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Location-based Services in Smart Education: An Example of Augmented Teaching and Learning Advancement System

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ABSTRACT: *Location-based services in the Smart City development have been used frequently by citizens which open up a new dimension to people's lives (Kohne & Sieck, 2014; Komninos, 2018). Location-based services are used for routing, marketing, education, emergency, and e-commerce, and there is an increasing need and demand for the applications of Smart City (Adams et al., 2003). This paper looks into one of the wireless communication technologies in location-based services i.e., Bluetooth Low Energy/iBeacon, and a case study of the "Augmented Teaching and Learning Advancement System (ATLAS)" developed by the Hong Kong Polytechnic University for teaching and learning purposes; and then demonstrates a case of using location-based services for navigation aid to visually impaired students in the Smart Campus development and future applications in relation to the developments of Smart City.*

KEYWORDS: ATLAS, ibeacon, location-based services, smart city

INTRODUCTION

Location-based services have been used for routing, marketing, education, emergency, and e-commerce, and there is an increasing need and demand in many of the Smart City applications (Adams et al., 2003). Location-based services application has been initiated since the late 1990s (Adams et al., 2003). Location-based services applications come from three distinctive components including portable web, worldwide positioning, and realistic interface. Location-based services, when integrated with data analytics and inhabitant living, it has the potential to tap into the digital twins and enhance the quality of life for citizens. Integrating Location-based Services and Smart City activities leads to superior advancement of knowledge as well as empowers specialists to identify the applications at the right time and right place. There are numerous worldwide location-based services cases demonstrating unprecedented success by upgrading living standards for citizens.

The application of geolocation technologies improves different aspects of Smart City services such as traffic and transportation management, energy optimization, city marketing, real estate development, crime prevention, and event management

(Komninos, 2018). A comprehensive overview of location-based services applications has been published by Raper et al. (2007): they discovered that the most popular location-based services applications were mobile guides and navigation systems (e.g., auto navigation systems and pedestrian navigation systems) (Raper et al., 2007). Mobile guides are defined as "portable, location-aware, and information-rich digital guides to the user's immediate surroundings" (Raper et al., 2007). Another rapidly developing set of location-based services applications focuses on healthcare, including outdoor exercise and fitness monitoring (e.g., Running app, Moves, and Run keeper), remote healthy monitoring to assist dementia patients and caregivers in roaming events (Pulido Herrera, 2016), and emergency identification and reporting (e.g., fall detection) (Horta et al., 2015). Advanced parking management and emergency healthcare service are other examples to enable the use of smart location capability while the applications of these smart technologies can go far beyond traditional location-based services in the Smart City.

With urbanization and population growth, iBeacons can help emergency support services to better locate people in need (Jarosław Kozłowski, 2017). The tourism sector is benefited from the use of iBeacon, to provide relevant information on the popular attraction scenic spots, where tourists can easily navigate around the town to which they could travel. With the advancement of the push functions, the nearby merchandises have also benefited from this technology as they can have their promotions and services pop up on the device of a tourist or potential customer in their proximity. The benefits of iBeacon technology are fundamental in the development of Smart Cities and provide the convenience of people's day-to-day life (Jarosław Kozłowski, 2017).

BLUETOOTH LOW ENERGY TECHNOLOGY

Bluetooth Low Energy originated from Nokia's Wibree technology in 2006 with Bluetooth 4.0 technical specification released in 2010 (Melamed, 2018). The protocol stack is different from traditional Bluetooth, and the corresponding devices are not backward compatible (Melamed, 2018).

Therefore, three types of equipment have been developed:

1. Bluetooth device (Bluetooth Basic Rate/Enhanced Data Rate): a device that only supports traditional Bluetooth. Such as some old-fashioned equipment, i.e., peripherals, car systems, old mobile phones, etc (Jean-Luc Aufranc, 2016).
2. Bluetooth Smart Ready device (Bluetooth 4.0 dual-mode): a device that supports both traditional Bluetooth and Low Energy modes. (iOS, Android system, etc.) smart phones, notebooks, tablet computers, etc (Melamed, 2018).
3. Bluetooth Smart device (Bluetooth Low Energy single-mode): a device only supports Low Energy mode, so it can run for a long time with one battery cell (Jean-Luc Aufranc, 2016).

ibeacon Technology

Primarily, engineers and surveyors have been utilizing iBeacon sensors to provide precise locational data for iOS applications in relation to positioning. iBeacon base stations for indoor positioning and routing are specially designed and linking up between individuals, merchandises, and products (Kohne & Sieck, 2014; Liu et al., 2020). When your handheld device is close to an iBeacon base station, the device can sense iBeacon signals, ranging from a few millimeters to 50 meters (Griffiths et al., 2019; Newman, 2014).

At present, the application based on location-aware service mainly uses Global Positioning System technology to obtain the location information, and the map navigation based on Global Positioning System technology is usually adopted in the location-based services (location commonly known as positioning been utilized in the modern world of Smart Cities, social amenities sites art exhibitions mapping and location functions with practical functions in Smart Cities) (Adams et al., 2003). Given Global Positioning System technology has a rather low positioning accuracy and low signal strength for indoor navigation, this has allowed exploring other technology (Ng, 2015; Obeidat et al., 2021). The most prominent feature of iBeacon technology is the reasonable coverage and low power features to enhance real-time data transmission, which benefits the development of indoor location-based service (Liu et al., 2020). Full adoption of iBeacon technology can expand to a more diverse physical space and applications (Liu et al., 2020).

The Use of ibeacon for the Smart Campus

The iBeacon has made a significant behavioral change to disseminate information within a specific time and place. For example in Smart Campus development: when a student enters the classroom with a mobile phone that turns on Bluetooth, the mobile phone can detect the iBeacons deployed in the classroom in which the student’s positional information can be detected and further fetch the information on the designated mobile applications. When students leave the classroom, students’ departure time can also be recorded.

Information push is one of the most common application functions based on iBeacon technology (Ng, 2015). By deploying iBeacon equipment in a certain area, the mobile application installed will generate a push related notification when a mobile device is detected in the vicinity. Using this function, it is possible to send information to both teachers and students who enter the area when deploying iBeacon equipment on the campus. This service can be applied to school campuses, libraries, museums, other participating venues, campus exhibitions, and other related scenes. The mobile phone application receives the signal sent by the iBeacon base station, which communicates with the background server via the wireless transmission network. The background server mainly includes an identity authentication server and an application server providing mobile services for teachers and students, a data server storing relevant data, interface servers that interact with other campus applications and backup servers.

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A Case Study of ibeacon Technology--The Hong Kong Polytechnic University
ATLAS is a mobile application that supports an array of features to promote on-campus convenience. Through the smart features embedded into the online platform, ATLAS has provided a range of teaching and learning services including recording attendance, facilitating in-class interaction, encouraging innovative learning and adaptive learning, and understanding students' performance (ATLAS, 2019). It is fundamental to develop a Smart Campus using iBeacon technology to enhance teaching and learning (Griffiths et al., 2019).

The iBeacon brings new opportunities and new service modes for constructing a Smart Campus (Jarosław Kozłowski, 2017; Raper et al., 2007). Through redesigning the existing learning space, students simply require to download the dedicated mobile application available for iOS and Android, and they could automatically get into the ATLAS teaching and learning platform (ATLAS Technology, 2019). Once students enter the classroom, their seating locations are identified and respective attendance is checked to show on the online platform automatically. The students can ask questions via the chat group function and send an individual message to the teacher or the whole class, in which the teacher can give their response using messages or make it in the group discussion during class. For the quizzes, students can conduct the test inside or outside the classroom and view the marked assignment and test results anywhere. Students can conduct some missions for outdoor activities to unlock the achievement on the campus orientation or outdoor wilderness learning.

Such use of ATLAS connects both in-class and out-of-class learning easier than before and provides increased opportunities to students in engaging more in educationally purposeful activities. The platform has incorporated Augmented Reality/Virtual Reality functions which increases the students' incentive to use the mobile application and conduct scenario-based learning with some interesting topics and practical exercises to complete. The enhanced functions include chat group functions and news notification which the students prevalently use. The positive outcome drives the pathway of changing the attitudes towards innovative teaching and learning enablers, and the iBeacon teaching system can be extended its huge influence across the disciplines of higher institutions and also across boundaries for engaging learning experiences over the world (Griffiths et al., 2019).

ATLAS can allow teachers to understand students' academic performance. Students can respond to the teachers' questions within a given timeframe when available on both app and web platforms. Based on various responses, the teacher can get a statistical result about the correctness of the answers through the instant feedback of visualized data. Students can also message their teacher or fill up the survey to express key points that may not fully understand and need further to be clarified. The platform also contributes considerably to the organization of classroom activities, the system can randomly group the students into specific groups if a teacher intends to assign group presentations or assignments, while the students will get a notification of the selection result. An alternate option is available for the students to group themselves and perform the assigned tasks in the ATLAS app and web platforms. The students can review and access the class-related materials on the platform which the lecturers upload. By equipping the "check-in" function based on iBeacon technology, the teachers are being notified of the real-time attendance status.

The general applications of iBeacon in the classroom are summarized as follows:
1. The knowledge content including various forms of content: text, video, links, etc., can be shared via iBeacon with the mobile application nearby;
2. The students can go through multiple e-contents simultaneously so that students can discover the novelty of various disciplines;
3. Expanding the learning boundaries with the deployment of iBeacon in any school or outside the campus, where the students can learn wherever they go with smart devices.

Aside from the benefits provided in the classroom, an additional feature has been added to the platform to assist visually impaired students by locating the campus facilities.
1. Active participation in various activities such as treasure hunt, to enable students to interact with each other.

The automated grouping can shuffle the team mix into different combinations of students rather than being in the same group for the whole semester to spark more learning opportunities.

More details of the ATLAS can be referred to:
ATLAS web: https://www.atlas-learn.com/#/home.
iOS: https://apps.apple.com/hk/app/atlas-for-student/id1450907363.
Android: https://play.google.com/store/apps/details?id=hk.edu.polyu.atlas.

Visually Impaired Students

Location-based services are also being utilized as assistive technology to help visually impaired persons, disabled, and elderly persons carry out their everyday activities independently (Hakobyan et al., 2013; Pulido Herrera, 2016); these assistive technologies provide assisted-living features such as personalized navigation and wayfinding, obstacle avoidance, and more (Hakobyan et al., 2013). A system developed by the Hong Kong Polytechnic University provides a smart navigation system for visually impaired students by the use of a voice function (Noorithaya et al., 2014): when the user opens the Voice Map on their device, the visually impaired students can give a command about their start point and destination (Noorithaya et al., 2014), the system receives route instructions that will generate voice output from the mobile application by calculating the iBeacons and start navigating (Noorithaya et al., 2014).

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DISCUSSION

In view of the emerging potential from the ALTAS, Big Data analytic is conducted by the research team based on classroom attendance, group formation, interpersonal interaction, classroom behavior, and any related issue arising from the study, so as to investigate the correlation between academic performance and learning effectiveness of the students.

User Acceptance of ATLAS

The learning performance of students has always been measured by the learning achievement from various academic subjects of the students' learning behavior in three-fold: (1) Usefulness, (2) Compatibility, and (3) Attitude to Technology, which directly associate with the learning performance. A survey was conducted by students who have joined the ATLAS subjects, while more than 80% of the student responses enjoyed the learning in class with the ATLAS, which helped their learning experience, while the positive feedback of using ATLAS implied that it is a fundamental move to guide the students towards better performance.

Table 1. Summary of user acceptance of ATLAS

Student Survey (After using ATLAS)	Positive Response (%)
Usefulness	
I find ATLAS useful for obtaining course materials.	100%
Using ATLAS functions such as "Activity" and "Test" enhances my physical participation.	83%
ATLAS functions are useful to my studying.	83%
ATLAS functions give me more control over my progress in the course.	83%
Compatibility	
Grade-checking functions on ATLAS help me to monitor my progress.	83%
Grade availability immediately after the test is beneficial to my understanding of learning materials.	83%
Attitude to Technology	
I believe that ATLAS can help me enhance my learning experience.	100%

Merits and Limitations of Using Location-based Services in Smart Cities

Location-based services in Smart Cities drastically improve the quality of life of citizens (Kohne & Sieck, 2014; Komninos, 2018), and brings vast advantages to both stakeholders, the government, and people. A perfect example is Dubuque in Iowa, the United States of America, which was designed to increase energy and water supplies and management efficiency (Draft, 2016). The advantage of location-based services in this instance is that the installed location-based services sensors can send the location of water or energy leakage to the relevant authorities, thereby helping the authorities better utilize the resources (Draft, 2016).

Despite the wide application of the iBeacon technology, the technology has some drawbacks to overcome. The location-based services have also proven not to be entirely accurate as many business people may assume that they can track all the consumer movements which is impossible. Due to privacy concerns, several service providers limit the amount of information that can be accessed about consumers for security concerns. That said, there are still improvements that need to be made in relation to the Internet of Things to improve accuracy and provide a relationship between online and offline.

Considering Bluetooth Low Energy technology has wide potential in the market, from the perspective of the Internet of Things, the future of location-based services in Smart Cities provides endless possibilities from e-governance, disaster management, and business profiling. As has been discussed in this paper with the case study of ATLAS, which provides a smart and intelligent campus with its powerful position sensing function, low power consumption, and easy deployment.

CONCLUSION

It is evident that location-based service functions in Smart City development are crucial. Based on the case study of ATLAS, we can conclude that location-based services enhance smart learning by providing a platform for interactive learning, promoting active participation, make room for teachers to better manage their classes through automated groupings. It can also be established that based on the existing technology, better inventions can be made along the lines of smart education to improve the quality of learning for visually impaired students (Hakobyan et al., 2013).

The development of location-based services aligns with the Smart City blueprint of Hong Kong which advocates for smart mobility, smart living, smart environment, smart economy, smart government, and smart people (Kohne & Sieck, 2014; Komninos, 2018). In terms of smart living, the applications mentioned above fall perfectly within the context as they provide support to people with the need to enhance their living standards and qualities. In terms of smart people, ATLAS contributes significantly to the government’s objective to promote STEM education and IT-related programs as it is a campus and education based app. However, to fully align with the goal it will need to be promoted in other institutions, i.e., primary and secondary schools as well. In terms of smart government, utilization of the 5G technology will go a long way in enhancing government security programs related to cyber, Artificial Intelligence, and city management among others. As far as the cases studied for this paper go, there are still a few limitations in that regard for the public sector to utilize.

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The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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