การพัฒนาระบบ **IoT** เพื่อการวิเคราะห์ข้อมูล

พฤติกรรมของนักศึกษา

The development of IoT system for data analytics on students' behavior

Assistant Professor Prajak Chertchom, Ph.D.
Nattagit Jiteurtragool, Ph.D.
Ferdin Joe John Joseph, Ph.D.
Chatchai Wannaboon, Ph.D.
Jirayu Samkunta
Patinya Ketthong
Sorawit Fongin

โครงการวิจัยสำหรับบุคลากรภายใน

สถาบันเทคโนโลยี ไทย-ญี่ปุ่น

พ.ศ. 2562

Abstract

The student behavior research conduct is the fundamental factor that straightforwardly influences the aftereffect of the examination. Thus, there are research teams from all over the world working on the studies to find some key correlation factors between study results and study behavior. This research applied the use of Beacon, one of the newest IoT technologies to obtain real-time information from the users. Then, collect the data on the cloud storage server (Google Firebase). After that, the data cleansing was done to purely confirm the originality of the collected data. The final process is to find a correlation of the user movement patterns and the study results. As a result, we found that the comfortable research participants (students) got a high performance on their full semester study results. However, we cannot extremely interpret the research findings due to various technology limitations at this moment (2019-2020). Moreover, the key design of our research methods might need some further improvements to gather very clear input data and obtain a significant research finding in the future.

Keywords: Student Behaviors, Beacon, IoT, Academic Profile, Movement Patterns

Table of Contents

Chapter 1
Description about presentation research for request research's fund (Project Details)

1.1 Background and Significance of the Study

Few years ago, Number of students that registered in university or high school was significantly decreasing. One cause and important factor is Thailand is completely going to be an aging society, which is clearly seen from the current number of students in high school is decreasing. Which is a trend contrast with growth and development of information technology. Therefore, this research has the target to use the Internet of Things (IoT) that helps increase the efficiency to control anything more easily for development to a system that can be used as a chance to collect individual student data and analyze student behavior patterns while in the institution. That includes information to develop into an intelligent model for analyzing and predicting the behavior of students to allow teachers and institutions control behavior of students which will affect learning. Including help to see trends of problems that may happen to prevent or solve faster, that allows the institution to maintain quality of education more easily.

1.2 Research Objectives

There are two objectives in this project:

1) To develop an IoT solution to collect data of the movement pattern (behaviors and interactions).
2) To find how a student's movement pattern affects academic performance.

Fig. 1 shows the hypothesis model of this research project for collecting and analyzing the data. The two aspects of student's behaviors are focused in this research. One is a student's behavior pattern of using a facility, the other is a student's interaction pattern when using a facility. Considering a student's academic performance, GPA is applied to be the criteria to find out the relationship between a student's movement pattern and academic performance. [1]

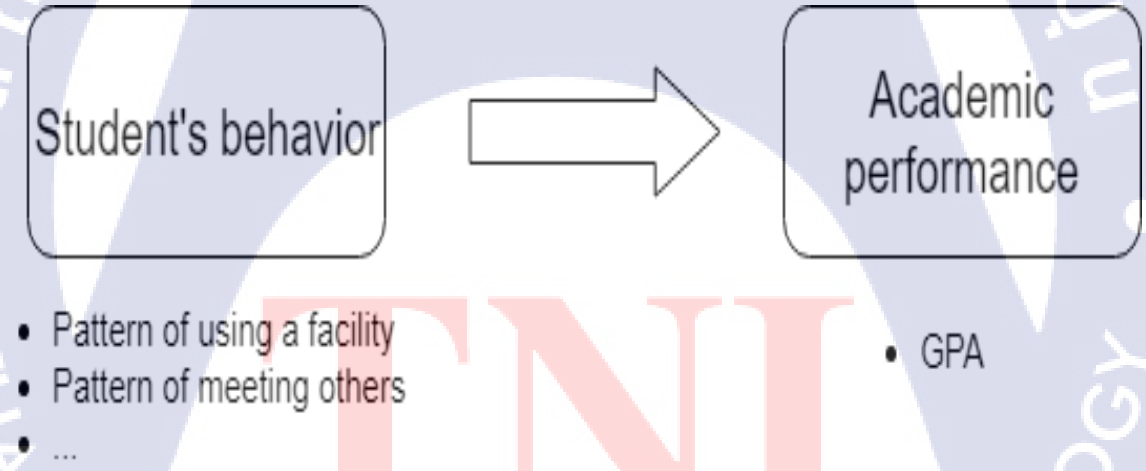

Fig. 1. Hypothesis model of this research project

Chapter 2
Related Research

Student's attendance behavior is a main factor that directly affects the result of study, so institutes of different countries have conducted many researches on collecting student's behavior data by applying various IoT technology and then analyze the collected data to discover the hidden facts. [1]

Radio Frequency Identification or RFID [2] is a technology which is using radio waves to identify tagged items. This technique became popular and also has been used in many kinds of work. There are many genres of RFID, in this case we focus on active and passive RFID. Active RFID is a battery-powered tag that connects to various access points so it provides a long battery life and much longer read range than passive RFID tag. Passive RFID is a tag without an internal power source and uses the power which the electromagnetic energy transmitted from an RFID reader instead, this kind of RFID is commonly used more than active because of its lower cost. RFID system consists of the important components such as transponder and transceiver. Transponder is generally known as tag which has a microchip to store tagged item data and has an antenna to transmit the data about tagged item to the transceiver. Transceiver or reader is a device that communicates with tags and reads data on them through radio signals. RFID tags can divide into 3 types. [3] First type is "read only" so it cannot rewrite the identification, next type is called "WORM" (write once read many) which can program on it but without the ability to rewrite or rewritable, lastly, "Read/Write" tag that can read and rewrite the information many times so

this tag is widely used. From the abilities of RFID technology [4], RFID has been utilized in many industries. In libraries, they used RFID to create a security system which provides secure facilities and safety for librarians and also protects the library resources. Moreover, department stores used the RFID technology to make a smart shopping system by integrating RFID readers into shopping carts and all of the items are tagged with unique RFID tags which will help customers to checkout items faster and to track purchases in real-time. The supervised machine learning is also implemented for human activity recognition to analyze human interaction with products. These are some examples of RFID technology which made many fields of work more easily, convenient and productive.

Silva F, Filipe V, Pereira A. “Automatic control of students’ attendance in classrooms using RFID.” 3rd International Conference on Systems and Networks Communications, 2008. [5] This research discusses the development of time attendance systems by using RFID technology to reduce the difficulty of instructors in recording student’s attendance behavior. The highlight of this research is that RFID reader devices are used to send data through an Ethernet connection (LAN) and it can work with power supply via Ethernet connection (POE, Power Over Ethernet) as well as database development for students record.

“Leveraging RFID Technology for Intelligent Classroom.” Procedia Computer Science, 2017. [6] This research has targeted to apply RFID technology for realizing intelligent classrooms by installing a high frequency RFID reader which has a wide reading distance at the center of the classroom to check the student’s attendance behavior. And by installing a low frequency RFID reader in front of the classroom, identity of the instructor can be verified. This research has reduced the difficulty for the instructor to

administer the classroom by automatically recording student's behavior with IoT solutions which have longer reading distance than traditional RFID technology with low frequency.

NFC stands for Near Field Communication [7] which is the short-range wireless communication technology. NFC can be seen as the development of RFID technology. NFC technology is a combination of interconnection and RFID technologies. Even though the RFID and NFC use radio frequencies to communicate and also use the same standard of work, they still have the differences. The differences between NFC and RFID [8] are the distance range for data exchange and the types of mobile interaction method. NFC has a shorter transmission range when compared with RFID so this provided a naturally secure for NFC transaction and extremely reduced eavesdropping problem. For the operating modes, RFID readers can only read or write a predefined tag but NFC devices have 3 different modes. The first mobile interaction method according to the interaction in RFID systems, also known as "Reader/Writer" mode, the NFC mobile device begins the data transfer by sending a signal to the tag. Then, the tag responds and sends the data back to the mobile device. The second alternative is the direct communication between two NFC mobile devices, this mode called "Peer-to-Peer". Finally, the NFC device performs as a smart card or tag so the information on NFC devices can be read when it touches the device on an NFC reader. We call this kind of mode "Card Emulation". Two basic components of NFC are initiator and target. The initiator looks like the reader in RFID and the target is the tag, similarly. Two types of NFC are active and passive. In active NFC, it can send and receive data using its own field of radio frequency. On the other hand, passive NFC can only send data through NFC when tap on the active NFC. The NFC technology has been used in

various tasks and related to us. One thing that we utilize in daily life is a mobile phone. The NFC in our mobile phones gives us an easy life, high security, and also efficiency with integrating all services such as payment, navigation, and healthcare into one single phone. Because of the advantages of NFC technology which made the developers try to implement this technology to their works for improving better performance.

Bluetooth Low Energy (BLE) [9] Beacon technology is one of the newest, fastest growing hardware technologies suitable for low transmission power and short data communication. Beacon is a small device that is used to transmit some information, for instance, the beacon's location, MAC Address or device's unique information, at a specific time interval and frequency that randomly change between 40 channels with range from 10 – 30 meters. It can send notifications or messages when it is approached by a scanner (smartphone). After the signal has been detected by nearby smart devices, the signal will give its ID number to the device. The smart device then sends that ID number to the cloud server. Then, the server checks what action is assigned to that ID number and responds to the smart device, for example, a merchant could have placed the beacon device close to a discounted item in the store and configure the server to alert the customer for discount when the customer is approaching the beacon. Apple and Google have developed and introduced their own application for beacon profiles, which are iBeacon and Eddystone. iBeacon [10] was the first profile that was introduced by Apple which is implementation of BLE beacon technology within iOS7 and later. After that, Google has launched their open protocol BLE profile which is Eddystone to compete with iBeacon of Apple. Difference from iBeacon is Eddystone gives more flexibility in the production of contextual information, as it does not require a completely independent

mobile application to communicate with the beacon. Furthermore, iBeacon can separate type of information by analyzing UUID, Major numbers and Minor numbers that are unique numbers assigned in each beacon, while Eddystone is separate information's type using UID, namespace and Instance, similar to iBeacon, but Eddystone can change data format between URL and TLM (Beacon's data). The Beacons have several usages. In a library, a customer receives basic information about the book in the smartphone application. And also, in health care applications that use BLE to monitor blood pressure and send user biological status to the smartphone. Although the main keys of BLE Beacon technology are low power consumption and quick implementation of hardware, its disadvantages are it requires devices that are able to receive BLE signal and limitations to trust and security.

From the examples of research in the above, it can be seen that the use of IoT solutions to develop a system that helps record the behavior of students is actually widely applied in many educational institutions. Therefore, in this research project, the operational team aims to design and develop an IoT system to collect data of student's behavior in the campus. After collecting data of student's behavior, behavioral factors for student's academic performance are planned to be discussed.

Furthermore, there are many previous researches focused on finding out the factors that can affect a student's academic performance. Jovanovic, Milos, et al. "Using data mining on student behavior and cognitive style data for improving e-learning systems: [11] a case study". International Journal of Computational Intelligence Systems, 2012. This research discussed how to improve E-learning teaching quality by using data mining on data of student's behavior. The data included attendance time, attendance frequency for

indicating a student's individual learning style. The highlight of this research is that information about student's behavior can be used to create a model for analyzing a student's learning style and finding appropriate teaching methods. However, the method of collecting student data is still a traditional method which asks students to fill in questionnaires. However, the data is not collected real time correlated with student's actual behavior.

In our research, an IoT system based on Bluetooth beacon technology is designed and developed to collect data of student's behavior of using facilities in the campus. Moreover, the relationship between student's behavior patterns and academic performance is discussed.

Factors influencing human behavior

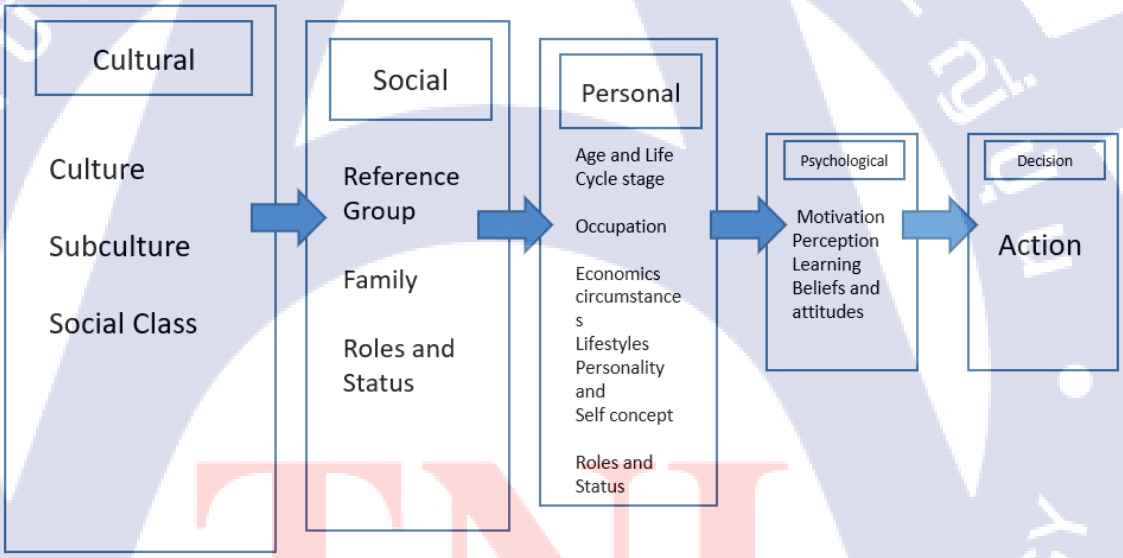

Fig. 2. Factors influencing human behavior [20]

There are many theories in human behavior that seeks to explain the factors that influence or determine human pro environmental behavior. As can be seen from the figure 2 above, all the factors that influence individual environmental behavior can be classified into 4 main factors; Cultural, Social,

Personal and Psychological. In order for individuals to act and undertake environmental behavior, they need to feel a personal sense of responsibility towards the environmental threats and issues. One of the greatest barriers in encouraging environmental behaviors in individuals is diffusion of responsibility. Diffusion of responsibility is the sense that someone else will do something about the problem or issue. It is concluded that the performance of human is being strongly influenced by Motivation, Perception, Learning, Beliefs and attitudes, cultural and environmental factors affecting the institution.

Reference Papers	Conclusion	Remark
A lifelog data portfolio for privacy protection based on dynamic data attributes in a lifelog service, 18th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD 2017), June 26-28, 2017 | Kinrousha Plaza, Kanazawa, Ishikawa, Japan. [12]	Data portfolio for lifelog	Apply portfolio for storing our pattern data
Jovanovic, Milos, et al. “Using data mining on student behavior and cognitive style data for improving e-learning systems: a case study.”International Journal of Computational Intelligence Systems, 2012. [11]	Using data mining on student behavior, such as attendant, quiz and creating a student profile.	Apply the student profile system and data mining techniques
Lopez-de-Teruel, Pedro E., et al. “Human behavior monitoring using a passive indoor positioning system: a case study in a SME.” Procedia Computer	Wi-Fi based positioning system to identify working patterns of the employees.	Apply the WI-FI based system to identify students learning behaviors

Science, 2017 Zheng, Mao, Sanhu Li, and Hao Fan. “Classroom Attendance Detection using a Wi-Fi Positioning Algorithm.” Proceedings of the International Conference on Software Engineering Research and Practice (SERP). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp), 2016. [13]		
Zheng, Mao, Sanhu Li, and Hao Fan.“Classroom Attendance Detection using a Wi-Fi Positioning Algorithm.” Proceedings of the International Conference on Software Engineering Research and Practice (SERP). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp), 2016. [14]	Wi-Fi based positioning system and a class attendance mobile application	Apply the idea of a class attendance mobile application

Chapter 3
Research Methodology

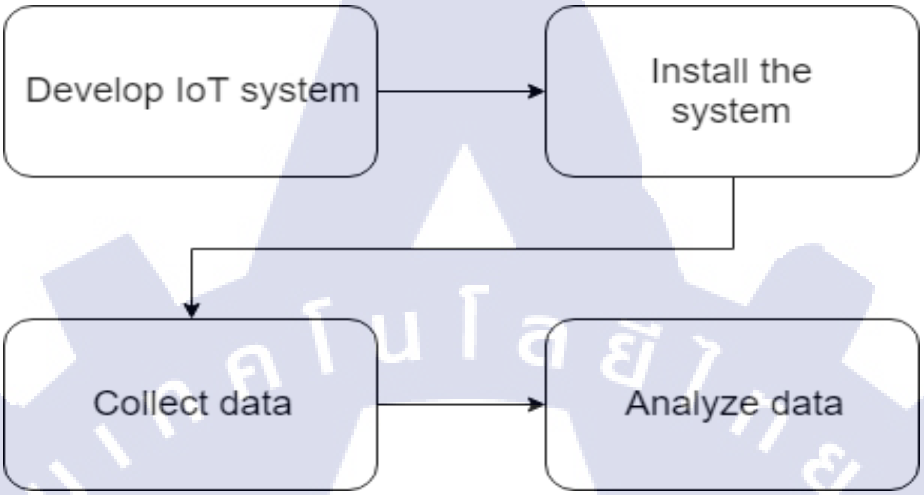

Fig. 3.1 Flow of conducting the project. (by Authors)

There are three steps for conducting this project as shown in fig. 2.

1. Design and install an IoT system for collecting data of student's behavior when using facilities in the university.
2. Testing RFID (Radio Frequency Identification) and BEACON
3. Collect data for preparing to analyze.
4. Analyze the data to find how student's behavior affects academic performance.

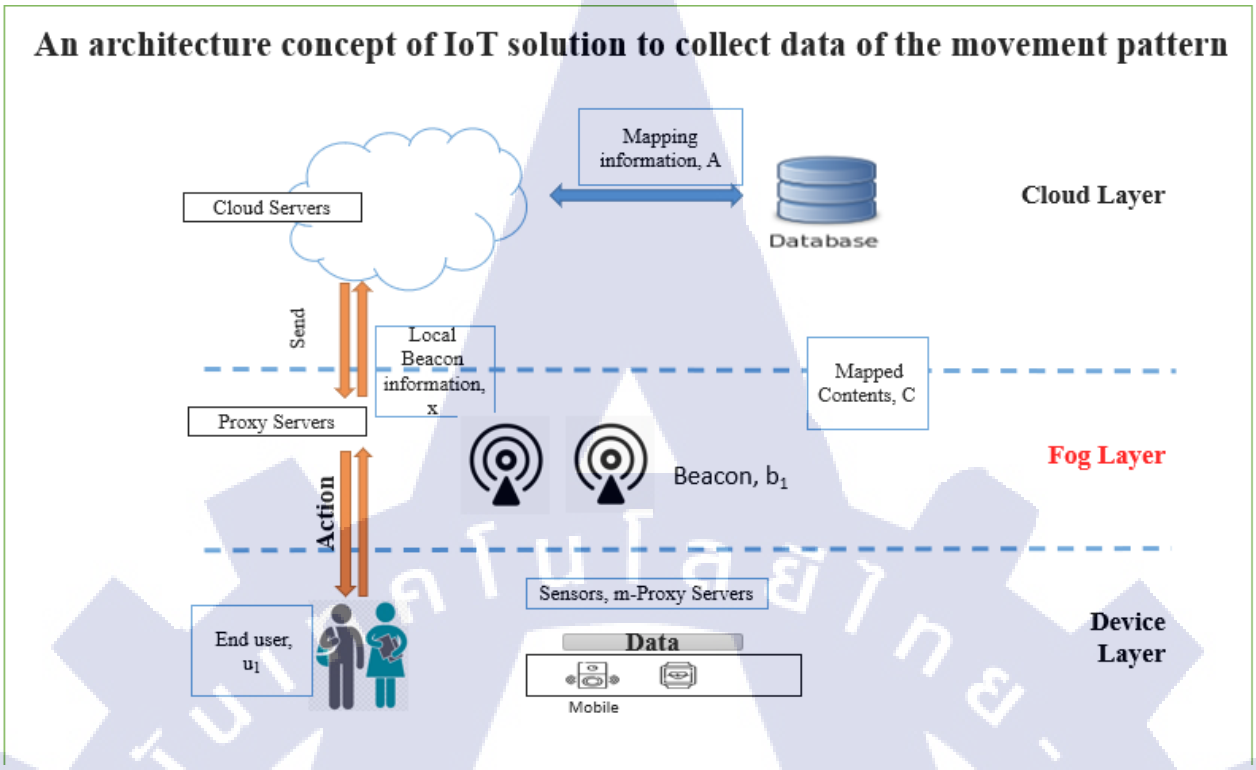

Fig. 3.2 An architecture concept of IoT solution to collect data of the movement pattern (by Authors)

The diagram presents the methodology that we used to monitor the behaviors of students at TNI. The beacon sensor solution is made up for acquiring information and a cloud service that provides visualization of that information (see Figure 3.2).

The BLE Beacon is a device that identifies the location of the user by connecting the BLE Beacon to the Line Application. When a mobile phone installs Line beacon and its users into the service station that has installed the BLE Beacon, the Line beacon will receive a signal from the BLE Beacon, which in turn will send a signal to the Web Server. This will send information that identifies the User and the Service Station. When the Web Server receives the signal, it will send the data back to the Line Application in the form of an alert.

The feature of the beacon sensor used is that the device can collect data on whether people are present (using infrared), with data transfer by Bluetooth Low Energy (BLE), a low-power communication mode of the Bluetooth* wireless communication technology. Used in conjunction with BLE beacons, the sensors can identify individuals

and objects and track their movements in real time. The positioning accuracy is in the range of 1 to 2 m when installed on the ceiling at 3-m intervals to form a mesh configuration.

Using BLE beacons to show people's movements not only indicates their location in real time but can also be used to display alerts when they enter particular areas or to track their past movements.

A strength of the solution is that it can consolidate this information across a number of different areas and building in university to provide institution with the ability to analyze what is happening over a wider area than ever before.

Table 3.1 Operational approach

Detail	2019									2020		
	4	5	6	7	8	9	10	11	12	1	2	3
1. IoT system Design and Development	x	x	x	x								
2. Database system Design and Development	x	x	x	x								
3. Data Collecting			x	x	x	x	x	x				
4. Data Analytic System Development				x	x	x	x	x	x			
5. Data Analytics								x	x	x	x	x
6. Publish Research								x	x	x	x	x

7. Present Project								x	x	x	x	x

The research into the design of the movement pattern using the IoT to collect the digital footprint was conducted by reviewing documents, the literature and related research. The research was conducted in three phases as follows:

Phase I: Design of a concept of IoT solution for monitoring student of the movement pattern using the IoT to collect the movement.

Phase II: Design of the movement pattern using the IoT to collect the movement. The research instruments for this phase were:

1) Relevant actors (Participants)

2) IoT process diagram, (see Figure 3.2).

3) The evaluation metrics of the designed system.

Phase III: The evaluation of the IoT (BLE beacons) to collect the movement by using data analytics.

Table 3.2 User Profile Database

Field Name	Description	Data Type	Data Format	Field Size	Example
Beacon User ID	Unique number ID for all users	Integer	NNNNNN	6	U333ecc614d71ab6ce44438ee0d7cb802
Number of Participants	Number	Integer	NNNNNN	6	81
Student Code	Student Code	String	-	25	1913310163
Subject	Subject	String	-	10	MSC-112
Grade mark	Grade mark	Integer	NNNNNN	6	80
Grade point	Grade point	String	-	3	A

Chapter 4

Results and Discussion

Technology-wise, RFID has been around for a while. The first uses of Radio Frequency Identification are from the second World War, when it was used as a method of identifying incoming aero planes. The benefits of RFID chips, as a method of information storage and identification, are many. It has been publicly acclaimed that the RFID chip will eventually replace the bar code, as it can store more data on a product and it does not need a clear line-of-sight to be read. For example, products tagged with RFID in a cardboard box can be read with a hand held RFID reader without having to open the box at all. Ultimately, the best benefits of RFID are to be witnessed in logistics, with the reading capabilities allowing for much faster logistics operations and better transparency reducing the time factor. All-in-all, a much better grasp of the product flow can be achieved tracking products at an individual level from the manufacturing point to the store shelf streamlining processes in an international

From our first purpose of research,

4.1 The development of IoT system for Students' Behavior Tracking using BLE Technology

According to our literature review, there are many technologies that can be used for the localization. As shown in fig. 4.1, Most IoT based localization systems appear to have a similar architecture which consisted of 4 main part:

1) Communication
2) Tracker device
3) Node/Gateway device
4) Database

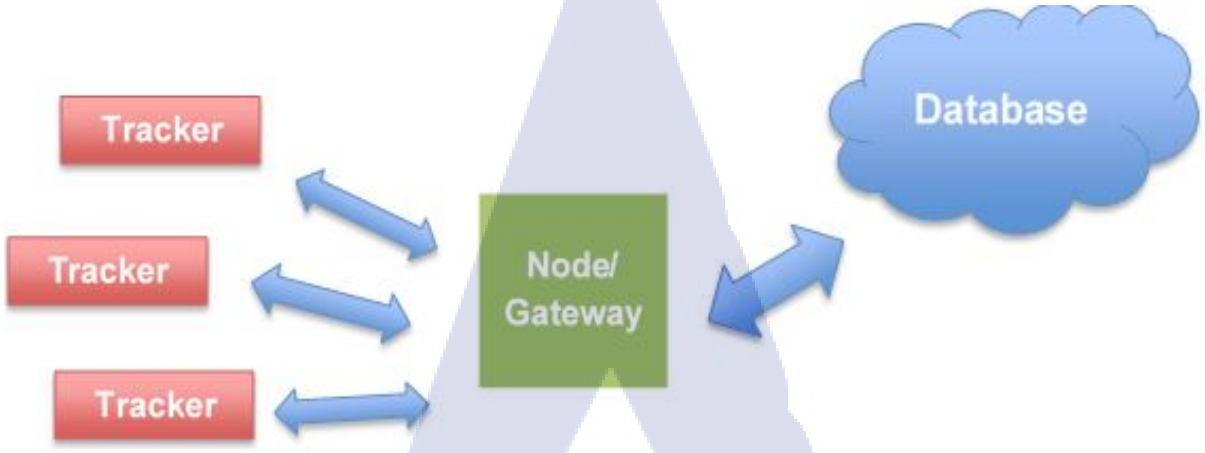

Fig. 4.1 General architecture of IoT based localization system [15]

There are 2 main reasons for choosing BLE technology over many other technologies:

1) **Price** – With BLE technology, the tracker device can be as simple as a normal smartphone and there are many inexpensive programmable IoT devices in the market that can be used as a node device of the system.
2) **Usability** – Compared with most technologies that required a carry-on tracker device for every student, while only requiring each student to have a smartphone.

Considering the advantage of each technology, we proposed a new system which is based on Bluetooth Low Energy (BLE) and Internet of Things (IoT) for the purpose of students' behavior tracking. The database of the system was designed and implemented by the Firebase Realtime Database from Google which is a NoSQL Database. Fig. 4.2 shows the diagram of the proposed system.

Fig. 4.2 Diagram of the proposed IoT system (by Authors)

The proposed system was designed and implemented using Line services platform called “Line Beacon” which is the one of several services from Line that can provide special messages sending functions to users on LINE Application via official account or LINE chat bot that have beacon devices (Bluetooth Low Energy Transmitters).

Inside TNI, most students are having smartphones with themselves all day when they stay on campus. Thus, LINE Beacon services are used to detect student's behavior by using Bluetooth Low Energy (BLE) devices which are installed at several locations around the institute for communication with students’ smartphones within a proximity range. Fig. 4.3 shows a system diagram of LINE beacon official services, which is separated into 4 modules.

The first module is BLE devices, the RuuviTag is utilized, which simultaneously emitted the signal in defined frequencies with configurable transmission power and intervals. The BLE can be detected by smart devices such as smartphones or devices, which can receive the Bluetooth signals. For smartphones, Bluetooth function needs to be turned on.

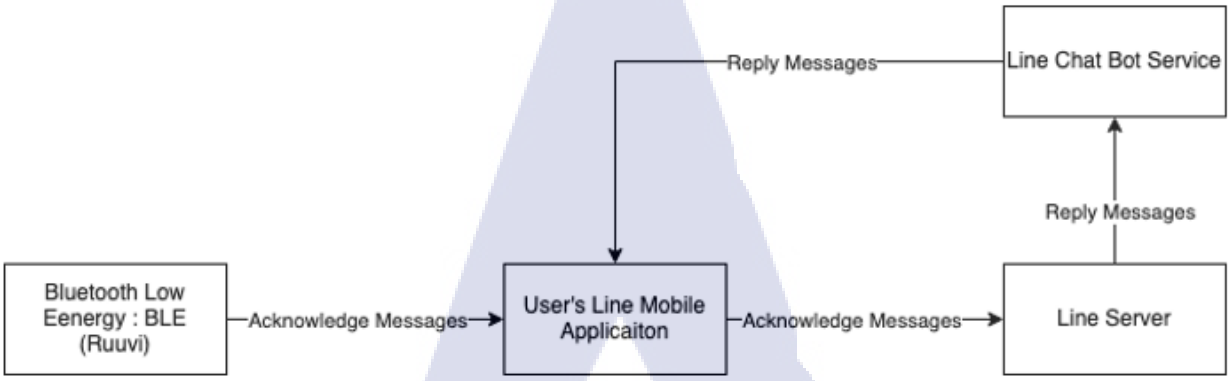

Fig. 4.3 An acknowledge message interacting with Bluetooth Low Energy Devices (Beacon) (by Authors)

For the background application services, LINE Beacon services [16] are applied into the system. On the other hand, Students must add the official LINE account, which is created by the administrator. These methods are included into a user's LINE Mobile Application module. In addition, the BLE has to compile the device ID, which is generated by a LINE beacon service.

4.2 Locations for installation of Bluetooth Low Energy (BLE) device

In order to cover the main area of TNI, the Bluetooth Low Energy (BLE) devices are planned to be installed at several locations as shown in fig. 4.4.

There are totally 6 BLE devices installed the area:

- The BLE Node 1 and Node 2 were installed at the B201&B401
- The BLE Node 3 installed at the 1st floor of B Building which is a cafeteria.
- The BLE Node 4 located at the Cafeteria of E Building

- The BLE Node 5 located at The Cafeteria of D Building.
- The BLE Node 6 installed at the library.

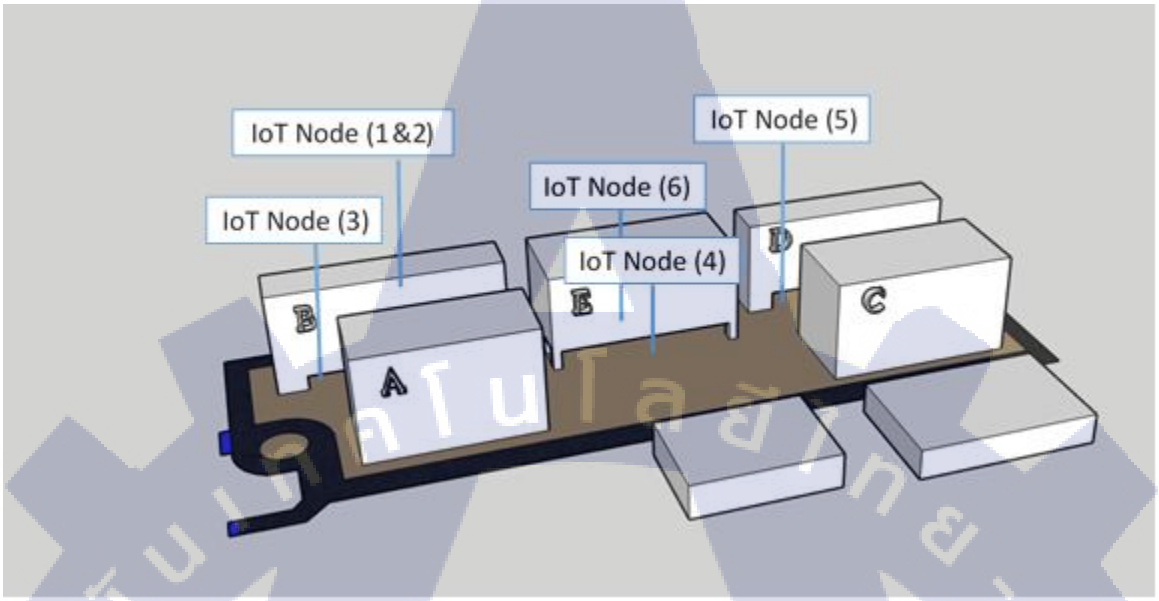

Fig. 4.4 The location expected to be installed in the area of Thai-Nichi Institute of Technology

As shown in fig.4.2 the proposed system was designed to store the data of each student in Firebase which is NoSQL. As a result, the actual data collected from the system was shown in table 4.1 which can be seen that the preprocessing data (raw data) are comprised of:

- Log_id which is a generate id from the firebase
- HW_id which is the BLE Node id
- Timestamp which is a special format of date and time, e.g., 1591654068 means 06/08/2020 10:07pm
- User_id which is the id that represent each student in this system

After the raw data were collected, the data will be cleansed and transformed into a usable form of data as shown in table 4.2.

Table 4.1 Example of preprocessing data from the IoT system

Log_id	HW_id	timestamp	User_id
-LvG3jNVaClXuaLilRaa	01350d9fb9	1575465712868	U333ecc614d71ab6ce44438ee0d7cb802
-LvG3p_OSJKiLLY6nibU	01350d3f9c	1575465738458	U333ecc614d71ab6ce44438ee0d7cb802
-LvG3pblCBFWuEgWOcmb	01350d9fb9	1575465738644	U333ecc614d71ab6ce44438ee0d7cb802
-LvGAWjSPaxew5i6Z-3z	01350d9fb9	1575467492120	U333ecc614d71ab6ce44438ee0d7cb802
-LvGBIPb9tMOWa-eKhzT	01350d9fb9	1575467695644	U333ecc614d71ab6ce44438ee0d7cb802

Table 4.2 Example of processed data from the IoT system

Log_id	Location	Date	User_id
-LvG3jNVaClXuaLilRaa	Cafeteria @B Bldg	12/4/2019 13:21	U333ecc614d71ab6ce44438ee0d7cb802
-LvG3p_OSJKiLLY6nibU	Teacher Office	12/4/2019 13:22	U333ecc614d71ab6ce44438ee0d7cb802
-LvG3pblCBFWuEgWOcmb	Cafeteria @B Bldg	12/4/2019 13:22	U333ecc614d71ab6ce44438ee0d7cb802
-LvGAWjSPaxew5i6Z-3z	Cafeteria @B Bldg	12/4/2019 13:51	U333ecc614d71ab6ce44438ee0d7cb802
-LvGBIPb9tMOWa-eKhzT	Cafeteria @B Bldg	12/4/2019 13:54	U333ecc614d71ab6ce44438ee0d7cb802

It can be seen that after the process of cleansing and transforming the data, we still use the User_id instead of the student id or actual name of each student in order to protect the privacy of the student. The data result collected using the proposed system is shown in fig. 4.5.

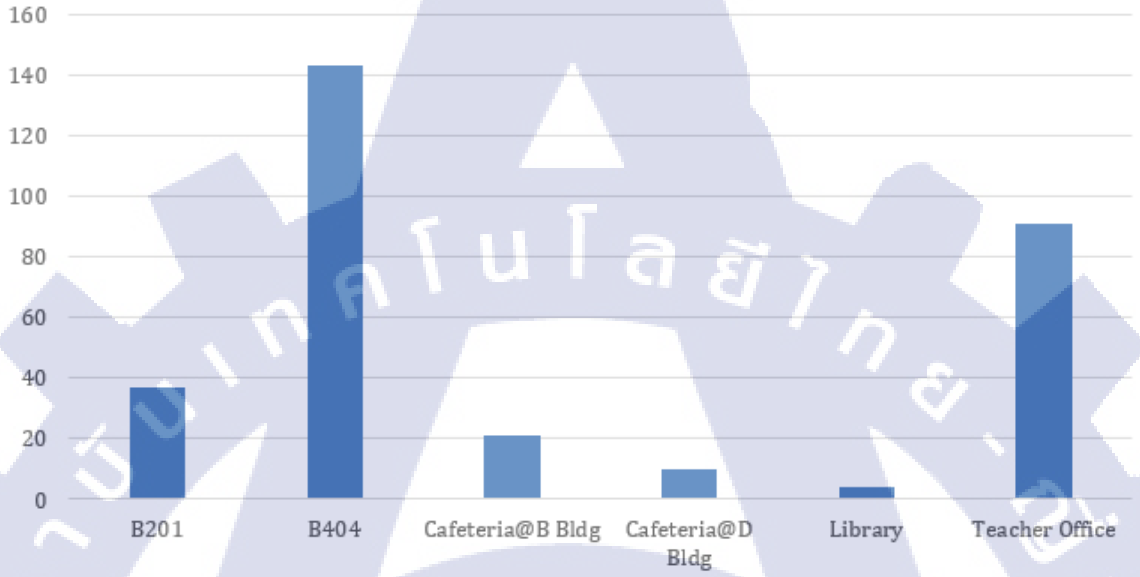

Fig. 4.5 Frequency distribution of facility used from December 2019 – March 2020

Table 4.3 Tracking Data from the IoT system

Beacon User_id	Number of participations	Student_Code	Subject	Grade mark	Grade point
Udc3f9a832c65df51987e8c6be77b30df	1	591210182	IoT	71.4	B
Uaee42e400325fcba02e84c7fdda52291	1003	591210265	IoT	67.2	C+
Udb25e657faf99088f69db6b496821495	6	591238027	IoT	73	B
U2ebd60fa81df227fcaa02388509da356	3	601210131	IoT	92.6	B+
U9ad62a1abd118ccdf0e8c5dda6d3b2b3	71	601210263	IoT	62.2	C+
Uaf14c78fe75fe85f04ef2aafb89e41d8	2071	601210537	IoT	97	A
U27eb3093cd7dfb9301d7f0fc16480c0c	1	601210636	IoT	91	B+

Table 4.3 Tracking Data from the IoT system (cont.)

Beacon User_id	Number of participations	Student_Code	Subject	Grade mark	Grade point
U2276fe5aaab8ab214990589f41e5a299	76	601210651	IoT	85.4	B+
U8df1235e7aa06462e0ff0c2daf7ab6f1	7	601210974	IoT	73.8	B
U769fcff5a5825c0cd8dc6fcd17e64cf7	18	601217029	IoT	74.4	B
U812712406936aa7ef9b37dab41964035	42	601230022	IoT	94.2	B+
Ue4bd5574cf43b462f40c0303b97656a9	24	601230071	IoT	96.2	A
U4a22464f98fbdc5602ede64b66bb9fda	2	601230253	IoT	90	B+
U7ac18ff47b33112ada3927a8daa9dfa7	4	1813230016	MSC-112	76	B+

Table 4.3 Tracking Data from the IoT system (cont.)

Beacon User_id	Number of participations	Student_Code	Subject	Grade mark	Grade point
U6c1c2b18e223dae0bc87af70bbe44ede	4	1913310049	MSC-112	70	B
U0142a9cc4ca073cdf4c89e10c43909dc	7	1913310056	MSC-112	77	B+
Ue349e53187e98a440c1549328ce43a13	9	1913310072	MSC-112	73	B
U33f7720038969 7c63bcf096873364c32	47	1913310098	MSC-112	80	A
U6a7e2503f9d62866d8cbdffa72fcd918	166	1913310114	MSC-112	70	B
Ub5a7c9171cebad22899828e1f0681b5f	18	1913310130	MSC-112	80	A
U3a5668a8e6a68fede28ee531edbc6b1d	4	1913310155	MSC-112	75	B+

Table 4.3 Tracking Data from the IoT system (cont.)

Beacon User_id	Number of participations	Student_Code	Subject	Grade mark	Grade point
U363c2cb48c2e9f12bf13e5234f2fb070	81	1913310163	MSC-112	75	B+
Ubee81685a3cb2520d2a003bc15335615	124	1913410021	MSC-112	80	A
U05245843e3c4dbba45f93fb328a7b9ca	17	1913410039	MSC-112	91	A
U052f9369df9c4e4ab92b75cb8c35e4b4	19	1913410062	MSC-112	84	A
U15526cd82da7e6a0c9afe1e4cf680fa3	34	1913410120	MSC-112	70	B
Uf2e93034e7d0236e4dfe4570b24ed40d	3	1913410138	MSC-112	74	B+
Uf2f19da6ec1b14cad54532e4d66e9292	13	1913410195	MSC-112	74	B+

Table 4.3 Tracking Data from the IoT system (cont.)

Beacon User_id	Number of participations	Student_Code	Subject	Grade mark	Grade point
U94041c7b7c4ebb0853736caf5f7ea1d6	4	1913410229	MSC-112	80	A
Uff902c35db20700640009e8182acc793	1	1913410260	MSC-112	80	A
U3dbdfc92eed9a641eac54ed8de34a176	31	1913430037	MSC-112	83	A

From data collected shown in table 4.3 reveals that it is not easy to collect information from students, there are several conditions to consider. For samples below;

1. Location Services in Line application should be on
2. Students' mobile should turn Bluetooth on (participants)
3. Students' mobile must opt-in to receive notifications from Google Survey Nearby (by default they are already opted in)
4. iOS needs to install a relevant application.

Additionally, after using data in table 4.3 for drawing using the area chart as shown in fig. 4.6.

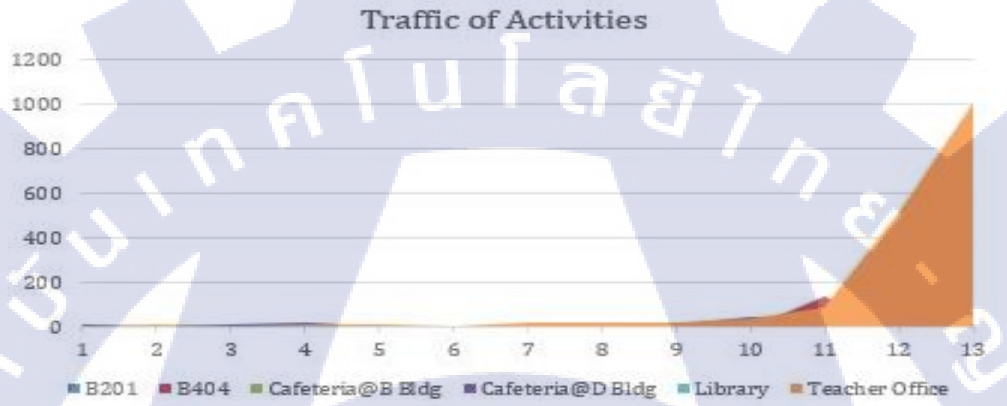

Fig. 4.6 illustration of traffic by Area Chart

Fig. 4.6 presents that students mostly communicate with beacons when they are going to the teacher office which is located on the 6th floor at building A. This place is an office of information technology's member. Thus, we can assume that the participating students always stay and go to the lecturer office for any consulting of their study.

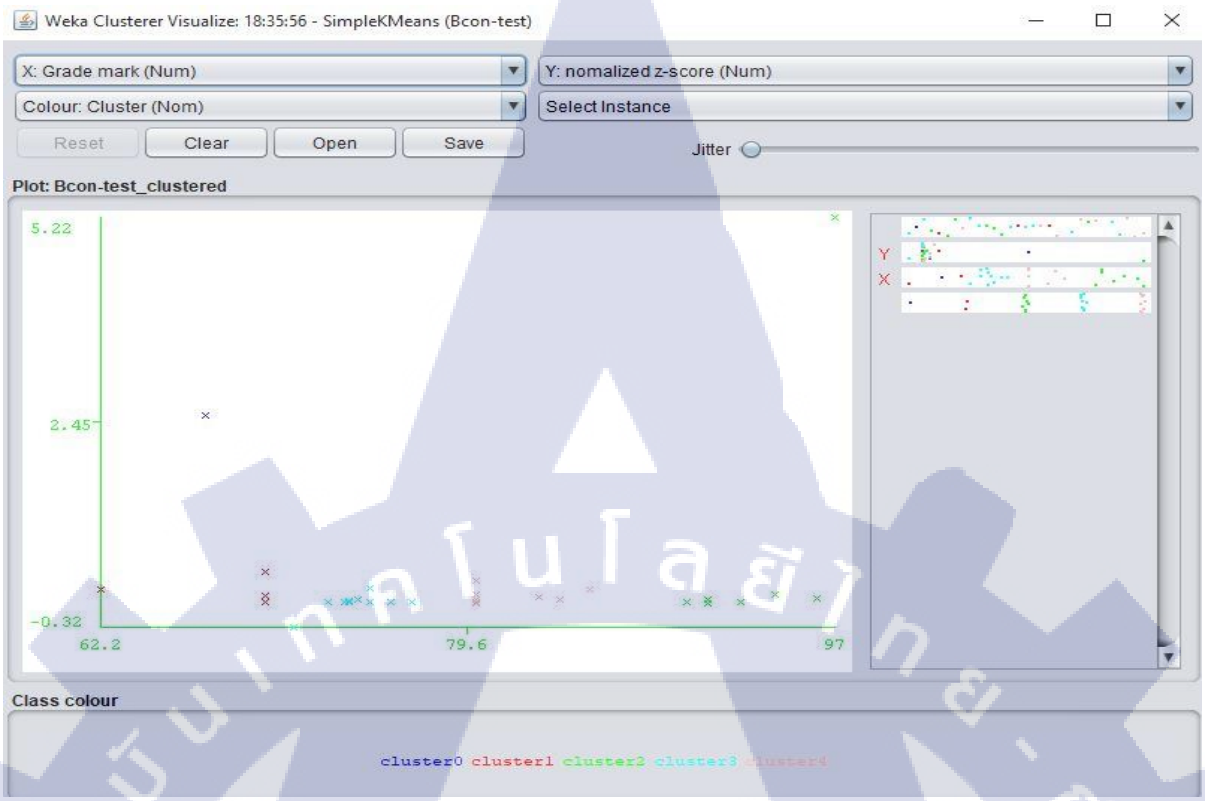

Fig. 4.7 Visualize Clustering Data Assigned by K-Mean

Fig. 4.7 and 4.8 are the pictures when one of our researchers tried to import the obtained data to the software in order to classify the input data using K-Mean. [17] Then, fig. 4.9 is the summarization information classified by the summation number of the entering status obtained in January 2020.

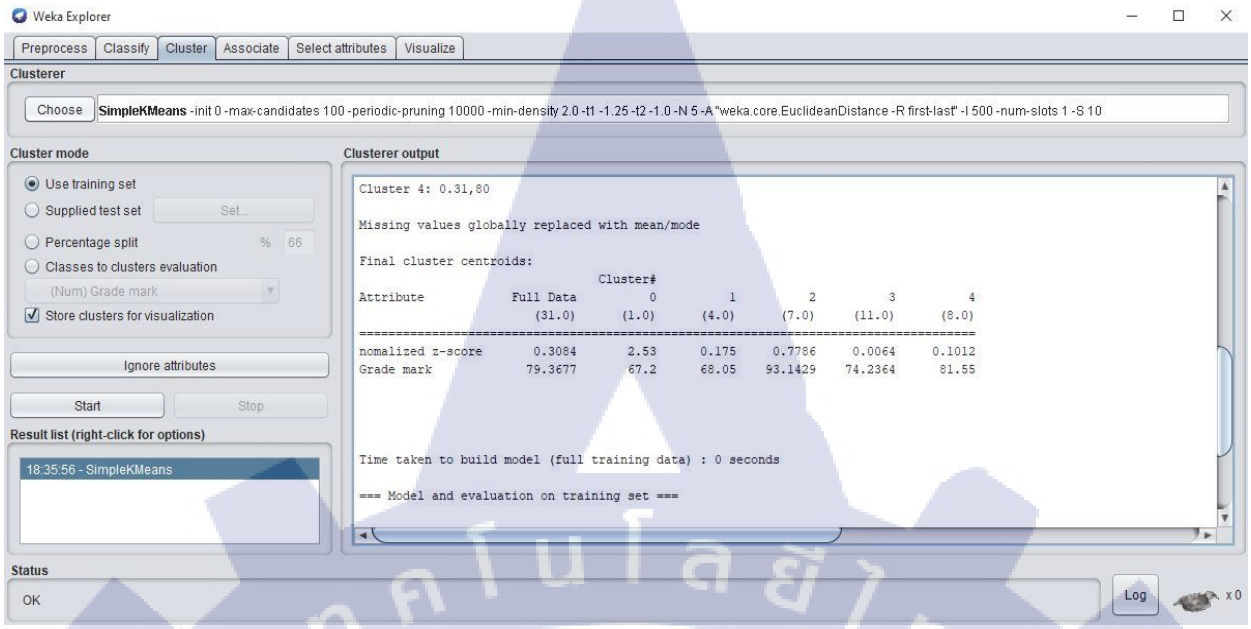

Fig. 4.8 Visualize Clustering Data Assigned by K-Mean

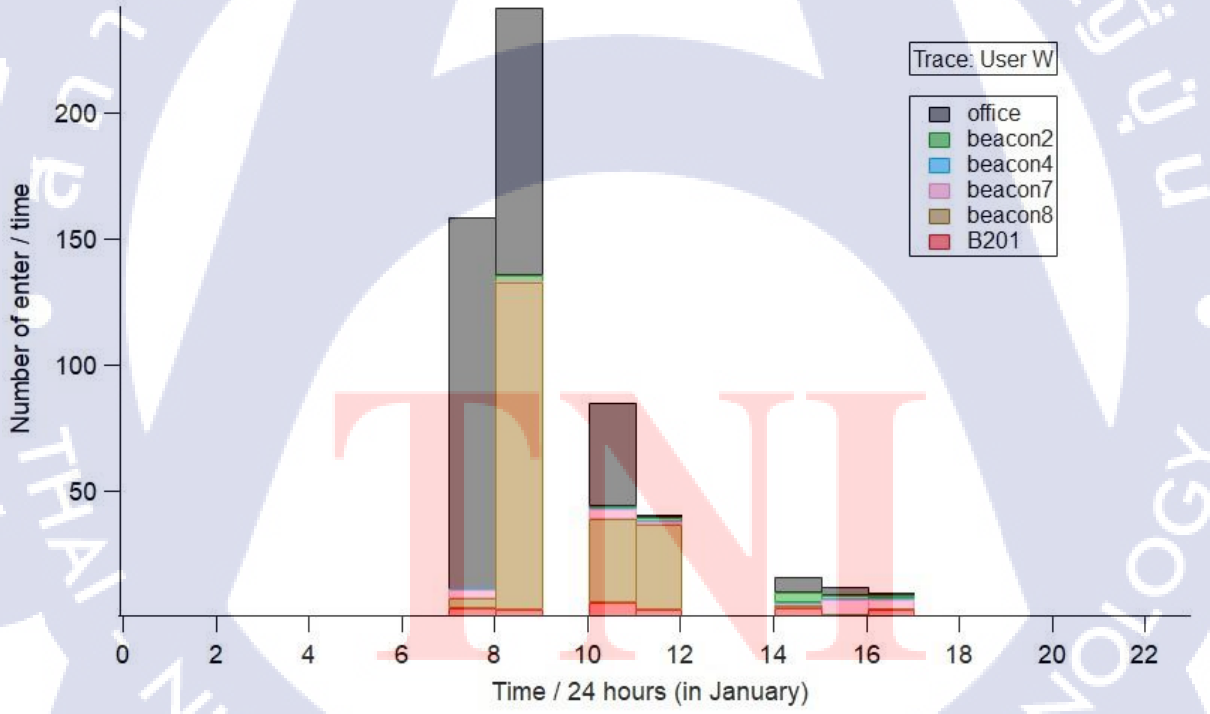

Fig. 4.9 January Summarization information classified by the summation number of the entering status

Chapter 5
Conclusion and Future Works

5.1 Expected Results

After successfully collecting the data with our IoT systems, data is planned to be analyzed to find out the relationship between student's movement pattern and academic performance. Then following application can be expected:

1. Build a Predictive Analytics model to analyze the movement pattern of the student to predict their performance.
2. Apply Intelligent Predictive Analytics model to provide guidance for students to help them to improve academic performance.

The agency expects that the research results will be used Thai-Nichi Institute of Technology for applying results of research to develop teaching and learning.

5.2 Research Limitations

There are several notable limitations in the research:

We have designed and implemented the IoT system for collecting data of student's behavior. We expected 100 hundred students might participate in our project. Each person may give their individual results, but with our system environment, the invited students were not willing to register to our beacon every time they met the signal and requested from the system. Thus, some data may be lost, this results in our analysis of their behavior. We are not always able to go through all the resources. We can't gather all the data we want for our research since it will take a lot of time. Because of it, our

work might not cover each aspect. Moreover, the Beacons system has its limitations.

Beacons cannot individually track students: [18] students have to install an “Line Application” for the beacon to work on their phone with a permission to allow beacons to communicate. However, no user likes to be often poked with offers/unwanted notifications. Secondly, movement tracking can only work when students are:

- Carrying a mobile device
- Switch the device on
- Have both Wi-Fi/Cellular Network and Bluetooth switched on for interaction with the beacon in the beacon range.
    - The BLE beacons can’t determine a students’ physical location with pinpoint accuracy, so it can be hard to know how many beacons are required, or where to position them in order to ensure that a zone is adequately covered.
    - As beacons is a system that sends out the signals to the device, “Signals are Easy to duplicate” as shown in the data set that was collected.

In order to take advantage of gathering more reliable information on how and where students are moving throughout college, we need to understand its drawbacks and pitfalls and then tackle [19] these with the right information and the right approach. Finally, when we implement beacons in too many places, students can get easily annoyed by receiving too many push notifications and may even stop participating in our research. As mentioned earlier, there are some problems and concerns from the limitations of both hardware and software. Fig. 5.1 below illustrates the found noise when we tried to interpret and transform the obtained information from

Beacon. Additionally, we found that the summation number of enter status is too high from midnight until 12 am, which is not possible. In other words, Thai-Nichi Institute of Technology is the university and there is no student during that period of time. This can be improved as mentioned later in the latest section.

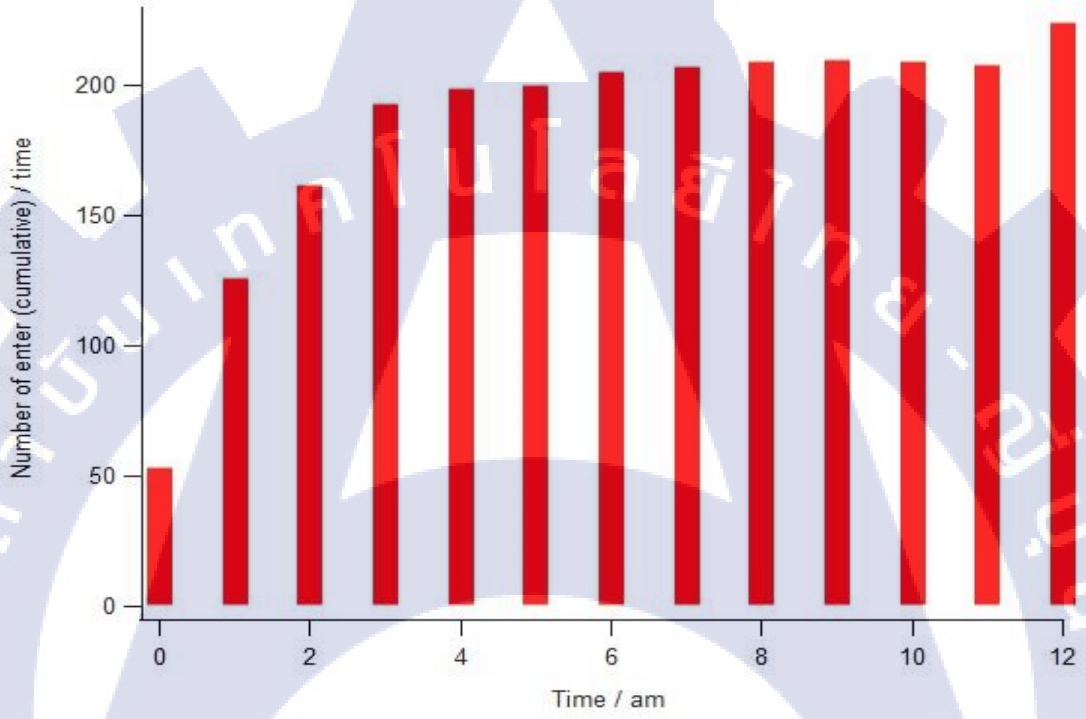

Fig. 5.1 Founded Noise in Information Interpretation

5.3 Future works

As a result, we found that the comfortable research participants (students) got a high performance on their full semester study results. However, we cannot extremely interpret the research findings due to various technology limitations at this moment (2019-2020). Moreover, the key design of our research methods might need some further improvements to gather very clear input data and obtain a significant research finding in the future.

References

[1] Chase, M. E., & Herrod, M. (2005). College student behaviors and attitudes toward technology on campus. Computer, 94, 98.

[2] Brady, M. J., Duan, D. W., & Kodukula, V. S. (2000). U.S. Patent No. 6,100,804. Washington, DC: U.S. Patent and Trademark Office.

[3] Want, R. (2006). An introduction to RFID technology. IEEE pervasive computing, 5(1), 25-33.

[4] Aubert, H. (2011). RFID technology for human implant devices. Comptes Rendus Physique, 12(7), 675-683.

[5] Silva, F., Filipe, V., & Pereira, A. (2008, October). Automatic control of students' attendance in classrooms using RFID. In 2008 Third International Conference on Systems and Networks Communications (pp. 384-389). IEEE.

[6] Ramadan, R. A. (2009, November). Leveraging RFID technology for intelligent classroom. In 2009 4th International Design and Test Workshop (IDT) (pp. 1-6). IEEE.

[7] Haselsteiner, E., & Breitfuß, K. (2006, July). Security in near field communication (NFC). In Workshop on RFID security (pp. 12-14).

[8] Chew, C. B., Mahinderjit-Singh, M., Wei, K. C., Sheng, T. W., Husin, M. H., & Malim, N. H. A. H. (2015). Sensors-enabled smart attendance systems using NFC and RFID technologies. Int. J. New Comput. Archit. Appl, 5, 19-29.

[9] Yu, B., Xu, L., & Li, Y. (2012, June). Bluetooth Low Energy (BLE) based mobile electrocardiogram monitoring system. In 2012 IEEE International Conference on Information and Automation (pp. 763-767). IEEE.

[10] Koühne, M., & Sieck, J. (2014, November). Location-based services with iBeacon technology. In 2014 2nd International Conference on Artificial Intelligence, Modelling and Simulation (pp. 315-321). IEEE.

[11] Jovanovic, M., Vukicevic, M., Milovanovic, M., & Minovic, M. (2012). Using data mining on student behavior and cognitive style data for improving e-learning systems: a case study. International Journal of Computational Intelligence Systems, 5(3), 597-610.

[12] Chertchom, P., Tanimoto, S., Ohba, H., Kohnosu, T., Kobayashi, T., Sato, H., & Kanai, A. (2017, June). A Lifelog Data Portfolio for Privacy Protection Based on Dynamic Data Attributes in a Lifelog Service. In International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (pp. 107-120). Springer, Cham.

[13] Lopez-de-Teruel, P. E., Garcia, F. J., Canovas, O., Gonzalez, R., & Carrasco, J. A. (2017). Human behavior monitoring using a passive indoor positioning system: a case study in a SME. Procedia Computer Science, 110, 182-189.

[14] Zheng, M., Li, S., & Fan, H. (2016). Classroom Attendance Detection using a Wi-Fi Positioning Algorithm. In Proceedings of the International Conference on Software Engineering Research and Practice (SERP) (p. 243). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp).

[15] Chertchom, P., Tanimoto, S., Konosu, T., Iwashita, M., Kobayashi, T., Sato, H., & Kanai, A. (2019, July). Edge Computing Platform Management: Design for F2C and F2F for Small Businesses to Reduce Costs. In 2019 8th International Congress on Advanced Applied Informatics (IIAI-AAI) (pp. 890-895). IEEE.

[16] Suda, Y., Arai, T., Yoshizawa, T., Fujita, Y., Zempo, K., & Okada, Y. (2019, January). Shopping baskets for on-line beacon sensor network in retail store. In 2019 16th IEEE Annual Consumer Communications & Networking Conference (CCNC) (pp. 1-2). IEEE.

[17] El Seddawy, A. B., Sultan, T., & Khedr, A. (2013). Enhanced K-mean algorithm to improve decision support system under uncertain situations. International Journal of Computer Science and Network Security (IJCSNS), 13(7), 50.

[18] Morgan, E. J., Alizadeh-Shabdiz, F., Jones, R. K., & Shean, M. G. (2008). U.S. Patent No. 7,403,762. Washington, DC: U.S. Patent and Trademark Office.

[19] Aulinas, J., Petillot, Y. R., Salvi, J., & Lladó, X. (2008). The slam problem: a survey. CCIA, 184(1), 363-371.

[20] Kotler P., and Armstrong G. Principles of marketing. Pearson education, 2010.

Appendix

Sample data from Beacon

Log_id	HW_id	timestamp	Date	type	User_
-LvG3jNVaClXuaLilRaa	Cafeteria@B Bldg	1575465712868	04/ธ.ค./2019 13:21:53	enter	U333ecc614d71ab6ce
-LvG3p_OSJKiLLY6nibU	Teacher Office	1575465738458	04/ธ.ค./2019 13:22:18	enter	U333ecc614d71ab6ce
-LvG3pblCBFWuEgWOcmb	Cafeteria@B Bldg	1575465738644	04/ธ.ค./2019 13:22:19	enter	U333ecc614d71ab6ce
-LvGAWjSPaxew5i6Z-3z	Cafeteria@B Bldg	1575467492120	04/ธ.ค./2019 13:51:32	enter	U333ecc614d71ab6ce
-LvGBIPb9tMOWa-eKhzT	Cafeteria@B Bldg	1575467695644	04/ธ.ค./2019 13:54:56	enter	U333ecc614d71ab6ce
-LvOrnC09BD7xHqiH9iV	Teacher Office	1575613311249	06/ธ.ค./2019 6:21:51	enter	U333ecc614d71ab6ce
-LvOrnVQXNXSS1VxAoIs	Cafeteria@B Bldg	1575613311403	06/ธ.ค./2019 6:21:51	enter	U333ecc614d71ab6ce
-LvOt1CKshsmS7ys_E6_	Cafeteria@B Bldg	1575613637302	06/ธ.ค./2019 6:27:17	enter	U333ecc614d71ab6ce
-LvP4oe20dqCCA7WByfF	Cafeteria@B Bldg	1575616989972	06/ธ.ค./2019 7:23:10	enter	U333ecc614d71ab6ce
-LvPHkeHddITf3CsaCK4	Cafeteria@B Bldg	1575620381105	06/ธ.ค./2019 8:19:41	enter	U333ecc614d71ab6ce
-Lvc0GgsQd1Qte3Je_fB	Teacher Office	1575850676235	09/ธ.ค./2019 0:17:56	enter	U333ecc614d71ab6ce
-Lvc0H8lf-a_Tvn-5cor	Cafeteria@B Bldg	1575850676273	09/ธ.ค./2019 0:17:56	enter	U333ecc614d71ab6ce
-LvcBtftzEliuTynazWz	Teacher Office	1575853728640	09/ธ.ค./2019 1:08:49	enter	U333ecc614d71ab6ce
-LvcBtiCm92qXQzufYYA	Cafeteria@B Bldg	1575853728640	09/ธ.ค./2019 1:08:49	enter	U333ecc614d71ab6ce
-LvcFwL9KeCdM9rzMoYQ	Cafeteria@B Bldg	1575854788047	09/ธ.ค./2019 1:26:28	enter	U333ecc614d71ab6ce
-LvdOQAse_OoEQrpxUyI	Teacher Office	1575873786334	09/ธ.ค./2019 6:43:06	enter	U333ecc614d71ab6ce
-LvdOQD8IjlGfzAwzLK4	Cafeteria@B Bldg	1575873786468	09/ธ.ค./2019 6:43:06	enter	U333ecc614d71ab6ce
-LvdOZvLCBvpaeab_WUK	Teacher Office	1575873826337	09/ธ.ค./2019 6:43:46	enter	U333ecc614d71ab6ce
-LvdOZxaY3twkMNZ2c3l	Cafeteria@B Bldg	1575873826412	09/ธ.ค./2019 6:43:46	enter	U333ecc614d71ab6ce
-LvdOuEMvm9yk519M2dh	Teacher Office	1575873913510	09/ธ.ค./2019 6:45:14	enter	U333ecc614d71ab6ce
-LvdOuGaQW8sFNMhsFQx	Cafeteria@B Bldg	1575873913509	09/ธ.ค./2019 6:45:14	enter	U333ecc614d71ab6ce
-LvdXX2ptbHDs2YJwx8r	Teacher Office	1575876173709	09/ธ.ค./2019 7:22:54	enter	U333ecc614d71ab6ce