Research Article

I-Campus: Towards The Information Integration For Uitm Cawangan Melaka Implementation Of Smart Campus

Noor Afni Deraman[1], Alya Geogiana Buja[2], Khyrina Airin Fariza Abu Samah[3], Mohd Nor Hajar Hasrol Jono[4], Mohd Ali Mohd Isa[5]

[12345]Faculty of Computer & Mathematical Sciences, Universiti Teknologi MARA, Malaysia

[1]noora465@uitm.edu.my, [2]geogiana@uitm.edu.my, [3]khyrina783@uitm.edu.my, [4]hasrol@uitm.edu.my, [5]mohdali@uitm.edu.my

Article History: Received: 11 January 2021; Accepted: 27 February 2021; Published online: 5 April 2021

Abstract: Due to the advancement in technology and management's needs on the go, i-CAMPUS is developed for UiTM Cawangan Melaka. The i-CAMPUS has been integrated with information and communication technology (ICT) and the Internet of Things (IoT). One of the emerging technologies in IoT that is still new in Malaysia is beacon technology with smartphone applications to serve information based on the user's contextual information. Information is currently is decentralized and disseminated among people on the campus through email and by publishing on the website. In order to allow effective information delivery, i-CAMPUS is proposed and developed using an agile development life cycle approach. The system used the Flutter environment and phpMyadmin as a database management system. Integrated with beacon and geofence technology, the i-CAMPUS user will receive notification information within the application when the mobile application sensed the signal emitted by the beacon in the form of Bluetooth Low Energy (BLE). Each beacon signal is unique, and the information delivered is specified according to the beacon. The i-CAMPUS has been evaluated in terms of functionality and usability. The result shows that i-CAMPUS is working well and enables the visitor to retrieve information anywhere at any time. For future work, the navigation function is recommended to be integrated with this application.

Keywords: beacon, e-Dashboard, geofence, Information System, smart campus

1. Introduction

University is a dynamic environment that requires management to be proactive in resolving different concerns, such as sustaining the university as a center of knowledge creation and research excellence, increasing equity, and reacting to student needs. Universiti Teknologi MARA (UiTM), which a key player among public universities in Malaysia, needs to concentrate on reforms, innovations, and developments related to the Industrial Revolution 4.0 (IR 4.0) and Sustainable Development Goals (SDGs) through its strategic plan UiTM2025 and in accordance with the national agenda of the Education Development Plan for Malaysia 2015-2025 [1]. The emerging advanced technology age in which the use of cloud computing, the Internet of Everything (IoE), and social media makes it imperative for UiTM to take a step forward and create different opportunities and challenges for the formal education system.

UiTM Cawangan Melaka took the first step in tackling this challenge with the mission of making UiTM Cawangan Melaka a smart campus. Smart Campus is an upgrade of the digital campus that provides a better environment, ubiquitous learning, resource virtualization, and enriching staff and students' experience through technology usage [2]. In-line with the development and implementation of the Fourth Industrial Revolution (IR 4.0) and the Internet of Everything (IoE), there is a need for UiTM Cawangan Melaka to adapt the technology and be a connected and responsive campus.

This first phase focuses on the integration of information and the efficient dissemination of information. A few problems in resource management of UiTM Cawangan Melaka have been identified. The current framework's key issue is decentralized information, which leads to an inefficient distribution of information to stakeholders. A survey by [3] concludes that centralized data management is vital in the smart city framework as part of the smart city requirement. Centralized data processing is required to ensure effective management and high quality of information delivery. In addition, it also restricts the ingenuity of top management in making better decisions, as overall data is difficult to see. These issues need to be addressed, and there is a need to digitize university resources in order to be readily available and respond quickly [4]. Over time, location-specific resources will become increasingly necessary and will become mandatory for all stakeholders in the campus compound for navigation and effective dissemination of information. Due to the issues that arise, initiatives have been taken to build a smart campus in UiTM Cawangan Melaka.

The rest of the paper is structured as follows. Section 2 outlines some of the relevant work on smart campus, location-based services, and data visualization. Section 3 applies the methodology for the proposed implementation of the system. Section 4 addresses the overall progress of the i-CAMPUS system. Finally, Section 5 draws some conclusions and possible work for the second phase.

2. RELATED WORKS

In this section, a brief explanation of some of the work related to the concept of smart campus and the activities that put it into practice, the perception of location-based services, and the data presentation are discussed.

2.1 Smart Campus

The smart campus benefits from the development of a digital campus and is considered a mini version self-contained of smart cities [4]-[9]. Table 1 shows the comparison between the digital and smart campuses regarding the technical environment, application, and management system [10]. Based on the comparison, the transition from a digital campus to a smart campus is in order as the IR 4.0 era approaches.

Using the same principle as smart cities, a smart campus should follow modern technology to support the number of campus stakeholders, namely students, educators, administrators, and visitors. It exploits the on-campus Internet of Things (IoT) service providers, cloud storage, and smart systems. The idea behind this approach is to transform common structures that can usually be found in a university setting into a specific intelligent campus environment [11].

Various framework has been proposed on designing smart campus. A central intelligence layer is proposed [12] to provide smart service at application based. The services are model based on sensor, social, research, and educational elements with the ability of data analytic processing. Similar to [13], the service layer is required and categorized into three groups: Practical Life, Academic Life, and Social Life. This layer will allow socializing between the user and sharing information. The technical framework proposed by [14] shows that sensor layer, network layer, cloud computing layer, services layer, and Internet are essential in ensuring IoT in smart campus functioning, see Figure 1. Previous studies also supported this where their proposed standard framework of smart campus comprises sensor layer, network layer, and application layer.

Table 1: Comparison of Digital Campus and Smart Campus [10]

Element	Digital Campus	Smart Campus
Technical Environment	Local Area Network Internet	IoT Cloud computing Wireless network Mobile platform Sensor
Application	Digital-based system (teaching platform, library, services)	A smart system with sensory ability, interoperability, control capabilities
Management System	Isolated system	Centralized system System sharing Intelligent Push-in notification

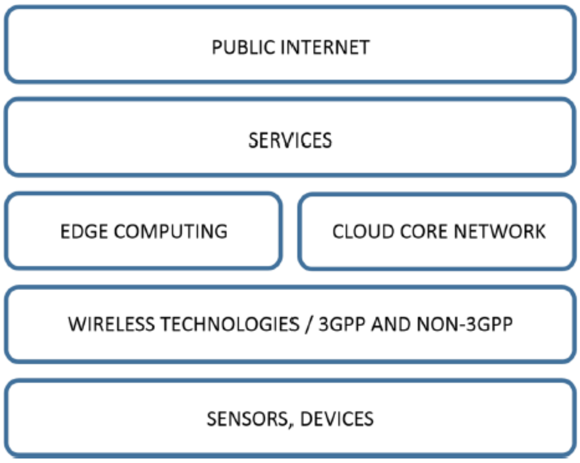

Figure 1: The technical framework of Smart Campus [11]

2.2 Location-Based Services

Location-Based Service (LBS) is a service that delivers information based on the user's current location [15]. The advancement of technologies and wireless communication makes the LBS a popular "killer-application" in the future [16]. There are two main discussions in the LBS, which are location and proximity. According to [17], location is a precise, unmoving place that is usually defined with a geographical coordinate system. At the same time, proximity is not an absolute location, which usually refers to a distance that has no direction. Location and proximity are usually used interchangeably; however, both works differently and are used in a different field.

A Bluetooth Low Energy (BLE) Beacon is a device that emits a signal of BLE to a mobile device that is nearby [18]. Since BLE draws a little power for the beacon to operate, it can last long for years, depending on its configurations [19]. The BLE beacon can operate up to 100m theoretically. However, due to walls and other kinds of physical interferences, the distances it can reach will be affected.

The beacon emits BLE packets to the surrounding with a different protocol based on the usage. Many types of protocols were introduced to be integrated with the beacon and the smartphone platform. The most popular protocol is iBeacon and Eddystone. Though, in the early year of the iBeacon protocol introduction, it was only used only in Apple. Recently, it can also be used by the Android platform.

Geofence is a virtual fence around a particular geographic area and typically represents a physical location, such as a house or site [20]. Geofence uses GPS reading, RFID, Wi-Fi, or cellular data to trigger a pre-programmed action when a mobile device or RFID tag enters or exits a virtual boundary set up around a geographical location. Geofence and beacon have similar objectives, which is to determine the location of the user. However, overlapping use of both devices can lead to redundant information. The rule of thumb in the placing of both devices relies on the distance covered. Beacon is preferably used indoors areas that span less than 50 meters, whereas geofence is defined as a macro-location-based system with an area of more than 50 meters. Table 2 displays the characteristics of beacon and geofence [21]. Based on these characteristics, i-CAMPUS will place the beacons for indoor navigation and geofence for outdoor.

Table 2: Characteristics of Beacon and Geofence [21]

Characteristics	**Beacon**	**Geofence**
Requires additional hardware	Yes	No
Requires Bluetooth	Yes	No
Requires user to opt-in for location service	Yes	Yes
Requires GSM/WiFi/GPS	No	Yes
Good for large areas (>50 meters)	No	Yes
Good for close proximity (<50 meters)	Yes	No
100% Accuracy	Yes	Accuracy varies with location and network coverage
Available on Android	From Android 4.4+	Yes
Available on iOS	From iOS 7.0+	Yes

2.3 Data Visualization

The University manages a significant amount of digital data to run, and the data stream comes from students, services, staff, campus events, and business transactions. Effective governance of university data would contribute to an immense opportunity to enhance its stakeholders' experience, generate revenue, and strategic planning [22]-[23]. Hence, university data experts need to thoroughly analyze the data to provide management with information on decision-making. One way of displaying data is by using data visualization - graphical representation of information and data. Using visual elements such as charts, graphs, and maps, data visualization tools offer an interactive way to see and interpret data trends, outliers, and patterns [24].

The digital dashboard is an electronic platform that aggregates and shows data from various sources, such as databases, locally hosted files, and web services [25]-[27]. E-Dashboards allow management to track their subordinates' key performance indicators (KPIs) by showing historical patterns, actionable data, and real-time information. Using a dashboard facilitates management in visualizing the KPI for effective planning strategy and communicating systematically to their stakeholders.

3. RESEARCH METHODOLOGY

This section addressed on system development life cycle (SDLC) model adopted for i-CAMPUS system development. The conceptual model of i-CAMPUS explaining the overall framework is also discussed.

3.1 Agile System Development Life Cycle

i-CAMPUS system development uses an agile development lifecycle model where the developer team must adapt and respond to the user's requirements [28]. Each development process, beginning with the requirement gathering to data analysis and system design, is carried out iteratively. The system is presented and delivered to the end-user every fortnight to obtain approval and end-user satisfaction.

3.1.1 Requirement Gathering and Analysis:During the requirement gathering, the main objective is to obtain as much information as required to develop the system. The aim of collecting the requirement is to ensure that the system developed meets the end-user requirements [29] [30]. Therefore, the compilation of the relevant details on the product is important since it will also decide the design of the product. The information is obtained by defining the key source of information: the Rector, all the Deputy, the Head of Department, and a range of data collection methods. Data collection is conducted by interviews and online meetings with the end-user, understanding the business process, and reviewing documents. Data collected is analyzed and converted to use case diagram, activity diagram, and domain class diagram, as shown in Figure 2.

3.1.2 System Design: At this stage, four activities are carried out: environment design, database design, user-interface design, and system flow. The i-CAMPUS system is designed to support both Android and iOS environments. Therefore, the Visual Studio Code is needed to code the program, and Genymotion, a free mobile device emulator for desktop, is used to emulate with Visual Studio Code. The system ERD is designed after the data collected is analyzed. In standardizing the user-interface of i-CAMPUS, the color code, design, and size of every layout and button elements in the system are adhered to stakeholder requests and approval. The storyboard of the system is modeled using Adobe XD while button and logo using Adobe Illustrator.

3.1.3 System Implementation and Testing:The i-CAMPUS mobile application is implemented using Flutter, an open-source Google's UI toolkit. Flutter is used as it supports code reuse across the operating system, particularly Android and iOS. It also allows the application to communicate directly with underlying platform services. Although the mobile application is widely known using Firebase, due to slow data retrieval and incompatibility with the existing system, phpMyadmin is chosen as software to manage the database. As the database is hosted on the campus server, the capacity of storage and access time is covered. In addition to the development of the system, geofencing settings are needed at this phase. Using the PlotProjects toolkit, three campuses' location information is configured to activate the end-user cell phones' push-notification. The functionality system is tested by the end-user immediately after the system reached its development milestone. Every feedback is taken seriously, and the developer expects rapid changes.

3.2 System Architecture

The system architecture is a conceptual model that describes the system's structure, behavior, and overall views. By analyzing of proposed smart campus framework [3], i-CAMPUS mobile application system architecture is comprised of 4 layers that will utilize IoT and serve as a centralized system, as shown in Figure 3.

Each layer is essential in making the system functioning well. The awareness layer is responsible for collecting signals from the environment and processing the data before passing it to the network layer. i-CAMPUS requires beacons and geofencing to collect and disseminate information to all campus stakeholders through their mobile phone. Beacons are placed at a strategic location on campus, both indoor and outdoor (micro location). Geofences will be used in a wider area (macro location), and stakeholders will be alerted on arrival once they reach the campus area. The stakeholder will be alerted with proximity-specific content using the push-notification method.

The network layer is responsible for information aggregation and providing a strong continuous Internet connection and strong Wi-Fi, 3G/4G network to handle data transactions. Meanwhile, the data layer serves as a centralized database that stores and manages user data and facilitates a dynamic query for report analysis to assist with decision making. The application layer is considered the most crucial element as it serves as a platform for various university management systems. It is responsible for collecting and utilizing data and providing information through data visualization.

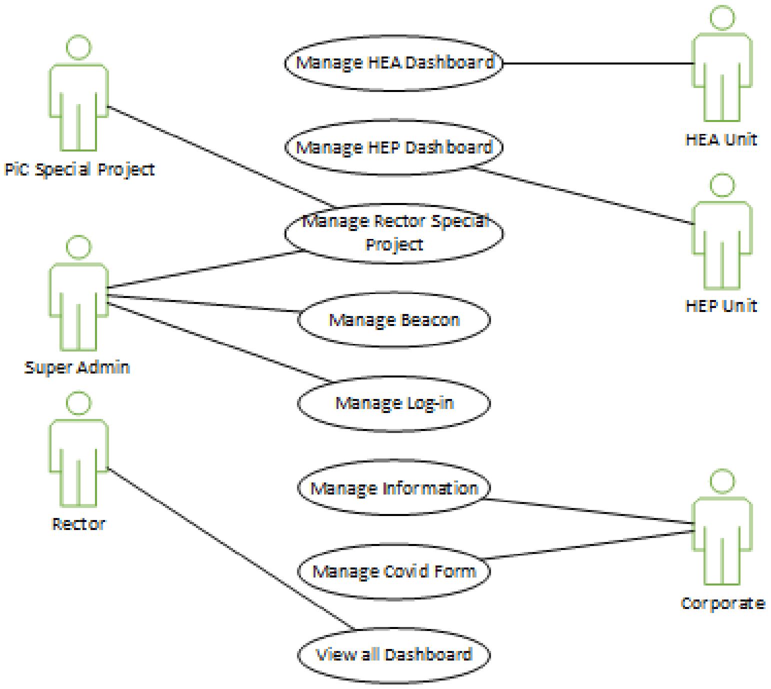

Figure 2: i-Campus use case diagram

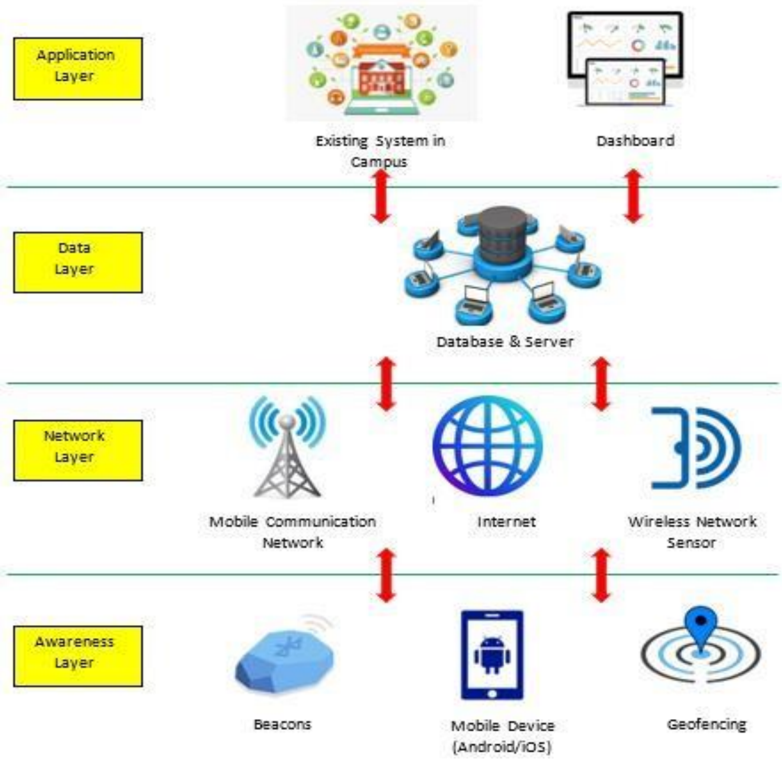

Figure 3: i-CAMPUS system Architecture

4. RESULT

This section addresses the entire i-CAMPUS component, which comprises the Rector Office, Academic Affairs Unit, Student Affairs Unit, and Covid Management.

4.1 System Implementation

The i-CAMPUS main menu is designed to provide an interactive and responsive system. This system will become the central platform of information dissemination from the UiTM Melaka Branch to its stakeholders. Initially, the i-CAMPUS system will ask users for permission to switch on their Bluetooth and GPS on their mobile phone. This is necessary in order to enable beacon and geofences to transmit their signal and opt-in push notification to the mobile phone. Beacon information can be viewed in i-CAMPUS, and the stakeholder can get detailed information on the location listed by clicking the location name. The main page of i-CAMPUS offers general information about UiTM Cawangan Melaka, such as the number of students, the programs offered, and the number of lecturers and relevant information for the other two campuses, KampusJasin and KampusAlor Gajah. Among the details given are the latest campus news, such as on-going activities, accessible rooms, and links to various university systems. In addition to that, i-CAMPUS is integrated with various existing systems, such as the Room Reservation Management system (RRMS). This is an intranet system that requires the stakeholder in the university compound to use it.

A feedback form is provided for the admin to collect comments, suggestions, or issues from the stakeholder about the system. Each feedback will be given a ticket ID for the issuer to keep track of the progress. To curb the spread of Covid19 among the stakeholder, SaringC19 is included in the i-CAMPUS, and a reminder will be sent to the stakeholder on a regular basis to fulfill the form. This initiative will help the management keeping track of their stakeholder well-being and as a precaution measure.

4.1.1 e-Dashboard: The i-CAMPUS system provides a centralized platform that links the six main components into one dashboard for Rector's monitoring purposes. This e-Dashboard able to provides at-a-glance key performance indicators (KPIs) of every unit in the university. Indirectly, this will enhance any decision-making by management as it is able to identify the strengths, weaknesses, opportunities, and threats (SWOT) of each component. Each unit has its e-Dashboard that manages different key processes for the respective unit to support this initiative. Thus, it enables the Head of Department or Unit to manage the department systematically.

Figure 4 shows the Rector office's login page, where it will lead to the e-Dashboard of all units in the university. The rector has his e-Dashboard for special projects where monitoring of the progress is much easier. All persons in charge are responsible for updating their progress accordingly. Each project will be classified into four groups: completed, on-progress, canceled/on-hold, and future project.

e-Dashboard for Student Affairs Unit is related to staff's PhD enrolment projection, management of curriculum review, administration of a new program, and KPI of the unit. Staff's PhD enrolment projection allows management to make strategic planning and efficient resource management. At the same time, the reputation and visibility of the lecturers in their respective fields are enhanced. All staff in faculty are classified into four groups; completed, on-going, inactive, and future candidate. Another component in the e-Dashboard of Academic Affairs Unit is the management of curriculum review. All responsible coordinators are expected to update their program's curriculum review status. Each milestone in the completion of the review is set out, and information such as the date of commencement, approval of the meeting committee, and input from the panel are required. This information helps the Rector and the Management in future planning and helps the coordinator achieve and present their results and status quickly. e-Dashboard for Student Affairs Units consist of college management and cashless services – Imbas dan Infaq and SedekahTabungAmanah using QrCode and the third-party payment gateway.

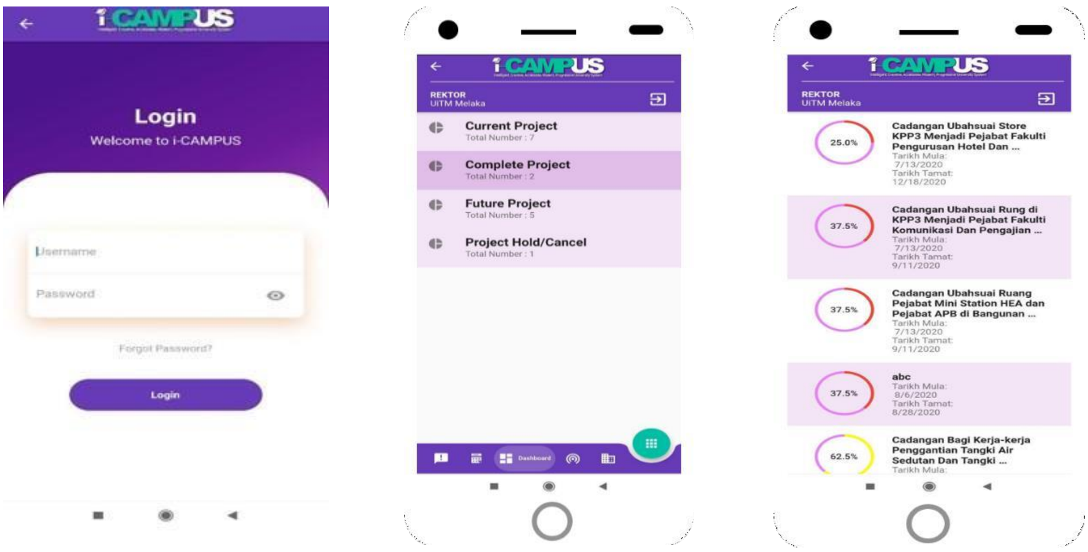

Figure 4. i-CAMPUS e-Dashboard Rector Office

4.1.2 Location-Based Services Setting: With the various features that are integrated into the i-CAMPUS system, there is a great need for the latest technology. Beacons and geofences are used extensively in i-CAMPUS. The strategic positioning of beacons for all three campuses was done with regard to distance – macro and micro-positioning, hotspot, and maintenance consideration, see Table 3. Beacons feature of opted-in ability allows learning about stakeholder preferences and, at the same time, activate proximity-specific content using push notifications and in-app messages.

Geofence information is used by i-CAMPUS to trigger events when a stakeholder enters or leaves the university compound provided; they allow opted-in function. This function enables the stakeholder to receive notifications using their mobile phone and have Wi-Fi or Internet connection and activate GPS location. GPS coordinates readings will be taken at Simpang Ampat toll entrance and UiTM Cawangan Melaka KampusAlor Gajah to be used by the user for navigation purposes.

Table 3: Coordinates of Building in KampusJasin

No.	Building	Coordinate
1.	Bangunan FSKM (Makmal FSKM)	Latitude: 2.228116 Longitude: 102.454921
2.	Banguan FSKM (Bilik Pensyarah)	Latitude: 2.228077 Longitude: 102.455560
3.	Bangunan FPA (Bilik Pensyarah)	Latitude: 2.228077 Longitude: 102.455560
4.	Makmal Komputer	Latitude: 2.227500 Longitude: 102.455611
5.	Perpustakaan	Latitude: 2.227267 Longitude: 102.45568
6.	Blok Kuliah	Latitude: 6FH4 Longitude: 4M
7.	Surau Al Taqwa	Latitude: 6FG4 Longitude: C3

4.2 Functionality Testing

Functionality testing has been carried out to verify the system's completion and meet all user requirements. As this project uses the agile approach, functionality testing is conducted rapidly. Functionality testing respondents are those who are directly involved in the system, including the Rector, the deputy rector HEA, the deputy rector HEP, the corporate, and admin staff. Table 4 displays the outcomes of the functionality tests consisting of 8 use cases. The entire use case has passed the test.

4.3 Usability Testing

Usability testing is a test conducted to assess client approval of the design or use of the system. This test adopts the System Usability Scale (SUS) consisting of 10 Likert-Scale questions. Table 5 displays the SUS questionnaire, which has been distributed to 15 participants who are management staff and practical students on campus. They are required to install the .apk file to test the system and answer the questions. The outcome of the SUS survey is translated into a SUS score. Table 6 reveals the SUS ranking of all participants. Using the standard formula, where the score from the odd number question is deducted by 1, and the score from the even number question is subtracted by 5, the SUS raw score for each participant is acquired by adding all the scores. The raw score is then multiplied by 2.5 to get the final score. The average score obtained is 72.67. Based on this analysis, the system can be concluded to fulfill all the specifications required by the stakeholder with some space for improvement.

The analysis was carried out for each question, and the output obtained was used for improvement. For instance, 7 out of 15 participants gave low scores to Question 2, where they thought the system was complicated. This is also confirmed by the result score of Question 4, where technical assistance is required to use the system. This is anticipated as the system needed the participants to enable their GPS and Bluetooth functions to allow the system to run fully functional. However, i-CAMPUS success relies on technologies used. It can sustenance one of the initiatives to support the digital lifestyle, in line with new learning and teaching methods, to address the IR4.0 wave. Furthermore, the platform i-CAMPUS system is operated in both web-based and mobile applications, which can be accessed anywhere at any time.

Table 4: Functionality testing result

Use Case	Description	Remark
Manage Rector Special Project	This use case allows the Person in Charge of special project updates on their project progress into the system.	Passed
Manage HEA e-Dashboard	This use case allows both Deputy of HEA and the admin of HEA to login to the e-Dashboard of HEA and access the functions under HEA e-Dashboard.	Passed
Manage HEP e-Dashboard	This use case allows both Deputy of HEP and the admin of HEP to login to the e-Dashboard of HEP and access the functions under HEP e-Dashboard.	Passed
Manage Beacon	This use case allows the system's admin to manage (CRUD) and configure beacons at three campuses.	Passed
Manage Information	This use case allows Corporate staff to manage (CRUD) all information and news related to UiTM Cawangan into the system.	Passed
Manage Covid Form	This use case allows the admin of the system to access confidential information related to the SaringC19 form.	Passed
Manage Log-in	In this use case, the super admin manages (CRUD) authorization to the system.	Passed
View all e-Dashboard	This use case allows Rector to view all KPI status in the system across all units.	Passed

Table 5: SUS Questionnaire

Scale: 1-Strongly Disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree						
No	**Question**	**Scale**				
1	I think that I would like to use this system frequently	1	2	3	4	5
2	I found the system unnecessarily complex	1	2	3	4	5
3	I thought the system was easy to use	1	2	3	4	5
4	I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5	I found the various functions in this system were well-integrated	1	2	3	4	5
6	I thought there was too much inconsistency in this system	1	2	3	4	5
7	I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8	I found the system very cumbersome to use	1	2	3	4	5
9	I felt very confident using the system	1	2	3	4	5
10	I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Table 6. SUS result scoring

Participants	SUS Raw Score	SUS Final Score
P1	35	87.5
P2	22	55
P3	34	85
P4	36	90
P5	16	40
P6	32	80
P7	36	90
P8	25	62.5
P9	32	80
P10	36	90
P11	16	40
P12	32	80
P13	36	90
P14	16	40
P15	32	80
Average Score		72.67

Participants	SUS Raw Score	SUS Final Score
P1	35	87.5
P2	22	55
P3	34	85
P4	36	90
P5	16	40
P6	32	80
P7	36	90
P8	25	62.5
P9	32	80
P10	36	90
P11	16	40
P12	32	80
P13	36	90
P14	16	40
P15	32	80
Average Score		72.67

5. CONCLUSION

In a nutshell, the UiTM Cawangan Melaka Smart Campus system is an emergence of technology-enabled in university, resulting in several benefits: helping the management control resource utilization, improving information dissemination, and generating the organization income. This system is customized according to the UiTM Cawangan Melaka need. Furthermore, the platform for the UiTM Cawangan Melaka Smart Campus system is operated in both web-based and mobile applications, which can be accessed anywhere at any time. For the second phase, the focus is more on integrating IoT to the service available on the campus.

ACKNOWLEDGEMENT

Sincere appreciation goes to Universiti Teknologi MARA Cawangan Melaka for the support given to this research endeavor, TEJA: Internal Grant (GDT2020-17).

References

1. Adnan A.S, Pelan Strategik UiTM2025 Pacu Universiti Taraf Global. Available online: https://www.bharian.com.my/berita/nasional/2020/02/654320/pelan-strategik-uitm2025-pacu-universiti-taraf-global (accessed on 20 August 2020).
2. AbuAlnaaj, K., Ahmed, V., &Saboor, S. A strategic framework for smart campus. Proceedings of the International Conference on Industrial Engineering and Operations Management, 790–798, March 2020.
3. Gharaibeh, Ammar & Salahuddin, Mohammad &Hussini, Sayed &Khreishah, Abdallah & Khalil, Issa &Guizani, Mohsen & Al-Fuqaha, Ala. (2017). Smart Cities: A Survey on Data Management, Security and Enabling Technologies. IEEE Communications Surveys & Tutorials. PP. 1-1. 10.1109/COMST.2017.2736886.
4. Vaghashiya, R., Thakore, R., Patel, C., & Doshi, N. IoT – principles and paradigms. International Journal of Advanced Trends in Computer Science and Engineering, 8(1.6 Special Issue), 153–158, 2019. https://doi.org/10.30534/ijatcse/2019/2481.62019
5. Min-Allah, N., &Alrashed, S. Smart campus—A sketch. Sustainable Cities and Society, 59, April 2020, 102231. https://doi.org/10.1016/j.scs.2020.102231.
6. Ahmed, V., Alnaaj, K. A., &Saboor, S. An investigation into stakeholders' perception of smart campus criteria: The American University of Sharjah as a case study. Sustainability (Switzerland), 12(12), 2020. https://doi.org/10.3390/su12125187.
7. Monti, L., Prandi, C., &Mirri, S. IoT and data visualization to enhance hyperlocal data in a smart campus context. ACM International Conference Proceeding Series, 1–6, 2018. https://doi.org/10.1145/3284869.3284878.
8. Badawood, A., &Albadri, H. Internet of thing (Iot) to enhance knowledge sharing between faculties, best practice and proposed modified systems for middle east and gulf region area. International Journal of Advanced Trends in Computer Science and Engineering, 9(1.1 Special Issue), 600–605, 2020. https://doi.org/10.30534/ijatcse/2020/9791.12020

9. Harrison C., Eckman B., Hamilton R., Hartswick P., Kalagnanam J., Paraszczak J. and Williams P., Foundations for Smarter Cities, IBM Journal of Research and Development, vol. 54, no. 4, pp. 1-16, 2010.
10. Nie, X. Research on Smart Campus Based on Cloud Computing and Internet of Things. Appl. Mech. Mater. 380, 1951–1954, 2013.
11. Liu Y., Zhang W. and Dong P., Research on the Construction of Smart Campus Based on the Internet of Things and Cloud Computing, Applied Mechanics and Materials, vol. 543-547, pp. 3213-3217, 2014.
12. Adamk' o, A., & Koll' ar, L. Extensible data management architecture for smart campus applications—a crowdsourcing based solution. WEBIST, 1, 226–232, 2014.
13. Kwok, L. F. A vision for the development of i-CAMPUS. Smart Learning Environments. A Springer Open Journal, 2(2), 1–12, 2015.
14. Jurva, R., Matinmikko-Blue, M., Niemelä, V. et al. Architecture and Operational Model for Smart Campus Digital Infrastructure. Wireless Pers Commun 113, 1437–1454 (2020). https://doi.org/10.1007/s11277-020-07221-5
15. Walunj, S., Bhaidkar, Y., Bhagwat, P., Bhalere, P., & Gujar, R. Tourist Place Recommendation. International Journal of Advance Research , Ideas and Innovations in Technology, 1(3), 3032–3037, 2016.
16. H. Huang, G. Gartner, M. Schmidt and Y. Li, Smart Environment for Ubiquitous Indoor Navigation, International Conference on New Trends in Information and Service Science, Beijing, 2009, pp. 176-180, 2009. doi: 10.1109/NISS.2009.16.
17. L. Dong, Research on Applications of LBS Based on Electronic Compass Assisted GP, Information Engineering and Electronic Commerce, pp. 599-602, 2009.
18. Herrera-Vargas, M.: Indoor navigation using bluetooth low energy (BLE) beacons. M.S. thesis, Turku University of Applied Sciences, June 2014.
19. Cheng, R., Hong, W., Wang, J., & Lin, K.W. An Indoor Guidance System Combining Near Field Communication and Bluetooth Low Energy Beacon Technologies. World Academy of Science, Engineering and Technology, International Journal of Computer, Electrical, Automation, Control and Information Engineering, 10, 1639-1645, 2016.
20. Sarah K. W., What is geofencing? Putting location to work. Available online : https://www.cio.com/article/2383123/geofencing-explained.html#:~:text=Geofencing%20is%20a%20location%2Dbased,location%2C%20known%20as%20a%20geofence (accessed on 18 August 2020).
21. Oleg M., How to Use Geofences And Beacons To Engage Mobile Users, Available online: https://www.mocaplatform.com/blog/how-to-use-geofences-and-beacons-to-engage-mobile-users (accessed on 18 August 2020).
22. Wang, F. The Application of Big Data in the Construction of Smart Campus Information. DEStech Transactions on Engineering and Technology Research, (apetc), 1536–1543, 2017. https://doi.org/10.12783/dtetr/apetc2017/11294.
23. Avery, P., Big Data & Higher Education: How Are They Connected? Available online: https://insidebigdata.com/2019/11/28/big-data-higher-education-how-are-they-connected/#:~:text=By%20using%20predictive%20analytics%2C%20universities,being%20successful%20versus%20dropping%20out.&text=Big%20data%20can%20also%20help,students%20want%20to%20drop%20out (accessed on 20 August 2020).
24. Tableau, Data visualization beginner's guide: a definition, examples, and learning resources. Available online: https://www.tableau.com/learn/articles/data-visualization#:~:text=Data%20visualization%20is%20the%20graphical,outliers%2C%20and%20patterns%20in%20data {accessed on 28 September 2020).
25. Klipfolio, What is digital dashboard? Available online: https://www.klipfolio.com/resources/articles/what-is-digital-dashboard (accessed on 28 September 2020).
26. Waris, F. A. Optimalisasi data pelayananmahasiswa dan dosendalamaplikasi smart campus melaluipenyediaan dashboard sebagaialatkontrolpimpinan di Politeknik, 2020. Retrieved from http://repository.pertanian.go.id/handle/123456789/10084.
27. Martinez, D.A., Kane, E.M., Jalalpour, M. et al. An Electronic Dashboard to Monitor Patient Flow at the Johns Hopkins Hospital: Communication of Key Performance Indicators Using the Donabedian Model. J Med Syst 42, 133 (2018). https://doi.org/10.1007/s10916-018-0988-4.

28. Balaji, S., &Murugaiyan, M. Waterfalls V-Model Vs Agile: A Comparative Study On SDLC, International Journal of Information Technology and Business Management, Vol.2 No. 1, June 2012.
29. Kramer, M. Best practices in systems development lifecycle: An analysis based on the waterfall model. Review of Business & Finance Studies, 9(1), 77-84, 2018.
30. Vaghashiya, R., Thakore, R., Patel, C., & Doshi, N. IoT – principles and paradigms. International Journal of Advanced Trends in Computer Science and Engineering, 8(1.6 Special Issue), 153–158, 2019. https://doi.org/10.30534/ijatcse/2019/2481.62019