Software Engineering Process for Development of Chiang Mai University Bus Information System and Bus Arrival Time Estimation

Ponlawat Weerapanpisit
Universitat Jaume I (UJI)
Castellón, Spain
al394260@uji.es

Abstract

In this project, information system for Chiang Mai University inside-campus bus [1] was developed. The buses had fixed route but no officially fixed schedule which led difficulties to their passengers. This project uses software engineering methodologies to study users' problems and to solve them. The project is divided into two parts. The first part involves data recording and analysing. The system regularly records bus arrival time at bus stops using provided location data, then analyses them to generate daily estimated timetables for each bus stop. The second part involves software engineering to develop a user-friendly application for passengers, to provide useful information to them, for instance: estimated bus arrival time, route transfer information, and to evaluate the software.

Keywords: transportation, software development, data analysis, arrival time estimation

Introduction

In Chiang Mai University, there were free short-distance bus services inside the campus to facilitate students' lives. All the buses were divided into six routes, and each bus had a GPS device to report its current location which was accessible on internet. However, surveying showed that the major problem for passengers to use the bus was lack of information. Especially information for new passengers who did not know the route nor locations of bus stops. Moreover, even for the frequent passengers that already got used to bus routes, as there was not official bus timetable, they still found the difficulty to know current bus location and arrival time.

User Study and Task Analysis

To understand the problem and to develop the solution to the problem, a requirement engineering method called *User Study and Task Analysis* [2] [3] was performed.

The result of user study led to task analysis. After doing task analysis, the solution should contain the following task. Firstly, route information service that allows users to search which route they should take or should transfer to go to their destination. Secondly, arrival estimation system which displays estimated arrival time of bus to users that are waiting at bus stop.

Use Case Diagram

After done user study and task analysis to understand passengers' requirements, the use case diagram of system can be drawn as shown in Figure 1.

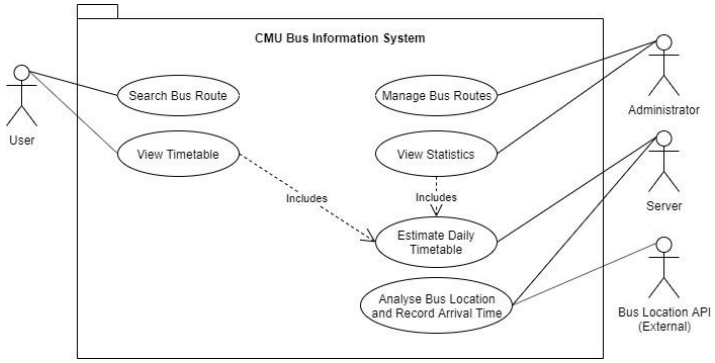

Figure 1: Software Use Case Diagram

Designing Database Schema

From the use case diagram, the database schema can be created as shown in Figure 2.

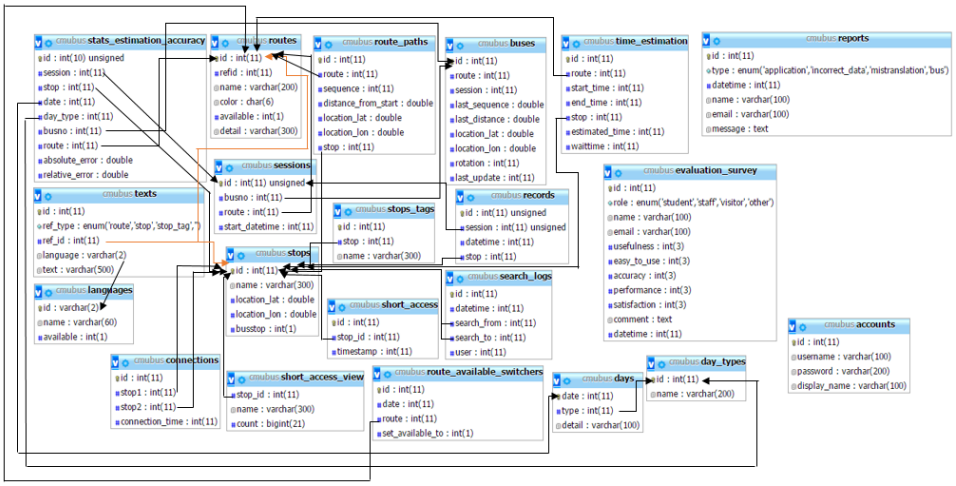

Figure 2: Database Schema

Recording Bus Arrival Time

An automatic programme to record bus arrival time was developed. The programme executed the command in the interval of five seconds from 06:30 to 22:30 every day (as the bus service is from 07:00 to 22:00).

On each interval of execution, the programme reads geographic location from the API and then converts it into arrival timetable of each bus run in each bus stop. The system will use this data to calculate waiting time and arrival time.

Estimating Waiting Time (Bus Interval)

The term waiting time in this project is the time that passengers have to wait in case of that they just missed the previous bus. In other words, waiting time is bus interval (how long between two buses in the same route). However, in this project, the waiting time is different depending on observing time of the day. Different observing time gives different value of waiting time.

Estimating Arrival Time

Estimated arrival time for a particular bus stop and route in this project depends on the last previous stop that nearest bus has arrived. For example, in the route has 10 stops named by alphabets from A to J. To find estimated arrival time at stop E, it is required to have a bus running between stop A to D.

$$\boldsymbol{TravelTime_{C\ to\ E}} = TravelTime_{A\ to\ E} - TravelTime_{A\ to\ C}$$

And to calculate time span from origin stop to any bus stop is to average the recorded data from previous day at the same period. For example, to estimate travel time from A to E, at 10:37 is:

$$\boldsymbol{TravelTime_{A\ to\ E,10:37}} = avg\left(RecordedTime_{last\ 15\ days,A\ to\ E,10:30\ to\ 10:59}\right)$$

Calculation Result

After doing time estimation and recording the real arrival time for 52 days (since 1 March until 22 April 2017). The error of calculation was summarised in Table 1.

Table 1: Time Estimation Error

	Minimum Error	Maximum Error	Average Error
From-Origin Estimation	0 seconds	983 seconds (16 min 23 sec)	40.47 seconds
Previous-stop Estimation	0 seconds	404 seconds (6 min 44 sec)	12.65 seconds

From the table Table 1, the term *from-origin estimation* means the estimated arrival time which is derived when the bus left the origin stop. And the term *previous-stop estimation* means the estimated arrival time which is derived when the bus has just left nearest anterior stop.

Software Development

To develop user interface of the software, the prototype version was developed for *Usability Testing* [4] to collect primitive feedbacks. Then, the software was developed with user interfaces shown in Figure 3. It was implemented in web application. After the development, the software was advertised around the university to collect real users' feedbacks.

Besides timetable estimation, there also was route transfer searching function. The system used Dijkstra's algorithm [5] to find bus routes, weighting edges between nodes (bus stops) by estimated travel time.

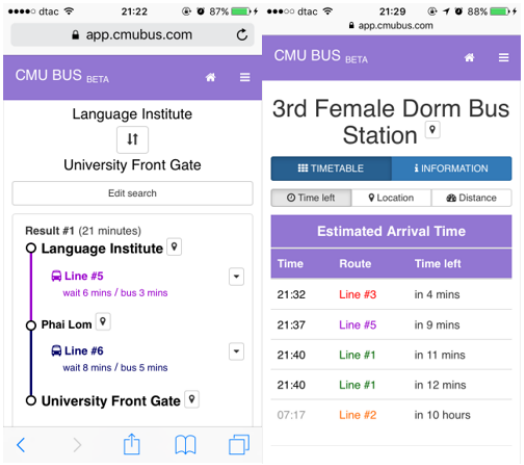

Figure 3: Application User Interface

Software Evaluation

After 28 days of public release, there were 937 usage sessions from 476 different users.

In the application, users will be asked to do a survey about their satisfaction. There were 25 users did it, and the results were summarised in Table 2.

Table 2: User Satisfaction from In-App Survey

Topic	Average Score (from scale 1 to 5)
Useful	4.76
Easy to Use	4.52
Accuracy of Information	4.52
Efficiency	4.28
Overal Satisfaction	4.44

Summary

Because of that buses were running in short distance, the software was able to estimate arrival time with small error, as its error average was less than one minute, by using only basic mathematic method of average. Moreover, the software satisfied users especially for its usefulness. The reason was that a thorough user study and task analysis were performed before the real software was implemented, so functionality of the software responded to users' requirements.

References

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