2017 International Conference on Information Technology Systems and Innovation (ICITSI)
Bandung, October 23 – 24, 2017
ISBN: 978-1-5386-3100-3

Smart Campus Features, Technologies, and Applications: A Systematic Literature Review

Wardani Muhamad[1], Novianto Budi Kurniawan[2], Suhardi[3]
[1,2,3]School of Electrical Engineering and Informatics, Institut Teknologi Bandung (ITB)
Bandung, Indonesia
[1]wardani.muhamad@s.itb.ac.id, [2]noviantobudik@s.itb.ac.id, [3]suhardi@stei.itb.ac.id

Setiadi Yazid[4]
[4]Faculty of Computer Science, Universitas Indonesia
Depok, Indonesia
[4]setiadi@cs.ui.ac.id

***Abstract*— Research in the smart campus area is still growing, where every researcher defines the concept of smart campus with a less thorough perspective that has not been conical in the same conception of the concept. In this paper, we summarize the existing condition of smart campus development in term of features, supported technologies, and applications were built using systematic literature review (SLR) as the standard methodology used to solve any problems by tracing the results of previous research. The problems declared in SLR are commonly called as research question (RQ). To achieve that goal, we define some RQs related to that scope and clarify each question by tracing previous research papers which are indexed in reputable journal databases such as IEEE Xplore, Scopus, Springerlink, and ScienceDirect. After synthesizing 29 articles, the results are: contactless technology provides an easier way to enter data when accessing a particular room or equipment than using a keyboard; IoT supports an easier way to report real-time environment status; cloud computing is used to organize various information effectively and provide data services; iCampus becomes a popular smart campus model and if we map the applications that have been built into iCampus; there is no applications as part of iHealth domain. The main contribution of smart campus development based on previous research is to make easier in all campus aspect life. The contribution expected through this paper is to provide an overview for researchers who want to build applications in a campus as research challenge so that they can use appropriate technology and meet the characteristics of smart campus.**

Keywords—smart campus, SLR, summary, research challenge

I. INTRODUCTION

The word "smart" is commonly used to describe the ability of an object in presenting the intelligence that has been implanted in it. The word "smart" is pinned on the phone to show its intelligence so as to support many activities or everyday human life through various services provided. Smart concept continues to grow and is not only limited to a single object but it also covers the aspects of human life more widely, such as smart city, smart campus, smart grid, etc. The development of the concept in the smart domain has become an interesting research, so that the technical committee was born in a global technical professional organization such as IEEE, for example: IEEE Smart Cities Community that develops the concept of smart city and its implementation, IEEE Smart Grid that overshadows the development of smart grid concept and implementation. Furthermore, observing the development of the concept of smart campus becomes an interesting discussion because there is no technical committee that shades, so there is no standard used for the development of smart campus concept and implementation.

The current meaning or definition of smart campus has not been conical to a common understanding. Various researchers who have built a smart campus, convey the definition based on different approaches. If grouped, there are 3 (three) approaches used in defining smart campus, namely: technology driven, smart city concept adoption, and based on the development of an organization or business process.

Based on the technological approach used by a campus, smart campus is a definite trend resulting from the development of digital campus [1], [2], [3] through the utilization of the appropriate set of technologies and the provision of services over the internet [4] using IoT service providers [5] and cloud computing to integrate isolated systems [2]. The IoT service is built by transforming common objects in a university environment into an intelligent object by adding sensors [6] and a comprehensive intelligence to support intelligent decision-making in a campus environment [7]. Smart campus creates a centralized digital nervous system (DNS) that directs a complete learning cycle across the campus ecosystem and facilitates the development of appropriate applications or services [8] to improve campus performance and graduate quality [4] and to facilitate all stakeholders in an adaptive environment including three factors: teaching, management, and service [1].

Based on the approach of smart city concept adoption, it is stated that smart campus has similarities with a smart city with various challenges faced by universities and cities. Through the same paradigm, smart campus adopts modern technology to support different users (students, employees, and visitors) performing multiple tasks in multifunctional buildings [9]. In other words, the smart campus is seen as a small self-contained city in some aspects such as the number of functions, users, activities, and connections [10].

The third approach defines smart campus based on the development of organization or business process at a

university. The main concept of smart campus is to develop the campus through efficient use of resources [11] by applying several types of intelligence in order to provide high-quality [12] and intelligent services to campus and environmental communities [13], thereby reducing operational costs and making life easier and better [11], [13]. Intelligence is implemented by involving various sensor technologies to automatically support reporting into all aspects of campus life, including learning, social interaction for work collaboration, intelligent building management, and a smart environment.

Based on the three approaches above, we conclude that the basic idea of smart campus is an effort to integrate a set of advanced intelligence technology by the university to improve the performance, the quality of the graduates, and the ease of life through the provision of information technology services that are valuable, dynamic, and user-oriented to support automation and reporting in real time, not only for learning activities but covering a broader aspect, including: social interaction, environment, office management, energy saving, etc.

To understand the concept and implementation of smart campus deeper, we conducted a literature review using Systematic Literature Review (SLR). SLR is commonly used in pharmaceuticals and medicine and began to be developed for software engineering by Kitchenham and Charters [14] in 2007. SLR became the standard methodology used to find solutions by tracing the results of previous research. The problems encountered in the SLR are called research question (RQ). Some of the most common reasons for doing SLRs are: summarizing existing research results, to identify gaps in current research, or to provide frameworks for specific research areas. In this paper, we summarize the conditions of smart campus development, especially to know the characteristics, supporting technology, and applications built. To get a comprehensive result, we explored a number of literature published on the popular journals database i.e IEEExplore, Scopus, SpringerLink and ScienceDirect from 2000 to 2017.

The rest of this paper is organized as follows. Section 2 describes the stages used in SLR. Section 3 presents the results and answers of research questions. The summary of SLR result is presented in section 4.

II. RESEARCH METHODOLOGY

A systematic literature review as the process of identifying, assessing, and interpreting all research results in order to provide answers to research questions [14] consists of several activities, namely: specifying the research questions, selecting studies, extracting required data, synthesizing data, and descripting the result.

The research question was determined to keep the review focused. The research questions defined for this study are shown in table 1 below.

TABLE I. RESEARCH QUESTION

ID	Research Question	Motivation
RQ1	What are the smart campus features?	Identify the features of smart campus to have objective guideline when developing a smart campus
RQ2	What kinds of technology support smart campus implementation?	Identify the suitable technology used to develop smart campus and its specific usage
RQ3	Is there the standard model for the smart campus?	Identify the generic model that could be adopted for smart campus development
RQ4	What are the applications implemented in smart campus?	Identify the variety of smart campus application and research challenges on it
RQ5	What are smart campus contributions?	Identify the contribution of smart campus that motivates university management to develop it

To answer each research question, from August 28th, 2017 until Sep 1st, 2017, we tracked published research results in popular journals databases using specific search string. The search string used in finding the appropriate literature is **("smart campus" OR "smart university" OR "intelligent university") AND (concept OR model OR technology)** and resulted in appropriate study findings according to the string as shown in table 2.

TABLE II. RELATED STUDY FINDING RESULT

Database journal	Article founds
IEEExplore	95
Sciencedirect	2
Springerlink	100
Scopus	52
Total	249

Then we applied inclusion and exclusion criteria to select the appropriate candidate for article will be explored further.

TABLE III. INCLUSSION AND EXCLUSSION CRITERIA

Criteria	
Inclussion criteria	- Articles in peer reviewed papers - The article discusses the concept of smart campus or technology implementation in smart campus - Articles written in english - Article is open access
Exclussion criteria	- Books, book titles, and theses - Non-peer-reviewed research articles, white paper and technical report - Editorial, abstract or short paper (less than 4 pages) - Articles use smart campus as a case study

After applying inclusion and exclusion criteria above, we get 29 appropriate articles that become the main reference in completing the SLR which is published in a periodical journal or international conference proceedings as shown in table 4.

TABLE IV. LIST OF ARTICLE DISTRIBUTION

Publication media	#Article
Periodical Journal Q1	2
Periodical Journal Q3	1
Periodical Journal Q4	3
Springer Open Journal	1
Conference Proceeding	21
Total	29

The last activities conducted in SLR are synthesizing and describing the result as described in section 3.

III. RESEARCH RESULT

This section details or describes every research question defined in section 2, namely: smart campus features, smart campus technologies, smart campus applications, and smart campus contributions.

A. Smart Campus Feature

In its roadmap, a university evolved into a smart campus after going through 3 (three) stages: traditional campus, e-campus, and digital campus [2]. In the traditional campus phase, teaching and learning activities at a university are held in a classical way, where faculty and students must meet face-to-face in the classroom and at the same time, the material to be studied is shared. Along with the development of ICT and adoption in the education environment, the process of teaching and learning activities has evolved. A university that adopts ICT transform into an e-campus or digital campus with the most common example is the use of the internet to disseminate the material to be learned, including the application of online learning. Intelligent campus became the highest achievement of academic information system at a university and developed based on digital campus [2], [3]. A key feature of smart campus is the rapid adaptation and reactions to change to fulfillment user demand and the diversity of intelligence embedded in systems that support it.

The main difference between digital campus and smart campus is described in table 5 below [2]:

TABLE V. DIFFERENCE BETWEEN DIGITAL CAMPUS AND SMART CAMPUS

	Digital campus	Smart campus
Technical Environemnt	Local area network internet	IoT, cloud computing, wireless network, mobile terminal, RFID
Application	Learning resource in digtal form, distance learning, digital library, network management	Intelligent system using sensor, interoperability, and control ability
System Management	Isolated	System sharing, intelligent, push

Alghamdi and Shetty [11], and Cață [6] pointed out several advantages of the intelligent campus: 1) Promoting intelligent energy management [11] by reducing electricity consumption [6] through automatic lighting controls and campus hotspots along corridors and rooms based on the movement of people in this area [6]; 2) Providing an interactive, creative environment [11] and conducive to improving the social interaction of all campus communities [6] in particular for lecturers and students; 3) Using accumulated data to produce useful applications [6] to improve business process automation [11]; 4) Facilitating the inventory of technology and devices [6]; 5) Providing real-time disaster response and warning services through the effectiveness of surveillance systems [11] through consistent monitoring of disturbances, temperature, humidity, and smoke in campus areas so as a safe learning environment could be created; 6) Providing campus map information services that make it easier for visitors to reach certain locations from the starting point of their positions [6].

To identify the characteristics or features of a smart campus, some researchers [3], [15], [16] have expressed their opinions. The characteristics of smart campus are:

1. Providing a thorough intelligent environment and integrated information service via dashboard [15] for students and lecturers, while the service can be customized based on user roles [3], [16]
2. There is a linkage to fostering creativity and collaboration [15] through an integrated information service using a campus computer network to access available applications and services [3], [16]
3. Availability of data and idea exchange between campus and the outside environment through the use of integrated intelligence and information service platform [3], [16]
4. Efficient management of energy and water [15]

B. Smart Campus Technology

The presence of smart campus can not be separated from the role or support of technology, especially ICT. In various studies related to the implementation of smart campus, there are 7 (seven) key technologies as presented in table 6.

TABLE VI. SMART CAMPUS TECHNOLOGIES

No	Technology	References
1	Radio-frequency identification (RFID)	[17], [2], [6], [18], [13], [4], [19], [20],
2	Internet of Things (IoT)	[2], [6], [5], [11], [19], [3], [16]
3	Cloud Computing	[2], [18], [4], [3], [16]
4	3D visualization technology; Augmented Reality	[21]
5	Sensor technology (motion, temperature, light, humidity, etc.)	[6], [16], [21], [22], [11], [20]
6	Mobile technology (include NFC, QR code, GPS)	[4], [19], [2], [11], [13], [23]
7	Web service	[19], [21], [5]

RFID has the ability to store data and is one type of contactless technology that provides several benefits to support smart campus including visitor authentication, record the attendance of lecturers and students, record the movement of people and objects and speed up evacuation when disaster strikes, room security, electrical equipment automation, recording catalog information, as well as support for self-service lending services.

IoT is a new concept in information technology built on a comprehensive network. IoT is able to connect people, instruments, devices, and buildings within the campus through a smart system. By using IoT, searching the location of an object or person exactly can be done in realtime.

Cloud computing is a comprehensive solution that integrates and manages all kinds of information effectively, provides data services, and supports information sharing. Databases and applications in a campus environment should be built on a cloud computing-based platform that includes service levels: IaaS, PaaS, and SaaS. From an e-learning point of view, cloud computing can support the application of virtual labs to help students and lecturers carry out activities in unstructured environments or by using ubiquitous devices through mobile services.

The capability of augmented reality (AR) technology in providing a video-based interface can provide different

experiences for users, one of which is presenting a map to a specific location rather than in a traditional view. When AR is integrated with various sensors located within the campus location, a route to a location can be displayed in real-time including calculating the distance to that location.

Building an intelligent campus that presents real-time automation and reporting processes is not enough with the support of intelligence systems. Sensors capable of detecting an event or a status change should be added. Intelligent campus sensors are housed in a variety of strategic locations according to the set of specific goals. Some of the uses of smart campus sensors include: detecting human movement, detecting changes in weather / humidity, detecting water and waste capacity, and detecting location so that it can be a path to a particular location search. To support practicality, most sensors are installed using wireless technology.

Mobile phones, tablets, laptops, and other similar devices have become a powerful equipment in today's life and should be utilized in education to improve quality, meet student needs, and reduce costs. Various capabilities offered by mobile device technology to support smart campus include: the development of mobile learning that enables learning to be done anywhere and anytime; the recording of attendance and access the door to enter or exit the room using contactless technology (Bluetooth, Quick response code, NFC, RFID) embedded in the mobile phone; the development of mobile social network (MSN) to support social interaction; the construction of location-based services (LBS) using GPS; and the access of AR technology to present a route to a location.

Web services are used to manage and provide unified access to a variety of heterogeneous and separate information. Web services connect various applications that increasingly diverse in smart campus so as to produce the suitable service dynamically. IoT services can also be a web service that has the ability to access IoT resources directly.

C. Model Smart Campus

To emphasize the characteristics of a smart campus, there are 6 (six) intelligence domains [24] that a university must have: iLearning, iGovernance, iGreen, iHealth, iSocial, and iManagement.

iLearning focuses on learning processes at universities that involve lecturers and students as the main actors. ICT involvement significantly affects the evolution of the learning process. In the iLearning domain, a smart campus system in addition to organizing traditional learning processes, should also be able to: 1) improve collaborative learning between lecturers and students; 2) provide equal opportunities for all students to study without being limited by distance and time; 3) support self learning in accordance with the correct path; and 4) evaluate learning competency achievement (self assessment).

iGovernance focuses on accountable university governance and meets the needs of stakeholders. In this domain, smart campus systems can at least: 1) enable internal and external campus governance at multiple stakeholder levels; 2) establish, monitor, implement and evaluate short, medium and long-term work plans; 3) process governance to improve organizational performance through optimization, root cause analysis, and improvement of preventive and corrective actions; 4) present a management workflow that supports automated reporting and scheduling, logging, and adaptation capabilities on configuration changes.

iGreen focuses on the "green campus" aspect, which gives attention to the degree of carbon pollution in the university environment as a whole. This is in line with the issue of climate change caused by air pollution. Some of the abilities that should be owned by smart campus on the iGreen domain include 1) energy creation and consumption intelligently; 2) buildings management that is energy efficient and environmentally friendly; 3) implementation of sensor technology for accurate reporting.

iHealth focuses on the health aspects of campus residents. The key to iHealth is to ensure, track, and maintain the overall health of the campus community. This domain is aligned with iGreen to support the creation of a healthy environment. Some capabilities that must be owned by the system on iHealth related smart campus include: 1) health services anytime and anywhere to the campus residents; 2) intelligent information systems that can report the level of health on campus, for example: reporting the extraordinary events of a disease; 3) proactive or preventive health services; 4) tracking and recording of campus health status in general.

The iSocial domain is present due to the growing use of current social networking technology. It is undeniable that today's social networks are used to record their profile and their daily status or feelings. Interactions that occur between students or students with lecturers is also a social process that occurs naturally. Collaborative learning that becomes one of the focuses on the iLearning domain also becomes part of the social process at a university. To meet the iSocial domain, the smart campus system should at least have the ability to: 1) identify student profiles so they can group them according to student interests; 2) perform sentiment analysis in accordance with data stored on social networks; 3) improve the service at the right time and location in accordance with student interests.

iManagement focuses on general management at a university. What concerns the iManagement includes the facilities and infrastructure that exist in the university, as well as the people (staff, lecturer, students, guests) who are inside the campus. It includes intelligent building management including setting the temperature in a building, setting the lights automatically, and doors that can be accessed in accordance with the permissions, and so forth. The system on smart campus should be equipped with various capabilities, including 1) face recognition to avoid crime or to record people who are in a particular area; 2) trace the movement or mobilization of people to know the distribution of humans at certain times; 3) smart cards to provide parking permits and non-cash transactions; 4) recording attendance on a teaching and learning activity.

D. Smart Campus Applications

Various applications are built to realize a smart campus. These applications are indirectly part of the smart campus model. Table 7 presents the smart campus applications based

on previously conducted studies and grouped into 6 (six) domains on the iCampus model.

TABLE VII. SMART CAMPUS APPLICATIONS

Domain	Smart Campus Application	References
iLearning	Smart Learning Management System	[25], [26], [12]
	Personalized Learning	[27], [26], [12], [19]
	Assessment	[8], [25], [26]
	Smart Classroom	[8], [25], [18], [26], [12], [19]
	Library Management System	[2], [18]
iSocial	Market Management System	[18]
	News Management System	[25], [18]
iManagement	People Identification	[17], [18], [20]
	Smart Attendance	[17], [20]
	Safe Learning Environment	[6], [17], [12]
	Smart Parking	[6]
	Campus Geographic Information System	[6], [17], [18], [12]
	Bathroom Management System	[18]
iGovernance	Teaching Management System	[2]
	Financial System	[2]
	Office System	[2], [25]
iHealth		
iGreen	Smart Building	[6], [17], [11], [20], [2]
	Waste And Water Management	[10], [11]

Based on previous research, there is no researcher who made the application in iHealth domain.

Figure 1 describes the distribution (number of) applications that have been built on each domain.

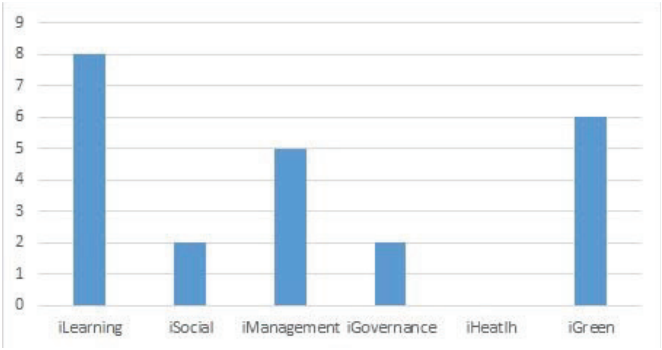

Fig 1. Number of applications in smart campus area

1) Smart Learning Management System

Management of online learning activities based on web technologies and/or mobile devices (mobile) or more commonly known as the Learning Management System (LMS) becomes a service that facilitates lecturers and students interact directly and indirectly to support teaching activities. LMS should be able to meet the needs of recording data relating to teaching activities, including the course syllabus, meeting schedule, student attendance, project group creation, and the provision and execution of tasks. LMS should also be able to manage and set the main supporting data of teaching process.

In addition, communication and interaction play a very important role in the success of online learning. Efforts to maintain or improve the quality of learning outcomes need to be developed carefully through the preparation of a routine and timely communication mechanism between lecturers and students to maintain the quality of knowledge construction in accordance with its standards, as well as increased collaboration with colleagues accompanied by guidance by lecturers on a regular basis so that the learning process remains on the correct path.

2) Personalized Learning

Personalized learning is a general term that involves the preparation of plans and the making of learning maps, information collecting, and learning resources exploration, as well as the preparation of learning activities, all of which are carried out personally or individually. To support the learning objectives, personalized learning should be complemented by the concept of adaptive learning, while learning refers to meeting the dynamic needs of students and providing feedback on achieving current learning outcomes in intelligent learning environments. That environment is an ideal place to connect all artifacts related to personal learning. Such artifacts may include: learning objectives, plans, learning maps, learning activities, competence levels, performance or achievement of learning outcomes, reflections, etc. Mobile device technology services could improve personalized learning so it can be done from anywhere.

3) Assessment

Assessment is an important component in learning which can ensure the alignment of learning objectives with the results achieved by students. Assessment has several capabilities, namely:

1. Recommendations generated based on behavior and learning progress.
2. The tests used as the basis for capability assessment can be made in various models, such as essays, practices, multiple choice, matching, and short answers.
3. Providing automatic grading and create performance reports like score distribution and statistics of student learning outcomes.
4. Presenting the results of a comprehensive data analysis with the concept of conceptual multi-tenancy data mining, resulting in:
    a. Analysis of student characteristics and provision of personalized learning support.
    b. Statistical analysis of learning outcomes.
    c. Recommended learning methods based on the analysis of learning activities, methods, behaviors, learning styles and other related records.
    d. Grouping learners based on their learning behavior.

4) Smart Classroom

The use of LMS to support the teaching process presents a virtual classroom (VC) concept to replace classes physically. As a class, VCs should also be able to present real teaching

atmosphere, such as presenting slides presentation (using standard PowerPoint) synchronized with streaming from recording voice of narration, as well as streaming video presentation indexed in a table. The VC in its more complete form contains windows (in video form) that show activities in the class as well as a series of text and image pages representing the whiteboard content. The access media used by students to interact through VCs can use any mobile phone, tablet, computer, or other supportive equipment. Improving the quality of VC by building a blend of virtual and real environments can bring an atmosphere of "being there" to enrich the teaching and learning experience. Through VC, students also seem to be able to manage their study space personally by following a series of teaching process organized by VC.

5) Library Management System

The new library management mode has been supported by the Internet of Things (IoT). Libraries get information through electronic tags that combine mobile phones, library cards, and other physical objects. The use of RFID as an electronic label can be developed to improve library services such as borrowing and returning books independently, storage information of shelves, book catalogs, and cart. At the same time, library members can also look for books that are being borrowed by other members.

6) Market Management System

Market management can fully display every campus network user initiative. The advantage is that each user can compare similar products laterally to choose according to their individual request character, which is very consistent with the way students do when using campus network resources rationally, can browse relevant products on the page freely, can choose products and keep doing ordering operations, including choosing payment method, shipping method, etc.

7) News Management System

It is used to facilitate users to rapidly check information on digital campus platforms, complement information browsing, download apps, participate in a topic, comment on comments, map campus operations, make asynchronous information sharing (e-mail, bulletin boards, discussion forums, newsgroups), and share information synchronously (chat, whiteboard, group browsing)

8) People Identification

It records data of each campus visitors, including students, faculty/staff, and guests using RFID. These records are used to control campus security by verifying and validating campus visitors.

9) Smart Attendance

It records the presence of students and lecturers/employees so as to monitor their presence in the campus.

10) Safe Learning Environment

It records infrastructure facilities with precision and intelligence, access to control facilities available on campus and carried out easily campus monitoring and surveillance.

11) Smart Parking

Smart parking management provides optimal service to the campus visitors. Capabilities that can be supported through smart parking services include: available parking or parking slot information, restrictions on parking usage, and disaster information involving vehicles in the parking area.

12) Campus Geographic Information System

By providing geographic-based services, campuses can manage space and information attribute more efficiently, intuitively and comprehensively and determine the location of campus facilities in an accurate position. Geographically based services involve multiple sensors such as RFID, WSN, and GPS. Through this service, the campus can present information using maps or augmented reality technology to help direct a visitor to a particular place/location based on his current position, complete with the route to go through. In addition, by adding sensors at various points within the campus environment, visitor's movement or even goods can be monitored appropriately.

13) Bathroom Management System

It automatically detects water management using RFID by reading the level of water use in the bathroom and is analyzed continuously. For further, analysis results are reported in real-time. Through the analysis can be known information on the status of the bathroom, which can be accessed also by students.

14) Teaching Management System

These applications are used by university management to monitor the implementation of the teaching process. This application provides services to management with the key capability of producing reports relating to the transaction teaching process, including the realization of teaching hours; the realization of course syllabus; percentage of teaching (attendance of lecturers and students); course graduation percentage; feedback or student satisfaction level; occupancy of classroom use.

15) Financial System

The management of the university as an organization undoubtedly involves the financial recording. In fact, one indicator of the development of an organization can be assessed from the growth of its financial capabilities. University management requires an application dashboard that can provide services in the form of financial monitoring. As an application for management, the application has the main capability of presenting reports relating to financial transactions, including the balance sheet; activity plan and budget; periodic financial growth; investment and asset value owned by the university.

16) Office System

Various operational activities and involving various entities in the campus are generally supported by ICT. A simple example of the application of office applications in smart campus is the electronic mail service (e-mail) that can be used by students and lecturers and digital announcement boards. More specifically, office applications can provide services to university management with specific capabilities such as the management of official letters; management of management review meetings; teleconference, videoconference, and

application sharing; as well as the making of reports periodically with the support of data stored in the database.

17) Smart Building

Smart building is developed with various sensors, which become an important part, to support the process of automation in a building. These sensors support various capabilities to build a smart building service such as turning off objects (lights, air conditioners, or projectors) in an empty room, detecting carbon dioxide (CO2) levels in certain areas, adjusting temperatures, measuring humidity and pollution around the building and open space, increasing the efficiency of energy consumption and the creation of alternative energy. No less important, smart building services should also be able to generate reports to university management, such as energy usage (consumption) reports, real-time warning, energy and space usage patterns, etc.

18) Waste and Water Management

In an effort to support the concept of the green campus, the university should be able to manage water and waste properly. Similarly, the construction of a smart building, to build waste management services and water, must be supported by various sensors and intelligent systems. This service has at least the ability to report the water and trash conditions in the campus environment in real time so that it can be made a decision as a follow-up when inappropriate conditions were found.

E. Smart Campus Contributions

The teaching process as the main business process on campus, supported by smart campus through various automation and ease of access. RFID, WSN, and NFC technologies play a role in facilitating and accelerating student attendance in class [20] and transactions involving payments in canteen or campus administration [28]. The enhancement of the role of mobile technology is capable of creating learning anywhere and anytime [2] involving multiple access media [23] through the support of cloud computing technologies [26]. Autonomic web service (AWS) support in personal learning can improve learning quality through the preparation of learning paths to achieve learning objectives [19]. Ultimately, the adoption of such technologies leads to convergence of educational programs traditionally into virtual form [25].

A smart campus not only improves the quality of the main business process but also improves the supporting business processes such as building management, facilities, and even the environment around the campus. Using RFID technology, detection of human presence in a room can be done easily [17]. This helps to regulate the power used in a room including lights, air conditioners, or other facilities contained in space. The use of sensor and IoT technology can be utilized to detect garbage capacity inside the garbage truck so as to facilitate and speed up the replacement process. The systems to support the waste recycling process can also be done at smart campus [17].

To support social interaction at smart campus, an MSN architecture is built based on a service-oriented perspective that collects and analyzes data from the public [29]. Dong et al. [30] produced a mobile platform used by students to share knowledge and send ideas. Interest mining analysis based on the data can generate campus emotion information and reported to campus management. To support MSN's performance, Yu et al [5] creates an algorithm for selecting services based on user preferences and user context.

GPS technology embedded in mobile technology as well as its ability to run AR is useful to show the path to a particular location in a more interactive way [21].

IV. Conclusion and Future Work

Research in the field of smart campus to date continues to grow. In the last 5 years (2013-2017), every year the number of research publications increases about 1.5 times. Various applications have been implemented to realize the concept of smart campus and we map these into iCampus as popular smart campus model. The proposed domain in the iCampus design confirms that smart campus development areas are not limited only to support learning and teaching processes, but also support all aspects of campus life such as environment, building, social life, health and university governance. According to the variety of applications that have been built based on Figure 1, the iLearning domain becomes the most targeted research area. This is certainly very reasonable because the main business process that is run is teaching. The next domains that are widely targeted as an application development are iGreen and iManagement. Both domains focus on the management of facilities and infrastructure and the environment intelligently. Smart campus development is also not separated from the contribution of information technology. There are at least 7 (seven) key technologies, as shown in table 3, that are used to support automation and reporting in real-time with the addition of various kinds of intelligence in it. Contactless technology (RFID, NFC, Bluetooth, etc) becomes the primary device for storing basic data on the client side. By using this data, the user does not need to enter any data such as username or password to get permission to access space, parking area, or even anywhere on campus. In other words, this technology makes it easy for users. Converting common objects into things by adding sensor equipment and some specific intelligence in it became the basic activity to implement IoT. By this way, finding the object or reporting environment status is easier and also could be reported real-time. Cloud computing chose as suitable technology to organize various information effectively and provides data service that includes service levels: IaaS, PaaS, and SaaS.

Based on the meaning and definition presented in chapter 1, the main role of smart campus is to present the dynamic services according to the needs of the users using some intelligence system. Therefore, service computing that cover the science and technology of services innovation research that leverages IT and computing technology to model, create and manage business solutions, scientific applications, as well as modernized services [31] become one of the keys to realizing smart campus. Another challenge is the development of technology to strengthen interaction and interoperability in every application across the domain

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