving the user engagement, making it more 'fun' to use. In using gaming elements and/or characteristics mixed with the smartphone, the mobile web, and social networks, gamified mobile apps

have become a platform for activities that are mixed with reality [6].

Gamified mobile apps are certainly prevalent in the area of health and wellness. Nike had success in introducing its Nike+ activity tracker device which connects to an iPod Touch or iPhone. The iTunes app on a personal computer can be used to view the users' historical performance and even compare it with other users. The success of Nike+ plus spurred Apple Inc. and Samsung to introduce their own lines of fitness tracking devices and/or applications. To increase the level of engagement and fun in wellness apps, several important features may be adopted which include: gamification, choosing the right platform, and making the app multiplayer (*7*). Kulkarni (2014) also proposed features such as leaderboards, leveling up, and reward points. The Bike App will adopt these features. Gamified features of the app are used to create engagement, make challenges, and introduce multiplayer features.

C. ANT+ Sensors

ANT+ is a wireless protocol for monitoring sensor data. The protocol is widely used in health based sensors such as speed and cadence (pedaling frequency) for bicycles, heart rate monitors, and electronic scales. The standards and protocols are maintained by the ANT+ Alliance, an alliance of companies that adopts the technology for its devices. ANT+ is an ultra-low power wireless protocol used to establish connections between devices and send information. ANT+ focuses on interoperability which facilitates products that use the protocol to be able to connect with any other ANT+ based products [6]. ANT+ can be used with any sort of low data rate sensor network topology, for example, peer-to-peer (P2P), star, or mesh topologies in a personal area network (PAN) which can be applicable for fitness, sports, and home health applications. The Galaxy series of Android smartphones by Samsung incorporates the sensor and protocol and is used in the development of the Bike App in conjunction with a paired speed and cadence sensor installed on a bike. Using ANT+ with sensors instead of a GPS location to calculate the speed and distance reduces battery drain on the smartphone.

D. Agile Methodology

The agile methodology will be used for the mobile application development process. To be precise, Scrum methodology will be used throughout the project. Scrum methodology is an iterative process that will proceed to the next stage of the development, right after the application has been accepted by the users.

III. Existing Solutions

Currently, there are several Android mobile applications that have been published in Play Store. These applications have the feature of measuring basic information when cycling such as one's speed, heart rate, and burned calories. The applications that are selected for a comparison review consist of cycling specific applications and/or fitness and wellness applications that have cycling specific features. Most applications use GPS to track locations and therefore use that technology to calculate distance traveled, speed, and even mapping. The following are popular sports/ fitness apps for cycling:

A. Move! Bike Computer

The Move! Bike Computer is an Android based mobile application available in Google Play Store. The main function of this application is to measure the speed of a bicycle and calculate important metrics for a ride. The app also tracks the actual path taken for a ride and can display it on a map. This mobile application uses GPS to determine the speed and location. This Android app simply functions as a replacement for a bike computer.

B. CycleDroid – Bike Computer

The CycleDroid – bike computer is also an Android based mobile application that can track speed, distance, and time. Although the app is somewhat minimalist, users can share their achievements through Facebook. This app can be downloaded from Google Play Store.

C. Strava Running and Cycling GPS

Strava Running and Cycling GPS is a multiplatform mobile application that has several features such as Activity Tracking, Personal Challenge, and Heart Rate (Fig. 3). This app is one of the most popular fitness apps and has strong gamification features. Activity Tracking is a feature where the user can get key stats such as time, heart rate, distance, speed, and calories burned. In contrast, Personal Challenge functions to push the user to train and cycle harder, while Heart Rate simply lets the user know one's heart rate while cycling by using another third party sensor. The application also compares the user's performance with others. It measures the user's speed with the help of GPS technology. The popularity of this app forces many wearable and bike computer companies to provide features to upload performance metrics to Strava.

D. Runtastic Road Bike Tracker

Runtastic Road Bike Tracker is another mobile application that can be used to help cyclists reveal basic information, such as the speed, distance, and duration they have cycled. The speed information contained in the application is based on GPS. Besides this basic information, there is also information about how many calories are burned during the cycling activity.

E. Map My Ride GPS Cycling Riding

Map My Ride GPS Cycling Riding is another mobile application which has several features, such as displaying basic key stats while doing physical activity, for example, running and cycling. The key stats mentioned consist of speed, calories, distance, and duration. These key stats are obtained mainly with the help of GPS. Aside from cycling, this application can be used for running. Similar to Runtastic, users can view the performance metrics of the activity and route/track information on a map.

The following table (Table I) describes the list of features of the above mentioned Android applications for comparison:

TABLE I. Existing Android Cycling Apps and their Features

Features	Application				
	Move! Bike Computer	***CycleDroid***	***Strava***	***Runtastic***	***Map My Ride***
GPS Logger (Tracking)	X	X	X	X	X
Speed	X	X	X	X	X
Distance	X	X	X	X	X
Altitude	X	X	X	X	X
Time Metrics	X	X	X	X	X

Track Sharing	X	X	X	X	X
Speed/Distance Calculation	GPS based	GPS Based	GPS based	GPS based	GPS based
Multi Sports			X	Different Versions	Different versions
Goal Setting			X		
Challenges			X		X
Achievements Sharing			X	X	X
Calories Burned			X	X	Using additional devices
Works with Bike Sensors				X	
Voice Coach				X	X
Leaderboard			X		X

IV. Proposed Solution – System Design

A. System Architecture

The System Architecture Diagram below (Fig. 1) shows the whole system of the mobile application starting from the user until the database and back to the user. The database is installed on a cloud server using the MySQL database server. Additionally, the RESTFul API is used to bridge the connection between the database server and the application [8]. Firstly, a user inputs data into the Android smartphone. Then the data will be transferred to the Internet which will then be processed by the application system. Inside the application system, the data will be controlled and processed either by the ANT+ library or the Google Maps library. The ANT+ library is used to control the searching and connecting process of the sensor to the mobile application itself, while the Google Maps library is used to control the data that is relevant to Google Maps, such as marking the start point, determining the end point, adding the waypoint, and creating the directions from the start point until the end point and passing through all the added way points in-between. However, the ANT+ and Google Maps libraries also use the BikeApp library to store and retrieve data from the database. From these libraries, the data then will be processed in the BikeApp API which is the "Pointer" of the database; it points out which database can have the data inputted.

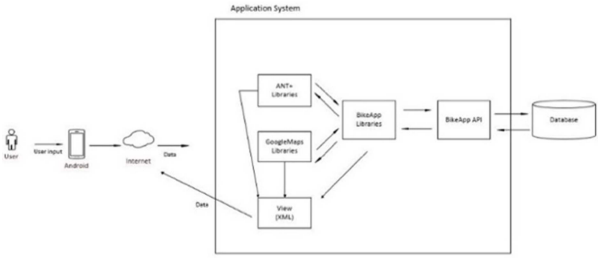

Fig 1. The System Architecture

In the meantime, if the user does some data retrieval, the BikeApp library will trigger the BikeApp API to retrieve the data and pass it to the XML page that will print out the data to the user through the Internet.

B. Use Case Diagram

The use case diagram below, depicted in Fig. 2, shows how a user interacts with the mobile application. Each user has an option to add an account and login to the application. Whenever they are logged in to the application, they are able to use the other features such as change the wheel circumference (this is used to ensure accurate speed readings – the tire size will affect the circumference of a wheel), find friends, view the friend list, view the leaderboard, start a cycling trip, scan accessories, view profiles, view the achievement list, view the trip history, and log out.

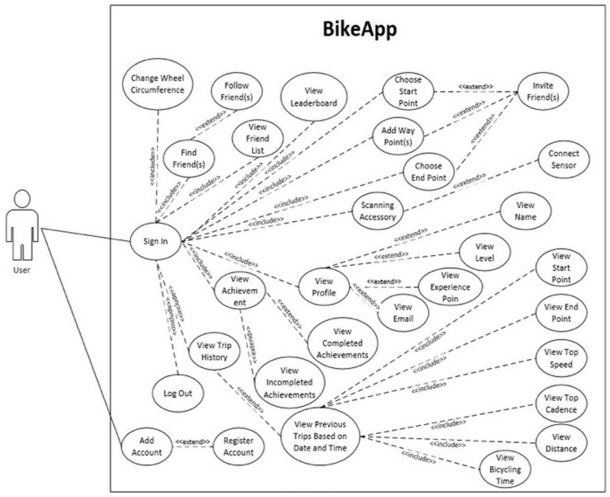

Fig 2. Use Case Diagram

V. Software Development Methodology

In developing the application, the cycling community was approached. A combination of in-depth interviews of three people were conducted and additional information was acquired through questionnaires to twenty five people. The questionnaire was designed to gain both opinions relevant to cycling and the participants' cycling behaviors. From the questionnaire, several insights were gained on the use of bike computers and/or the smartphone app used while cycling. One piece of information gained was that 88% of the people surveyed use bike computers. For those that use bike computers, distance and speed are the most important information they need. However, a follow-up question asked whether the concept of gamification in a bike app would be of interest to the respondents, and 88% of them were interested. Additionally, they were also asked in a follow-up question about the type of gamification that would be of interest to them. The results of the responses are described in Table II below:

TABLE II. Interesting Features to Add

Rank	List of Features	Response
1	Achievement	88%
2	Challenge	80%
3	Touring	60%
4	Racing	32%

5	Trip History	68%

Based on the in-depth interviews and questionnaires given, the following insights were gained about the bike app:

1. All of the respondents choose cycling as their hobby.
2. Almost all of the respondents use bike computers.
3. The information needed while cycling includes: distance, speed, maps, and cadence.
4. The features that will be interesting to be added include: achievement and challenge.
5. The respondents agreed that a challenging feature can improve a user's cycling experience.
6. The respondents agreed that a gamification feature in a cycling application is interesting.

Agile methodology was chosen in developing the application because of its flexibility. Each iteration will be explained below:

A. Iteration 1

The first iteration focuses on identifying the requirements, gathering data, and designing the system to develop the application. This iteration includes the basic features to be developed such as the sign-in, start, and end points on the map, and how to scan the accessory/ bike sensor. The technology chosen for the study comprised: ANT+ technology, Android Studio, and ANT+ SDK. First, the questionnaire was designed for the survey. Then the respondents were contacted. After the planning phase, all the features were chosen to be developed for iteration 1. The list of features are as follows: view profile; view achievement list; scan bike sensor using ANT+ technology; and show information bar that displays speed, cadence, distance, and runtime. It enabled detection of the current location, as well as determination of the start and end points using Google Maps API. It also enabled the user to log in and log out [9]. Figure 3 shows the main menu and main features of the application.

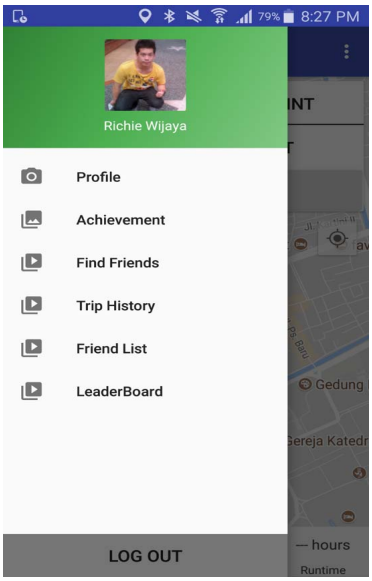

Fig 3. Main Menu of the Bike App

B. Iteration 2

In the second iteration, the data was collected after the testing. In order to develop the application even further, the results were compiled to better understand the problems and inputs from the users. The beta testing was done on the same respondents as the previous iteration in order to prevent biased results. After the planning phase, all the features were decided to be developed for iteration 2. The list of features is as follows: trip history and adding waypoint(s), as shown in Fig. 4, and the leveling feature, as shown in Fig. 5.

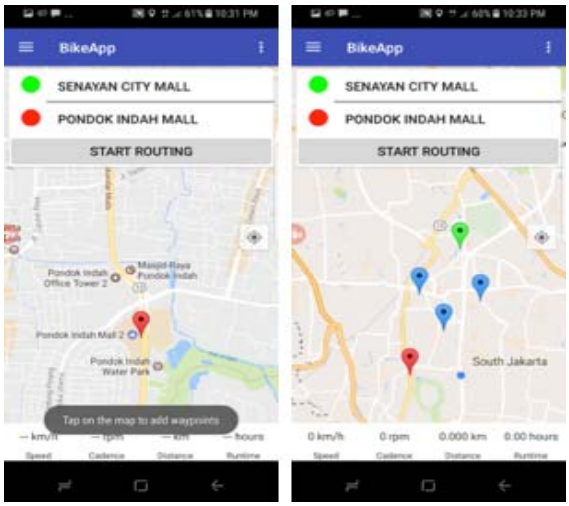

Fig 4. These 2 screens show how a user can choose a destination and waypoints before a ride.

Additionally, the leveling up is done through completing challenges by gaining experience points.

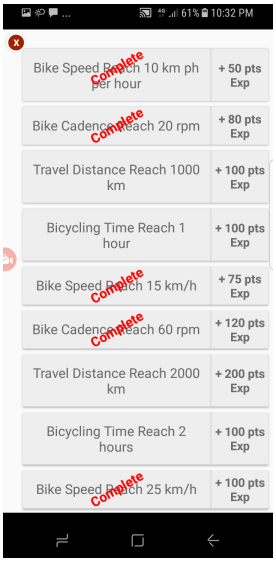

Fig 5. This screen shows challenges that can be completed. Users will gain experience points based on the challenges.

C. Iteration 3

In this iteration, for further improvements in the application and to provide more features for the user, the study focused on the data gained after the second iteration's testing. Similar to the previous iteration, the same respondents were used for the beta testing. After the planning phase, all the

features were chosen to be developed for iteration 3. The list of features is as follows: change the circumference value, leaderboard, and social media feature. The implementation of the leaderboard is shown below in Fig. 6.

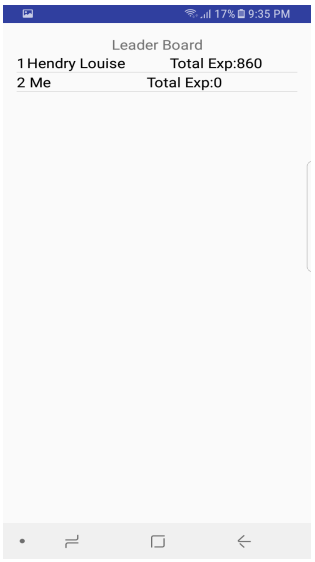

Fig 6. This screen shows the implementation of a leaderboard. One's individual performance compared to friends' performances can be viewed.

VI. TESTING

Before the BikeApp application was tested by the end user, the system was tested first to see if there were any major bugs. If the system had errors or bugs, it would need to have the errors and bugs fixed and solved first, to ensure that the application with all of its features was running properly. The resulting data gathered from the developer testing is as displayed in Table III:

TABLE III. THE TYPE OF FEATURE TESTING BASED ON THE 'USE CASES'

No.	Test Description	Result
1	User sign-in	Pass
2	Enter start and end points	Pass
3	Add waypoints	Pass
4	Scan and pair bike sensors	Pass
5	Achievement feature is working properly	Pass
6	Trip history is properly recorded	Pass
7	Level feature is working	Pass
8	User logout	Pass

Additionally, beta testing was conducted with the bike community. In each iteration, functional testing was conducted for the application. Throughout the three iterations, the users requested additional features, and those features would be incorporated in the next iterative process. Table IV shows the complete beta testing done for the application.

TABLE IV. BETA TESTING DONE (TEST CASES)

Test ID	Module	Test Name	Pre-Condition	Result
TCU-01	BikeApp Application Unit Testing	Start Application	Internet Connection & GPS	PASS
TCU-02	BikeApp Application Unit Testing	Sign-In (First Time)	TCU-01	PASS
TCU-03	BikeApp Application Unit Testing	Sign-In (Account Added)	TCU-01	PASS
TCU-04	BikeApp Application Unit Testing	Display User's Current Location	TCU-03	PASS
TCU-05	BikeApp Application Unit Testing	Zoom In	TCU-03	PASS
TCU-06	BikeApp Application Unit Testing	Zoom Out	TCU-03	PASS
TCU-07	BikeApp Application Unit Testing	Choose Start Point	TCU-03	PASS
TCU-08	BikeApp Application Unit Testing	Choose End Point	TCU-03	PASS
TCU-09	BikeApp Application Unit Testing	Scanning Accessory (Before Start Routing)	TCU-03	PASS
TCU-10	BikeApp Application Unit Testing	Scanning Accessory	TCU-07 & TCU-08	PASS
TCU-11	BikeApp Application Unit Testing	Adding Waypoints	TCU-10	PASS
TCU-12	BikeApp Application Unit Testing	Clear all the marker points	TCU-07, TCU-08, & TCU-11	PASS
TCU-13	BikeApp Application Unit Testing	Start Routing	TCU-10	PASS
TCU-14	BikeApp Application Unit Testing	Finish Routing	TCU-13	PASS
TCU-15	BikeApp Application Unit Testing	View Profile Menu	TCU-03	PASS
TCU-16	BikeApp Application Unit Testing	Achievement Menu	TCU-03	PASS
TCU-17	BikeApp Application Unit Testing	View Trip History Menu	TCU-03	PASS
TCU-18	BikeApp Application Unit Testing	Generate an error when user click 'Start Routing'	TCU-07	PASS
TCU-19	BikeApp Application Unit Testing	Generate an error when user click 'Start Routing'	TCU-08	PASS
TCU-20	BikeApp Application Unit Testing	Check 'Speed Sensor'	TCU-13	PASS
TCU-21	BikeApp Application Unit Testing	Check 'Cadence Sensor'	TCU-13	PASS
TCU-22	BikeApp Application Unit Testing	The Runtime	TCU-13	PASS
TCU-23	BikeApp Application Unit Testing	The Distance	TCU-13	PASS

TCU-24	BikeApp Application Unit Testing	Achievement speed testing "Bike speed reach 10km per hour"	TCU-13	PASS
TCU-25	BikeApp Application Unit Testing	Achievement cadence testing "Bike cadence reach 20rpm"	TCU-13	PASS
TCU-26	BikeApp Application Unit Testing	Achievement travel distance testing "Travel distance reach 5km"	TCU-13	PASS
TCU-27	BikeApp Application Unit Testing	Achievement bicycling time testing "Bicycling time reach 1 hours"	TCU-13	PASS
TCU-28	BikeApp Application Unit Testing	Top speed testing	TCU-13	PASS
TCU-29	BikeApp Application Unit Testing	Top cadence testing	TCU-13	PASS
TCU-30	BikeApp Application Unit Testing	'Find Friends' testing	TCU-13	PASS
TCU-31	BikeApp Application Unit Testing	'Friend List' testing	TCU-13	PASS
TCU-32	BikeApp Application Unit Testing	View friend's profile	TCU-13	PASS
TCU-33	BikeApp Application Unit Testing	'Leaderboard' testing	TCU-13	PASS
TCU-34	BikeApp Application Unit Testing	Change 'Wheel Circumference'	TCU-13	PASS
TCU-35	BikeApp Application Unit Testing	Send ride invitation	TCU-10	PASS
TCU-36	BikeApp Application Unit Testing	Accept ride invitation	TCU-03	PASS
TCU-37	BikeApp Application Unit Testing	Decline ride invitation	TCU-03	PASS

VII. Discussion

The Bike App from the analysis and design to final implementation with three iterations took almost four months to complete. The first month was spent analyzing the users' behaviors and needs and deciding the core technologies that would be used; mostly in the form of APIs, cloud systems, and platform related APIs. The software development started in the second month throughout the third month with the three iterations. The app's features list and design were continuously discussed with the users, and testing was done by the users as well. The core technologies used were: ANT+ API, Google Maps API, and cloud based database API. The most difficult technological hurdles that were faced included: adding waypoints for route creation and implementing them in Google Maps API, connecting multiple sensors using the ANT+, and designing and implementing the database tables in the cloud; specifically for implementing the leaderboard and other information sharing (multi-user) aspect of the application.

VIII. Conclusion

After a thorough development and evaluation of the prototype software, it can be concluded that the software prototype yielded positive results based on users' feedback. In terms of design and functionality, it implemented the concept of gamification through leaderboards and challenges where users can gain 'experience points'. Additionally, the application improves the experience in cycling as group members can track the locations of others and whether they are on track while riding together. The Bike App compared existing cycling specifics or fitness apps that provide cycling features, which is innovative in terms of its features and intended use. The challenges are designed so that users reach a level of ability and confidence in the sport, rather than focus on beating other users' achievements. In other words, achieving experience points helps members of a cycling club to gain confidence in doing club rides. Mapping features also are designed for the 'community' in mind. Setting destinations and waypoints help all users in a ride to complete the task together as a group. Additionally, the users also requested additional features for future development. The following features described in Table V are features that have not been implemented but recommended by the users:

TABLE V. Requested Features

Rank	List of Information	Response
1	Calories burned information	90%
2	Power meter information	30%
3	Pace information	20%

In conclusion, the prototype has proven its worth as a proper tool to assist cyclists in substituting a dedicated cycling computer by using a smartphone and is hoped to be a cost-effective viable solution for many cyclists seeking to improve their overall cycling experience and performance through challenges. The gamification features implemented include: individual challenges to complete and a leaderboard. Gamification is used so that users can develop their cycling performance so that they reach a level of performance where they will be capable of keeping up with others in group rides. Cycling as a group is a core activity that provides the motivation and purpose of a cycling community. The app provides cycling communities with an innovative solution using an existing mobile platform with a new experience in improving performance metrics and engagement in group rides through the tracking feature of friends. The Milagro cycling community considers the app useful in getting members to improve themselves, and at the same time it improves the sense of community while on group rides.

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