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DEVELOPMENT OF SMART POSITIONING ATTENDANCE MANAGEMENT IN ERP SYSTEMS USING BLE BEACON

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Abstract

Conventional employee attendance model primarily involves employees manually completing the timesheet or using time stamping machines. Such model requires employees to queue to clock in, which delays their clock- in times, and occasionally, it is also associated with the loophole of employees asking their colleagues to clock-in for them. These deficiencies render employee salary calculations time- consuming and labor intensive. In addition, by using such conventional model, corporate administrators cannot accurately and immediately control and manage employee attendance, which lowers the efficiency in interdepartmental communication and management.

The prevalence of mobile devices and cloud computing technologies have increased the application of cloud- based software and hardware in various industries. In addition to traditional time stamping machines, current attendance systems mostly involve using passive approaches such as the use of radio frequency identification technology, barcode swipe cards, and proximity access control. However, these technologies are associated with high setup cost, and they cannot be comprehensively used easily. This study developed a Beacon attendance system (BAS), which

is a Bluetooth low energy (BLE)- based smart employee management system. Through integrating mobile apps and BLE using Beacon technology, the BAS enables attendance data of community service personnel to be quickly stored on cloud systems, and users can clock- in/out whenever they start work, get off work, or work overtime simply by using their mobile app. This study expects that the developed BAS can assist corporate administrators and community monitoring management units in managing the attendance of their employees and enhancing the personnel dispatch efficiency. Furthermore, by accessing data on cloud systems, BAS users can automatically calculate employees' salary based on their attendance, thereby reducing the time and costs required for performing the calculations manually.

Keywords: Property Management, Indoor Positioning, Attendance Management, Bluetooth Low Energy, Cloud Data

Introduction

In a globally competitive environment, businesses of varying sizes can achieve sustainability only by adequately using information technology (IT) to strengthen the integration of business operating procedures and effectively utilize their resources. Enterprise resource planning (ERP) is a real- time information integration system that plays a crucial role in the integration of IT techniques on a process- oriented platform. With the increasing internationalization trend, most enterprises introduce ERP systems to resolve common problems in corporate operating procedures such as wastage of human resources, sending information repeatedly, or delayed information transmission. Thus, their operating efficiency can be improved, thereby reducing operating costs (Lin, 2014). However, introducing ERP systems affects not only the decision making regarding the use and integration of corporate resources, but also the recreation and organizational transformation of business procedures, as well as the reallocation of internal authority powers. Because the aforementioned factors determine whether business goals and expectations conform to the mission and vision of the business, these factors must be carefully evaluated when introducing ERP systems (Hsu, 2005).

Currently, personal attendance is typically managed by using time

stamping machines, barcode swipe cards, and proximity access control. However, these approaches are flawed. For example, the time stamping machine is commonly associated with the loophole of employees asking their colleagues to clock in for them (i.e., unauthorized clock in/out), which impedes determining who actually attended work and thereby negatively affects performance appraisals. Although the barcode swipe card approach can resolve the mentioned loophole, it easily causes clock- in/out delays because employees have to queue to clock in and clock out. Moreover, the barcode card is associated with unavoidable problems such as limited durability and counterfeit cards.

Regarding the proximity access control, users often have to hold their proximity card 10 cm apart from the card reader for door access. This type of access control system mostly uses high- frequency field coupling system (13.56 MHz), with a sensing distance limited to approximately 10 cm. Card holders must stand closer to the card reader in order to achieve better sensing effect; however, this requirement renders the proximity access control inconvenient for individuals with impaired mobility. Moreover, this type of control system simply involves controlling the opening and closing of access doors, and lacks a function that automatically links the backend system information with the access control information. This deficiency makes the proximity access control ineffective for personnel attendance management.

The Beacon Attendance System (BAS) developed in this study is a smart personnel management system designed on the basis of the Bluetooth low energy (BLE) technology. This system was integrated with mobile devices (smartphones and tablet computers) and Beacon positioning technique, thereby actualizing the storage of community service personnel attendance data onto cloud systems. Beacon is a type of physical Bluetooth transmission device integrated with BLE technology; A Beacon device has a high penetration rate and is small, energy- efficient, inexpensive, and durable. In this study, a Beacon device was installed at fixed location; this location served as the base station for simultaneously transmitting messages to Bluetooth devices (mobile device) located within a fixed distance. With the developed BAS, users can clock- in/out whenever they start work, get off work, or work overtime simply by

using their mobile app.

This study expects that the developed BAS can assist corporate administrators and community monitoring management units in managing the attendance of their employees and other personnel and enhancing the personnel dispatch efficiency. Furthermore, by accessing data on cloud systems, BAS users can automatically calculate employees' salary based on their attendance status, thereby reducing the time and costs required for performing the calculations manually.

Related Works

Enterprise Resource Planning

Since the twentieth century, numerous companies across the globe have begun formulating strategies for information technology (IT) development and replacing their self-developed systems with commercially available application software such as the ERP system (Hong and Kim, 2002). IT industries often face challenges in reducing costs, increasing implementation efficiency, and maintaining system quality when customizing system designs. Nevertheless, the use of ERP is a solution to the aforementioned problem (Lucas et al., 1988). Directly purchasing application software suite is conducive to meeting customized system design needs without having to develop tailored software (Gross and Ginzberg, 1984). However, software suite remains associated with limitations and problems such as the uncertainty about its applicability after purchase and the hidden cost involved in implementing it (Lynch, 1984).

One of the features in introducing ERP systems is the need to adjust organizational procedures and operating methods when the system goes online. Therefore, stakeholders must participate in the entire project life cycle to assist in system adaptation (Yeh, 2011). Studies have explored the importance of introducing ERP systems into corporate settings. However, few studies have focused on the corporate organizational environment after ERP systems have been successfully introduced (Ifinedo et al., 2010). Therefore, ERP systems are crucial information assets for an enterprise, and IT management in an ERP system environment must be emphasized. Appropriate IT management can help enterprises save maintenance costs and increase their management quality, thereby improving the efficacy of

information systems and raising the enterprises' competitive advantage (Huang, 2015).

Based on the aforementioned discussions, although enterprises must overcome design problems when customizing and developing their own systems, they can avoid problems pertaining to the inapplicability of software suite and hidden costs. Nevertheless, in the current environment where the Internet, information, and communication technologies are rapidly developing, ERP must be applied to facilitate corporate sustainable development. The BAS developed and designed in this study is aimed at managing personnel attendance and integrating with an ERP system to promote interdepartmental flow of business information, thereby increasing the quality of interdepartmental communication and implementation efficiency.

Personnel Attendance Management

Property management units play a crucial role in the operational maintenance phase of a building life cycle. Such unit is in charge of maintaining and managing not only building facilities but also the apartment buildings itself (Chung et al., 2015). Because of the industrial characteristics of property management, a wide range of service personnel (e.g., security guards, cleaners, electrical engineers, and secretaries) must be dispatched to execute tasks at the target apartment building or community. Currently, the attendance of various service personnel is managed by using timesheets or time stamping machine. Therefore, their attendance status cannot be effectively managed, and occasionally, inspectors must be dispatched regularly or irregularly to conduct onsite inspections (Lin, 2010). These attendance management methods are not only ineffective in monitoring the personnel status at various business locations, but also pose problems when calculating employees' salaries. Seo et al. (2015) adopted WiFi fingerprinting and smartphones to develop a personnel attendance system that helps reduce cost and increase personnel management efficiency. Lee et al. (2014) applied near field communication (NFC) technology to personnel attendance management to obtain information on personnel location. Huang (2011) integrated RFID with cloud technology to determine in real- time the region where employees are located, thereby facilitating the management of personnel attendance.

In personnel attendance management, the most common methods used to manage personnel attendance conditions include time stamping machine and barcode swipe card, as well as proximity access control and RFID approaches. However, these management methods are associated with several problems, such as unauthorized clock in/out, having to queue to clock in/out (which leads to crowding), high installation cost, and lack of accuracy and immediacy in personnel management. Moreover, such methods do not automatically facilitate calculating personnel salary based on their attendance, necessitating additional manpower in processing employee attendance records and calculating the labor cost. Through introducing the BAS developed in this study, we expect to assist corporate administrators and community service monitoring management units in instantly monitoring the personnel attendance status, to enhance personnel dispatch efficiency, minimize the use of labor resources, and prevent time wastage.

Application and Development of Bluetooth Low Energy

BLE technology is a novel wireless transmission technique proposed by the Special Interest Group (SIG) for short- distance communication. This technology is regulated under the new Bluetooth 4.0 specification and differs from that of previous Bluetooth devices because BLE is a low- power applied design that consumes low amount of electricity (Gomez et al., 2012). BLE devices are small, inexpensive, prevalent, and durable, rendering them an alternative application in future Internet of Things (IoT) development (Faragher and Harle, 2015). Collotta and Pau (2015) integrated wireless network and BLE technology, proposing a novel smart home energy management method. By realizing communication among home appliances, they developed a Home Energy Management (HEM) program with the goal of reducing electricity load demand and power consumption during peak hours. Lin et al. (2005) applied BLE to develop an Intra- Vehicular Wireless Sensor Network (IVWSN), resolving the past routing problems inherent in IVWSN environment. Such development assisted manufacturers in developing vehicles with more economical and better performances.

Saltzstein (2013) employed BLE as the basis for medical applications, developing a new blood glucose monitoring and insulin de-

livery device. Jara et al. (2013) applied the concept of IoT to a Bluetooth device equipped with built- in memory and backup power supply, and developed a telemobile monitoring system for home care. Galinina et al. (2015) developed a smart home access control system, which is based on the BLE technology and the IoT concept; the system can be used to complete multiple home tasks in daily living.

The aforementioned literature review indicates that BLE has been widely applied in many fields and that common personal attendance management practice involves the use of barcode systems, RFID, NFC, barcode swipe card, and proximity access control systems. However, no cases relevant to the research direction of this study have been identified. The present study adopted BLE as the base station for personnel attendance management and enhanced broadcasting functions to allow multiple users to simultaneously record and report their attendance status, which is then transmitted to the server for data storage. Furthermore, corporate administrators and monitoring units can enquire and statistically analyze this information at any time by using their mobile devices or desktop computers. Therefore, this study contributes to industrial development by proposing a research orientation that is both innovative and distinct from those of previous studies.

Methodology

System Development Architecture

The development of the BAS involved two phases: establishing the Beacon system and developing the attendance system. In the standard Bluetooth 4.0 specification, two formats are included, naming basic rate (BR) and BLE. The BLE device transfers small packets using minimal amount of power; therefore, the BLE device consumes less power than do BR devices. Generally, smartphone or notebooks that support BR (voice receiver transmission) and BLE are referred to as dual-mode devices, whereas devices supporting only BLE or BR are categorized as single- mode devices, which are often used in system applications that require low power consumption. In the present study, the Bluetooth 4.0 BLE single- mode device was used to develop the Beacon system (Figures 1 and 2). The BLE module was the CC2540/CC2541 product developed by Texas Instrument and comprised the most cost- effective

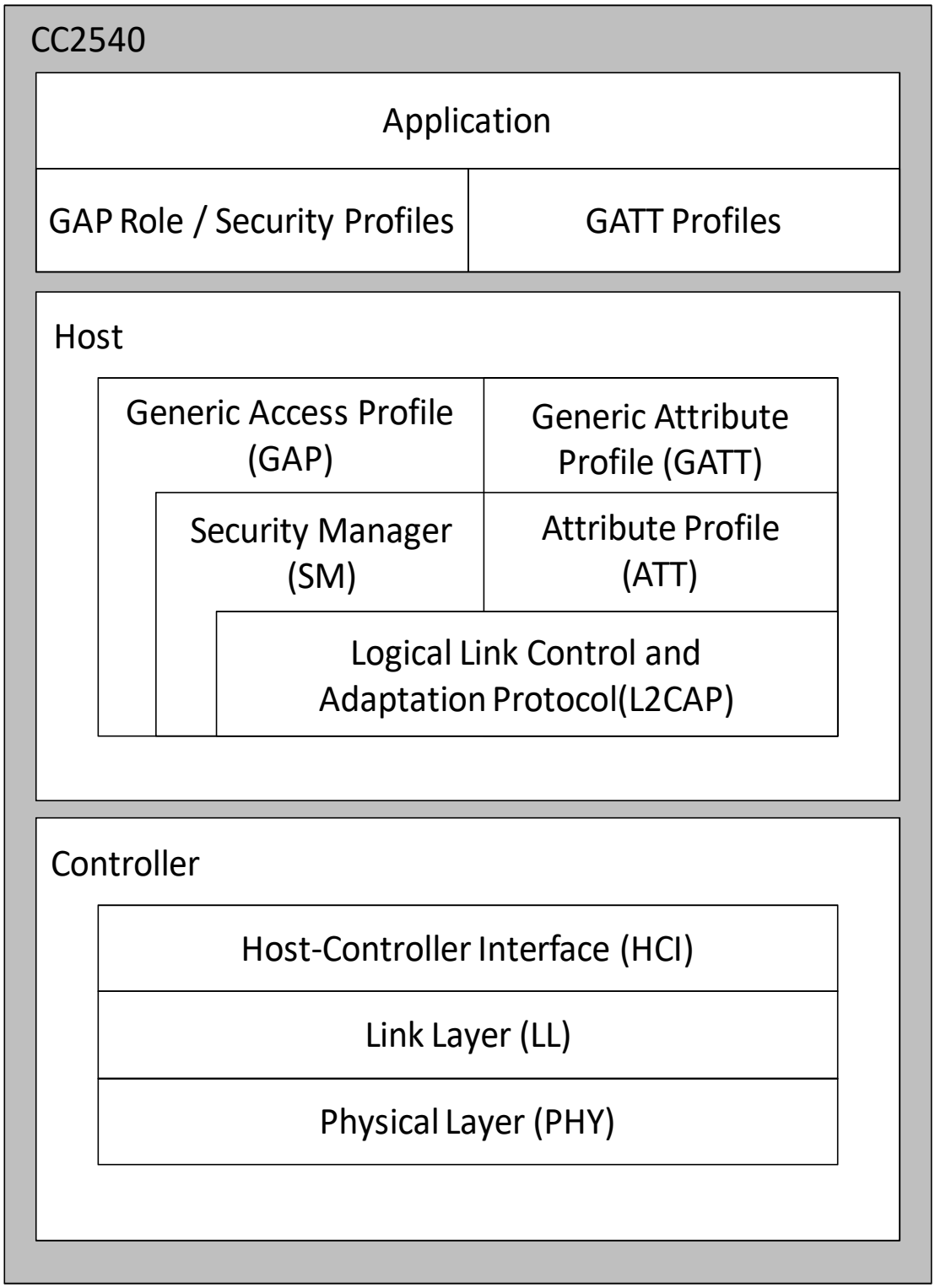

Figure 1. Single-Device Configuration

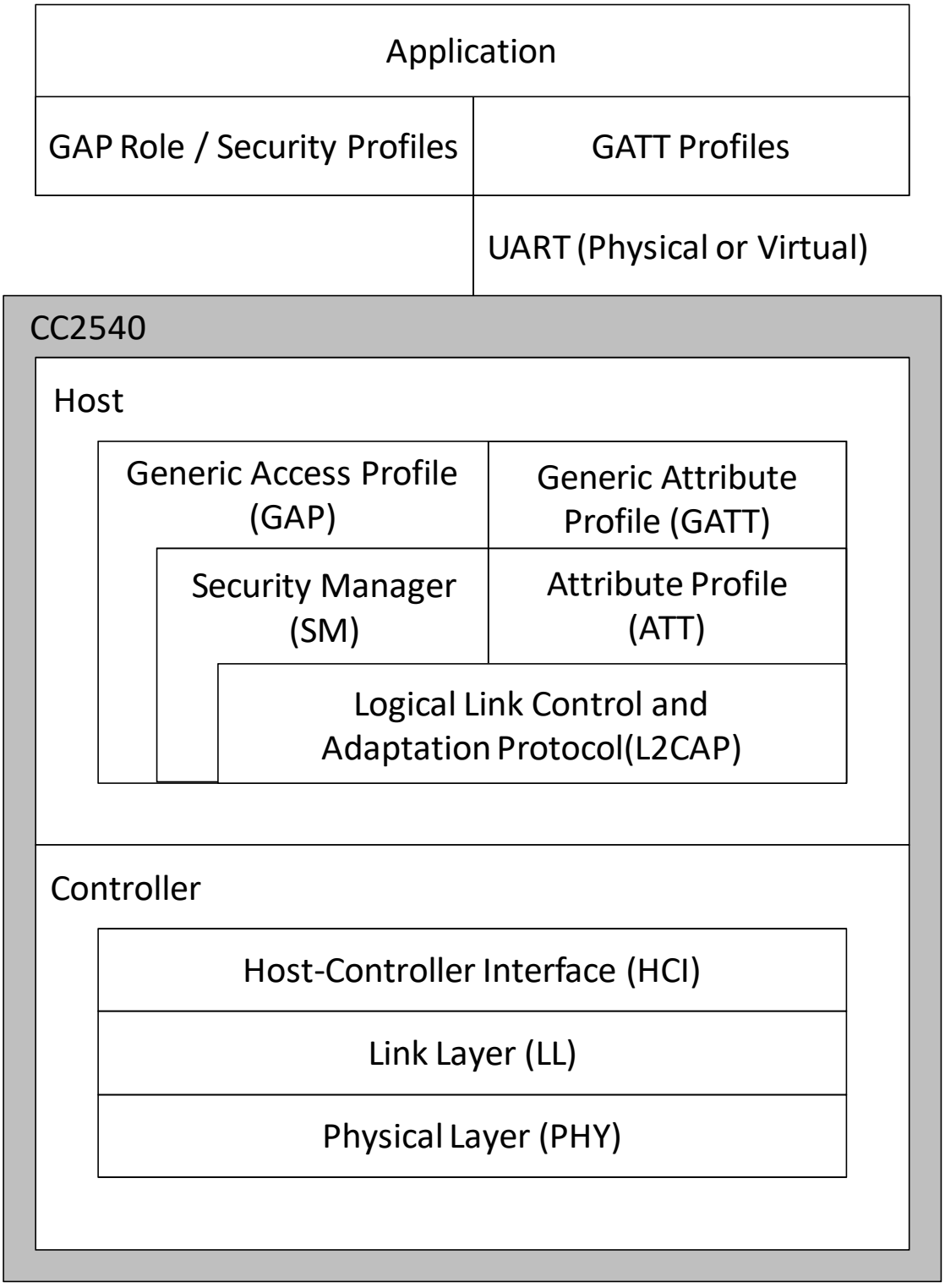

Figure 2: Network Processor Configuration

configuration in terms of controller, host, profiles, and application.

Regarding the application of the system hardware architecture, the Beacon device deviated from the previous Bluetooth one- on- one pairing concept. Instead, the Beacon base station can continuously transmit signals within a 15 m radius by using broadcast- like functions. Moreover, accessories integrated with Bluetooth devices can simultaneously receive these Beacon signals within this range. In terms of the Beacon hardware setting, this study adopted the Universally Unique Identifier (UUID) installed in the Beacon device to configure the attendance attributes of the base station, including company code (4 byte), community code (2 byte), date (4 byte; yy/mm/dd), building code (2 byte), floor code (2 byte), and equipment serial number (2 byte). Thus, users can record their attendance status through using the UUID.

The 1080*1776 Android platform was used as the software architecture for developing the Beacon system program and the attendance management system based on the cloud service concept. Through data processing by the server, mutual communication between the message at the mobile phone end and the Beacon is achieved (Figures 3 and 4). In the process of developing an APP system for the Beacon base station, first- time users must first set their mobile number and cloud master server IP, to enable the database to compare the user information with their mobile phone number. Once the number is confirmed, the system writes the IMEI code to complete the registration procedure and store the code in the mobile phone. Attendance status records are divided into online and offline environments. In an online environment, the mobile phone downloads the community's site information, and users can directly upload their attendance information. In an offline environment, users can record their attendance by using Bluetooth to communicate with the Beacon station; this information will first be stored in the mobile phone, and then when in an online environment, the system will automatically transfer the recorded information to the cloud database for data synchronization (Figure 5).

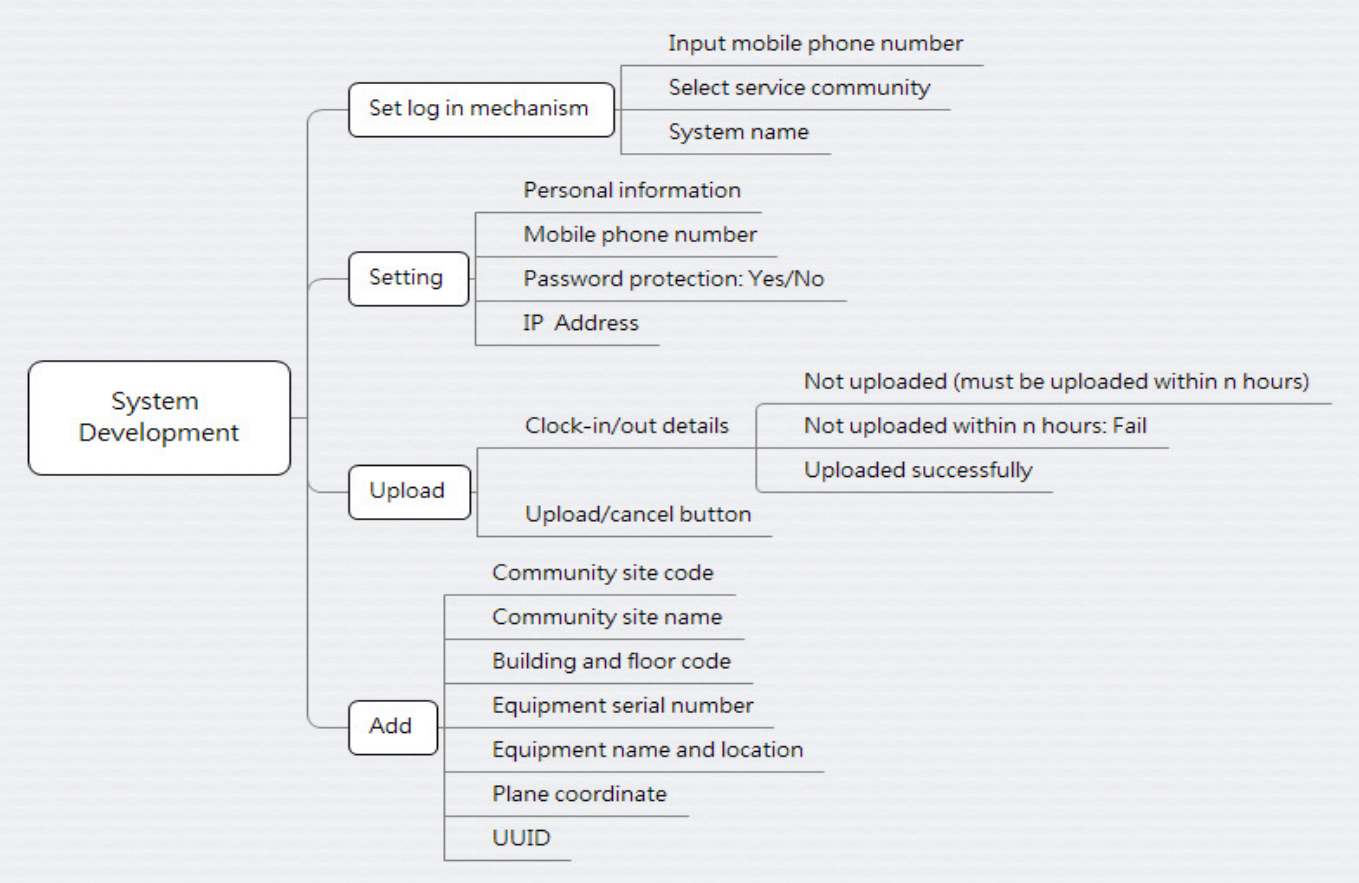

Figure 3. Tree Diagram For Beacon System Development

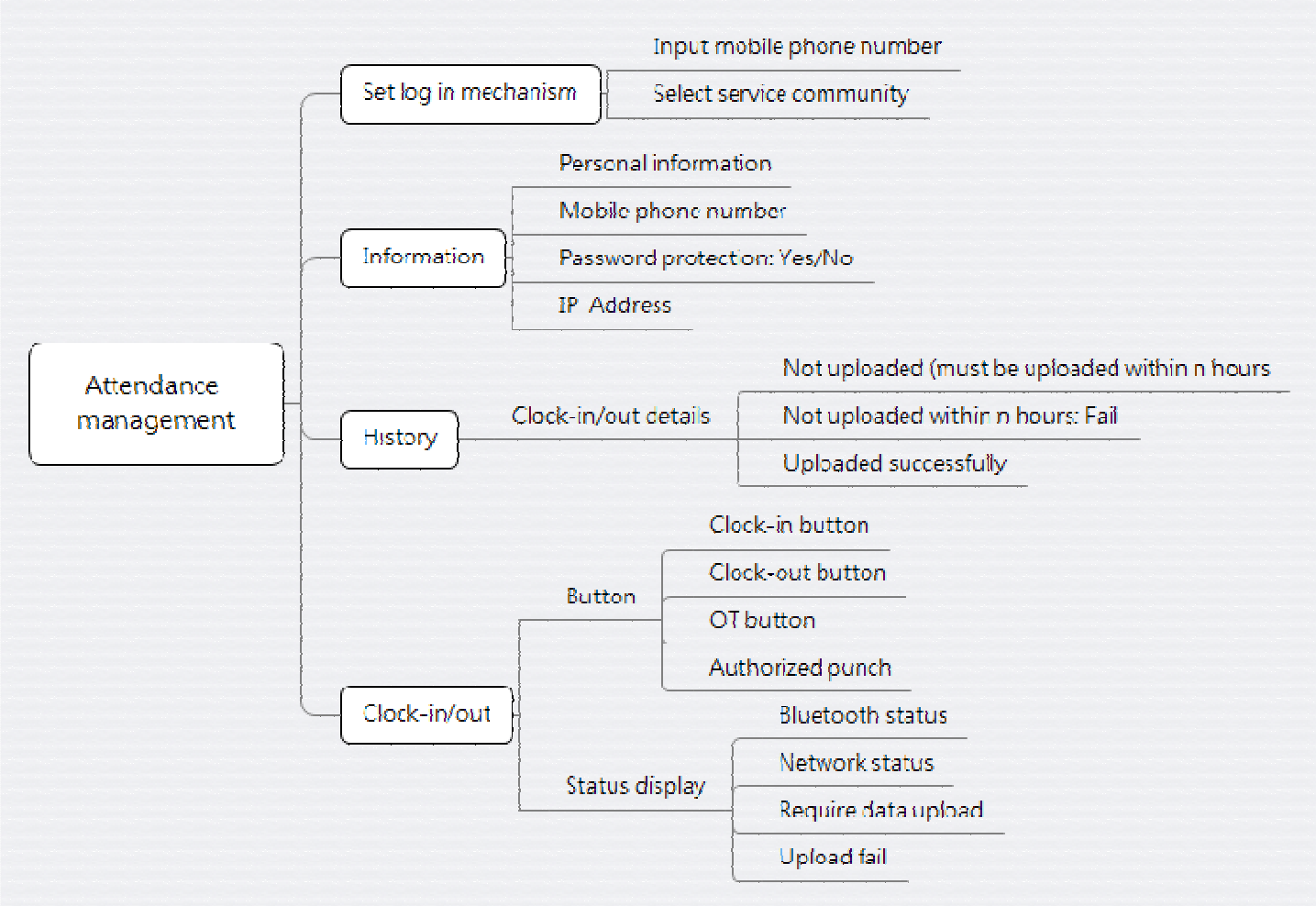

Figure 4. Tree Diagram For Attendance System Development

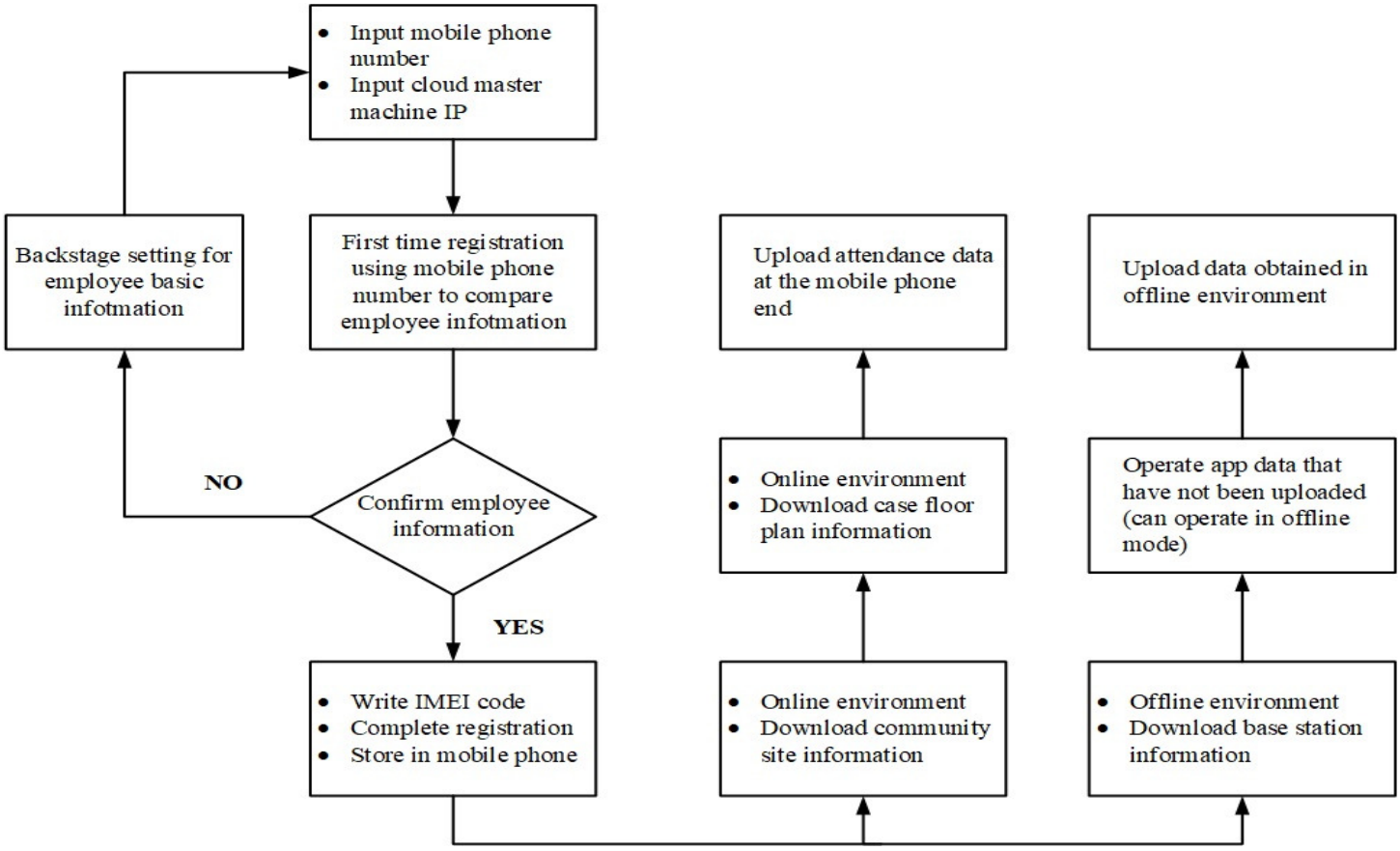

Figure 5. APP System Process For Beacon Station Establishment

Function Build of Attendance System APP

The purpose of developing the BAS was to introduce it into property management industries to aid companies in managing employee attendance status. The BAS was integrated with an ERP system, thereby enabling the employees' salaries to be calculated automatically according to their attendance. The BAS included six major functions: punch in, punch out, overtime punch in, authorized punch, history (for enquiring attendance record), and settings (Figure 6).

When users (property service personnel) are located in an area nearby the Beacon base station, their Bluetooth device (smartphone or tablet computers) can then receive the broadcast signals from the Bea-

con station, allowing users to update their attendance status (punch in, punch out, or OT punch in). If users are situated in an environment where their mobile phone cannot pick up Beacon signals, the system will notify the users of the connection failure on the main page (Figure 6). By identifying the UUID of both the mobile phone SIM card and Beacon attendance base station, the system can analyze and determine the identity, job title, and work location of the users uploading their attendance information. Once upload is complete, users can use the history function to enquire their past attendance record and determine their overall attendance (Figure 7). Considering the minority of people who do not use smartphones and tablet computers habitually, this study also established an authorized punch- in function for authorized users to punch in for their colleagues. Managers then supervise and manage authorized users to help them record the attendance status of employees who do not use smart mobile devices. Furthermore, this study developed BAS to improve deficiencies associated with previous attendance management approaches. Through the use of UUID, unauthorized punch- in can be prevented, preventing employees to punch- in outside of work locations via Bluetooth to evade consequences from being late for work. Furthermore, the broadcast range of the Beacon base station for receiving signals was set to 10 m, thereby ensuring the implementation of personnel attendance management.

Illustration and Discussions

This study applied the BAS system to one of the communities managed by the Taiwan International Building Management (TWIBM). This community comprises 442 households and six buildings; 60 service personnel were dispatch by the TWIBM to manage the community, including one property manager, one supervisor, two electrical engineers, one gardener, 14 cleaners, 16 security guards, and 25 community secretaries. The TWIBM manages 99 sites; thus, if it adopts the conventional attendance management, such approach is not only time consuming, labor intensive, and expensive, but also easily leads to poor interdepartmental communication and salary calculation problems. When the conventional time stamping machine is used in attendance management, employees' salaries based on their attendance are calculated as follows:

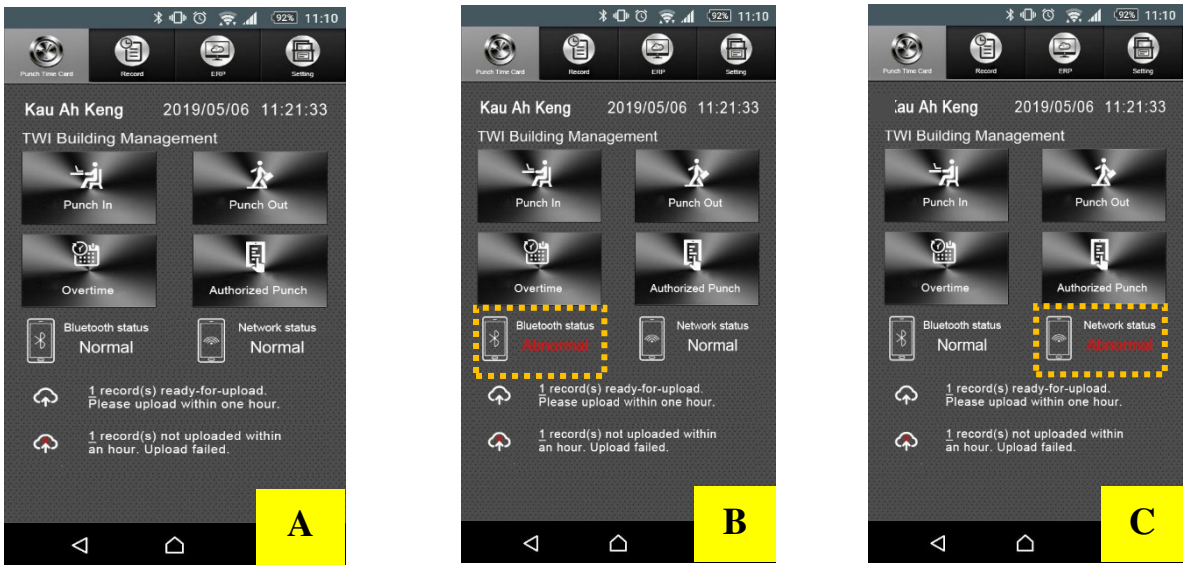

Figure 6. The main screen of the BAS APP (A: function page; B: Bluetooth connection failure; C: Internet connection failure)

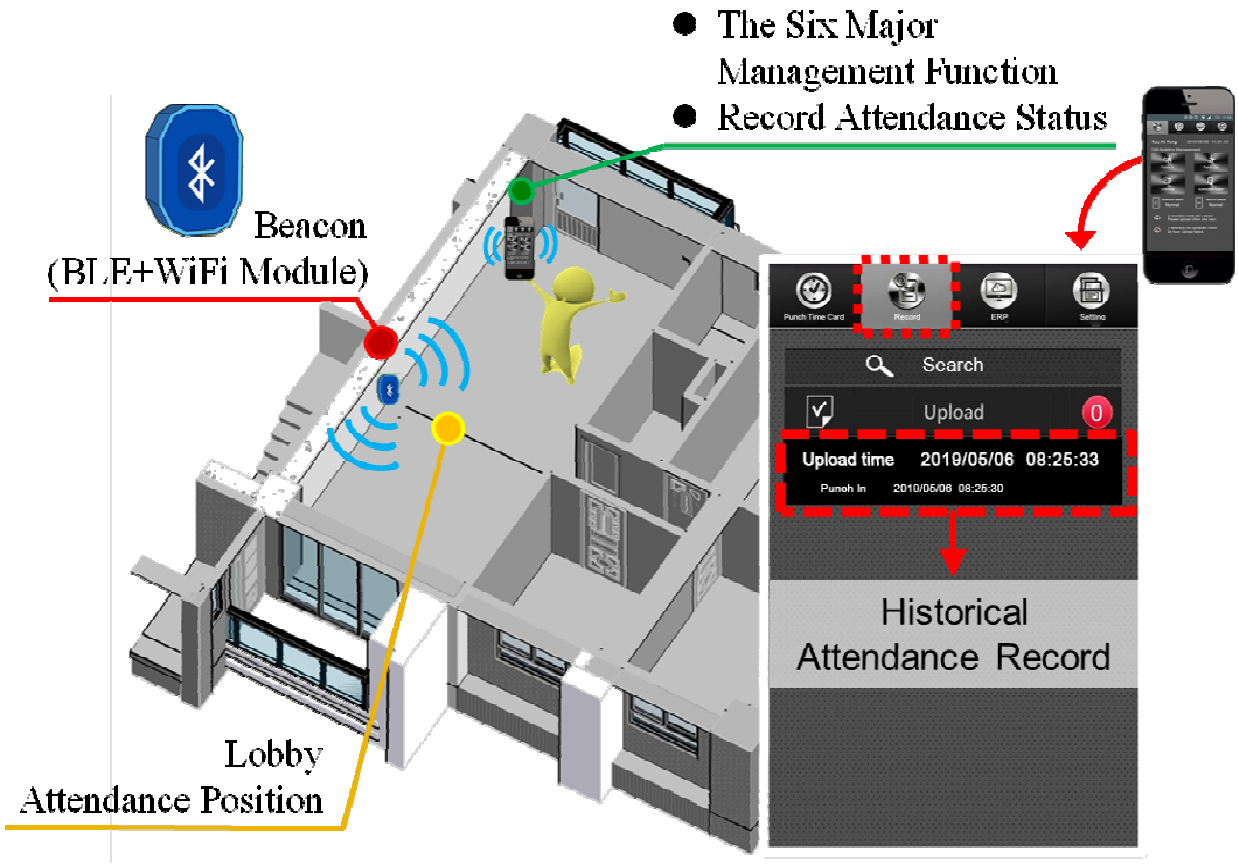

Figure 7. Schematic diagram of the BAS attendance system operation

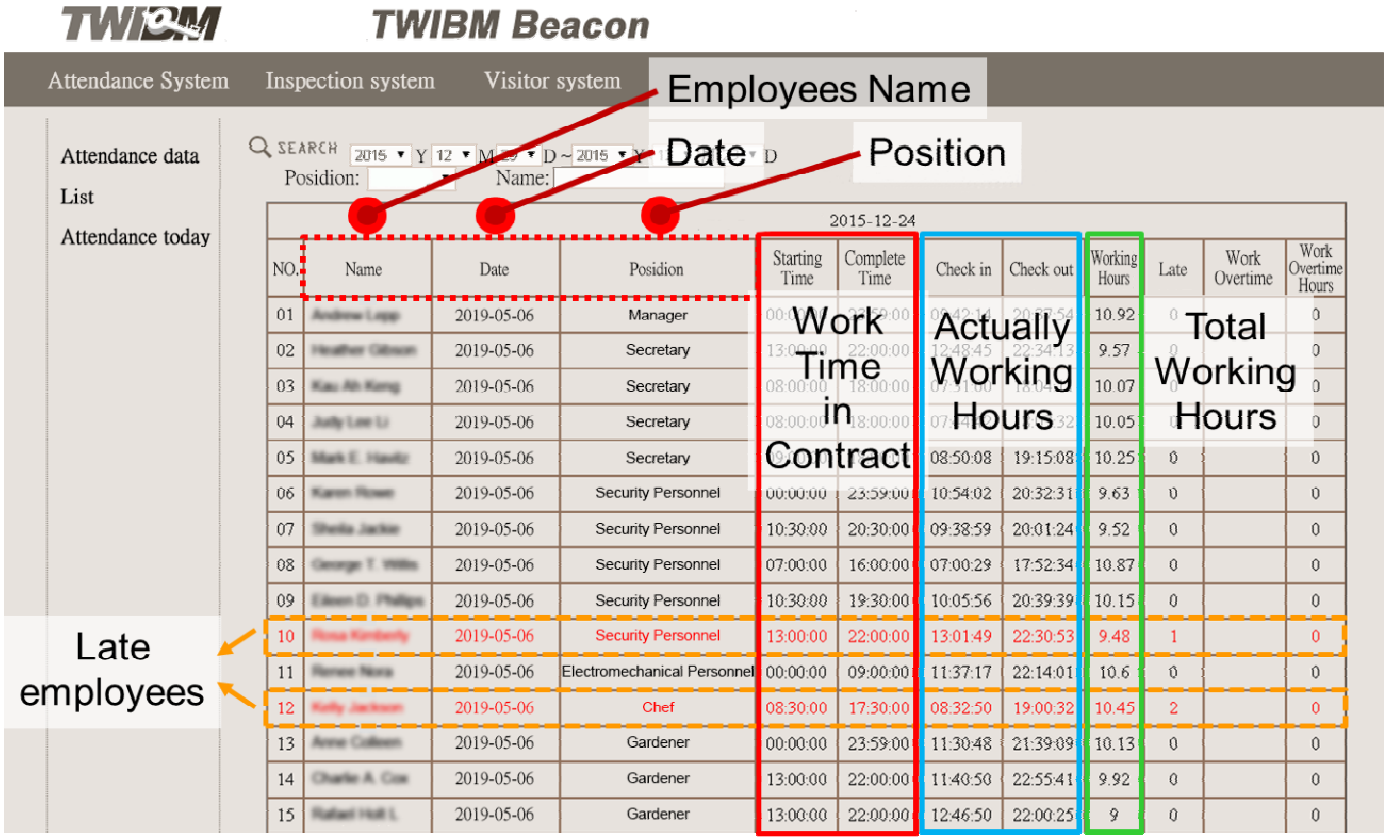

Figure 8: BAS management interface

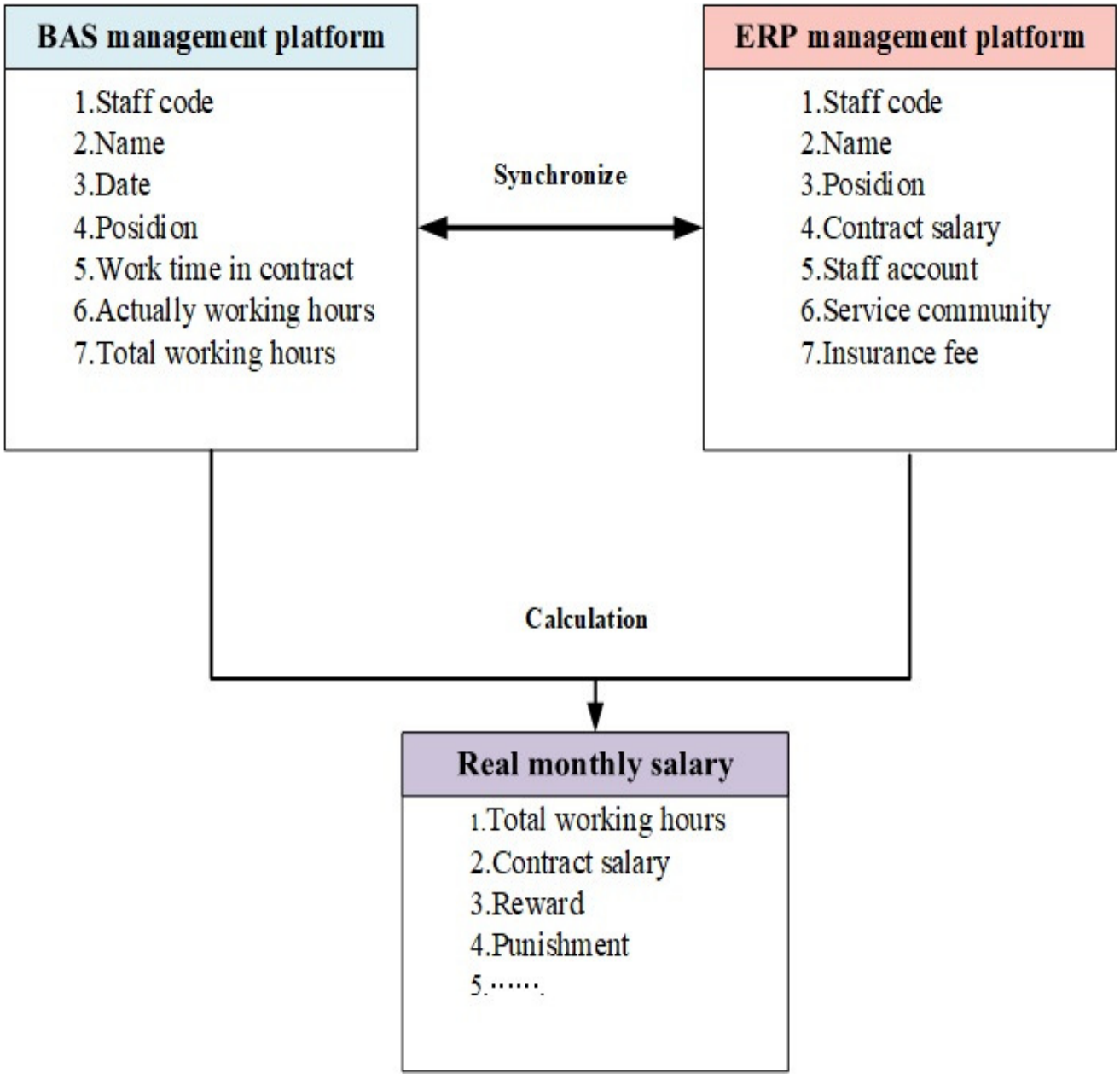

Figure 9. System connection

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Company: Taiwan International Building Management Company Employee:	
1.Total hours: 2.Contract hours: 3.Overtime hours: 4.Contract salary: 5.Allowance: 6.Special responsibility allowance: 7.Rewards and penalties: 8.Total amount for this month: 9.Advance payment: 10.Bank fee: 11.Labor insurance fee:	12.Health insurance fee: 13.Additional health insurance fee: 14.Educational training fee: 15.Honest insurance: 16.Court: 17.Seal: 18.Others: 19.Temporary payment of uniforms: 20.Refund the cost of uniforms: 21.Total amount received this month:
Remarks	

Figure 10. Salary report

first, employee attendance is evaluated to determine whether they were absent or on leave; subsequently, the generated statistics are manually input into the system, which generates the total salary amount; finally, the salary calculation formula is checked and employee salary advances are evaluated, thus completing the salary calculation process (salary calculation based on labor and health insurance is not discussed). This calculation procedure is not only complex, time consuming, and labor intensive, but also easily results in disputes arising from erroneous calculations. In the past, the TWIBM calculates its employee salary by designating a supervisor to spend 1 hour per day on compiling and manually inputting personnel attendance into the company system. Assuming that a month comprises 30 days and that TWIBM has 99 case sites (clients), a total of 2,970 man- hours are required per month to calculate employee salary, namely 35,640 man-hours are needed in a year. The BAS introduced in this study can automatically perform statistical analysis on employees' salaries based on their work attendance at the locations recorded on the BAS (Figure 8). While BAS system completes the salary calculation of employees, it will synchronize with the database of ERP system automatically including labor insurance fee, health insurance fee, and so on. These information will account for the real salary of employees in the specific period (Figure 9). After completing the calculation, salary information will be transmitted to each employee for acquiring the detailed salary report (Figure 10). If employees have any question in salary, they can feedback to the company for enquiry and problem solving immediately. Thus the whole system can significantly enhance the operation efficiency of organization and thereby achieving real- time, automated statistical analysis, eliminating the complex operating procedure.

Conclusions

With the increasing prevalence of mobile devices and cloud computing, property management industries worldwide including Taiwan have actively integrated cloud- based software and hardware and introduced systemized tools in their business operations. Currently, the commonly used attendance management approaches are associated with high setup cost, and they cannot be comprehensively used easily. This study developed a BAS, which is a Beacon- based system that combines BLE and mobile APP to actualize the conversion of community service personnel attendance data into cloud-based data, thereby achieving remote, real- time personnel attendance man-

agement. After BAS is introduced, the system can identify employee identity, automatically calculate the total attendance time, and import the summarized attendance information to the ERP system when calculating the employees' salary for the month. The BAS enables the company to save 35,640 annual man- hours on salary calculation and reduce operation burdens and personnel cost. Furthermore, corporate administrators and community service monitoring management units can monitor personnel attendance in real- time and remotely through the BAS, thereby increasing personnel dispatch efficiency. In summary, the introduction and application of BAS and ERP verifies the innovation and benefit of using the BAS in the operating procedure of property management practices.

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