Empirical Study of Routine Structure in University Campus

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Abstract. This paper presents the use of wireless usage data as a research tool for analyzing the routine structure of people. The patterns of wireless usage can infer the routine of student life in campus. In our experiments, we discover the student routine structure from the volume and time of the wireless usage. Without following an individual trace for any particular person, we use the volume and time of the whole accesses for particular time and location in a university campus. The analysis is based on the large wireless LANs, one-year log data of the city campus of Bangkok University (August 2011 - July 2012), and the experiment is focused on the wireless access points provided in important places of student activity such as canteens, classrooms, libraries. The resulting outputs are the location preference vectors and a new calendar based on student routine structure. The results can support the computational and comparative analysis of space through the lens of service management and enhance user-driven facilitates of the university campus.

Keywords: Eigen-decomposition, Eigenplaces, Eigenbehaviors, Eigenvectors, Principal component analysis (PCA), Behavior research, Wireless networks, Segmentation, Classification.

1 Introduction

On university campuses, the need of wireless usage has been increasing with the number of use of mobile technology in higher education. This is due to the rapid adoption of cell phonesparticularly Blackberries, iPhones, and dual-mode phones. Students use PDAs not only to make calls, but also to perform a variety of tasks such as viewing class material, checking bus schedules, finding locations, monitoring laundry machines, and updating their Facebook status. As a results, they prefer to keep their mobile online whenever they are in wireless access area.

The merit of the investigation on wireless networks usage is for supporting campus communications, and providing reliable and competitively priced voice, data and video services. Surprisingly, student lifestyles, i.e. attending classrooms, self-studying, meals, outdoor activities, can be influenced with these

A.A. Ozok and P. Zaphiris (Eds.): OCSC/HCII 2013, LNCS 8029, pp. 201–209, 2013.

facilitates [1–6]. Contrasting to the unidirectional radio and television infrastructure, the bidirectional wireless data networks can act as probes, propagating data about their users environment back to a network observer. Assuming that the volume, timing, and distribution of packets across networks is able to let us study the student lifestyle in campus.

Unlike most campus Wi-Fi deployment studies have focused on network performance and management or inferred user mobility. For these few years ago, there were some interesting works such as Jong Hee Kang and his colleagues [7] incorporating the concept of place allows a more sophisticated analysis and understanding of wireless environments. Calabrese et al. [1] introduced a method to analyze and categorize wireless access points (APs) based on common usage characteristics that reflect real-world, place-based behaviors. Lastly, Eagle and Pentland [8] exploited the mobile usages for understanding the people mobility. In this paper, we will study the student routine structure from the volume and time of the wireless usage. Without following an individual trace for any particular person, we use the volume and time of the whole accesses for particular time and location.

This paper is organized as followings. Section 2 reviews the use of wireless technology in daily life as well as the description of an essentially increasing number of the Internet usage in university. Section 3 summarizes with a common framework for applying eigen-decomposition to analyze the campus life. Section 4 gives a case study in Bangkok University, Thailand, and shows the experiments and their results. Section 5 reports and discusses on the obtained results. Section 6 will conclude the paper.

2 Student Daily Life with Wireless Network

2.1 Wireless Network Technology

Wireless technologies can be categorized according to their coverage areas. Wireless Local Area Networks (WLANs) are designed to provide wireless access in areas with cell radius up to hundred meters and are used mostly in home and office environments. Wireless Metropolitan Area Networks (WMANs) cover wider areas, generally as large as entire cities.Wireless Wide Area Networks (WWANs) are designed for areas larger than a single city. Different network standards are designed for each of these categories. However, some of these standards fit into several of these categories.

As of today, WLAN is the most widely deployed wireless technology. The most notable WLAN standard is IEEE 802.11 family. Another WLAN standard is the HiperLAN family by ETSI. These two technologies are united under the Wireless Fidelity (WiFi) alliance. Both technologies serve a local area with a radius of 50100 m at most. A typical WLAN network consists of an Access Point (AP) in the center and Stations (STAs) connected to this AP. Communication to/from a STA is always carried over the AP. There is also a decentralized working mode of WLAN, in which all STAs can talk to each other directly in an ad-hoc fashion. While WiFi initially provided an aggregate throughput of 11 Mbps (per AP), the current standard provides a throughput of 54Mbps. Also, in the market there are WiFi devices that support data rates up to 108 Mbps using various additional techniques. With the emerging IEEE 802.11n standard, WiFi is expected to standardize these improvements and provide throughput values up to 540 Mbps.

2.2 Internet and Its Uses in Daily Life

Being reachable anywhere and at any time has obvious advantages, such as improved coordination and the elimination of wasted time when waiting for input from individuals who may be traveling, visiting, or wandering. Some people strongly agreed that mobility mean efficiency.. This is because, given that wireless phones are carried around by users, they may be able to fill time, implying the users can call someone, check email, or send text messages in time slots between other scheduled activities, while wandering from one point to another on campus or while traveling from home to work. Sometimes, the filling of time is equivalent to the killing of time when the individuals use the mobile devices merely to keep themselves engaged or entertained in a free time slot (or in a time slot that should have been put to more productive use); otherwise, mobile devices can enable shifting of time, for example, by checking email and reading/sending short messages during time slots between scheduled activities.

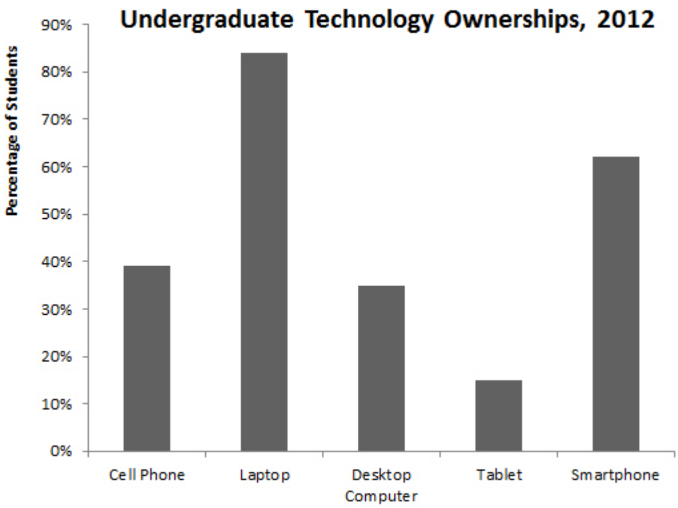

Fig. 1. Students show a need of technology use with the number of their own communication devices (Retrieved from [9])

Use for Studying. Mobile technology is also increasing the productivity of faculty members because they no longer need to go to their offices to set up meetings on their calendars, make phone calls, or use email to respond to student questions. Many professors use mobile devices to notify students of class updates, conduct quick quizzes or polls, and submit data while doing classroom field work. As shown in the statistic chart of technology ownership (Fig. 1), a full 86 percent of students own laptops and 62 percent own smart-phones; tablets and e-readers are not far behind. These devices can do so much more than serve as a word processor or a research tool.

The study found that 70 percent of students learn best in a blended environment consisting of face-to-face learning and an online supplement. The solutions such as WebEx and TelePresence are efficient e-learning tools that help improve productivity, decrease costs, and lower carbon emissions. University staff use TelePresence to hold administration and cabinet meetings, present dissertations, conduct campus interviews and recruit students, meet with professors outside the office, and provide distance learning.

For example, our campus also used the WebEx as an alternative way for a classroom. The WebEx is making inroads "inside" the classroom, simulating visual communications between students and teachers in the traditional classroom setting. For example, professors use the WebEx "attention indicator" feature to monitor whether students are giving the class their full attention. Professors can also require students participating in the WebEx session to turn on "desktop sharing" to ensure that the students are actively engaged in the class.

2.3 Wireless Access Data as a Research Tool

The knowledge of the student lifestyle can let the universities know their needs to improve and increase the facilities in campus. The universities, then, have a guideline for a new project such as a new location of cafeteria is required to serve the need. Sometimes, a change of cafeteria hours should be extended or not. Those are some possible arguments the university will be questioned after investigating the routine structure of their students. Not only students' routine but also the routine of faculty staff will be investigated. For faculty staff, this can be determined by the location of the wireless access points. To understand the people behaviors in campus, the wireless usage data will be exploited to explain the routine structure.

3 Framework of Applying Eigen-Decomposition

The technique of using decomposition was applied to the segmentation of campus universities. For example, the authors in [1, 5] applied it to the data of Wi-Fi network at the Massachusetts Institute of Technology (MIT) because correlating data is as a consequence of network activity with the physical environment. Their approach provides an instant survey of building use across the entire campus at a surprisingly fine-grained level. Their methodology can discover the important information about activity distribution across campus without recourse to any reference data. For example the particular area can be defined with their functions such as exclusively academic, incorporating classroom and administrative functions.

In conclusion for the campus universities, the resulting eigenvectors (namely eigenplaces) have implications for research across a range of wireless technologies as well as potential applications in network planning, traffic and tourism management, and even marketing.

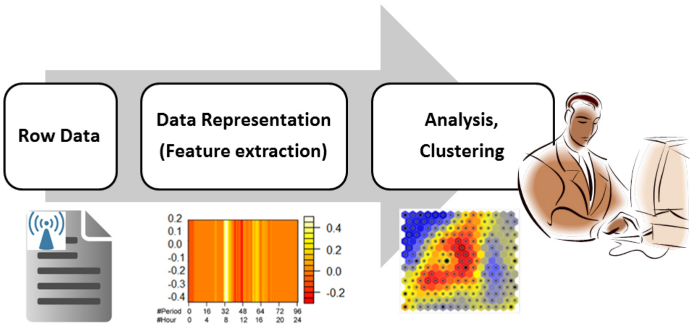

Fig. 2. Framework for applying eigendecomposition

From the aforementioned applications, their methodologies can be illustrated as shown in Fig. 2. We called it as "Framework of applying eigen-decomposition" before the employment. This framework shows three main steps:

1. Input data are scrupulously chosen to be an answer for the formulated questions. From the aforementioned applications, the input data are traces: ex., traces of avatars in MMORGs, traces of visitors in exhibitions, art galleries, and museums [10–12]. For acquisition of people movement, Wi-Fi access log files are one of most suitable sources because Wi-Fi access log recorded must be required under a computer crime law.
2. Intermediate data are the feeding input before analysis, i.e., data representation. The data representation is depended on the purpose of analysis. We will give two examples. First, for grouping APs based on the usage, we will use a matrix of Wi-Fi usage time for representing a particular AP. Second, for grouping people based on visited locations, we will track the people location and create a matrix of visiting time. This matrix is a representative of an individual routine.
3. Analysis and clustering are the final step before the employment. After preparing the intermediate data, we have a set of matrices each of which is a representative. Then, we start with transforming them to the zero-mean data, and computing their covariance matrix. After that, the eigen-decomposition is proceeded to the covariance matrix. For analysis, we interpret the characteristics of either places or people from the resulting eigenvectors. Also the classification is further applied to a set of the eigenvectors. The classification can be either supervising or unsupervised training techniques. For example, an unsupervised k-means clustering can be chosen.

4 Experiments

In this experiment, we firstly match the WiFi usage with the student activities in campus university. Then, we design three experiments based on the distinct functionality of places: canteen, library, and classrooms, and the summarization of WiFi usage is categorized into the activity places and the school calendar as shown in Fig. 3. In this experiments, we conduct the analysis on Bangkok University located in Bangkok Thailand and the map of university . The WiFi access data at areas of canteen, library and classroom were used for analysis. Because of the severe flooding disaster in Bangkok, the flooding period was not included from our analysis. Then, the duration of our analysis is for only the second semester (Jan. 4 - May 13, 2012). We also defined the number of time slots is 96 because the WiFi system generates the access log for every 15 minute.

Table 1. Academic Calendar

Semester	Academic Activity	Calendar Date
1/2011	Study	Jun 13, 2011 - Jul 31, 2011
	Midterm exam	Aug 1, 2011 - Aug 8, 2011
	Study	Aug 9, 2011 - Oct 4, 2011
	Final exam	Sep 27, 2011 - Oct 4, 2011
	School break	Oct 5, 2011 - Jan 3, 2011
2/2011	Study	Jan 4, 2012 - Mar 8, 2012 Jan 4, 2012 - Apr 17, 2012
	Final Exam	Mar 8, 2012 - Mar 15, 2012 Apr 18, 2012 - Apr 25, 2012
	School break	Apr 26, 2012 - May 13, 2012
3/2011	Study	May 14, 2012 - Jul 1, 2012
	Final exam	Jun 2, 2012 - Jul 4, 2012
	School break	Jun 5, 2012 - Aug 13, 2012

From the visualization, there are 4×3 eigenvectos for representing the routine structure of students at canteen, library, and classroom. The one-day routine is considered because it is a repeating structure. On weekdays, students at city campus will have the study time table between 9:00-16:30 for undergraduate programs but 18:00-21:00 for graduate programs (as shown in Table 1).

5 Results and Discussions

Following the proposed methodology in Section 3, the resulting eigenvectos of AP access data are shown in Fig. 4. The first eigenvectors are the most influenced routine. The second, third, and so on are in decreasing order. The tone-shading is the quantitative indicator. The brightest tone indicates the highest amount of people at particular place.

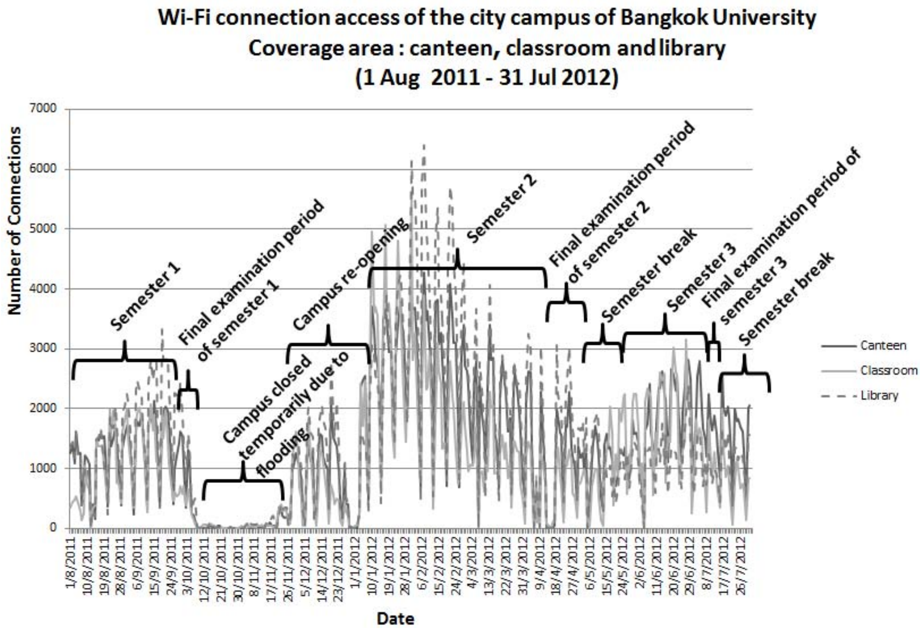

Fig. 3. Visualization of extracted routine structure at canteen, library, and classrooms

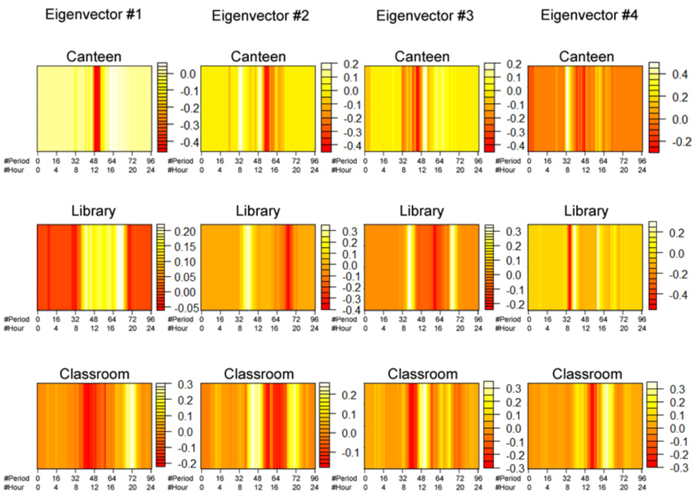

Fig. 4. Visualization of extracted routine structure at canteen, library, and classrooms

1. First primary routine structure at the following places:.
2. Canteen: Interestingly, students decided not to have a small talk or leisure time during lunch by 12:00-13:00. It is because the canteen was much very crowded.
3. Library: Basically, the library is full of students during 16:30-17:00 but very most crowded during 16:30-18:30. The reason is a transition period between undergraduate and graduate students.
4. Classroom: The WiFi usage at classrooms is mostly from graduate students because most of them use the tablets, notebooks for searching, typing their short note, etc. Comparing with the morning classes, the afternoon classes got busier than the morning.

6 Conclusions and Future Works

In the information age, the enormous data is around us. People can access through the Internet everywhere and every time, as well as connect through their family, friends, colleagues, and others. With the Moore's law, notebooks, net- books, and tablets are affordable for every people. The WiFi service area is extensively provided to serve the increasing demand and easily found in the public places. The WiFi log files of APs can infer to the number of people connected to APs at particular date and time.

This paper considered the patterns of wireless usage that can infer the routine of student life and developed a systematic approach for discovering the patterns. We also gave a case study of Bangkok university, Thailand. In this study, we found very interestingly patterns such as the canteen has least WiFi usage at noon. Library is the most crowded during 16:30-18:30 because the undergraduate students finished their class and also the graduate students are coming before their class at 18:00. For classrooms, the afternoon classes might be much busier than the morning, and the most busiest period is in the evening classes.

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