Interactive Building Environments: A Case Study University Building in UAE

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Abstract

Microprocessor-based technologies are fast becoming a key instrument in building intelligent facilities. Educational sectors are sought to be one of the critical segment in the society, an environment that has a massive impact on the learning process on the growing generations. Hence, an intelligent building with integrated advanced digital technologies becomes an exemplar for the modern existing building. This paper discusses the state of intelligence levels of an existing university building in the United Arab Emirates; the building is ESTIDAMA certified. In this study, several intelligent building system indicators have been evaluated. Building structure and in the relation between interior facilities and exterior construction will be studied. Furthermore, surveys including questionnaires and interviews have been undertaken among the building management staff, the university academics and students. After identifying weaknesses in the building system through a framework adopted using eight intelligent building indicators, recommendations are proposed enhancing the existing systems and the intelligent strategies in the case study university campus to also improve both the users’ performance and productivity.

Keywords: Intelligent Buildings Systems; Interactive Buidling Environments; Intelligent University Campus; UAE.

1. Introduction

The role of digital technology in the creation of energy-efficient buildings is ahead today than it than 10 years ago. The rapid growth of technological advances and its role in the communication of human’s social and living

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aspects has made it an inseparable part of the present lifestyle. The demand and dependency on intelligent technologies in the modern life have reflected on the complexity of the built environment.

An intelligent smart building system connects various major services in a building. Fig. 1 illustrates the key components of a connected building system (Fire/Life safety, Security, Lift/Elevators, building access, Lighting, Energy Management, HVAC, Communications). However, it is necessary to point out that not every claimed intelligent building can be classified as smart/intelligent without corresponding to the functionality of the system and operational efficiency of the installed intelligent system.

![Fig. 1. Integrated Building System](image)

Until the present day, the term “intelligent building” has been in a constant change as a technological breakthrough, and are progressing and developing day by day. Manufacturers of technological systems are in competition to present intelligent innovations that cope with the needs of the society.

Wong et al. (2008) have conducted a research based on the system intelligence model using findings of Bien et al. [1,3]. The study introduced a holistic set of criteria to evaluate the performance of intelligent buildings. The proposed system is called key performance indicators (KPIs), and these indicators target eight main areas depending on the selected building:

- Integrated Building Management System, IBMS.
- Telecom and Data System, TDS.
- Heating, Ventilation and Air-conditioning Control System, HVAC.
- Addressable Fire Protection and Alarm System, AFA.
- Security Monitoring and Access Control System, SEC.
- Digital Addressable Lighting Control System, DALI.
- Smart/Energy Efficiency Lift Control System, LS.
- Computerized Maintenance Management System, CMMS.

The paper is an extract from a research completed in 2015 as part of Master’s coursework at the British University in Dubai (BUiD) within the ‘Sustainable Design of the Built Environment’ programme.

2. Methodology

New York University Abu Dhabi (NYUAD) is distinguished to be one of the most sustainable and contemporary built campuses in Abu Dhabi. The aim of this study is to investigate three points in the overall university environment:

- To what level the sustainable campus has integrated building systems.
- The end user awareness about these systems.
- Providing solutions related to interior special problems.
The university campus as a whole is a big space to investigate and analyze, thus in this study, it was aimed to select one area to study. Furthermore, the focus is on the interior aspect of the building. Tackling the problems linked to the semi-transparent structure of the building, which brings many problems about energy consumption and user comfort. For example, excessive daylight entering the body of the building will cause temperature increase, which will lead to the increase in HVAC demand during the day. Moreover, users will feel irritated to the light glare from glass structure and rooftop opening. This study will focus on providing solutions related to:

- Integrated Building Management System, IBMS.
- Heating, Ventilation and Air-conditioning Control System, HVAC.
- Digital Addressable Lighting Control System, DALI.
- Security Monitoring and Access Control System, SEC.

To assess the building, site visits were undertaken as well as interviews within the NYUAD building management department and their sustainability course’s dean, tutors and students in order to see their point of view about their campus. Additionally, to get the campus user (worker, facilitators, students, residents), a questionnaire-based survey was conducted aiming at the awareness of the users about the problems they face regarding lighting, HVAC systems and IBMS properties.

3. Case Study

United Arab Emirates is considered as developing country that has grown rapidly. One of the major reasons for the rapid growth is the promotion of Dubai Expo 2020, in order to promote the future city of Dubai, the government started to plan for a smart city and slowly to reflect on other emirates. To achieve this target, creating sustainable built environment sought to be vital.

Another reason to focus on creating a sustainable city is because the UAE is ranked as one of the top countries with high Ecological Footprint. The WWF’s Living Planet Report 2014 stated that the UAE as the third highest per capita Ecological Footprint. Thus, the urgency to alternate the damaging behavior to the environment became a priority; government initiated drastic changes on social aspects (awareness), regulation (DEWA BMW sustainable plan) and the built environment structure (promoting sustainability assessment methods, like LEED and ESTIDAMA, with stakeholders who are the decision makers).

For this study, New York University Abu Dhabi as an existing campus has been selected. The campus stretches out to 15.4 hectares. The campus is located Saadiyat Island in Abu Dhabi, the capital of United Arab Emirates (see Fig. 2).

![Fig. 2. New York University master plan [7].](image)
The campus includes academic buildings, information technology facilities, a library, an art center, laboratories, sports facilities, students and faculty residences. As seen in Figure 2, the structure of the building is designed in a matter that it responds to its surrounding, creating an interactive environment for the users and visitors.

The smart composition of the campus creates a unified body between the building structure, the interior and the landscape design. The coherence in the body of the university reflected the harmony between learning experience and living environment, between teaching faculty, staff and students and finally, between the various disciplines being taught at the university. The unique characteristic of the campus is the connection between the different facilities of the university through landscape design that connects to the interior of the facilities.

NYUAD is considered a sustainable campus, built to meet all requirement of ESTIDAMA sustainable certificate. Therefore, the outdoor environment features follow the indoor environment features, thus the intelligence of the case study will also highlight and evaluate the outdoor features of the campus. Sustainable features of the existing building are divided into two sections:

- Outdoors features: Based on observed site visit.
- Interior features: Based on questionnaire survey with staff and students.

### 3.1 Outdoor features:

- Internal side streets to be relatively narrow and shaded by the surrounding buildings.
- Use of local plants/palm trees and water channels that does not require excessive water while offering a soothing atmosphere during summer time, and pleasant scenery for the people (see Fig. 3).
- High Line is the dominate feature of the campus. The High Line is the connected roof top, at level two of all university campus, bridges and stairs creating pass way for users to move between the buildings. As can be seen in Fig. 4, the advantage of the High Line is to provide a green roof, which works as an insulator from heating. Moreover, High Line creates a variety of pathways between different facilities of the university, providing a lively and interesting campus. Also, having attractive passage will encourage students, facilitators and workers of the university to adopt a healthy lifestyle by walking between the buildings rather than using elevators and escalators. The high line shaped easy accessibility between campus for pedestrian, making walking distance more enjoyable with rooftop landscaping and view.
- Solar Panels installed on vast spaces on rooftops (see Fig. 4).

![Fig. 3. Water ponds (a) and shading devices (b) between the buildings](7).
3.2 Indoor Features:

- **Digital Addressable Lighting Control System, DALI.**
  The semitransparent building has successfully managed to source huge amount of light to the interior of the buildings. As can be seen in Fig. 5, each building has irregular geometrical glass structure in the center of the building open to the roof. This allows the entry of maximum daylight across the two stories building which helps to minimize the use of electrical lights, therefore minimizing energy consumption. The shafts and shading devices along the envelope of the building also help to reduce the glazing daylight to the classrooms. Usage of glass walls as internal walls to allow more daylight penetration to a wider space. Dimming light systems, the system can recognize moving objects and interacts by it. For example, the light automatically brightens when people walk along in long internal corridors.

- **Addressable Fire Protection and Alarm System, AFA.**
  The system included sensory devices to detect smoke. Information signage to guide people around the building is used excessively around the campus, both inside the building and in the outdoor spaces, this creates an easy guide for all visitors to recognize their locations and find their destination with minimum help. All lifts were connected with fire alarm system linked to the building, however, this system is only connected to the fire alarm system per building.

- **Smart/Energy Efficiency Lift Control System, LS.**
  One of the unique systems found in the building was the usage of intelligent lift system for security purposes. The residence buildings were located on the second floor at the east section of the university campus, leaving the ground and first floor for community interactive spaces and part of the visual art studio. Furthermore, the residence floors were connected to the Highline of the university, putting all the dormitory entrance available to the access of any visitor of the university. This is considered as a high security issue that may cause possible safety problem to the occupants. However, during site visits, it has been noticed that the lifts, which are connected to the residence area, only takes the user to the common space such as the high line (walking roof top) and the community space floor. Another feature of the lift was a smart card scanner. As shown in Figure 6, the scanning system belongs to smart card system specified for residents of the building. The system identifies the identity number of the student, which tracks the profile of the student and identifies whether they are a resident of that particular building, hence it allows access to the residential floors. This intelligent lift system is considered an intelligent security monitoring and access control system, which gives residence community a relief and feel of being in a safe environment.

- **Security Monitoring and Access Control System, SEC.**
The most outstanding feature of this system is the integration of this system with the lift control systems that has been mentioned in the previous section.

Fig. 5. Glass structure in the body of the building.

4. Discussion and Recommendations

This section will elaborate on the proposed recommendations from analyzing the NYUAD campus state of building intelligence. The study is looking to provide solutions for improving the intelligence of the university following Wong et al. (2008) intelligent building key indicators [1]. Nevertheless, the focus of recommendations is as follows: (1) Heating, Ventilation and Air-conditioning Control System, HVAC; (2) Digital Addressable Lighting Control System, DALI; (3) Security Monitoring and Access Control System, SEC.

Only a group of 10 students answered the surveys, and the main reason for this is because of the timing concurred during summer. Only students who were available at the university during summer courses agreed to answer the survey questions. Students were asked to answer simple questions about lighting systems; HVAC system; the
temperature difference between their class indoor environment and the outside climate; level of controllability for 
HVAC system and lighting system. As can be seen in Fig. 7, most students found their classrooms with good amount 
of natural light, which is due to the massive glass structure in the center of the building that allows large amount of 
natural light to be transferred to the body of the building. In contrast, almost half of the respondents found 
controlling HVAC systems to adapt to their needs in the classroom to be very poor, making the HVAC system not 
user-friendly (see Fig. 7).

Fig. 7. Weaknesses and strength of student’s survey.

The study conducted an interview with only one staff as the rest of the team members were on summer leave, 
moreover, only partial answers were provided in the questionnaire as part of confidential information. Weaknesses in 
the building system found from the interview, which were around the integrated building management system as a 
whole functioning body, although the structure of the building worked in a harmony as one body, however, building 
automation systems work separately. HVAC system works independently; the system does not have self-diagnosis 
feature to detect any error.

Linking related systems into one single system that works efficiently and provides improvement the service given 
to the end user. For example, integrating Security Monitoring and Access Control System, SEC with Smart/Energy 
Efficiency Lift Control System, LS. Similar to the use of smart card and smart access for all students, one single card 
to provide smart access to many departments in the university (library, classrooms, parking, etc.). The smart card can 
also be beneficial for teaching faculty have access to classrooms in their department.

A live example of a successful building integration is provided in the University of West England, United 
Kingdom where Schneider Electric, a specialist electric company in energy management and automation, in 
collaboration with.

Schneider Electric’s integrated security system in the existing university campus in addition to the new expansion 
departments. The company integrated switch system called Juniper switches with an existing Schneider Electric 
Andover Continuum building management system; these two systems enabled monitoring and control on security 
system in addition to heating and lighting system in the building.

Moreover, the university provided a single card security solution. Schneider Electric has implemented security 
measures, which work around the MIFARE Smart Card. This allows students to use just one card for access to
university buildings and residential areas, but also for cashless vending and as a library and photocopying card. Benefit from such building systems is summarized in reducing operational expenditure, reducing staff training, maintenance, requirements and personal cost and less hardware.

HVAC systems to have interference with management system and building automation system, in addition to its ability to work coherently with outside temperature, this feature can be the major source of increase of decrease of energy consumption among other systems. Another recommendation of integration between two systems is the adjustable external shading devices, which is connected and controlled by an advanced HVAC system. This will help in having better control over the process of heat gain during the day and finding the mutual temperature between the indoor environment and outdoor environment.

Another recommendation would be related to Telecom and Data Systems, TDS. It has been sought that the major weakness in the building system is the lack of having a single platform where all data/ key statistics of building systems are gathered in one location. Having a dashboard and visual panel of information for building management department is very beneficial. Easy access and log in into other systems, whilst being able to locate an error in the damaged systems. In addition, it would be good to present a new type of awareness to the students about the campus they are studying/ living in, this can be done by setting an interactive information board that presents in main lobbies / reception and visually demonstrates energy savings being achieved.

Finally, as the structure of the building has nice architecture narrative designs using sustainable features linking the outside to the inside. The narrative must be carried inside the building to create a new sense of interactive integrated technologies that creates a bridge between architecture, landscape and interior design.

5. Conclusions

With the rapid growth of population, the economy growth also increases parallel to the population. The driven force of technology has been the only outlook for the promising future, for many years improving the built environment was the key to sustain good living conditions. Intelligent building systems do not only provide a better efficient building, but also promise a better living environment for its occupants. This paper aimed to present an overview of an existing university campus, and brief about the current state and the method that can help adapting to assess, evaluate and then provide suggestions on a holistic approach towards IBMS giving solutions for areas of problem. The assessment method for this study is extracted from Wong et al. (2008) research [1]. Advantages of an integrated IBMS is having single management platform where all the building components come together, saving energy, saving operational costs, in addition to the reduction of installing and cabling costs.

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Reference: