

Preliminary Mobile Beacon Application Framework for Higher Education Co-Curricular Engagement

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Abstract. Mobile beacon application leverages the beacon technology as location-based or proximity sensors to notify or interact with user via mobile apps. There are many instances of these applications especially as an engagement platform across many domains like marketing, retails, exhibitions, or public services. Mobile beacon application holds potential as an engagement tool for empowering co-curricular engagement in higher education. Integrated with personalized mobile notification, users can be notified and interact with co-curricular events within their proximity in the campus. However, literature indicates limited insights on the design applicability and empirical studies of mobile beacon application for higher education context. This new application context poses its own unique challenges, but imperative in helping researchers to discover the extents of mobile beacon potentials. This concept paper introduces a preliminary mobile beacon application framework for supporting co-curricular engagement in higher education. The framework aims to enable design applicability of a mobile beacon application integrated with personalized notification for education engagement purposes. Characterization of mobile beacon application components along with the deliberation of mobile notification features are highlighted in the framework. The presented conceptual framework offers the foundation for application designers in building a mobile beacon application for higher education engagement.

1 Introduction

The advances of network communication and mobile technology greatly transcends the way modern society interact and engage. Mobile devices are now ubiquitous with many great applications on various aspect of human daily life like productivity, entertainment, or finance. Mobile beacon is one of the recent advances in leveraging ubiquitous technology to enhance engagement towards a location or environment. Industries like retail market, real-estate, and tourism have utilized mobile beacon technology to improve user engagement with their

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services [1, 2]. The global beacon technology market is expected to project \$45M by 2026 with 75.4% growth rate since 2018 [3].

The main motivation of this work is to leverage the potential of beacon technology and mobile app into real-world education applications. Apart from the traditional curriculum of the programmes' syllabus, co-curriculum is also imperative in developing students' character [4]. Co-curricular activities like symposiums, gatherings, and competitions are often conducted outside of class schedule, prone to be missed with resulting low engagement [5]. Furthermore, the absence from co-curricular events may hinder students' interpersonal skills and limit their holistic growth, posing long-term developmental risks. Students who forego these opportunities may miss valuable chances for networking, leadership, and skill enhancement, impacting their overall educational experience.

Mobile beacon application can be great supporting tool for empowering co-curricular engagement in higher education. By strategically deploying mobile beacons across campus, the application can deliver broader and targeted notifications, thus enhancing relevant co-curricular opportunities. However, mobile users are often flooded with push notifications from many different installed apps with limited controls. Therefore, this work proposes the integration of mobile beacon application with personalized notification that will enables smart co-curricular engagement for the students. However, literature indicates limited insights and discussions on the design conceptualization and applicability of mobile beacon application for higher education context. This new application context poses its own unique challenges, but imperative in helping researchers to discover the extents of mobile beacon potentials.

This paper proposes a preliminary conceptual framework of mobile beacon application for supporting education engagement. The proposed framework particularly addresses the application design development for facilitating co-curricular engagement in higher education level. The purpose of this framework is to enable mobile beacon application design and integration with notification features for education engagement. This paper also highlights the characterization of essential mobile beacon application components and mobile notification features based on the presented framework.

Section 2 discusses the background of the presented work including discussions on prior work on mobile beacon applications and mobile notifications. Section 3 then introduces the preliminary conceptual framework in detail comprising the components, processes, and features. Section 4 discusses the potentials and implications of the preliminary framework. Finally, Section 5 provides the conclusion of this initial work.

2 Background

This section discusses the prior work related to mobile beacon applications and utilization of mobile notification for cultivating engagement.

2.1 Overview of Recent Mobile Beacon Applications

Beacon is a transmitter device that uses Bluetooth Low Energy (BLE) to continuously send signals to any smart devices within its range. The transmitted signals contain unique location information that prompt responses in various way via programmable mobile app. The beacon can deliver customized push notifications on the mobile app as the user enters the proximity range [6].

Literature indicates many applications of mobile beacon technologies across various domain that particularly thrives on engagement metrics. A prior study highlighted the applications of mobile beacon in retail market with features like indoor localization, proximity

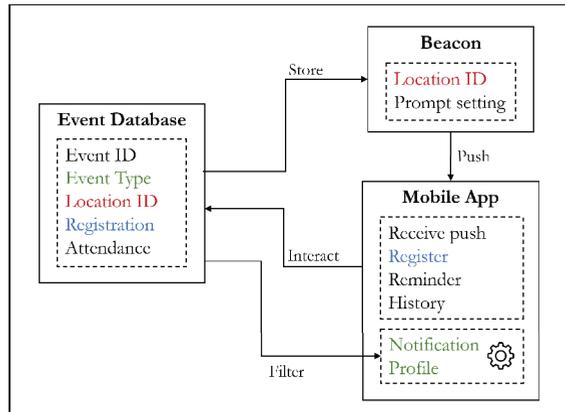


Fig. 1: Preliminary Mobile Beacon Application Framework for Supporting Co-Curricular Engagement.

detection, and activity sensing [7]. Other studies also discuss the use of mobile beacon as experience-enrichment tool in indoor exhibition like the museums and artwork showcases [8, 9]. For the domain of education, a study addresses the integration of beacon devices in education, proposing a methodology to enhance virtual learning environments through smartphone applications [10]. The presented prototype demonstrates improved learning processes, showcasing the potential of education-oriented beacons in IoT-based education.

Apart from engagement, mobile beacon is also utilized as environment awareness medium to alert any user within the proximity range. A prior study demonstrated the deployment of mobile beacons in the construction sites as hazard alarm via mobile app notification [11]. Another work presented the use of beacon proximity detection in smart parking system delivered via mobile app [12]. Upon detection, the beacon will prompt the online parking system to provide information on recommended nearby space to be forwarded to the user. In the context of education, a study proposed a beacon-based campus management system to enhance interaction between lecturers and students [13]. The proposed system enables personalized notifications and innovative teaching modes through the use of location information.

The reported applications of mobile beacon as engagement and awareness tool eventually inquires its potential use in the context of education. Education institutions continuously seek methods and mechanisms for providing comprehensive learning experience for their students.

2.2 Mobile Notification and User Engagement

The advances of mobile technologies and increasing affordability has turned mobile devices mainstream and delicately ubiquitous within human daily life. Mobile devices like smartphone, tablet, and smartwatch are now common, equipped and integrated with many available mobile apps. However, the devices and the apps often flooded the users with mobile notifications for alert or action. To mitigate the risk of overwhelming notifications, there are many works conducted on advancing intelligent or smart notification features.

For instance, a previous work introduces a high-performance context-aware push notification system for the converged mobile and Internet-of-Things messaging [14]. The presented system enables efficient message dispatching for push notification based on highly personalized interest of the user. Another study investigated the determinant factors of user reaction

Table 1: Mobile Beacon Application Components for Supporting Co-Curricular Engagement.

Application Components	Designable Elements
Beacon	Beacon profile, message trigger
Mobile App	Receive push notification, register event, reminder, history
Event Database	Event creation, event signup, attendance
Notification Profile	Event filter, notification design

from push notifications with regards to behavioural preferences [15]. The study presented a framework for selecting reactionary users towards notifications and provide recommendations to discover the target of push notification. Evidently, push notification is a latent interest initiation mechanism in cultivating or growing user engagement towards the intended subject or activity.

However, uncontrolled notification frequency can also be disruptive in sustaining engagement due to negative user reception and information disorientation. A study found that user reception towards mobile notifications is influenced by its presentation, alert type, interests, and complexity of expected tasks [16]. Another study investigated the effect of message content and frequency of push notifications in promoting engagement for self-health monitoring [17]. There are also reported work on the effects of push notification in education engagement with regards to display method, message frequency, and delivery mode [18]. Although, the focus of engagement in this work is the student one-directional interactions towards the learning contents provided in the app.

Despite the advances highlighted by these works, there are limited discussions or applications of mobile beacon application as engagement tool in education context. Therefore, this study investigates the applicability of mobile beacon technologies integrated with smart notification for empowering education engagement.

3 Preliminary Conceptual Framework

This section introduces the preliminary conceptual mobile beacon application framework for supporting higher education co-curricular engagement. The preliminary framework is conceptualized based on a literature review of existing works in mobile beacons, then customized for co-curricular engagement. Figure 1 shows the composition of the preliminary application framework including the components and process. Characterization of the proposed components and its designable elements for constructing mobile beacon application are described in Table 1.

Based on Figure 1 and Table 1, application designer can identify and design the elements for constructing medium for co-curricular event engagement. For setting up, the beacons can be programmed with unique event information or notification trigger into its beacon profile. The event information can be generated via a database system that also records signup and attendance from the students. A mobile app with online connection is required to allow the students to receive notification, register for event, and configure reminder. The mobile app can also display the record of previous attended events attended via synchronization with the database. Finally, the app can be equipped with customized notification profile that allows for

Table 2: Mobile Notification Profiles and Operations.

Notification Profile	Operation
Academic	Filter events related to student learning i.e., symposium, workshop, lecture.
Sports & Interests	Filter events related to sports or interests i.e., training, tour, theatre play.
Social	Filter events related to social activity i.e., gathering, fundraising, meetup.
Competition	Filter events labelled as competition as secondary attribute on top of main attributes above.

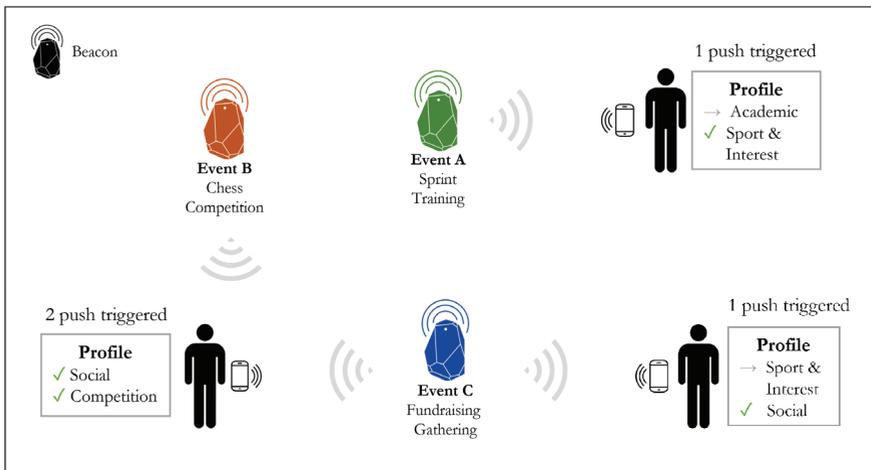


Fig. 2: Case Scenario of Co-Curricular Engagement Using Mobile Beacon.

event preferences and filters. The profile feature can be imperative in mitigating the risk of event engagement disruption due to aggravating user receptivity. This work also proposes the following notification designs in Table 2 as preliminary profiles to be outfitted in the mobile beacon app. The proposed profiles represent major types of co-curricular event based on a previous study on participation factors of co-curricular activity [19].

Based on the discussed preliminary concept and features, an application case scenario can be envisioned as shown in Figure 2. The beacons are placed near the location of upcoming events and the common routes of students’ movement within the campus. The beacons can be encoded with event information via wired or wireless connection depending on its connectivity specifications. The beacons will continuously emit signals to nearby devices within the vicinity that can be interacted via mobile beacon app. Nearby students with installed app in their device can receive push notifications regarding the events that matches their configured notification profiles. Beacon signals from other events regardless of the matching profiles are still received by the app for optional viewing. The event information can be browsed in the app but does not interfere with push notifications. Through strategic deployments of mobile

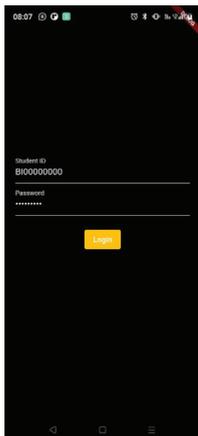


Fig. 3: Prototype Login Interface.

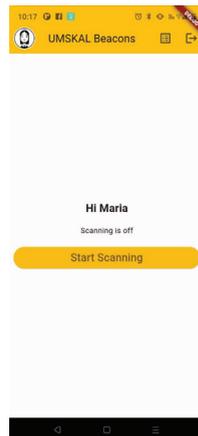


Fig. 4: Main app home screen.

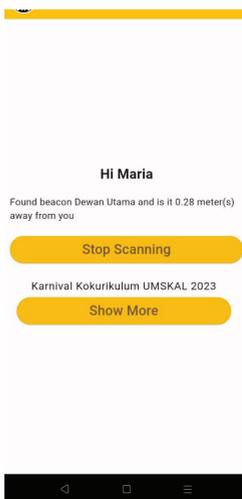


Fig. 5: Event detection via scan.



Fig. 6: Example event details.

beacons across campus, the application can deliver targeted notifications, enhancing relevant co-curricular opportunities and minimizing notification fatigue. This personalized approach ensures that students receive timely and tailored information, optimizing their engagement with campus activities.

4 Preliminary Prototype

This section describes several technical details of the preliminary prototype that has been developed with guidance from the framework. The developed early prototype will serve as the translated tangible artifact for evaluating the usability of the proposed framework. Screenshots of the preliminary prototype are shown in Figure 3 until Figure 6. The prototype mobile app is developed using Flutter, a versatile framework that allows for cross-platform development. The Flutter development environment in Android Studio was utilized to create a unified

application for both Android and iOS platforms. This approach streamlines the development process and ensures consistent user experience across devices. The prototype app integrates "beacons_plugin" Flutter package (version 2.0.8), which facilitates seamless communication with Bluetooth beacons. This package provides the necessary tools to scan for nearby beacons, retrieve their unique identifiers, and process the corresponding data. The application is designed to work with both iBeacon and Eddystone beacon protocols, enhancing compatibility and expanding the scope of potential beacon deployments. Currently, the prototype is only deployed exclusively on Android devices. This deployment choice allows us to focus on refining the app's functionality and user experience within a controlled environment. As the future development progresses, the app compatibility will be extended to iOS devices.

5 Conclusions & Future Work

The presented work discusses the potential application of mobile beacon integrated with personalized notification in higher education engagement. The positive results of mobile beacon applications from other studies indicate the expected feasibility of this unique implementation and warrant further investigation. Investigating the application into this new context can provide further insights into unique mobile beacon advantages or implementation challenges. Furthermore, the application case from this framework can help education researchers in examining the paradigm of user engagement. Researchers can investigate the potential determinant or influencing factors of engagement that are enabled by the facilitation of the mobile beacon application. The next steps for this study is implement the notification profiles into the prototype app and evaluate the usability and effectiveness of the app via a case study. The work on this is presently underway by the authors.

This paper has presented a preliminary conceptual framework of mobile beacon application for supporting higher education co-curricular engagement. Currently, the presented framework is in its initial stages and will require further empirical study reach a mature level. To evaluate the effectiveness of the presented framework and prototype, comprehensive function testing will be conducted alongside experiments measuring student's increased awareness of co-curricular events on campus. The framework highlights the necessary components and personalized notification integration of beacon application for enriching education engagement. Each component and notification feature proposed in the framework were characterized by its functions and interactions of expected user engagement in co-curricular activities. Education technologists and designers can leverage the framework to initiate their development process of building a co-curricular engagement mobile beacon application. With time, the proposed framework can be operationalized and implemented into tangible applications with concrete processes.

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