

# Smart Apartment Service: Survey and Architecture

Qiudi Zhao

*Institute of Higher Education  
Beihang University  
Beijing, China*

Ke Chen

*School of Chemistry  
Beihang University  
Beijing, China*

Fan Zhan

*School of Biological Science and  
Medical Engineering  
Beihang University  
Beijing, China*

**Abstract**—With respect to the university apartment management and service, together with an explosive growth of information technologies (IT), it is presently facing various challenges and undergoing an overwhelming tendency from the traditional experience to smart logistic service in China. Obviously, the smart development level of the apartment management and service is not only increasingly becoming one of the core competencies of cultivating high-quality talents to realize as an important part of the leap-forward development of a university or college, but also embodies the role of the education. In this paper, through analyzing the difficulties and bottlenecks of traditional students' apartment management and service, together with our results of the questionnaire survey, we try firstly to design and build a new type of smart apartment service system based on a design of the networked control model, referring to smart building, smart network, smart service, and smart culture, in order to serve the higher education development in China.

**Keywords**—smart apartment, apartment management, logistic service, university

## I. INTRODUCTION

Internet is increasingly becoming an essential part of human life, as the most effective and convenient communication way is which not bounded by time and place [1,2]. Under the context of the mobile internet [3], artificial intelligence [4], big data [5], mobile cloud computing [6], and other rapid development of science and technology, these information technologies lead to re-examine our market, the user of products, the enterprise value chains, and the whole business ecosystem. For example, with respect to the education and management, the mobile could network has formed a unique and systematic mode, in order to improve the learning efficiency [7,8].

Since the IBM first introduced the concept of 'Smart Planet' in 2008, the concept of wisdom quickly penetrated into all walks of our lives, such as "Smart City", and then "Smart Campus" came into being gradually [9]. For example, "Smart City", as defined by IBM, is to use information and communication technologies sense to analyse and integrate the various key information of urban operation system, and to give quickly smart response of various demands derived from people's livelihood, environmental protection, public safety, urban services, and industrial and commercial activities [10]. However, 'Smart

---

**Corresponding Author:** Fan Zhan, School of Biological Science and Medical Engineering Beihang University, Beijing, China

Campus', analogous to "Smart City", refers to smart integrated environment of campus work, learning and life based on the local internet platform where the teaching, scientific research, management and campus life are fully integrated in various application service system [11,12]. It has three core features: first, it not only provide a comprehensive intelligent awareness environment and integrated information service platform for all the students and teachers, but also offer personalized service; second, it can integrate the information services into various fields of the school, and fully achieve the interconnection and cooperation; third, it can open an interactive window between the school and the outside world by the intelligent awareness environment and integrated information service platform. Comparatively, students' apartment is also an important place for university or college students to live and study, which plays a key role in "Smart Campus" [9]. Therefore, the convenient and comfortable apartment will directly give a great improvement on the efficiency/quality of the study and life.

In the study, to efficiently enhance the level of student's apartment management and service to promote one of the core competencies of cultivating high-quality talents in universities or colleges, this paper firstly analyses the bottlenecks of traditional students' apartment management and services, and then presents a comprehensive survey on the awareness and demand for the existing apartment management services, and finally designs the architectures of smart apartment service which will be exactly a product of this era, because it actually reflects the demands of student-centred apartment management and services and modern educational development. Therefore, the design and construction of smart apartment service which refers to the perfect combination of smart building and surrounding environment, smart network, personalized services, and harmonious culture, will be an inevitable trend of development in more and more China's colleges and universities.

## II. THE BOTTLENECKS OF TRADITIONAL STUDENTS' APARTMENT MANAGEMENT AND SERVICE

### A. Old-fashioned concepts of the management and service

In the planned economic system, traditional management and service concept of student's apartment is generally believed that the apartment is just a place for students to rest and live, ignoring its other functions (e.g., education, culture). Under the effect of this concept, many colleges and universities still keep the mode of traditional apartment

management and services. At the same time, there has no good method/approach to improve staffs' educational level, which is largely restricted by the quality of the service and educational effect on students' apartment.

#### B. *Unsound management mechanism*

As we know, students' apartment management and service follow student-centered principle. So, as student's apartment is an important place in a campus, the managers of students' apartment can not only provide personalized services, but also carry out moral guidance and education for students. However, there is a separated management mode between the apartment management and educational management in many colleges or universities. Though the apartment management apartment is only responsible for the basic apartment management services such as the security and environmental hygiene in dormitory, students' behavior management/education is seldom guided by students' management apartment. Therefore, the joint management just stays on paper or ideal. Obviously, with respect to these colleges or universities, there is no co-ordination of the resources to train and educate students, so that students' apartment management apartment can play an important role in education, which should not be ignored in the near future. Besides, there is also lack of thinking for the plan and design of the apartment, cultural construction and ecological development.

#### C. *Under-developed information system*

In recent years, with the socialized development of students' apartment and accelerated enrollment growth, the management apartment of students' apartment bears more and more dorm work, including the basic recording for students' accommodation information, students' behavior management, equipment maintenance, facilities repair, security, energy management and so on. In this case, the managers of students' apartment still use traditional manual ways to manage these diverse and complex affairs, which not only causes inaccuracy and insecurity, but also restricts the information development of the apartment management level. Besides, although some colleges or universities are attempting to use some information or intelligent system to manage these affairs of students' apartment, most of them only establish a basic information system for students' apartment management such as entrance guard, which faces similar embarrassment of Online-to-Offline (the discrepancy between practical needs and information services). The case's main limits are the hardware condition, the instability of post-maintenance and redevelopment team, as well as lacking of financial and technical support.

#### D. *The relatively low-qualified staffs*

From the perspective of students' apartment management group, most of staffs as temporary workers are hired from the society. They mainly are responsible for the daily management and services for students' apartment as dorm staffs, cleaners, maintenance workers, door-keepers, and so on. However, due to their low educational level, unstable awareness, and mobility of labors, these factors

have greatly restricted the healthy sustainable development of students' apartment management and services in colleges and universities.

Based on the above analysis, these facts have seriously affected the informatization development of students' apartment management and service in colleges or universities, which cannot keep pace with the construction of Chinese colleges and universities in the new period. Fortunately, developed internet-based information technologies (e.g., mobile internet, big data, cloud computing, and artificial intelligence) provide a good opportunity to enhance the level of students' apartment management and service. Therefore, the term "Smart Apartment" will be introduced now after the concept of "Smart Campus", based on these advanced information technologies and hardware facilities, which owns abundant connotation such as intelligence, automatism, remote, alternation, and sharing. "Smart Apartment", like an artificial intelligence system, can comprehend the needs of students' accommodation, statistically analyze various data about students' apartment management and services, and then response rapidly to solve these needs and problems. Therefore, the construction of Smart Apartment is inherently the requirement of the existence and development for students' apartment in universities or colleges.

### III. THE CONSTRUCTION OF SMART APARTMENT SERVICE

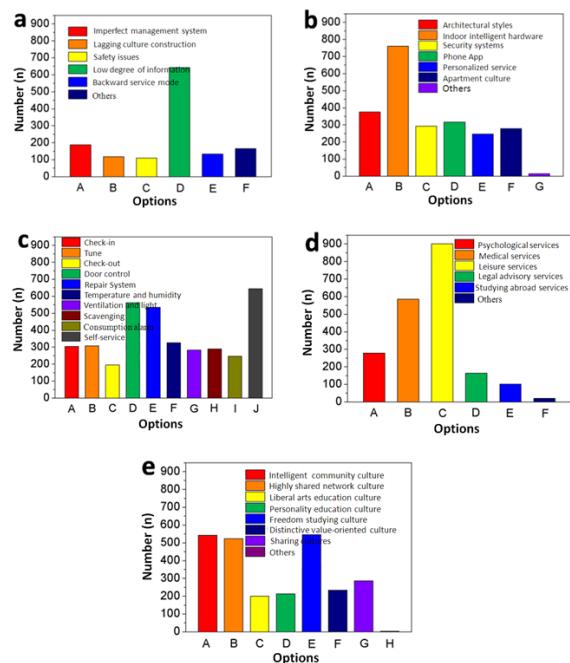
#### A. *Questionnaire*

In this work, to achieve precisely the awareness and demand for the existing apartment management services by boarders (students), the questionnaires including questions about management and services, smart functions, culture and so on. We design and distribute more than two thousand questionnaires, and cover all students which include undergraduates, graduate students and doctoral students lived in apartment buildings in Beihang University.

##### 1) Overall situation analysis of questionnaire

Through statistically analyzing the survey results, it is suggested that the current management and services of traditional students' apartment have many shortages (Figure 1a), 47.4% of the students believes that the apartment information system is low-level, 13.8% of students considers that the apartment management system is inadequate, and a few students think that the apartment has problems in the way of services (9.8%), cultural construction (8.7%) and security (8.0%). The results suggest that low-level informatization and unsound management system are prominent issues. In Figure 1b, 38.0% of the students consider that hardware facilities within the dormitory should be improved, 17.1% of the students show that the style of the dorm building need to be changed, a small part of the students believe that the traditional apartment management system should be improved on phone APP (14.4%), security systems (13.2%), personal services (11.2%) and apartment culture (11.0%). Therefore, traditional apartments' hardware facilities have been unable

to meet the accommodation students' needs, meanwhile, students also have certain requirements in accommodation in aspects of personalization and intelligence.



(a) The shortage of the management and services in traditional apartment

(b) The improvement of traditional apartment

(c) Long-range control in smart apartment

(d) Community functions in smart apartment

(e) Cultural diversity in smart apartment

Fig. 1. Traditional apartment and smart apartment survey statistics

When it comes to long-range control in the apartments (Figure 1c), 32.2% of the students believe that the self-services including room services and bottled water deliveries need to be improved; 28.1% of the students consider that the door access controlling of apartment and dormitories needs improvement, followed by repair services (26.8%); the rest of the students also have a certain demand in daily check-in, check-out, tune lodging and maintenance. The feedback statistics and analysis show that the enhancement of the life service is the inherent requirement of the development of university apartment services. Figure 1d further shows the community functions smart apartment may have that go beyond the traditional basic accommodation function, 43.9% of students deem that rich apartment living should set fitness, and leisure and entertainment services, emergency medical rescue service as second (28.5%). In addition, the psychology, study and legal advisory, which can be related to student's growth and development, are increasingly being needed and concerned. So that, diversified services become an essential function of the smart apartment. Moreover, boarding students generally agree that a highly intelligent and harmonious community (21.3%), highly shared network (20.5%) and free and open learning culture (21.4%) is the three main aspects of smart apartment cultural construction in the future (Figure 1e), at

the same time, liberal arts, personality, tolerance and sharing culture are also essential.

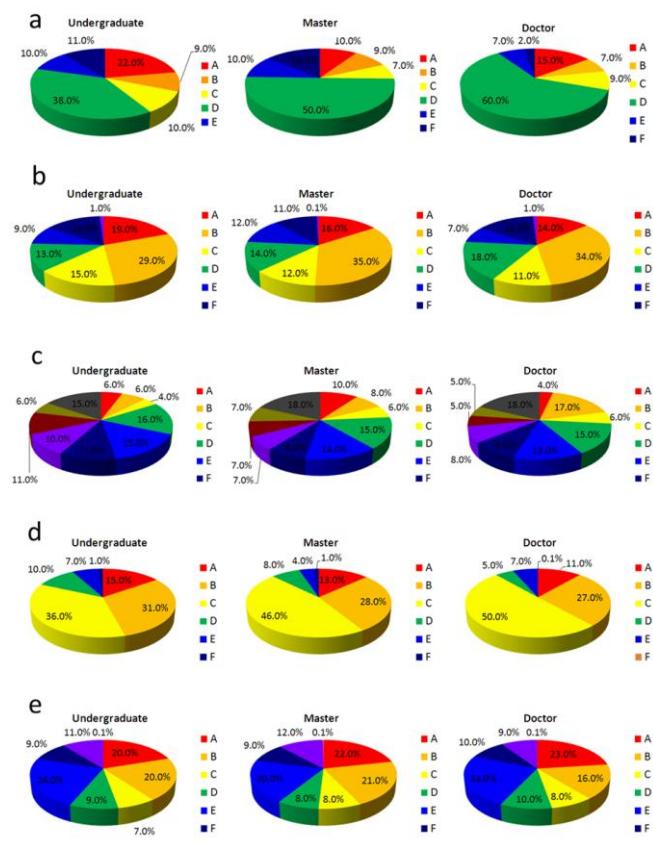
Finally, the open-ended questions results demonstrate that, most of these students believe that the current apartment's indoor hardware facilities and network informatization degree are low, and need to be further improved and enhanced in the near future.

## 2) The different categories of students' questionnaire analysis

By further analyzing the statistics of traditional apartment and smart apartment by different categories of students, we find that traditional apartment owns inadequate management and service (Figure 2a). Low-level informatization in traditional apartment is considered the highest proportion by students, consistent with results in Figure 1a. Moreover, as the grades increase, the proportion of the students who believe the informatization level of traditional apartment is relatively low obviously increases. Their percent proportion are about 38.0% (the undergraduate), 50.0% (the graduate student), and 60.0% (the doctor) respectively. The proportion of students who think the management mechanism is not sound is also listed as secondary, and the statistical results are listed in Figure 2a, consistent with Figure 1a. Compared with the graduate student (10.0%) and doctor (15.0%), the undergraduate (22.0%) pays more attention to build management mechanisms. Students have similar recognitions in inadequate culture, security, services and methods, as shown in Figure 2b. While 30.0% of students hope that the indoor hardware facilities and equipment should be improved, the percent proportion of the graduate and doctor is higher than that of undergraduates. With respect to the architectural style of smart apartment, the students from the undergraduates to doctor students show a decreasing trend. However, for the phone App, personalized service and apartment culture improvements, the selection of different categories of students have difference.

Figure 2c shows that the long-range control in smart apartment. In the apartment entrance aspect, the graduate students prefer to accept the remote control, higher than the undergraduates and doctors. Dealing with the remote control of the room environment, with the grader growing demand gradually increase, the proportion is from about 6.0% (the undergraduate) to about 17.0% (the doctors). As for handling the others, the proportion is similar. In the repair and cleaning, the demand from the undergraduate is higher than the graduate or the doctor. With respect to access control and fire alarm system, the proportion of different types of students is basically the same. In controlling room environment aspect (e.g., temperature, humidity, lighting, and so on), the undergraduates have more demand, however, the graduate students and doctoral students prefer self-service implementation remote control. In general, the undergraduate is more concerned about the indoor environment and the master, and doctor are more concerned about handling the remote controls check, change places and self-service area. In the whole, students believe in the

community function in smart apartment has basically the same proportion, as shown in Figure 2d. As the grade increases especially in doctoral students, the needs of the fitness, leisure and entertainment services increase significantly, from about 36.0% for the undergraduate up to about 50.0% for the doctor. Compared with the graduate and doctor, the undergraduates have higher demand in counseling, medical assistance and legal counseling. In addition, the undergraduate and doctor prefers the study advisory services. Considering different types of students, the discrepancy is not obvious in Figure 2e. All the students are more inclined to enjoy intelligent community culture, highly shared network culture and freedom to study culture among all the cultures. However, except for them, the doctor prefers to possess harmonious community and personality education culture in smart apartment.



(a) The shortage of the manage and service in traditional apartment

(b) The improvement of traditional apartment

(c) Long-range control in smart apartment

(d) Community functions in smart apartment

(e) Cultural diversity in smart apartment

Fig. 2. Different types of students for traditional apartment and smart apartment survey statistics (the options are consistent with figure 1)

Based on the above questionnaire analysis, we can conclude that the several aspects in the management information, intelligent hardware and service diversification of smart apartment have formed the main construction direction. Intelligent, harmonious and network-based

informatization will be the best approach to satisfy the above requirements, and which can fully reflect future services and educational philosophy in the university apartment.

In addition, for different types of students, the smart apartments possess personalized, intelligent design and characteristics of the services. For example, for junior undergraduates, Smart Apartment should fully reflect their pursuit of new personalized things and provide advanced network services to reflect the more humanistic care; and for the seniors and doctoral students, the apartment should pay more attention to the construction of highly harmonious apartment community culture and humanized intimate service to create a multi-dimensional life and scientific research innovation environment.

### B. Architectures of smart apartment service

From the above analysis of traditional students' apartment services and questionnaire, we attempt to design a service-oriented smart apartment system, in order to fully satisfy the demand of the student accommodation and enhance the apartment service efficiency. Firstly, to understand clearly the run mode of smart apartment, the general architecture of smart apartment service can be seen in Figure 3. In Figure 3, four modules such as students/teachers, quick response, data management and control, and student apartment are connected to the smart apartment network via data service center (platform) that establishes and controls the connections and functional interfaces between the networks and various electrical devices. Here, firstly, students/teachers' requests and information are transmitted to the data service center that are connected to others. On the one hand, students/teachers can directly control the indoor environment of the dormitory; on the other hand, the network managers can receive students/teachers' requests and information quickly via the



Fig. 3. Smart apartment service architecture

fast-optic links; simultaneously, apartments can provide quickly services to students/teachers. Next, how to further design smart apartment referring mainly to the four parts which are (i) smart building, (ii) smart network, (iii) artificial intelligence service, (iv) smart cultural construction. They are going to be discussed.

#### *1) Smart building*

Firstly, smart building contains the main building and some surrounding infrastructures including the apartment common area and natural environment design. Next, we will discuss them one by one.

a) *Interior design of smart apartment.* Except for rational design of the main building, we consider that interior design of smart apartment should pay more attention to its security, privacy and comfort feature [8]. By installing artificial intelligent control hardware in students' apartment, our managers can efficiently acquire the real-time data of the indoor environment including temperature, humidity, lighting, working order of electric devices and so on, and they can also know the students' habits in life and study in order to provide better service for them, because it will analyze these efficient data and provide feedback to managers.

b) *Apartment design at public areas.* The public area of smart apartment is an important part of the hardware equipment, since it can provide students with much more comfortable learning and leisure space at public area. To satisfy students' personalized and diversified needs, various types of rooms such as activity room, recreation room, study room, as well as advisory services room (e.g., psychological counseling, legal advice, study advice, employment and entrepreneurship guidance) should be designed in the public areas. Besides, some hardware facilities such as self-service terminal system, security management control system, data collection system, together with network equipment for some other services, form an integrated hardware service system at smart apartment [10].

c) *Design of surrounding environment.* The design of surrounding environment of smart apartment is also a very important part to reflect the harmonious culture of university students' community. The surrounding environment contains the learning space and entertainment space. Firstly, to efficiently construct a better learning environment, we should construct much more separated space, where some plants such as shrubs, canopy and trees are planted. These green areas are located around these apartment. Second, in these green areas, we should fit greenery flower beds and lounge chairs around the apartment. In spare time, students can enjoy their leisure time in these areas, and some public square can provide various holiday gatherings for students. The construction of the public environment also stimulates students to participate in cultural activities at the surrounding apartment. Meanwhile, the surrounding environment can be

efficiently managed and monitored by smart network system to ensure people's safety.

#### *2) Smart Network*

Smart network is a very important part in smart apartment and the purpose of our smart network realization mainly lays in Do-It-Yourself (DIY) service for students and teachers. With the development of the internet and mobile phone, our smart network can be easily applied by the use of the APP in mobile phone and software in panel computer and laptop. Students and teachers can completely use them in their DIY services by the electronic equipment. For example, through the APP, students can control their indoor environment in their room such as temperature, light, and certain services (e.g., requesting for repairs, booking dinner, cleaning room, and so on), and at the same time, the managers can collect the real-time information, in order to obtain intelligent identification, positioning, tracking, monitoring, management and quick responses [11].

#### *3) Intelligence services*

To fully satisfy diverse needs of students' accommodation, the construction of the intelligence service system is a key for smart apartment in colleges or universities. Except for some basic services (e.g., cleaning, security), some other services such as mental health advisory and emergency medical services, various types of consulting services, and domestic service, will fully embody our intelligent service system.

a) *Mental health and emergency medical services.* Reynolds noted that counselling service of psychological problems is closely related to the relationships. For some students who have troubles in relationships, our smart apartment will establish the special counselling rooms to offer a certain extent service. In addition, in order to deal with health emergencies, smart apartment also set up the emergency room to fully supply the emergency medical service for students.

b) *Various types of consulting services.* Smart apartment can establish policy advice, study counseling and guidance services, and employment advice to provide a full range of convenient consulting service for students.

c) *Life services.* By building a local area network platform in smart buildings, students can stay at the dormitory to enjoy a rich and convenient campus life services, because smart apartment widely uses WeChat, forums and other network platform language to provide the life guarantee for one-stop service.

#### *4) Smart culture*

Smart apartment, like a harmonious community, possesses a strong cultural atmosphere, embodies the vitality of students, reflects their thinking, learning, and a good life and psychological state. Therefore, smart apartment also has a highly shared network culture for all the students to provide free and open learning platform and innovative ideas, since they learn how to communicate with

each other, to cognize oneself, to stimulate their individual learning potential, to develop their value orientation and ideas, and gradually forms their lofty ideals.

In addition, as smart apartment constructors and participants, we need to transform and upgrade service concept and role for enhancing service awareness and education, to promote smart apartment building fundamentally. Although the smart apartment can take advantage of advanced technologies and instantly grasp the current demands for information services dynamically to provide users with the most appropriate services, but it only stays at a technical level, apparently unable to fully reflects the essence of our construction, which is efficient, convenient and personalized service, more than reaching the purpose of university apartment education [12, 13].

The construction of “smart apartment” starts from people, that is, the wisdom comes from the builder and acts by the participants [14]. Therefore, it is particularly important to build a high-quality, professional and standardized intelligent service group for building smart apartment.

#### IV. CONCLUSIONS

Nowadays, China’s higher education is changing from denotative expanding to connotative development, according to the requirements of the scientific outlook development. The development mainly focuses on the scale, structure and quality of higher education, in order to accomplish the coordinate development. Meanwhile, the rapid development will also put forward new and higher requirements to the logistic service system. Therefore, based on the statistical analysis of questionnaire survey of students’ accommodation demands in some colleges or universities in Beijing, China, we propose to meet the high-level demands of apartment management and service, focusing on the quality and efficiency, to achieve the ultimate goal of the education in students’ apartment and construction of internet thinking-based smart students’ apartment.

More significantly, we have tried to design “Smart Apartment” in terms of architecture, network, service, culture and other aspect, considering students’ expectations of building a smart apartment for the future.

I hope that in the near future, we will finally complete the construction of smart apartment by gradually exploring in practice. This not only can effectively improve students’ living and learning environment, but also to exert a subtle influence on the education and guidance for students who live in “Smart Apartment”. It will have an important and far-reaching significance in the quality of training,

perception coordination, and people cohesion.

#### ACKNOWLEDGMENT

The author thanks students’ discipline committee of Beihang University for its study support and assistance.

#### REFERENCES

- [1] J. Gikas, and M. M. Grant, “Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media,” *Internet High. Educ.*, vol. 19, pp. 18-26, June 2013.
- [2] A. Sheftel, and S. Zembrzycki, “Slowing down to listen in the digital age: How new technology is changing oral history practice,” *Oral Hist. Rev.*, vol. 44, pp. 94-112, April 2017.
- [3] B. Balaji, A. Bhattacharya, G. Fierro, J. Gao, J. Gluck, D. Hong, A. Johansen, J. Koh, J. Ploennigs, Y. Agarwal, M. Bergé, D. Culler, R. K. Gupta, M. B. Kjærgaard, M. Srivastava, and K. Whitehouse, “Brick: metadata schema for portable smart building applications,” *Appl. Energ.*, vol. 226, pp. 1273-1292, February 2018.
- [4] H. R. Ekbia, “Fifty years of research in artificial intelligence,” *Annu. Rev. Inform. Sci. Tech.*, vol. 44, pp. 201-242, March 2012.
- [5] H. Ekbia, M. Mattioli, I. Kouper, G. Arave, A. Ghazinejad, T. Bowman, V. R. Suri, A. Tsou, S. Weingart, and C. R. Sugimoto, “Big data, bigger dilemmas: A critical review,” *J. Assoc. Inform. Sci. Tech.*, vol. 66, pp. 1523-1545, December 2014.
- [6] H. T. Dinh, C. Lee, D. Niyato, and P. Wang, “A survey of mobile cloud computing: architecture, applications, and approaches,” *Wirel. Commun. Mob. Comput.* vol. 13, pp. 1587-1611, December 2013.
- [7] M. S. Kerr, K. Rynearson, and M. C. Kerr, “Student characteristics for online learning success,” *Internet High. Educ.*, vol. 9, pp. 91-105, March 2006.
- [8] S. Figueiredo, N. E. Mayo, and A. Thomas, “Future rehabilitation professionals’ intentions to use self-management support: helping students to help patients,” *Physiother Can.*, vol. 69, pp. 73-80, September 2017.
- [9] D. McNeill, “Global firms and smart technologies: IBM and the reduction cities,” *Transac. Inst. Brit. Geogra.*, vol. 40, pp. 562-574, April 2015.
- [10] N. Khabou, I. Bouassida, R. GhadaGharbi and M. Jmaiel, “A threshold based context change detection in pervasive environments: application to a smart campus,” *Procedia Comput. Sci.*, vol. 32, pp. 461-468, June 2014.
- [11] K. Karima, N. Peter, and S. John, “The significance of digital data systems for smart city policy,” *Socio-Econ. Plan. Sci.*, vol. 58, pp. 13-21, February 2017.
- [12] H. Farhangi, “Smart microgrids-lessons from campus microgrid design and implementation,” *IEEE Electr. Insul. Mag.*, vol 33, pp 57-57, August 2016.
- [13] K. Egvall, E. Lampa, P. Levin, P. Wickman, and E. Ofverholm, “Interaction between building design, management, household and individual factors in relation to energy use for space heating in apartment buildings,” *Energ. Buildings*, vol. 81, pp. 457-465, October 2014.
- [14] R. J.-C. Chu, and C. C. Tsai, “Self-directed learning readiness, internet-efficacy and preferences towards constructivist internet-based learning environments among higher-aged adults,” *J. Comput. Assist. Lear.*, vol. 25, pp. 489-501, 2009.