Course: Internet of Things - 521043S

Exercise 1: Smart campus

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1. Describe the concept of your idea. What is the problem you are solving?

we talked about different problems that the students and staffs are struggling during the times they spend in the university campus in our group. We defined many problems such as individuals safety during winter, navigation to different areas of the campus, the crowd in public places, etc.

Why is it important?

We decide to think about an IoT solution in order to solve issues related to the crowdedness of public places such as libraries, restaurants, Tellus, etc. because we all had an experience of wasting time in queues of the restaurants in pick time. Also for library and Tellus students mentioned that sometimes they go to this places for studying and they have to spend lots of time to find an empty space.

Why to use smart solution instead of traditional one (if existing) and what value your solution adds for the students of the Oulu campus?

There is some traditional solutions for libraries but these solutions can not applied for other public places and also the implementation of our solution is much more easier and we can add many different features to this solution and expand its application that we will describe later in this document. Also our solution will make use of the current platform of Tuudo application, so this is going to decrease the complexity of the development and deployment of our solution.
With this solution we can provide better QoE (quality of experience) for students and professors (or staffs) and also QoS (quality of service), so that restaurants can provide better services for the customers.

2. Use Case

Recommendation for Restaurants

The main device used in recommendations for restaurants would be mobile phones, which uses the information of the sensors for measuring the crowdedness of the restaurants. For building a recommendation feature in Tuudo(mobile-based application), the user has to fill out the form of the food interests. In the form, there would be a list of main foods, desserts and salad types with a different sauce, where the user would select the interests. The form also provides an allergy section, where the user is defining what kind of food it won’t tolerate.

Since we are building this feature for Tuudo, we have access to their database, and therefore we are able to get real-time data of the current foods of each restaurant. We are recommending the restaurants to the user based on the crowdedness of the restaurant and by types of foods, the restaurants are offering.

Our solutions are providing more time for student, teachers or other workers in the university, that are a lot of time in a hurry for catching the next lectures or meetings. Previously the users had to check each restaurant to look up the types of food they are offering. When the users were interested in the food, they didn't know about the lines in the restaurants. Therefore, when the lines were long, they had to choose another restaurant for making it to lecture or any other appointments.

https://www.pasadenastarnews.com/2016/03/04/these-are-the-best-restaurants-near-the-new-gold-line-foothill-extension-stations/

the user finding restaurant with liked food and short line

Detection of Empty Places

After collection of real-time data from tables and chairs in public places, if a student would like to consider an empty public place for studying or discussion, he/she can open the application to ask a specific place which is suitable for the number of students. In particular, the result of the sensor is sent to a server or a cluster of servers. Once receiving the data, the server will consider the number of occupied tables or chairs before responding to the students.

In term of management with a huge area, the server firstly needs to understand that the number of tables and chairs in each room it needs to manage. From that, the

server constantly collects the data from every room after every fixed period or based on the request of students. The student has to send a request with specific information such as the number of students and the room where they would like to go. With the request's information, the server can respond are there any places in the room for the students. For example, in our campus, especially the Tellus area, every chair and table is set up these types of sensors. After that, the result of sensors is automatically sent to a server where the final decision is responded to users if there are some students who ask a room for their business. This idea also can apply in the restaurants where the students understand the number of available seats.

In the case of installation, a set of Wireless Vibration Sensors (WVS-100)[1] or (VIB161010-ACC3-016)[2] can be utilized to detect whenever someone sit on the chair or use the table for writing. Moreover, the Force Sensor (AWL Light Loadlink Series)[3] or (TBS Series)[4] can be used to support vibration sensors. Particularly, in a simple case, a set of rules can be estimated to understand the available and occupied chairs and tables. For example, if the vibration sensor transmits the data of vibration, it means someone uses the chair or table which the sensor is installed.

3. Methodologies

Detection of Empty Places

Collecting data and Communicative protocol

In term of the transmission from the sensor to servers, there are two basic general communications (wire and wireless). Due to installing sensors into chairs and tables, the sensors which utilize the wireless communication should be used; however, in special cases which fixed tables and chairs, the sensor based on wired communication can be considered.

Since this is a local network (the cluster of servers is placed in the Linnanmaa campus), the data from sensors can be directly sent to a cluster of servers.

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1 https://www.valmet.com/globalassets/products/automation/valmet-dna-dcs/condition-monitoring/br81586_en_01-wvs-100-sensor.pdf

2 https://iqunet.com/shop/sensors/industrial-wireless-battery-operated-vibration-sensor/

3 https://www.althensensors.com/sensors/weighing-sensors-load-cells/wireless-load-cells/7557/awl-light-loadlink-series/

4 https://www.transducertechniques.com/tbs-load-cell.aspx?utm_source=rb-community&utm_medium=forum&utm_campaign=force-sensor-wireless-solution

Therefore, in the case of wireless communication-based sensors, an access point is set up in a public area to collect the data from sensors and forward to the servers.
In a general view of protocol which can be used as transmitted methods, MQTT and HTTP are the most common. In more details, HTTP is utilized as a scheme supporting the communication between servers and clients. Meanwhile, to collect the data from the sensors, the connections should be based on the protocol named MQTT which is based on the publish-subscribe model for lightweight many to many communications. With the use of MQTT, the bandwidth of the system can be more efficient since MQTT is lighter than HTTP[5].

Storing data

In our proposal, the data from the sensors should be sent after every period of time due to the efficiency. Battery life is a challenge if the system desires to collect data from the sensors. As a consequence, in this case, after a period, a bunch of data from the sensors is sent to the servers. In a basic case, this data can be stored in a database for processing later. Then, it raises a question that "which kind of database should be suitable in this case?". In the case of the traditional relational database, there are several limitations; however, with the use of this database, the management on the data can be simple and easy. Meanwhile, with the utilization of NoSQL, records from the sensors can be flexible in many different types. Moreover, the use of NoSQL can obtain fault-tolerance problem instead of traditional relational database[5].

Analyzing data

Due to an application detecting empty places for a group of students in a specific place, the requirement for an analysis of data is just a statistic. That means based on the request with the number of required students and a specific place, the system can respond based on the collected data.

Recommendation for Restaurants

The recommendation for restaurants contains two part - dish preference and measuring crowdedness in restaurants. Users can decide which restaurant to go based on these two information.

Dish Preference

In terms of dish preference, In Tuudo app, we create a profile for each user based on the form their have filled in, which contains interests of different kinds of food and also allergy section. These data will be stored on server safely. Also, we have the real-time data of the current foods of each restaurant. Then to do suggestion, we create a recommendation system algorithm. For each restaurant in the current time,

[5] https://www.eclipse.org/community/eclipse_newsletter/2014/february/article2.php

if it has the food that included in user's preferred categories, the restaurant will definitely get higher suggestion. On the other hand, if the it has food that users don't like, the degree of recommendation will be reduced accordingly. What's more, the preferences are not always the same. If a user happens to want to have a specific food, the recommendation system can increase the recommendation degree of restaurants with such food besides the normal suggestion.

In the future, if restaurants are able to give diverse enough dish, we can change the rule-based recommendation system to learning-based system such as collaborative filtering[6]. Using that kind of system, users can rate each dish they have tried. Based on their rating history, the system tries to predict their rate to new dish and then do recommendations. Thus, in this way, the more dishes a user has rated, the more accurate the recommendation system will be.

Measuring Crowdedness in Restaurants

To measure the crowdedness in restaurants, we can use similar idea in last section - Detection of Empty Places. By collecting the sensor data from tables and chairs, we are able to know whether there's enough place for certain amount of people to have meal. It is worth noticing that different from finding empty place to study, the purpose of measuring crowdedness in restaurants is to reducing the waiting time and find a comfortable rather than enough place. Thus, the system may need to consider the size of the restaurant, combined with the sensor data of the tables and chairs, to get the degree of crowdedness in restaurants.

[6] https://en.wikipedia.org/wiki/Collaborative_filtering